Erol Esen, Veli Ercan Çetintürk,
Cem Şentürk (eds.)

Climate Change and Migration

Global Challenges and Local Mitigation Strategies

PETER LANG

This volume explores the complex intersection of climate change and migration from interdisciplinary and international perspectives. Based on the 2023 Antalya Science Forum (ANISF), the book brings together leading scholars and practitioners to analyze climate-induced mobility, food security, legal frameworks, urban resilience, and policy responses at global, national, and local levels. Contributions span empirical research, legal analysis, and case studies from Africa, Türkiye, and the EU. With a focus on inclusive and rights-based approaches, the volume challenges Eurocentric narratives and calls for stronger academic cooperation and policy innovation to address two of the most pressing global issues of our time.

Cem Şentürk is the program manager of "Participation in Economy and Local Governments" at the Centre for Studies on Turkey and Integration Research (ZfTI) in Essen, and lecturer at the HSPV NRW and the University of Witten/Herdecke.

Veli Ercan Çetintürk, PhD, focuses on local governance and migration studies. He currently works as a lecturer at Alanya Alaaddin Keykubat University.

Erol Esen, PhD, is a professor at Akdeniz University and director of the Center for Applied Research on Social Policies and Migration Studies.

ISBN 978-3-631-94419-6

9 783631 944196

www.peterlang.com

Climate Change and Migration

Erol Esen, Veli Ercan Çetintürk and Cem Şentürk (eds.)

Climate Change and Migration

Global Challenges and Local Mitigation Strategies

PETER LANG
Berlin · Bruxelles · Chennai · Lausanne · New York · Oxford

Bibliographic Information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data is available online at http://dnb.d-nb.de.

Library of Congress Cataloging-in-Publication Data
A CIP catalog record for this book has been applied for at the Library of Congress.

The publication of this volume was supported by the Centre for Studies on Turkey and Integration Research (ZfTI). The ZfTI is a member of the Johannes Rau Research Association (JRF). The institutes of the JRF are institutionally funded by the state of North Rhine-Westphalia.

Stiftung Zentrum für Türkeistudien und Integrationsforschung
Türkiye ve Uyum Araştırmaları Merkezi Vakfı
Institut an der Universität Duisburg-Essen

Ministerium für Kinder, Familie, Flüchtlinge und Integration des Landes Nordrhein-Westfalen

UNIVERSITÄT DUISBURG ESSEN
Offen im Denken

JRF
MITGLIED DER Johannes-Rau-Forschungsgemeinschaft

ISBN 978-3-631-94419-6 (Print)
ISBN 978-3-631-94440-0 (ePDF)
ISBN 978-3-631-94441-7 (ePUB)
DOI 10.3726/b23370

PETER LANG Open

Published by Peter Lang GmbH, Berlin, Germany

info@peterlang.com

This publication has been peer reviewed.

www.peterlang.com

Contact for General Product Safety Regulation (GPSR): gpsr@peterlang.com

Table of Contents

List of Figures 7

List of Tables 9

Acknowledgments 11

Introduction 13
Erol Esen, Veli Ercan Çetintürk and Cem Şentürk

PART I
Global Challenges

Doom or Adaptation? Research Findings on the Complex Interlinkages Between Climate Change and Human Mobility and Their Implications for Societal and Political Discourses 31
Benjamin Schraven

Climate-Induced Migration and the Response of International Law: Human Rights as a Key Framework 47
Önder Bakırcıoğlu and Yavuz Selim Alkan

Climate Migration as a Human Security Problem in Africa 73
Ishmael Adjei and Sevilay Zehra Aksoy

Possible Effects of Global Climate Change on Plant Health 97
Hüseyin Basım and Esin Basım

PART II
Local Mitigation Strategies

Priorities in Türkiye's Climate Policy Within the Framework of Medium-Term Programs ... 121
Pelin Demircan Yıldırım

The European Green Deal: Leverage or Obstacle for EU–Türkiye Relations? ... 143
Yaşar Aydın and Bettina Emir

Climate-Resilient / Friendly City and Sustainable Urban Development ... 157
Ahmet Özaslan and Hüseyin Gül

Cooling Cities Through Street Tree Plantation as a Nature-Based Solution: Case Study of Antalya ... 177
Derya Arabacı, Çağdaş Kuşçu Şimşek and Büşra Öztürk

The Reflection of Urban Climate Justice on Urban Agricultural Lands: Evidence from Antalya Kırcami Case ... 197
Gülşah Tırış, Hilal Erkuş and Yavuz Selim Alkan

Investigation of the Effect of Green Roof Systems on Building Heating Load and Cost Relationship ... 225
Ender Yetim and Aynur Kazaz

Local Government Policies to Combat Climate Change: The Examples of Kyoto and Stockholm ... 251
Hülya Küçük Bayraktar

Conclusion ... 295
Erol Esen, Veli Ercan Çetintürk and Cem Şentürk

Notes on Contributors ... 299

Core Institutional Partners of ANISF ... 307

List of Figures

Figure 5.1: Codes Related to the Theme of Environmental Protection and Infrastructure 130
Figure 5.2: Codes Related to the Theme of Energy and Transportation 131
Figure 5.3: Codes Related to the Theme of Agriculture and Water Resources 132
Figure 5.4: Codes Related to the Theme of Green Financing and Financial Compliance 133
Figure 5.5: Codes Related to the Theme of National Climate Change Strategy 134
Figure 5.6: Codes Related to the Theme of Green Transformation and Sustainability 135
Figure 8.1: Study Area 180
Figure 8.2: ANN Model 184
Figure 8.3: Synthetic NDVI Image 185
Figure 8.4: Thermal Change Detection Analysis 186
Figure 8.5: Cooling Distances of Afforested Streets 187
Figure 9.1: Neighborhoods Included in the Kırcami Region Development Process 204
Figure 9.2: Flood Risk Map of the Düden River 211
Figure 10.1: Impacts of Green Roofs on the Urban Ecosystem 228
Figure 10.2: Typical Structural Section of a Green Roof 228
Figure 10.3: (a) Türkiye’s Position in the World (b) Degree-Day Regions of Türkiye 231

Figure 10.4: Base Building Model: (a) Site Plan, (b) Floor Plan 233
Figure 10.5: Building Envelope Layers: (a) Hollow Brick Wall, (b) Concrete Wall, (c) Roof Flooring, (d) Earth-Contact Flooring 235
Figure 10.6: Base Building Model View: (a) South Facade, (b) West Facade, (c) North Facade, (d) East Facade 235
Figure 10.7: Green Roof Scenarios Applied to the Base Building 236
Figure 10.8: Details of the Roof Types: (a) Gravel-coated Roof, (b) Green Roof 237
Figure 11.1: Greenhouse Gas Emissions of Kyoto 266
Figure 11.2: Badges of Kyoto 266
Figure 11.3: Greenhouse Gas Emissions of Stockholm 274
Figure 11.4: Badges of Stockholm 274

List of Tables

Table 5.1: Greenhouse Gas Emissions by Sectors (CO_2 Equivalent), 1990–2021 126
Table 8.1: Daily Climate Data for Satellite Image Dates 180
Table 9.1: Descriptions of the Character of the Region in the Development Plans of the Kırcami Region 205
Table 9.2: Findings on Gender, Age, Education, Profession, Additional Income, and Neighborhood of the Residents 208
Table 9.3: Findings Related to Spatial Justice 210
Table 10.1: A Comparison of Extensive and Intensive Green Roofs 229
Table 10.2: Climatic Characteristics of Antalya, İstanbul, Ankara and Erzurum 232
Table 10.3: Design Parameters of the Base Building 233
Table 10.4: Optical Design Parameters of the Base Building 235
Table 10.5: Building Components of a Green Roof System 236
Table 10.6: Cost Analysis of Roof Systems 241
Table 10.7: Comparison of Energy Saving and Cost Relationships of Green Roof Systems 242
Table 11.1: Kyoto City's Legal Arrangements for Climate Change 259
Table 11.2: The Anticipated Vulnerability of Kyoto Local Government to Climate Change 265
Table 11.3: The Role of Each Level 269
Table 11.4: The Anticipated Vulnerability of Stockholm Local Government to Climate Change 273
Table 11.5: Criteria for Stockholm's European Green Capital Award 276
Table 11.6: Kyoto's and Stockholm's Climate Goals 279

Acknowledgments

We express our heartfelt thanks to the reviewers who supported us throughout the selection process of the contributions included in this volume. Their expertise and constructive feedback played a key role in the careful selection and further development of the articles from a wide range of disciplines.

Prof. Dr. Şennur **Akansel** *(Trakya University)*, Assoc. Prof. Dr. Elvettin **Akman** *(Süleyman Demirel University)*, Dr. İsmail Sarp **Aykurt** *(Freelance Researcher)*, Prof. Dr. İsa **Cavidoğlu** *(Van Yüzüncü Yıl University)*, Dr. Eylem **Ceylan**, Dr. Bilge **Çakır** *(Hatay Mustafa Kemal University)*, Prof. Dr. Fikret **Çelik** *(Anadolu University)*, Assoc. Prof. Dr. Hamza **Çelikyay** *(Düzce University)*, Assoc. Prof. Dr. Serkan **Doru** *(Akdeniz University)*, Assoc. Prof. Dr. Şerife **Durmaz** *(Akdeniz University)*, Dr. Derya **Düzgün Top** *(Antalya Belek University)*, Vanessa **Edelmann** *(University of Applied Sciences for Police and Public Administration in North Rhine-Westphalia)*, Prof. Dr. Duygu **Gökçe** *(Süleyman Demirel University)*, Assoc. Prof. Dr. Ayça **Gülten** *(Fırat University)*, Prof. Dr. Dirk **Halm** *(University of Münster)*, Assoc. Prof. Dr. Sibel **Hoştut** *(Akdeniz University)*, Dr. Sümeyye ***Kahraman*** *(Süleyman Demirel University)*, Prof. Dr. Mustafa **Kara** *(Çanakkale Onsekiz Mart University)*, Prof. Dr. Gürsel **Karaca** *(Isparta Applied Science University)*, Assoc. Prof. Dr. Esra **Kaya Erdoğan** *(Freelance Researcher)*, Dr. Canan **Kışlalıoğlu** *(Bitlis Eren University)*, Prof. Dr. Mustafa **Kocaoğlu** *(Necmettin Erbakan University)*, Dr. Burak **Korkmazyürek** *(Süleyman Demirel University)*, Prof. Dr. Mustafa **Lamba** *(Burdur Mehmet Akif Ersoy University)*, Assoc. Prof. Dr. Levent **Memiş** *(Giresun University)*, Dr. Neva **Övünç Öztürk** *(Ankara University)*, Dr. Güliz **Öztürk** *(Akdeniz University)*, Prof. Dr. Songül **Sallan Gül** *(Süleyman Demirel University)*, Assoc. Prof. Dr. Hayriye **Samur** *(Selçuk University)*, Prof. Dr. İsmail **Sevinç** *(Necmettin Erbakan University)*, Dr. Çiğdem Sema **Sırma** *(Başkent University)*, Prof. Dr. Bülent **Topkaya** *(Akdeniz University)*, Prof. Dr. Mehmet **Tunçer** *(Çankaya University)*, Prof. Dr. Şefik **Tüfenkçi** *(Van Yüzüncü Yıl University)*, Dr. Onur **Yerlikaya Şaşmaz** *(Fırat University)*.

Introduction

Erol Esen, Veli Ercan Çetintürk and Cem Şentürk

Our world is currently undergoing an era of profound transformation, prominently shaped by two global phenomena: climate change and migration. Recognizing these developments does not require highly sensitive measuring instruments—the changes in both meteorological and demographic conditions are clearly visible to the naked eye. However, while simple observation may suffice to perceive these processes, the precise scientific analysis of these developments remains essential in order to adequately shape and manage the necessary adaptation strategies. Against this background, the growing global academic interest in both fields is of particular significance.

A closer examination of the available data, however, reveals that scientific production—like many other resources in the world—is geographically highly unevenly distributed. A bibliometric analysis of academic publications on climate change conducted by Haunschild, Bornmann, and Marx found that approximately 220,000 scholarly articles and reviews on this topic were published between 1980 and 2014 (Haunschild et al., 2016). During this period, the number of publications doubled approximately every five to six years, with a tenfold increase between 1990 and 2010 alone. This analysis provides two key findings that are also of particular relevance to the present volume:

1. The significant rise in climate change research since the 1990s has been predominantly driven by the natural and engineering sciences. Although an increase in social science publications can also be observed, the gap in the total number of publications between these disciplines remains considerable.
2. In terms of geographic distribution, researchers from the United States dominate the field, contributing 62,000 publications. Among the ten countries with the highest number of publications are—with the exception of China and Australia—exclusively G7 member states or countries with observer status. Germany ranks third with approximately 14,900 publications, while Türkiye, with around 1,200 publications, is positioned at the lower end of the list, alongside countries such as Greece, Portugal, and Taiwan. This distribution is particularly concerning given that the adverse effects of climate change are most acutely felt in developing and emerging economies.

Similar patterns can be observed in bibliometric analyses of migration research. The World Migration Report 2020 (IOM, 2019), published by the International Organization for Migration (IOM), indicates that the number of migration-related publications quadrupled between 2000 and 2018. However, a detailed analysis of publications from 2017 to 2018 reveals that the majority of these contributions originate from researchers based in Europe and North America. Authors from these two continents account for 79 percent of migration-related publications, whereas scholars from Africa and Latin America—despite the significant migration movements within these regions—contributed only 5 percent of the total output.

In order to counteract this Eurocentric perspective on two pressing global challenges, it is crucial to give greater recognition to, and actively promote, academic voices from other world regions. This objective constitutes the primary motivation behind the present volume and the Antalya International Science Forum (ANISF), on which it is based.

The ANISF was held for the first time from November 29 to December 1, 2023, bringing together scholars, political and administrative decision-makers, as well as representatives from civil society and the private sector. The forum provided an interdisciplinary platform to discuss the topics of climate change, environmental crises, and migration. Organized under the leadership of the Social Policy Research Center for Migration Studies (ASPAG) at Akdeniz University, in cooperation with the Antalya City Administration and the Centre for Studies on Turkey and Integration Research (ZfTI) in Germany, the event was supported by numerous renowned institutions from both countries.

This edited volume presents a selection of the contributions discussed at the conference, compiled within a conceptually coherent framework for an international academic audience.

As editors, we selected the cases and themes in this collection to functionally illuminate the causal and governance bridges between the climate change-migration interaction—"global challenges" and "local adaptation/mitigation strategies." The African cases represent a broad ecological and sociopolitical spectrum where high climate vulnerability and human security-based migration dynamics intersect. Türkiye, and specifically Antalya, embodies the multilayered climate policy of a middle-income country, nature-based solutions (such as cooling urban green infrastructure), agritourism tensions, and the spatial implications of climate justice. Stockholm and Kyoto offer the opportunity to compare local climate change adaptation policies through their decentralized innovation capacity. This selection is designed to encompass (i) different climate risk typologies, (ii) the gradient in governance and institutional capacity, (iii) the evolutionary diversity of policy instruments, and (iv) the potential for cross-scale learning. Thus, the book aims to present transferable lessons from normative frameworks to local practice with analytical coherence.

It must be acknowledged, however, that bringing together the results of a conference involving scholars from highly diverse academic disciplines—who approach the topics of climate change and migration either in relation to one another or as separate issues—into a coherent conceptual framework represents a considerable challenge. In addition to a formal and methodological review of all contributions as part of an editorial evaluation process, each article underwent a double-blind peer review. While this ensured the formal and methodological quality of the publication, we also sought to establish a consistent conceptual orientation across the volume. To this end, we aligned the selection and organization of the contributions with two key research questions:

1. Is climate change a decisive factor influencing migration?
2. How are climate change and migration perceived and governed at different political levels?

The relationship between climate change and migration is neither linear nor monocausal. Rather, long-term climatic changes affect migration movements within complex contexts shaped by multiple, interrelated factors. When examining those regions that are frequently identified in the literature on climate-induced migration as high-risk areas—such as sub-Saharan Africa, North Africa, East Asia, and South Asia—it becomes evident that these are often regions where food security is threatened and political instability prevails. Against this backdrop, it seems plausible to conceptualize climate-induced migration primarily as a problem of food security. Consequently, this volume also includes contributions that explicitly address questions of food security.

The second guiding question focuses on how these two major global challenges are perceived and addressed at various political levels—from the global level, through the continental level, to the national level in Türkiye, and finally down to the local level in Antalya, the host city of the forum. A closer look at the local level reveals that climate protection and climate adaptation measures increasingly come to the fore. This observation is consistent with the insight that the relationship between climate change and migration is not linear, and that local climate policies—even if not directly migration-specific—can nonetheless serve as preventive adaptation strategies in the long term.

The first of the 11 articles included in this volume is by Benjamin Schraven from the German Institute of Development and Sustainability (IDOS). Schraven analyzes the relationship between climate change and human mobility, offering a critical perspective on alarmist scenarios that predict millions of so-called climate refugees arriving at Europe's borders. Instead, he emphasizes that although climatic changes may indeed act as migration drivers in crisis regions, the primary cause of climate-induced migration is to be found in issues of food security—a thesis that also underpins the conceptual framework of this volume. His contribution draws on international migration data and key reports on climate-related displacement, providing valuable insights into the field of international protection.

In his broader work on the nexus of climate change and mobility, Schraven repeatedly highlights the need for a differentiated approach to understanding the link between climatic changes and migration. He points out that there is broad consensus within the academic literature that frequently cited projections of millions of so-called climate refugees migrating to Europe or North America are often based less on robust empirical data and more on alarmist assumptions. Building on this assessment, Schraven proposes a policy model for addressing climate-induced migration, which is characterized by the following principles: preventing forced migration, maximizing the benefits of voluntary migration, and minimizing negative consequences, such as the exploitation of migrant labor.

Given the complexity and multidimensionality of mobility processes, Schraven advocates for moving beyond simplified concepts such as the problematic term "climate refugee" and the rigid patterns and power structures associated with it. In this context, he assigns a central role to the academic community. In particular, he argues that scholars should resist being guided by media narratives or public discourse and should instead commit to independent, empirically grounded research.

The phenomenon of climate-induced migration, which is already observable today and is expected to increase further in the future, calls for effective measures to mitigate the negative impacts of climate change, as well as a human rights-based approach to managing migration movements. In the second chapter of this edited volume, Önder Bakırcıoğlu and Yavuz Selim Alkan build upon the social science perspective provided by Schraven and expand the discussion through an international legal analysis. The authors structure their investigation around several key areas: international climate agreements and initiatives, gaps in legal recognition, and the roles played by international organizations and courts in addressing climate-induced migration, case studies of decisions by the Inter-American Court of Human Rights and the European Court of Human Rights, and the importance of adherence to human rights principles—particularly in light of the United Nations' Guiding Principles on Internal Displacement and the Kampala Convention.

Bakırcıoğlu and Alkan argue that there remains an urgent need to regulate the issue of climate-induced migration on the basis of human rights principles. While agreements such as the Paris Agreement, the Kyoto Protocol, and the United Nations Framework Convention on Climate Change (UNFCCC) represent key pillars of international climate law, they do not adequately address the specific needs of populations displaced by climatic changes. Similarly, although initiatives like the Sendai Framework and the Nansen Initiative offer valuable orientation, their non-binding nature and largely framework-setting character make them inadequate for ensuring effective protection. This situation highlights the necessity of establishing a binding international agreement specifically tailored to climate-induced migration and grounded in global cooperation.

In the view of the authors, a supranational regulatory framework on climate-induced migration should pursue the following core objectives:

- Recognize and actively protect the rights of climate-induced migrants.
- Adopt a comprehensive and forward-looking approach that includes both immediate protective measures and long-term strategies to address the root causes of displacement.
- Create opportunities for voluntary return where conditions allow.

- Place the protection of the human rights of affected individuals at the center of all actions and policies.
- Develop this regulatory framework in cooperation between states, international organizations, and legal experts.
- Include both internally displaced persons (IDPs) and cross-border migrants, as both groups remain insufficiently protected under the current legal frameworks—regardless of whether the arrangement is regional or universal in scope.

Furthermore, the authors emphasize the importance of taking into account the interests of both origin and host countries, as well as those of the affected local communities, particularly regarding existential security needs. From their perspective, a long-term, coordinated policy approach across local, national, regional, and supranational levels is essential for sustainable migration management.

The need for a binding supranational framework on climate-induced migration, as outlined by Bakırcıoğlu and Alkan, therefore closely aligns with Schraven's argument for the prevention of forced migration and the strengthening of human rights-based solutions. Building upon existing initiatives such as the Kampala Convention and advocating for their further development, the authors propose the establishment of an international legal instrument to provide a structured framework for climate-induced migration. Central to this proposal is the principle of safeguarding vulnerable populations and ensuring the protection of their fundamental rights.

While the first chapter of this volume focuses on the international perception of the phenomenon, and the second chapter highlights the legal robustness of the Kampala Convention, the third chapter provides an important complement to the breadth of the debate through its specific regional focus and critical examination and, they propose a supranational regulation from a different perspective than Bakırcıoğlu and Alkan. In the third contribution of this edited volume, Ishmael Adjei and Sevilay Zehra Aksoy, in their chapter *Climate Migration as a Human Security Problem in Africa*, analyze the issue of climate-induced migration from the perspective of the African continent—a region that, despite contributing relatively little to global greenhouse gas emissions, is disproportionately affected by the adverse impacts of climate change.

Adjei and Aksoy structure their analysis around four central thematic areas: migration in Africa, climate change and migration as threats to human security, the absence of a global regulatory regime for climate-induced migration, and the current framework conditions and challenges of migration management within the African context. The authors argue that migration has been an established topic on Africa's political agenda for several decades and that migration and displacement movements driven by climate change will likely further exacerbate the existing challenges faced by many vulnerable population groups. They emphasize that regional institutional mechanisms remain insufficient or cannot be fully utilized and further developed due to a lack of political will on the part of many African governments.

The authors conceptualize climate-induced mobility as an existential threat to human security in Africa. Despite the urgency of the problem, their analysis reveals a significant gap between expectations regarding governmental action and the actual measures taken. In line with the positions outlined by Bakırcıoğlu and Alkan in the second chapter, Adjei and Aksoy also stress the necessity of a cooperative approach that includes both state and non-state actors.

Particular priority, according to the authors, should be given to strengthening education and literacy, raising awareness of the impacts of climate change, and fostering effective cooperation between local communities, the broader population, and state institutions at the regional level. They advocate for decentralized and inclusive policies capable of responding effectively to the complex dimensions of climate-induced migration. The long-term objective, they argue, should be the establishment of a sustainable institutional mechanism based on clearly defined principles, norms, and rules that ensure the implementation of appropriate policy frameworks for addressing climate-related displacement. At the heart of all such efforts must be the strengthening of human security, particularly in the protection of those whose livelihoods are increasingly threatened by climate change.

Adjei and Aksoy further emphasize that even within a supranational regulatory approach at the international level, technical and financial support from global actors is indispensable for facilitating efforts to combat the climate crisis and mitigate its consequences.

Another central effect of global warming and climate change, undeniably, lies in the increasing threat to global food security. This issue is addressed in the fourth chapter of the volume by Hüseyin Basım and Esin Basım in their contribution *Possible Effects of Global Climate Change on Plant Health*. The authors present compelling evidence on the risks posed to global food production systems, analyzing the impacts of climate change on crop cultivation as well as the effects of rising temperatures, elevated CO_2 levels, and increased humidity on plant pathogens. They highlight the alarming fact that, within the next quarter-century, a significant portion of the world's population will live in low-income countries, while two-thirds of the plant species that form the backbone of global caloric supply will be at serious risk.

Drawing on historical examples, the authors offer concrete recommendations for safeguarding global food security. Recent scientific studies already demonstrate the wide-ranging negative effects of climate change on the stability and quality of food supply chains. Basım and Basım warn that current methods of disease control—particularly chemical-based strategies—not only lead to direct crop losses but also exacerbate social and economic problems and pose risks to food safety through chemical residues. They argue that developing new approaches to disease management is of central importance in addressing the challenges posed by a changing climate.

To meet these challenges, the authors advocate for the diversification of plant protection strategies. Beyond the traditional use of chemical pesticides, they recommend a stronger focus on digital and precision agriculture technologies, the advancement of plant biotechnology methods, the use of biopesticides, and the establishment of early warning systems for disease forecasting based on weather predictions.

The promotion and dissemination of scientific research on the effects of climate change on plant health thus constitute a crucial prerequisite for preventing the escalation of the global food security crisis.

In the fifth chapter of this edited volume, Pelin Demircan Yıldırım, in her contribution entitled *Priorities in Türkiye's Climate Policy Through the Framework of Medium-Term Programs*, examines Türkiye's climate policy from a programmatic perspective. The author analyzes the 16 *Orta Vadeli Programlar* (OVP, Medium-Term Programs) published between 2006 and the present, outlining a conceptual framework around the subtopics of climate change as a global threat and climate change in the context of Türkiye. Within the priority areas of environmental and infrastructure policy, energy and transportation, agriculture and water resources, green financing, and the national climate strategy for sustainable transformation, Demircan Yıldırım identifies key policy priorities and developmental trajectories that shape Türkiye's climate policy as an emerging economy.

Demircan Yıldırım finds that Türkiye's strategies for combating climate change have continuously evolved and intensified since 2006. She highlights that the designated priority areas within the OVPs provide a comprehensive roadmap for achieving national climate objectives. Particular emphasis is placed on political measures promoting renewable energy and local resources, low-emission transportation projects, and technology-based approaches to the sustainable use of natural resources. Other strategies embedded within the OVP include zero-waste programs, greenhouse gas reduction measures, the expansion of recycling and circular economy models, and investments in sustainable forestry.

However, the analysis also reveals that the budgets allocated for environmental protection, infrastructure development, agriculture, and water resource management within the OVP remain limited. Against this backdrop, the author calls for strengthening these policy areas and increasing financial allocations. Among her concluding recommendations are the intensification of public participation, the definition of specific and measurable targets, and the expansion of education and awareness-raising programs. The author underscores that the success of climate policy measures depends not only on state actors but also on the active involvement of all sectors of society and the private sector.

In the sixth chapter of this volume, Yaşar Aydın and Bettina Emir, in their chapter *The European Green Deal: Leverage or Obstacle for EU–Türkiye Relations?*, analyze the issue within the current context of EU–Türkiye bilateral relations. Focusing on key areas such as EU–Türkiye trade relations, the goals and measures of the European Green Deal (EGD), Türkiye's decarbonization efforts, potential obstacles and risks, as well as the necessary conditions for success, the authors provide a comprehensive assessment of the subject. Their contribution complements the previous chapters depiction of Turkish climate policy by adding a European dimension.

The European Union, as a supranational actor, plays a pivotal role in international climate policy. Political instruments such as the EGD and the recommendations and decisions of the European Commission exert considerable influence, particularly on EU member states and candidate countries, by establishing binding climate-friendly standards across economic and social sectors. Aydın and Emir specifically examine the impact of the EGD on EU–Türkiye relations, concluding that the EGD represents both a potential barrier and an opportunity for the Turkish economy and bilateral trade between Türkiye and the EU.

The transition toward a low-carbon economy presents significant challenges for companies, requiring them to adjust production methods and undertake substantial investments. While this transformation often involves considerable costs, it also creates opportunities for innovation, the expansion of renewable energy use, and access to new sectors and markets. Although the unilateral introduction of regulatory measures by the EU—particularly in energy-intensive industries—may pose risks to the global competitiveness of Turkish products, the EGD could simultaneously serve as a catalyst for necessary political and technological modernization processes within Turkish industry. It could foster incentives for the transition to clean energy and thus contribute to the achievement of Türkiye's own decarbonization goals.

Drawing on analyses and statements from industry representatives and experts, Aydın and Emir emphasize that major corporations in Türkiye increasingly recognize the challenge and, at the same time, the opportunities presented by decarbonization as integral to their long-term strategic planning.

Following on from this, the contribution by Ahmet Özaslan and Hüseyin Gül, entitled *Climate Resilient / Friendly City and Sustainable Urban Development*, marks the transition to the local level and at the same time serves as an introduction to the subsequent place-based analyses in this volume. The authors structure their examination around several key thematic areas: climate change and urban environments, the relationship between climate resilience and climate change mitigation strategies, the concept of the climate-friendly or climate-resilient city, and the significance of sustainable urban development within the broader context of climate policy.

Based on a comprehensive review of the literature, Özaslan and Gül discuss the structural conditions that enable local governments to sustainably address climate-related challenges. Historically, cities have always been in a state of continuous transformation—a process that persists today. High rates of urbanization expose cities worldwide to complex social, economic, and ecological challenges. Urban growth not only impacts quality of life but also significantly contributes to environmental degradation through excessive consumption of fossil fuels and natural resources, with rising CO_2 emissions being one of the primary drivers.

Given that cities are both contributors to and potential arenas for solutions to climate change, the development of healthy and sustainable urban living spaces assumes critical importance. Climate-resilient city strategies aim to enhance the capacity of urban environments to withstand adverse climate impacts while simultaneously promoting principles of sustainability. Existing concepts such as compact, eco, green, and smart cities reflect integrated approaches that combine climate mitigation measures with adaptation strategies.

Key elements of these strategies include the use of renewable energy, green infrastructure, and urban transformation processes. The authors emphasize that developing climate-resilient cities not only serves to address climatic risks but also makes a significant contribution to achieving overarching sustainability goals. The design of related policies must therefore balance environmental protection with the promotion of healthy urban development processes. Only through the consistent implementation of such approaches at the local level can an effective interplay between climate protection, adaptation, and sustainable urbanization be achieved.

In their chapter *Cooling Cities Through Street Tree Plantation as a Nature-Based Solution: Case Study of Antalya*, Derya Arabacı and Çağdaş Kuşçu Şimşek demonstrate that the planting of street trees—based on satellite-based analyses of thermal changes—represents an effective measure for reducing surface temperatures, particularly in urban areas characterized by low building density. The authors employ Artificial Neural Networks (ANN) in combination with remote sensing data to model the microclimatic effects of street tree plantations. In contrast to conventional approaches that rely on direct air temperature measurements, this study utilizes surface temperature data derived from satellite imagery as the primary data source for the ANN modeling.

The findings confirm the high sensitivity and accuracy of ANN-based simulations in monitoring climatic variations within urban environments. Consistent with similar studies in the existing literature, the authors conclude that an increased density of street tree plantations significantly influences local climatic conditions and exerts a cooling effect on the adjacent road network. In the specific case study of the Muratpaşa district, the greatest thermal variation was observed in densely built-up urban areas. This suggests that street tree plantations may be particularly suitable for urban centers where the problem of urban heat islands caused by high building density has not yet fully manifested.

Moreover, the study highlights that the most substantial cooling effects are evident in coastal zones, with the potential for these effects to be further enhanced through the combination of coastal influences and street greenery. The research demonstrates the effective application of remote sensing technologies for the analysis of urban-climate phenomena, providing a cost-efficient approach to assessing regional climate structures and identifying vulnerable zones. The authors advocate for a methodological framework in which the analysis of urban climatic conditions should begin with remote sensing data, be supplemented by small-scale measurements, analyses, and simulations, and finally be integrated into strategic urban planning instruments.

In their chapter *The Reflection of Urban Climate Justice on Urban Agricultural Lands: Evidence from Antalya Kırcami Case*, Gülşah Tırış, Hilal Erkuş, and Yavuz Selim Alkan present the results of interviews conducted with residents in Kırcami, a rural area within the city of Antalya. Within a conceptual framework addressing the interconnections between urban climate justice, and the climate crisis, and urban agriculture, the authors identify major challenges faced by the region. Particularly alarming is the finding that more than half of the interviewees expressed no intention of continuing agricultural activities in the future—an observation the authors interpret as a warning sign for the future of agricultural land use in the area. This is especially concerning given that food security depends on the long-term economic stability and viability of agricultural producers.

Cities play a dual role as both contributors to and potential mitigators of the climate crisis. According to the authors, equitable and climate-sensitive urban development can only be achieved through participatory planning processes. Climate-responsive strategies should prioritize implementation in currently undeveloped areas and ensure that existing urban zones are transformed with equal care and sensitivity.

The study highlights urgent infrastructural deficits, particularly in the areas of water supply and sanitation. The survey data also reveal a growing loss of public trust in local governance due to the lack of transparency in planning and implementation processes. Extreme weather events, such as heavy rainfall in Antalya, could significantly increase the risk of flooding, especially where drainage infrastructure is insufficient or obstructed.

While 60 percent of respondents indicated a willingness to remain in the area following the planned interventions, a significant portion (40%) stated that they would consider relocating to areas where agricultural production remains viable. The study underscores the importance of climate-sensitive planning in the Kırcami district and highlights the necessity of multi-actor, participatory planning processes. The authors conclude that the development of climate-resilient communities can only succeed if the affected populations are actively involved in the planning process and if climate-responsive measures are firmly embedded in urban development policies.

In their contribution entitled *Investigation of the Effect of Green Roof Systems on Building Heating Load and Cost Relationship*, Ender Yetim and Aynur Kazaz explore the potential of green roof systems, analyzing cost-benefit relations and energy-saving potentials in comparison to conventional roof structures across different climate regions of Türkiye. Applying various construction scenarios, the authors demonstrate that green roofs, under certain conditions, can represent a financially viable alternative without significantly higher initial costs.

Their methodological approach includes a structural analysis of a Base Building and model simulations of different green roof variants. The study calculates the extent to which green roof systems can contribute to reducing heating energy demand across Türkiye's diverse climatic zones. The focus on sustainable energy use and the linkage between energy savings and investment costs make this research highly relevant not only for academia but also for the construction industry, municipal administrations, and climate policy decision-makers.

In the final chapter of this volume, Hülya Küçük Bayraktar, in her chapter *Local Government Policies to Combat Climate Change: The Examples of Kyoto and Stockholm*, compares the climate protection strategies of two emblematic cities—Kyoto, as an early reference point in global climate policy, and Stockholm, as a widely recognized example of successful urban climate action.

Following an extensive literature review to develop a conceptual framework, Küçük Bayraktar provides a detailed analysis of the climate policy measures implemented by these two cities. Her analysis focuses on several key policy areas, including the expansion of district heating and cooling systems, the promotion of energy-efficient buildings, the minimization of chemical use, the adoption of renewable energy sources, energy savings in the building sector, waste management, water, air, and noise protection, as well as sustainable transport and energy consumption.

The author highlights how both Kyoto and Stockholm have developed and implemented ambitious and effective local climate protection strategies. She derives practical recommendations for Turkish municipalities from these examples. The successful policies and measures implemented by these cities not only serve as best-practice examples but also hold the potential to inspire and guide other actors engaged in climate policy.

This volume is the result of joint efforts by the Social Policy Research Center for Migration Studies (ASPAG) in Antalya and the Centre for Studies on Turkey and Integration Research (ZfTI) in Essen to further deepen the German-Turkish academic dialogue. It is intended as a contribution to the discussion of two globally relevant challenges—climate change and migration—from a German-Turkish perspective. Naturally, this publication cannot claim to cover all aspects of these complex topics exhaustively. Nevertheless, it is our hope that future publications within the framework of the Antalya International Science Forum (ANISF, www.anisf.com) will continue to provide valuable impulses and help close existing research gaps.

Our aim is to establish ANISF as a platform for dialogue and the development of viable solutions across local, national, and global levels—thus contributing to a sustainable future. We hope that this book will not only stimulate scholarly discussion but also encourage other colleagues to continue and enrich the debate on these crucial issues.

Numerous individuals have contributed to the preparation of this publication. First and foremost, we would like to express our gratitude to the peer reviewers from various academic disciplines whose expertise significantly enhanced the quality of the volume. A complete list of reviewers is provided at the end of this publication.

We are also grateful to all institutions and organizations involved in the realization of ANISF, particularly the Foundation of the Centre for Studies on Turkey and Integration Research (ZfTI) and its director, Prof. Dr. Haci Halil Uslucan, as well as its board member, Prof. Dr. Dirk Halm.

Special thanks are due to Alexander Eser-Ruperti for his valuable assistance in editing the volume, as well as to Nilüfer Keskin and Ercan Verim for their

coordination of the financial aspects of the publication process. We would also like to thank the team at Peter Lang Publishing, in particular Esra Bahsi, for their professional cooperation.

We wish all readers an inspiring and insightful reading experience.

Bibliography

Haunschild R, Bornmann L, Marx W (2016) Climate Change Research in View of Bibliometrics. PLoS ONE 11(7): e0160393. https://doi.org/10.1371/journal.pone.0160393.

International Organization for Migration (IOM) (2019). World Migration Report 2020. IOM.

PART I

Global Challenges

Doom or adaptation? Research Findings on the Complex Interlinkages Between Climate Change and Human Mobility and Their Implications for Societal and Political Discourses

Benjamin Schraven[1]

1.1 Introduction

In the face of ever-new temperature records and serious natural disasters, the effects of climate change no longer appear to be just abstract visions of the future. The fears triggered by global warming, particularly in the Global North, are strongly focused on the issues of forced displacement and migration. The fear that climate change could rob millions of people—especially in the Global South—of their homes soon, and that these people could then set off for Europe or North America as climate refugees, is reflected in countless media reports in recent years. Furthermore, non-governmental organizations regularly use the alarmist, if not to say doomsday, narrative of a steady increase in the number of climate refugees and the existential threat posed by climate change to billions of people worldwide to promote their work.

The scientific debate on the links between climate change and human mobility has intensified considerably over the last 15 years, and numerous research projects, some of them large-scale, have been launched on the topic of "climate migration." This chapter wants to reflect on the findings of these research activities, also considering global migration trends. The fundamental implications for the political and (global) social handling of the nexus between climate change and human mobility will be worked out.

[1] Senior Consultant and Associate Fellow of the German Institute of Development and Sustainability (IDOS), E-mail: contact@benjamin-schraven.org, ORCID: 0000-0003-2584-2389.

1.2 Global Migration Trends

A look at the available data and trends regarding global migration puts alarmist narratives into perspective. An important source is the United Nations Department of Economic and Social Affairs (UNDESA) data. This data shows the number of international migrants. A migrant is defined as any person who changes their country of usual residence (UNDESA, 1998). Strictly speaking, this is information on the total number of international migrants who are in the respective country at any given time. This data on the number of migrants per country is mainly based on the respective country's foreign-born population and foreign citizenship. The data is usually collected every five years (UNDESA, 2023). This data does have its weaknesses. Data on the number of migrants is available for a total of 232 UN countries and territories. As the Global Migration Data Analysis Centre of the International Organisation for Migration states, this makes it the most geographically comprehensive information on international migration. However, there are major differences in the availability of data in the various regions of the world: A full 43 percent of Central and South Asian countries and 16 percent of sub-Saharan African countries have no data source on population proportions of international migrants. As many as 90 percent of the countries in East and Southeast Asia, Oceania and North America have sufficient data on the respective proportions of international migrants. In cases where the data are unavailable, data on citizens of a country other than their country of residence are estimated. Another weakness of the data is that the stock of migrants is often confused with migration flows. Migration flows refer to the number of migrants entering or leaving a country during a given period (e.g., a calendar year). These migration flows are not reflected in the UNDESA data, or at best only very indirectly (IOM-GMDAC, 2022).

If you bear these weaknesses in the UNDESA data in mind and look at the current version of the data (UNDESA, 2023), many things initially appear rather unspectacular. For example, the majority of all approximately 281 million international migrants (78%) are between 15 and 65 years old, over 65 years old are around 12 percent, and under 15 years old are just under 15 percent. The proportion of migrants in the total world population is around 3.6 percent; by comparison, in 1970 the proportion was around 2.3 percent. A slight majority are male (52%), and a corresponding minority are female (48%). It becomes more interesting when you look at the countries that—in absolute terms—have the largest "contingents" of migrants: In first place here is the United States of America as a classic country of immigration with 51 million people. In second place is Germany with 16 million people, followed by Saudi Arabia with 13 million and the Russian Federation with 12 million. In fifth place is the United Kingdom with 9 million. Saudi Arabia's position in third place emphasizes the importance that the Persian Gulf states have gained as immigration countries in the last few decades. This becomes even clearer when looking at the proportion of migrants in the total population (World Bank, 2022). Here, the Gulf states of the United Arab Emirates (88%), Qatar (76%) and Kuwait (74%) "take the lead" with very high numbers.

Behind these figures is a trend that has become increasingly important in the last few decades: South-South migration. This primarily refers to migration within the Global South. This includes migration processes between—to use the rather judgmental terminology—developing countries and emerging countries or from developing countries to emerging countries. The latter are, as the name suggests, (formerly) poorer countries whose socioeconomic status is on the threshold of achieving industrialized country status. Many countries can now be counted among this group: In addition to the Persian Gulf states already mentioned, this group of countries includes South Africa, India, Mexico, Brazil, China, Malaysia, Russia, Türkiye, the Philippines, and Pakistan. Furthermore, measured in absolute numbers, the top five countries in terms of the origin of international migrants are almost exclusively populous emerging economies—with India (18 million migrants) in first place, Mexico (11 million) in second, Russia with almost 11 million in third and China with 10 million migrants in fourth place. Syria follows in fifth place with 8 million people, although this is mainly due to refugee migration because of the conflict that has been ongoing since 2011 (UNDESA, 2023). When analyzing which countries of origin account for most international migrants, emerging countries, such as Mexico and India in particular, dominate accordingly.

In terms of migration corridors—measured by the number of migrants per country of immigration, all of whom come from one country of origin—the dominance of emerging countries is also clearly recognizable. According to UNDESA data (2023), the corridor between Mexico and the United States of America is the largest migration corridor, with around 11 million people migrating from Mexico. This is followed by the migration corridor between

Syria and Türkiye (approx. 4 million people), the corridor between India and the United Arab Emirates (approx. 3 million people) and the corridor between the Russian Federation and Ukraine (approx. 3 million), with the reverse corridor between Ukraine and the Russian Federation being almost as large. It should be noted at this point that the figures date back to the time before the start of the Russian war of aggression in Ukraine. Overall, the UNDESA data shows that international migration mainly takes place within world regions. Particularly migration within Africa, Asia and Europe is much more pronounced than migration from these regions or continents to other regions of the world. Only migration between Latin America and North America, which is much more pronounced than migration within Latin America, is an exception here (Porter and Russel, 2018). These results are also supported by the research findings of the British demographer Guy Abel (Abel and Sander, 2014), for example, who simulates global migration flows based on UNDESA data in the absence of other data sources (see earlier). Estimates assume that intra-regional migration is also very pronounced in regions such as East Africa (with well over 60%) or West Africa (with well over 80%), which—from a European perspective—are the focus of debates on regions of origin for refugee migration or irregular migration (Dick and Schraven, 2019).

The South-South trend in international mobility becomes particularly clear when looking at a specific group of international migrants: people on the move. Their numbers have risen sharply in the last decade and a half, not least due to the armed conflicts in Syria, South Sudan and other countries and regions. A look at the figures from the United Nations Refugee Agency UNHCR (2023), which include people who flee to another country and are officially registered there, speaks for itself. The countries from which most people are forced to flee are all countries in the Global South. These are Syria (6.7 million people), Venezuela (4.6 million), Afghanistan (2.7 million), South Sudan (2.4 million) and Myanmar (1.2 million). These figures are also from 2021 and therefore do not include Ukrainian refugees who have left their country since February 2022 due to the Russian war of aggression. The UNHCR put the number of these people at 7.8 million at the beginning of December 2022. For 2022, it can be assumed that more than seven out of ten refugees worldwide come from just five countries (Syria, Ukraine, South Sudan, Afghanistan and Venezuela). However, we see a relative dominance of the Global South not only in terms of refugee origins but also in terms of host countries. Türkiye leads this top five list with 3.4 million refugees living here, followed by Colombia (1.8 million), Uganda (1.5 million) and Pakistan (1.3 million). Only in fifth place comes Germany, the first industrialized country, which has taken in 1.3 million refugees (based on UNHCR, 2023).

The debate in the Global North tends to overlook the fact that most people on the move are not refugees—that is, people fleeing to another country—but internally displaced persons. These internally displaced persons (IDPs) are fleeing within their home countries and, according to the Internal Displacement Monitoring Centre (IDMC), accounted for the majority of forcibly displaced people worldwide at the end of 2021 with approximately 53 million people or just under 60 percent. Syria led the way in terms of conflict-related internal displacement at the end of 2021 with 6.7 million people, followed by the Democratic Republic of the Congo with 5.3 million and Colombia with 5.2 million people. Within Afghanistan and Yemen, 4.3 million people each are internally displaced due to armed conflict. Internal displacement, which exclusively or primarily is caused by disasters such as cyclones or floods, likewise affects countries in the Global South in the first place: Afghanistan (1.4 million people), China (943,000), the Philippines (700,000), Ethiopia (579,000) and South Sudan (527,000). Internal displacement is particularly high in the regions of sub-Saharan Africa (14 million), East Asia and the Pacific (almost 14 million), and South Asia (6 million). In comparison: in Europe and Central Asia 337,000 people were considered internally displaced in 2021 (IDMC, 2022).

1.3 Research Findings on Climate Change and Migration

Research activities of the last decade and a half reveal a more complex and differentiated picture of the relationship between climate change and human mobility (or climate mobility for short), on which meanwhile there is a broad consensus in the scientific debate. The key points can be summarized as follows (see Schraven, 2023):

Even in regions of the world and countries that are already heavily affected by the impacts of climate change—such as the Horn of Africa, the Pacific Island states or Bangladesh—it is not always easy to determine how the consequences of climatic change will affect processes of human mobility. In general, for these and other areas affected by climatic or ecological change, other, often interrelated factors—political, social, economic or demographic—also have a (sometimes significant) influence on mobility decisions. Determining the dominance or non-dominance of global warming in these decisions is conceptually and empirically almost impossible. It is therefore also very difficult to clearly define terms such as "climate refugee," "environmental refugee" or "climate migration," of which there are no generally accepted definitions in a legal, political, or scientific context (see later). Even if in some cases people must leave their homes in the medium to long term due to rising sea levels, for example, this attribution, that is, the unambiguous identification of a main causal factor, is difficult to achieve in many other cases.

For this reason, the figures and forecasts frequently cited in politics and the media regarding "climate refugees" should be viewed with great skepticism. The forecast by British biodiversity expert Norman Myers mentioned in the introduction, for example, which predicted 200 million "climate refugees" by the middle of the twenty-first century back in the 1990s, is simply no longer methodologically tenable from today's perspective (Schraven, 2023). Another frequently cited source, often referenced by the media when discussing the figure of (over) 200 million "climate refugees," is the Groundswell Report published by the World Bank (Clement et al., 2021). This second report was preceded by the first Groundswell Report (Rigaud et al., 2018), in which slowly occurring environmental events such as sea-level rise, declining water availability and declines in agricultural productivity were "offset" against the future population distribution and migration patterns for the year 2050 for the first time. In other words, demographic, socioeconomic and climatic data were brought together in one model. The "migration results" for three different climate scenarios were modeled here, ranging from pessimistic to rather "climate friendly." In the case of the pessimistic scenario, the simulation produced a result of 216 million internal migrants worldwide. It is important to note that this is the result of a simulation, not an actual prediction of what the situation regarding climate-induced forced displacement and migration will look like in 2050. Additionally, this simulation explicitly models internal or national migration, not cross-border refugee migration. Furthermore, such large-scale modeling methods are generally not uncontroversial, as they easily simplify or neglect local contexts, cultural characteristics, and human behavior (Adams and Kay, 2019).

Another sensationalist forecast, from the Institute for Economics & Peace, dates back to 2020 (IEP, 2020). This forecast, according to which almost one billion people will leave their homes by 2050 because of the adverse effects of climate change, is based on figures from the IDMC, which collects data on internal forced displacement and displacement worldwide. In addition to other reasons for forced displacement and displacement, the IDMC has also been publishing data on people who are forced to flee their home countries exclusively or primarily because of disasters for several years now. However, the IDMC figures are by no means official statistics on the extent of climate-related (internal) displacement or similar. Instead, the data is derived from local media reports to obtain estimated values. In addition, many of the people recorded in the IDMC data were able to return home shortly after the disaster. Meanwhile, the forecast by the think tank IEP, founded by Australian IT entrepreneur Steve Killelea, is based on the following approach: it takes the annual IDMC figures between 2008 and 2019 for disaster-related displacement and adds them together. This suggests that all these people are no longer able to live in their home country or return there permanently. A growth rate for the period between 2008 and 2019 generated by an artificial or inappropriate addition to global disaster and climate-related migration is then taken as the basis for an expected future growth rate and carried forward to 2050. This results in an overwhelming figure of one billion people. The figure for 2019, which IEP (2020) estimated at around 300 million climate or disaster refugees, was already highly questionable. In contrast, the UNHCR estimated the total number of all refugees worldwide (internal and cross-border) at 79.5 million for the same year (UNHCR, 2023). Overall, meta-studies conclude that migration is caused more by slowly occurring climate changes and less frequently by sudden events such as floods (Kaczan and Orgill-Meyer, 2020).

Human mobility in the context of climate change often takes place within countries or between neighboring countries, as most of the poorer population groups mainly affected by climate change live in the Global South. These are mainly smallholder households, the urban poor or nomadic cattle herders, none of whom have the necessary means to migrate over long distances. Contrary to the widespread assumption that poverty is a major driver of migration (above), it is also evident here that poverty tends to prevent migration over longer distances. It is also very often a case of circular migration, that is, migration processes in which people move back and forth between two or even more regions several times. In most cases, this also involves repeated movements between the region of origin and the destination region. Furthermore, this is not the migration of entire families or households, but rather that of individuals who often move elsewhere for a limited period to work and then eventually return to their homes and families (see Schraven, 2023).

From the point of view of those affected, the opposite of mobility is perhaps even a much worse consequence of climate change: many of the particularly vulnerable population groups either lack the resources to be mobile at all, or climate change contributes significantly to the loss of these resources—for example, through the drought-related death of cattle among nomadic cattle herders. Over the last ten years, the study of these so-called trapped populations has become another focus of research into the climate-mobility nexus. The decision to migrate primarily depends on financial resources, which is often a major challenge, particularly for households who struggle to afford the journey. However, social networks also play a key role in migration (see earlier; Black et al., 2011). Some studies (e.g., Ayeb-Carlsson et al., 2022) show that populations are often trapped due to structural problems such as restricted access to the labor market and neglect by the government. The consequences of climate change, with slow and sudden environmental changes, can contribute significantly to the emergence and persistence of trapped populations, as it weakens the resources and means of the affected households and thus prevents a potential migration strategy. This in turn increases the vulnerability of households to the future impacts of climate change.

Bangladesh is a prime example of how climate change contributes to the creation of trapped populations. It is one of the countries most severely affected by climate change, particularly by cyclones, tsunamis, and floods. Some studies (Penning-Rowsell et al., 2013) show that migration in this context often only occurs as a last resort in times of extreme need and that people threatened by environmental risks usually only migrate over short distances and periods. This—often due to a lack of alternatives—remaining in a location that is regularly exposed to severe environmental risks makes many people prisoners, so to speak. Permanent migration is often only possible if no land is owned that the family or household must use as its main source of income. When people do migrate, it is often the men who migrate, while women and children stay behind and are particularly vulnerable to climate and environmental risks. It is much more difficult for women to justify their mobility. Preconceived and socially anchored gender roles often make female migration impossible or at least very difficult (Penning-Rowsell et al., 2013). Other societal variables or organizational structures, such as marriage or kinship, also play a major role in determining who is ultimately able to migrate and who is not (Schraven, 2023).

It is not the case that all people who do not migrate due to the negative consequences of climate change are automatically trapped or imprisoned. On the contrary, many people make a conscious decision not to leave their place of origin despite major risks because, for example, they feel a deeply rooted connection to their homes, which can be a fundamental part of their identity (Adams, 2016). Accordingly, some authors are cautious with the term trapped populations and prefer terms such as voluntary or involuntary immobility (Ayeb-Karlsson et al., 2022).

In general, gender is a very important factor in climate-related mobility, as women and men experience very different effects of climate change. In many regions and countries around the world, women have less access to natural resources. As a result, they are potentially more affected by events such as droughts or floods. Additionally, if women must migrate or flee, they are often exposed to greater risks than men, as they are generally less protected and more frequently affected by sexual assaults or labor exploitation (see, e.g., Lama et al., 2021). However, research into the specific experiences of different gender, age, or otherwise defined groups in the context of the climate-mobility nexus is still largely in its early stages. Given all these findings, alarmist scenarios predicting a million-fold influx of "climate refugees" toward Europe lack a serious scientific basis (Schraven, 2023).

The question of whether climate change will lead to more armed conflicts, which in turn will result in more forced displacement and distress migration, is difficult to answer based on the current state of research. Quite a few studies warn that the effects of climate change could contribute to growing competition for increasingly scarce resources and thus to an increase in the potential for conflict. This would in turn make climate change an indirect driver of (forced) migration movements (Abel et al., 2019). Empirical evidence of a connection between the effects of climate change and an increase in armed conflicts is rather rare and a direct correlation is so far not discernible (Koubi, 2019).

However, there is no doubt that climate change is a risk multiplier—in other words, it makes conflicts over precious resources such as water and land fundamentally more likely. People fleeing conflicts or migrating due to worsening climatic conditions also make heavy use or overuse of natural resources in the regions of migration more likely, which could potentially lead to new conflicts there too (Přívara and Přívarova, 2019).

However, the effects of conflicts, climate change and migration can also reinforce each other. The case study of Afghanistan shows that simultaneously occurring environmental risks and violent conflicts undermine the resource base of the affected population in two ways: A lack of rainfall and persistent droughts, for example, severely limit agricultural production, while conflicts and migration prevent people from compensating for the economic damage caused by the loss of production. Afghanistan is one of the most vulnerable countries in the world to climate change and is already significantly affected by it, particularly by more frequent and intense flooding and droughts. The effects in the form of locally increasing food insecurity can in turn be identified as a major driver of migration (Přívara and Přívarova, 2019).

However, migration in the context of climate change should not simply be viewed as a negative phenomenon: Many studies in recent years (see, e.g., Vinke et al., 2020) emphasize that migration can also be an adaptation strategy under certain circumstances. In other words, migration can also help to ensure that people are better protected against the future effects of climate change in economic or other terms. It is important to note that not only migrants should be considered, but also their families, the places/ regions of origin and the places of immigration. The basic mechanisms for such positive effects are clear: A proactive migration process can increase the resilience of households. To put it another way, they move before the effects of climate change become too severe, making local adaptation impossible for them. Ultimately, this can also lead to an improvement in the economic situation and enable access to various sources of income. Migration can also provide opportunities for education, further diversifying livelihoods. All of this is particularly the case when the new livelihoods largely defy climatic stress factors.

Remittances from migrants to their families in the countries or regions of origin play a vital role in helping them cope with the consequences of climate-related loss and damage. However, it is not solely a matter of money.

The dissemination or exchange of knowledge or skills by migrants, both in the areas of origin and in the regions of destination, can also be of great benefit when it comes to adapting to climate change. Knowledge of new farming methods or irrigation practices can be key to making agricultural production more resilient.

Ultimately, host cities and communities can also benefit from immigration by addressing labor and demographic shortages and stimulating local economic growth by increasing demand, promoting trade, and creating new businesses. In some cases, government funding can also be made available to support migrants, which can benefit host communities if invested in public infrastructure and services, such as healthcare facilities. If migrants bring knowledge and skills that benefit the receiving communities in climate adaptation measures, the current and future benefits of immigration can be substantial (McInerney et al., 2022).

However, this all describes an ideal situation. In many cases, migration tends to make migrants and their families poorer and even reduce their ability to adapt to climate change. The lack of adequate employment, exploitation or marginalization are just some of the factors that often hinder the positive effects of migration. In general, the benefits of migration are greater if it is a voluntary and well-planned decision. However, if migration is a last resort, this usually increases vulnerability and the chance of slipping into a poverty spiral. Many migrants also move to regions that will be increasingly affected by the effects of climate change in the medium to long term. This is particularly true for coastal cities, where rising sea levels already pose an enormous risk to large sections of the population. Migration in the context of climate change can therefore resemble a migration “from the frying pan into the fire” (Black et al., 2011; Vinke et al., 2020).

1.4 Conclusion and Prospects

A broad consensus has emerged in research on the climate-mobility nexus, according to which the connection between climate change and migration requires a differentiated view and the expectation of a million-fold influx of climate refugees to Europe or North America soon corresponds more to alarmist expectations than empirically observable foundations. Based on these findings, the following political model can be formulated for dealing with this challenge: avoiding forced migration, maximizing positive migration mechanisms (e.g., remittances, knowledge transfers), and minimizing negative aspects (e.g., the exploitation of migrant labor). This guiding principle of actively shaping mobility policy, which is seen as the global norm, naturally also applies beyond the context of the effects of climate change. Given the complexity and multidimensionality of mobility processes, the general debate should (further) move away from the rigid patterns and power structures that underlie the problematic concept of climate refugees and the associated discourse. This starts with the question of exactly what role climate change plays in which processes of human mobility. Better support for people who had to migrate under duress, but whose forced migration does not fall under the narrow definition of the Geneva Refugee Convention, should not be centrally linked to the question of whether climate change was the main cause or not. Not only would this question be almost impossible to answer in many cases, but it also raises further complex ethical questions. It is evident that there are now more and more political initiatives—including at regional and national levels—that are taking up these findings, but this will not be discussed further here (see, for instance, Schraven, 2023).

A permanently securitized and overly simplified portrayal of both human mobility and its side effects as well as the consequences of climate change—especially at their interface, that is, alarmist climate refugee scenarios that are unlikely to materialize in this form, at least not in the near future—can also have the effect of not further sensitizing society to the topic or certain political objectives in this context. This might rather be leading to oversaturation. However, this perhaps is precisely where an opportunity lies: Current political and social discourses on the legacy of colonialism, for instance, might sensitize people to a different or broader perspective on complex processes of forced displacement and migration. This could indeed offer the opportunity to discuss the topic of human mobility within a broader framework of global justice and (historically evolved) power structures between the Global North and South. Greenhouse gas emissions alone are only an inadequate answer to the question that has been frequently asked in recent years as to how forced displacement, migration or poverty in the Global South could or even should be (also) causally linked to the Global North.

Academia has a special role to play in that regard. It could indeed indulge in lamenting that certain segments of the public debate are still characterized by alarmism and take far too little notice of the findings of migration research. However, it would certainly be more expedient to open further to the aforementioned political initiatives at the global, regional and national level that are already addressing the issue of mobility in the context of climate change. The scientific community should also not shy away from public and media debate. Some recent media reports, which also take an in-depth look at the current state of research, are encouraging.

Bibliography

Abel, G., & Sander, N. (2014). Quantifying global international migration flows. Science, 343(6178), 1520–1522.

Abel, G., et al. (2019). Climate, conflict and forced migration. Global Environmental Change, 54, 239–249.

Adams, H. (2016). Why populations persist: Mobility, place attachment and climate change. Population and Environment, 37(4), 429–448.

Adams, H., & Kay, S. (2019). Migration as a human affair: Integrating individual stress thresholds into quantitative models of climate migration. Environmental Science & Policy, 93, 129–138.

Ayeb-Karlsson, S., et al. (2022). Who is the climate-induced trapped figure? Wiley Interdisciplinary Reviews: Climate Change, 803.

Black, R., et al. (2011). Foresight: Migration and global environmental change—Final project report. London: The Government Office for Science.

Clement, V., et al. (2021). Groundswell part 2: Acting on internal climate migration. Washington: World Bank.

Dick, E., & Schraven, B. (2019). Afrika auf dem Weg nach Schengen? Diplomatisches Magazin, 4, 34–37.

IDMC (2022). Global Report on Internal Displacement 2022. Geneva: IDMC.

IEP (2020). Ecological thread register 2020. Retrieved from http://visionofhumanity.org/reports (Accessed: January 22, 2024).

IOM-GMDAC (2022). Migration data portal. Retrieved from https://www.migrationdataportal.org/de/themes/bestand-internationalen-migrantinnen-und-migranten (Accessed: February 10, 2024).

Kaczan, D. J., & Orgill-Meyer, J. (2020). The impact of climate change on migration: A synthesis of recent empirical insights. Climatic Change, 158(3), 281–300.

Koubi, V. (2019). Climate change and conflict. Annual Review of Political Science, 22, 343–360.

Lama, P., et al. (2021). Gendered dimensions of migration in relation to climate change. Climate and Development, 13(4), 326–336.

McInerney, E., et al. (2022). Migration as a climate change strategy: Challenges and opportunities for USAID programming. Washington: United States Agency for International Development (USAID).

Penning-Rowsell, E. C., et al. (2013). The "last resort"? Population movement in response to climate-related hazards in Bangladesh. Environmental science & policy, 27(1), 44–59.

Porter, E., & Russell, K. (2018). Migrants are on the rise around the world, and myths about them are shaping attitudes. Retrieved from https://www.nytimes.com/interactive/2018/06/20/business/economy/immigration-economic-impact.html (Accessed: February 2, 2024).

Přívara, A., & Přívarová, M. (2019). Nexus between climate change, displacement and conflict: Afghanistan case. Sustainability, 11(20), 1–19.

Rigaud, K. K., et al. (2018). Groundswell: Preparing for internal climate migration. Washington: World Bank.

Schraven, B. (2023). Klimamigration—Wie die globale Erwärmung Flucht und Migration verursacht. Bielefeld: Transcript.

UNDESA (1998). Recommendations on statistics of international migration. Revision 1. Retrieved from https://unstats.un.org/unsd/publication/seriesm/seriesm_58rev1e.pdf (Accessed: December 18, 2023).

UNDESA (2023). International migrant stock. Retrieved from https://www.un.org/development/desa/pd/content/international-migrant-stock (Accessed: January 10, 2024).

UNHCR (2023). Refugee data finder. Retrieved from https://www.unhcr.org/refugee-statistics/download/?url=2bxU2f (Accessed: February 29, 2023).

Vinke, K., et al. (2020). Is migration an effective adaptation to climate-related agricultural distress in sub-Saharan Africa? Population and Environment, 43, 319–345.

World Bank (2022). International migrant stock (% of population). Retrieved from https://data.worldbank.org/indicator/SM.POP.TOTL.ZS?most_recent_value_desc=true (Accessed: March 1, 2024).

Climate-Induced Migration and the Response of International Law: Human Rights as a Key Framework

Önder Bakırcıoğlu[2] and Yavuz Selim Alkan[3]

2.1 Introduction

This chapter will explore the legal intricacies surrounding climate-induced migration. It will analyze how existing international legal frameworks intersect with climate-induced migration by identifying key legal gaps and examining the evolving roles of international law and human rights law, as well as policy considerations, in crafting effective responses. This study argues that addressing the escalating challenge of climate-induced migration necessitates comprehensive and realistic legal frameworks. It underscores the importance of collaborative efforts among nations, international organizations, and legal experts to formulate binding agreements that protect the rights of those displaced by environmental challenges. An effective model of such universal and/or regional cooperation is the African Union's Kampala Convention, which offers a blueprint for stronger global strategies. There is an urgent need to initiate international efforts prioritizing the human rights of displaced individuals, striving for a legal framework that respects and protects their rights and dignity.

This chapter is structured into four parts. The first part begins with a concise account of legally binding international climate change agreements and non-binding initiatives that address climate-induced migration indirectly. The second part seeks to explain the legal gap created by the 1951 Refugee Convention, illustrated by significant international cases. The third part sheds light on relevant cases from the Inter-American and European human rights

2 Assoc. Prof. Dr., University of Leicester, Law School, onder.bakircioglu@leicester.ac.uk, https://orcid.org/0000-0001-9909-1827.

3 Assoc. Prof. Dr. Akdeniz University, Public Administration and Political Science, yavuzselimalkan@akdeniz.edu.tr, https://orcid.org/0000-0002-5211-5809.

bodies to showcase that there is growing recognition within other international human rights systems regarding the impact of environmental disasters on human rights. Finally, the last part aims to identify the pivotal role of human rights that should be recognized in effectively addressing climate-induced migration, drawing inspiration, especially from the Guiding Principles on Internal Displacement and the Kampala Convention.

2.2 The General Framework: Climate Change Agreements and Initiatives

Migration has long been governed by national and international laws, with various legal mechanisms addressing its complex facets. Likewise, some steps have been taken to confront the newer challenge of climate change and global warming, particularly in the international arena. However, the creation of effective international legal mechanisms to combat potential migration driven by climate change, from a human rights perspective, remains an unresolved issue. With this in mind, and given the scope of this discussion, it is appropriate to first provide a brief review of the international climate change agreements and initiatives that provide a general framework for crafting legal mechanisms to more effectively handle climate-induced migration from a human rights standpoint. Within the international community, there is indeed growing recognition of climate-induced migration, and efforts are being made to address it through various UN resolutions and international initiatives. While there is not yet a specific international convention or initiative directly addressing climate-induced migration, these efforts signal a potential trajectory toward the establishment of hard law in this area.

Some of these international instruments that underpin the general legal framework are as follows: The United Nations Framework Convention on Climate Change (1994) (UNFCCC) is a legally binding international treaty that sets the overarching framework for intergovernmental efforts to tackle climate change. While the Kyoto Protocol to the United Nations Framework Convention on Climate Change (1997) is a legally binding agreement, adopted under the UNFCCC, committing its parties to internationally binding emission reduction targets, the Paris Agreement to the United Nations Framework Convention on Climate Change (2015), established under the UNFCCC, "technically" replaced the Kyoto Protocol in 2020. It is legally binding for those countries that have ratified it. The Paris Agreement (2015, art. 2(1)(a)) creates an international framework to "reduce the risks and impacts of climate change" by "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels."

In addition to the binding international agreements mentioned previously, several prominent non-binding agreements and initiatives indirectly address the intersection of environmental disasters, migration, and human rights. For instance, the Sendai Framework for Disaster Risk Reduction 2015–2030 (2015) is a non-binding agreement that sets out the action objectives and priorities for preventing new disaster risks and mitigating existing risks. The Nansen Initiative (2015) is a state-led, non-binding process that particularly targets the needs of persons who have been relocated across international borders due to disasters or the consequences of climate change. Established under the UNFCCC, the Warsaw International Mechanism for Loss and Damage Associated with Climate Change Impacts (2013), while part of the broader, legally binding framework of the UNFCCC, functions primarily as a platform for facilitating action and support rather than imposing legally binding commitments. The Warsaw International Mechanism created a Task Force on Displacement (2015). This is a non-binding task force developing "recommendations for integrated approaches to avert, minimise, and address displacement related to the adverse impacts of climate change." In a similar vein, a non-binding declaration adopted in 2016, the New York Declaration for Refugees and Migrants (2016), underlines the significance of both human rights and international refugee law in protecting people displaced for various reasons, including climate change. Finally, the Migrants in Countries in Crisis Initiative (2014) is also a non-binding initiative establishing standards for the protection of migrants in countries hit by conflict or natural disasters.

In summary, the UNFCCC, Kyoto Protocol, and Paris Agreement are legally binding international treaties that do not directly regulate but provide a general framework for creating internationally binding legal instruments to cope with climate-induced migration from the perspective of human rights. In contrast, the Sendai Framework, Nansen Initiative, Warsaw International Mechanism for Loss and Damage, Task Force on Displacement, New York Declaration for Refugees and Migrants, and the Migrants in Countries in Crisis Initiative are non-binding initiatives, serving as frameworks or guidelines for voluntary action by states. These non-binding efforts, however, indicate a shift toward a more cohesive approach to the issue of climate-induced migration. While they reflect a soft law approach, the increasing frequency and depth of discussions on this topic at high-level international forums suggest that there is momentum toward the development of hard law in this area.

We will now proceed with a detailed legal-technical analysis that underscores the legal gaps within existing frameworks. This analysis will lay the foundation for our examination regarding the potential development of binding agreements that could afford comprehensive protection to migrants relocated owing to climate change in the future.

2.3 Legal Recognition Gap

Climate-induced migration encompasses a broad range of movements. Sudden-onset events like hurricanes and wildfires can displace populations abruptly, while slow-onset changes, such as rising sea levels and desertification, gradually erode living conditions, leading to eventual relocation (see Laczko and Aghazarm, 2009; Koubi et al., 2018). This type of migration is unique in its causality, as it generally blends environmental, economic, and social drivers. The global impact of climate-induced migration is profound and far-reaching. Low-lying island nations face existential threats from alarming sea-level rises, while arid regions confront desertification. The legal recognition and protection of these potential migrants is not just a humanitarian issue but also a matter of international security, as displacement can lead to increased tensions and conflicts.

The legal frameworks regulating displacement, notably the Convention Relating to the Status of Refugees (1951), also known as the Refugee Convention, are woefully inadequate for climate-induced migrants. These migrants do not typically fit within the narrow confines of the Convention, which focuses on persecution due to specific reasons. Indeed, the 1951 Refugee Convention, along with the Protocol Relating to the Status of Refugees (1967), establishes a narrow definition of a refugee and outlines the type of legal protection to which they are entitled. Under the Refugee Convention (1951, art. 1 A(2)), the legal term “refugee” can be applied to any person who is incapable of or reluctant to return to their homeland “owing to [a] well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group, or political opinion." This definition does not encompass individuals who are forced to leave their homes due to climate change or environmental factors, which creates a significant protection gap.

Since climate-induced migrants do not, in general, face the sort of persecution outlined in the Refugee Convention, they lack legal recognition and status that provides access to a set of protections and rights. This includes the right not to be returned to a country where they would face substantial danger to their life or freedoms, access to social services, and the ability to seek lawful employment. It is of particular importance to examine the first aforementioned form of protection, known as non-refoulement. The non-refoulement principle is a fundamental tenet of human rights conventions such as the European Convention on Human Rights (ECHR) (1950) and the International Covenant on Civil and Political Rights (ICCPR) (1966). Not only do these legal instruments impose a positive obligation on states to refrain from returning individuals to countries where they face a threat to life, torture or ill-treatment, or severe violations of other fundamental rights, but also the Refugee Convention (1951, art. 33). However, the current version and application of this principle are ineffective in safeguarding those who migrate as a result of climate change (see Verdu Baeza, 2023; McAdam, 2020).

Similarly, it is crucial to highlight the connection between stateless refugees and climate-induced migration. Climate change has intensified concerns about weather-related disasters, particularly the potential submergence of small island states due to rising sea levels, which could lead to the disappearance of entire nations. As a result, the risk of creating a new category of stateless migrants has emerged. These individuals often lose access to protections that were once available in their home countries, and they do not fall under the established legal framework for refugees. Statelessness due to climate displacement is not yet fully recognized in international law, leaving these individuals in a legal limbo without the specific protections afforded to traditional refugees.

This situation exposes stateless individuals to greater vulnerability, particularly as they face climate-related hazards, while also limiting their access to the assistance typically available to refugees fleeing persecution. The current international legal framework is ill-equipped to address the impacts of climate change on stateless populations or to prevent new cases of statelessness. Therefore, there is an urgent need for a more robust and comprehensive system to address this gap. It is essential to consider how the existing international legal regimes for the protection of stateless persons and the prevention of statelessness can be adapted to the context of climate-induced migration (see UN Refugee Agency, 2021; Del Grande, 2021; Alexander and Simon, 2014).

Accordingly, in the absence of a clear legal status under human rights conventions or a revision of the non-refoulement principle and international legal mechanisms to address the emerging threat of climate-induced statelessness, these migrants are frequently deprived of access to essential mechanisms that facilitate international protection. Without formal recognition under the Refugee Convention, climate migrants are often classified as irregular or economic migrants, which significantly limits their access to protection and increases their vulnerability to human rights violations.

The gap in protection for climate migrants is highlighted by a case in New Zealand. In Teitiota v Chief Executive of the Ministry of Business, Innovation, and Employment (2013), the High Court of New Zealand decision, the applicant sought refugee status after his visa had expired, claiming that rising sea levels and other environmental risks in Kiribati posed a serious threat to his and his family's lives. He argued that returning to Kiribati would result in indirect persecution due to the deteriorating environmental conditions, which compromised the habitability of the islands and access to essential resources like fresh water and food.

The courts in New Zealand grappled with the application of the Refugee Convention to Teitiota's predicament owing to the aforementioned legal gap: whether the Convention could be broadly interpreted to include threats to life caused by environmental disasters and climate change. Ultimately, in 2015, the decision was appealed to the New Zealand Supreme Court, and the Court ruled against Mr. Teitiota. In *Teitiota v Chief Executive of the Ministry of Business, Innovation and Employment* (2015), the court held that while it accepted the reality of climate change and its potential impacts, the Refugee Convention did not apply to his case. The Court stated that the Convention requires a "serious" and "individual" threat, whereas the risks from climate change are generally widespread and not specific to one individual or family. Moreover, the court found no credible evidence that "the Government of

Kiribati is failing to take steps to protect its citizens from the effects of environmental degradation to the extent that it can" (*Teitiota v Chief Executive of the Ministry of Business, Innovation and Employment*, 2014, footnote 5. para. 12).

After his deportation to Kiribati, Mr. Teitiota brought his case before the UN Human Rights Committee (UNHRC), which delivered its views in January 2020. In *Teitiota v New Zealand* (2019), the UNHRC did not overturn the conclusions reached by the courts in New Zealand, yet it made some key observations (paras. 9.1–9.14): Significantly, the committee recognized that environmental degradation, including through climate change, could compromise the right to life, potentially obligating states not to return individuals to countries where their lives are at risk as a result of the negative effects of climate change.

This decision suggests that there may be cases where environmental threats could meet the threshold of being considered persecution. However, such cases must meet stringent requirements, including the demonstration of an immediate risk of serious harm upon return to the individual's home country. The committee also drew attention to the positive obligations of states to protect persons from anticipated risks to life, including from environmental problems, and the critical need for international cooperation in addressing such issues.

Although the committee's decision did not result in a positive ruling for Teitiota as a refugee, it has been widely interpreted as a recognition that climate-induced displacement could involve violations of human rights, which calls for the development of international legal frameworks to address this growing challenge (see Bergova, 2021; Sommario, 2021; Foster and Adam, 2022; Neef and Benge, 2022). The case has also set a precedent for potential future claims related to climate change and displacement and indicated the growing importance of environmental factors within international human rights.

There are also other examples of growing recognition from international bodies and courts regarding the adverse impacts of climate change. These cases demonstrate that environmental degradation and disasters can have consequences that infringe on human rights. The following section reviews relevant examples and cases from the Inter-American and European human rights bodies.

2.4 Role of International Bodies and Courts in Climate-Induced Migration

2.4.1 Examples from the Inter-American Court of Human Rights

The first pertinent case comes from the Inter-American Court of Human Rights (IACtHR)'s *Advisory Opinion OC-23/17* (2017), titled "The Environment and Human Rights." This Advisory Opinion (sec. VI–VIII) examines the intricate relationship between environmental protection and human rights. Firstly, the IACtHR clarifies that the American Convention on Human Rights imposes obligations on states to prevent significant environmental damage within and beyond their territories, underpinning the right to a healthy environment as essential for the survival and well-being of humankind and the enjoyment of other human rights. Secondly, the Court notes that environmental harm could affect the enjoyment of several human rights, including the rights to life and personal integrity. It thus holds that severe environmental degradation could threaten individuals' lives and health by impacting essential elements such as food, water, and air. The Opinion further stresses the imperative for states to adopt preventive measures when there is a risk of environmental harm. Such measures are to be taken even if scientific certainty about potential harms is not absolute. This underscores the significant importance of the precautionary principle.

The Opinion has far-reaching implications for environmental protection and human rights law. It has particularly served as a point of reference for domestic courts within member states of the Organization of American States (OAS) when dealing with similar cases. While the Advisory Opinion is not a binding judgment on a specific case, it has been invoked in subsequent litigation as a legal basis to argue that environmental harm violates certain human rights. Consequently, the Opinion has influenced the development of environmental jurisprudence in the Americas and may potentially affect other legal systems around the world (see Campbell-Duruflé and Atapattu, 2018; Bautista, 2019; Ollino, 2020; Siwior, 2021a).

The following cases from the IACtHR system also demonstrate that environmental harm, such as degradation and the mismanagement of natural resources, can lead to human rights violations. These are germane to discussions on climate-induced migration, signifying how environmental degradation can undermine the rights and livelihoods of communities, potentially leading to forced displacement. One pertinent case is *Mayagna*

(Sumo) Awas Tingni Community v. Nicaragua (2001), where the IACtHR found that Nicaragua had violated the rights of the Indigenous Awas Tingni community under Articles 1(1) (obligation to respect rights), 2 (duty to adopt domestic legal effects), and 25 (right to judicial protection) in connection with Article 21 (right to property) of the American Convention on Human Rights (*Mayagna (Sumo) Awas Tingni Community v. Nicaragua*, 2001, sec. XII). The Court held that the Nicaraguan government failed to ensure the Awas Tingni community's right to property by granting logging rights within their traditional lands without proper consultation or consent. The ruling required Nicaragua to demarcate the territory of the Awas Tingni and refrain from

> actions that might lead the agents of the State itself, or third parties acting with its acquiescence or its tolerance, to affect the existence, value, use, or enjoyment of the property located in the geographical area where the members of the Community live and carry out their activities. (*Mayagna (Sumo) Awas Tingni Community v. Nicaragua*, 2001, para. 153).

The case establishes the duty of states to recognize and protect lands traditionally occupied by Indigenous communities, even in the absence of formal title deeds, which is crucial for the survival of Indigenous communities and the preservation of their traditional ways of life deeply tied to their ancestral lands and environment (see Amiott, 2002; Anaya and Grossman, 2002; Alvarda, 2007).

In another landmark ruling of *Yakye Axa Indigenous Community v. Paraguay* (2005), the IACtHR emphasized not only the violation of property rights under Article 21 of the American Convention on Human Rights but also found a more profound infringement of the right to life under Article 4, especially Article 4(1), which prohibits arbitrary deprivation of life. This right is interpreted expansively to include the right to life with dignity, which the Court views as being inextricably linked to the community's access to their ancestral lands and resources (*Yakye Axa Indigenous Community v. Paraguay*, 2005, paras. 161–162, 164, 167, 170–176). Furthermore, the Inter-American Court of Human Rights determined that the Paraguayan government's failure to respect the community's ancestral land rights posed a direct threat to their access to such essential resources as food, water, and healthcare, which in turn severely impacted their survival and violated several human rights outlined in the Convention, including

Articles 4 (right to life), 8 (right to a fair trial), 21 (right to property), and 25 (right to judicial protection) (*Yakye Axa Indigenous Community v. Paraguay*, 2005, paras. 104, 118, 156, 176).

Significantly, the Court's decision recognized that human dignity was the cornerstone of human rights. In this context, the inability of the Yakye Axa community to live on and cultivate their ancestral lands compromised not only their cultural identity but also their dignity as human beings. By connecting human dignity to the right to life, the Court established that environmental factors, such as the loss of ancestral lands, had profound implications for a community's ability to live with a sense of dignity.

This case also has a significant relevance in discussions about climate-induced migration. It validates how environmental changes, leading to forced displacement, can affect the physical survival of communities along with their dignity and cultural identity. The principles articulated in this ruling underscore the importance of legally recognizing and safeguarding the human rights of individuals affected by environmental and climate-induced displacements. This would ensure that such migrations respect the fundamental human right to live with dignity.

2.4.2 Cases from the European Court of Human Rights

The European Court of Human Rights (ECtHR) has also dealt with cases wherein environmental issues intersect with human rights, particularly the right to life, dignity, and privacy. A landmark case is *Fadeyeva v. Russia* (2005), where the applicant, Ms. Fadeyeva, lived near a large steel plant in Cherepovets, Russia. She claimed that emissions from the plant had a detrimental impact on her and her family's health and well-being (*Fadeyeva v. Russia*, 2005, para. 3). The ECtHR found a violation of Article 8 of the ECHR, which guarantees the right to respect for private and family life. The Court held that the State had been unsuccessful in achieving a fair balance between the economic well-being of the community (through the operation of the steel plant) and Ms. Fadeyeva's right to respect for her home and private life (*Fadeyeva v. Russia*, 2005, para. 134). Thus, this case established that severe environmental pollution could constitute a violation of the right to respect for private and family life, given its impact on individuals' health and well-being (see Stratilati, 2019; Siwior, 2021b; Ungureanu, 2023).

Another significant case worth mentioning is *López Ostra v. Spain* (1994). Ms. López Ostra, the applicant, lived near a waste treatment plant that caused severe odors and potential health problems. She argued that the plant's operations infringed on her family's right to a healthy and peaceful home environment (*López Ostra v. Spain*, 1994, paras. 30, 34, 47). The ECtHR found a violation of Article 8, emphasizing that severe environmental pollution, even without physical injury, could affect private and family life (*López Ostra v. Spain*, 1994, para. 51). The Spanish government's failure to take timely action constituted a breach of its obligations. Again, this case illustrates the wider effects of environmental degradation on living conditions and suggests how environmental harm, such as pollution or mismanaged waste, can trigger climate-induced migration, particularly when state actions fail to safeguard the rights of the affected communities.

Another related case is *Kyrtatos v. Greece* (2003), where the applicants complained about the Greek authorities' failure to prevent the deterioration of a protected natural wetland area near their home, arguing that this affected their property rights and their private and family life (*Kyrtatos v. Greece*, 2003, para. 2). However, the ECtHR ultimately did not find a violation of Article 8 of the ECHR. Although the Court acknowledged the importance of environmental protection and its connection to the enjoyment of private and family lives, it concluded that the evidence presented by the applicants did not sufficiently demonstrate that the environmental degradation of the wetland directly affected their rights under Article 8 (*Kyrtatos v. Greece*, 2003, paras. 51–55). This case serves as an example of the complexities involved in linking environmental harm to human rights violations under the ECHR. For a case to succeed, one must establish a direct and significant effect of the environmental harm on private and family life, which is crucial for a successful claim under Article 8.

For climate-induced migration, this case clearly shows the challenges of legally proving the detrimental impact of environmental degradation on human rights. Although it does not directly address climate-induced migration, the principles discussed in the case are highly relevant to situations where environmental harm could potentially lead to displacement due to its effects on fundamental human rights. Significantly, the principles also underscore the obligation of states to actively protect individuals from environmental harm, which can impinge upon the basic rights and, in some instances, precipitate displacement or migration.

Finally, it is pertinent to cite three very recent decisions of the ECtHR. The first case was initiated by a collective of Swiss women aged 70 and above, who raised concerns about the adverse impacts of climate change. In *Verein KlimaSeniorinnen Schweiz and Others v. Switzerland* (2024), the applicants argued that their age group was particularly vulnerable to the adverse effects of heat waves resulting from climate change. The Court ruled that Switzerland had violated Article 8 of the ECHR, which guarantees the right to private and family life, by failing to adequately reduce carbon emissions. The judgment highlighted critical gaps in Swiss climate policy and ordered the state to take further action. This decision was significant because it was the first time the ECtHR ruled on climate change and recognized that insufficient climate action can constitute a violation of human rights. In this case, the Court not only addressed the issue of climate change for the first time but also issued its first ruling against a state for failing to take sufficient action. This precedent-setting judgment establishes that climate protection is recognized as a human right under the ECHR. It also sets an important legal foundation for addressing climate-induced migration within the European Union, as it underscores the obligation of states to take measures to mitigate climate change to protect fundamental human rights.

The ECtHR dismissed two similar cases that claimed States Parties to the Convention were failing to adequately address climate change, infringing on the applicants' rights. In *Duarte Agostinho and Others v. Portugal and 32 Others* (2024), six young applicants from Portugal alleged that 33 contracting states had violated their human rights due to insufficient action on the climate crisis, in breach of the positive obligations set out in the ECHR in light of the 2015 Paris Agreement. The Court dismissed the case on the grounds that the applicants had failed to exhaust domestic remedies in Portugal. It also rejected the extraterritorial jurisdiction claims against the other states, as the Convention does not extend to emissions outside the state's borders affecting another country. Similarly, in *Carême v. France* (2024), the former mayor of Grande-Synthe alleged that France was not taking sufficient measures to combat climate change, thereby violating his right to private and family life under Article 8 and his right to life under Article 2 of the Convention. The Court ruled the case inadmissible because the applicant no longer resided in the municipality affected by climate risks and, therefore, could not claim victim status under the Convention. The aforementioned precedents compellingly demonstrate that states should address escalating environmental degradation and pollution to effectively manage potential issues caused by climate-induced migration. These principles can thus be applied to mitigate conditions that might cause the displacement of individuals who believe their health, living conditions, and dignity are compromised by environmental degradation.

2.5 Engagement and Commitment to Human Rights Principles: An Essential Need

Human rights can play a pivotal role in addressing climate-induced migration. Observing the limited scope of traditional refugee law, which is bound by stringent criteria, it becomes crucial to highlight the more inclusive framework of human rights law for those displaced by environmental changes. Human rights law arguably extends beyond the constraints of refugee law, encompassing a wide spectrum of fundamental rights that are directly pertinent to the predicaments faced by displaced individuals. Indeed, it offers a solid foundation for advocating the protection and basic rights of those compelled to migrate due to the adverse effects of climate change.

The right to life, in this sense, is a cornerstone of human rights law that can be broadly construed to include threats to survival arising from environmental and ecological circumstances. The Human Rights Committee, in its *General Comment No. 36* (2019) on the right to life, exemplifies this expansive interpretation. In its detailed deliberation, the Committee does not shy away from contemporary challenges and discusses the right to life in the context of weapons of mass destruction (*General Comment No. 36,* 2019, para. 66), the complexities surrounding abortion (*General Comment No. 36*, 2019, para. 8), and the growing problem of climate change (*General Comment No. 36*, 2019, para. 62). It is here, within the discourse on environmental degradation, that the Committee's insights are particularly relevant to our discussion of climate-induced migration. The Committee recognizes that the degradation of the environment and the disruptive force of climate change pose a profound threat to human life, necessitating that states take preventive actions and safeguard against the displacement of people (*General Comment No. 36*, 2019, para. 62). This intersection of environmental protection and the right to life with dignity lays the foundation for protecting those who find themselves at the mercy of a changing climate (see Le Moli, 2020; Feria-Tinta, 2021; Mladenov and Serotila, 2022).

The Committee holds that the conditions necessary for life extend beyond the mere absence of violence; they include environmental and climatic elements integral to human existence (*General Comment No. 36*, 2009, paras. 26, 62). This broad understanding is pivotal for climate-induced migrants, whose plights can be situated under the umbrella of human rights law. Displacement typically results in the loss of homes, livelihoods, and access to essential resources. In this context, the rights to adequate housing, food, and water are not merely ancillary but are critical. The fulfillment of these rights, while challenging, is essential in displacement contexts. The General Comment thus becomes a critical tool in our advocacy for using human rights as a key framework: It supports the notion that protecting life from environmental harm is a duty borne by states under international human rights law. This duty encompasses ensuring that individuals are not compelled to live in conditions that threaten their survival and dignity.

Another essential instrument that can serve as a legal mechanism to address climate-induced migration from a human rights perspective is the Human Rights Council's *Resolution 41/21* (2019), titled "Human Rights and Climate Change." Acknowledging the immediate and extensive threat posed by climate change to people and communities worldwide, the resolution addresses its adverse impact on the full and dignified enjoyment of human rights (Resolution 41/21). The Council pays special attention to vulnerable groups and communities that are disproportionately affected by climate change, such as children, women, persons with disabilities, and Indigenous peoples (Resolution 41/21). The resolution stipulates that these vulnerable groups, especially persons with disabilities, should actively participate in disaster risk management and climate-related decision-making. Furthermore, it emphasizes the obligations of states to address the adverse effects of climate change on human rights, including the duty to implement comprehensive measures to protect the human rights of all (Resolution 41/21).

Even though the resolution does not explicitly address climate-induced migration, its implications are clear. The Human Rights Council recognizes the negative impacts of climate change, such as sea-level rise, extreme weather events, and desertification, as contributing factors to displacement and migration (Resolution 41/21). Consequently, the protection of human rights in the context of climate change is intrinsically linked to addressing climate-induced migration.

Another Human Rights Council resolution, *Resolution 35/20* (2017), also frames climate change as a human rights issue. It emphasizes the impacts of climate change on human rights and underscores the need for effective measures to combat the challenges arising from environmental degradation and for comprehensive policies to protect the rights of those most affected. The Resolution calls for national and international cooperation to mitigate the impacts of climate change and support climate migrants, accentuating the necessity of global action and solidarity.

In sum, as we confront the multifaceted challenges of climate-induced migration, human rights law serves not only as a legal framework but also as a moral compass guiding us toward a just and humane response. It compels the global community to recognize the plight of climate-induced migrants not as a distant problem but as an immediate and pressing human rights issue.

In this regard, we should closely examine other non-binding international instruments that aim to address the needs of displaced individuals. This examination will better underscore the crucial importance of grounding international efforts in human rights principles. Even though the following non-binding instruments may not directly pertain to climate-induced migrants, they can still serve as a model for how the international community can draw inspiration in its efforts to develop a more comprehensive and binding framework tailored to the needs of people displaced for various reasons, including environmental causes.

2.5.1 Guiding Principles on Internal Displacement

The United Nations' *Guiding Principles on Internal Displacement* (1998) incorporate a wide range of rights and protections for internally displaced persons (IDPs). These protections include, but are not limited to, safeguards against arbitrary displacement (Principle 6), rights to basic shelter, food, and water (Principle 18), access to health care (Principles 18 and 19), education (Principle 23), and the right to seek voluntary resettlement or return (Principle 28).

While the Guiding Principles are primarily designed for internal displacement and not directly applicable to climate-induced migration, they illuminate a range of rights that are highly relevant to the plight of those who cross borders due to significant climatic changes. The adaptation of these principles to cross-border scenarios is grounded in the universality of human rights and the imperative to protect fundamental rights regardless of national borders. The Principles not only protect against arbitrary displacement, emphasizing the right of individuals to be safeguarded from forced evacuation but also cover other fundamental rights essential to human existence. Rights such as the right to life, security, an adequate standard of living, and health are intrinsic to the Principles and serve as a model for addressing the needs of climate-induced migrants.

However, integrating these principles into policy and legal frameworks presents challenges, particularly in balancing state sovereignty with international responsibilities. Effective policy implementation necessitates strong international cooperation, adequate resource allocation, and a steadfast commitment to upholding human rights standards (see Gemenne and Brücker, 2015; Ferris, 2017; Schloss, 2018).

To illustrate, the right to education, outlined in Principle 23, is crucial for ensuring that displacement does not irreparably disrupt the educational pursuits of young migrants. The Principles urge states to provide educational services attuned to the cultural and linguistic backgrounds of displaced children. The Principles also emphasize the importance of the right to property and possessions, which for climate-induced migrants can mean the stark difference between the ability to rebuild lives elsewhere or facing extreme poverty. Principles 21 and 29 call upon states to respect the property rights of displaced individuals and to provide fair compensation when restitution is not feasible. Likewise, Principles 22, 28, and 29 regulate the right to participate in public affairs, an essential right that is often overshadowed in the chaos of migration yet crucial for enabling migrants to influence the policies and decisions affecting their lives and futures. It is also worth mentioning that the right to freedom from physical violence and abuse, enshrined in Principles 10, 11, 19, 21, and 26, is paramount and provides crucial safety for climate-induced migrants who may face vulnerabilities during and post-displacement.

The Principles offer potent inspiration for the global community, serving both moral and practical purposes while realistically enumerating human rights in the context of migration. They can function as a navigational aid, guiding us toward legal strategies that prioritize the dignity and rights of climate-induced migrants within our overarching climate action plans. By weaving the Guiding Principles into the fabric of our response to climate-induced migration, we commit to a future where the rights of all displaced persons are actively protected and promoted as a central aspect of our collective action against climate change.

2.5.2 The Kampala Convention

The African Union Convention for the Protection and Assistance of Internally Displaced Persons in Africa, known as the Kampala Convention (2009), illustrates how regional cooperation can create effective legal frameworks for addressing forced displacement, including that caused by environmental factors. The Convention's comprehensive approach to internal displacement offers a valuable model for other regions facing similar challenges. In this sense, the Kampala Convention exemplifies how soft law can inform and drive the development of binding international agreements. The Convention advances the core tenets of the Guiding Principles, embedding them into a legally binding text, with particular emphasis on environmental concerns and climate-induced migration.

In the spirit of the Guiding Principles, the Convention addresses displacement caused by environmental disasters, including those exacerbated by climate change. It provides a specific legal framework that considers the rights and needs of climate-induced migrants, representing a significant step in recognizing environmental causes as legitimate grounds for displacement. This acknowledgment marks a dramatic shift in the legal paradigm and serves as a model for future instruments (The Kampala Convention, 2009, arts. V(4) and X). Furthermore, the Kampala Convention mandates that States Parties not only prevent such displacement but also establish measures to protect and assist displaced persons when prevention is not possible. These obligations include ensuring the rights of those displaced by environmental and climate-related factors through the development of legislation, policies, and strategies that address the unique circumstances of climate-induced migrants.

By identifying specific environmental factors as drivers of displacement, the Convention recognizes the growing impact of climate change on human mobility. Grounded in the fundamental principles of human rights and largely shaped by the Principles, it constitutes a binding and concrete legal instrument that acts as a catalyst for the protection of climate-induced migrants. Crucially, it provides a framework for states to harmonize their national laws with the commitments outlined in the Convention, ensuring that individuals forced to migrate due to environmental changes receive the necessary protections.

Given the Convention's direct applicability to climate-induced migrants, this instrument is not merely a regional accomplishment but also a significant exemplar for the global community. In other words, the Convention serves as a call to action for other regions to adopt similar binding instruments to address the multifaceted challenges of climate-induced migration. The success of this initiative lies in its demonstration of how soft law can lead to significant changes in international law (see Jegede, 2016; Beyani, 2020; Dieng, 2017; Soares, 2023).

2.6 Conclusion

International efforts to address climate-induced migration are gathering pace, yet there remains a critical need to anchor these efforts in human rights principles. The current landscape is characterized by non-binding agreements and preliminary initiatives, highlighting the necessity for more concrete, legally enforceable frameworks. Significant climate change agreements like the Paris Agreement, the Kyoto Protocol, and the UNFCCC, while crucial, do not directly address the specific needs of climate-induced migrants. Furthermore, initiatives such as the Sendai Framework and the Nansen Initiative provide valuable guidance but remain non-binding and offer only foundational frameworks.

This situation underscores the urgent need for global cooperation in developing realistic and enforceable conventions specifically tailored to climate-induced migration. The Guiding Principles and the legally binding Kampala Convention provide clear guidance for shaping international agreements. Such agreements should not only recognize but actively protect the rights of climate-induced migrants. They must be both thorough and forward-looking, providing immediate protective measures and simultaneously addressing the root causes of displacement. These frameworks should also facilitate the eventual return of individuals to their homes when conditions permit. The Kampala Convention exemplifies the efficacy of regional cooperation in establishing effective legal mechanisms to protect the rights of displaced individuals. Addressing climate-induced migration demands collaboration among states, international organizations, and legal experts.

The objective is to establish frameworks that are both adaptable and capable of addressing the intricate nature of displacement caused by environmental changes. Central to these endeavors must be a steadfast commitment to the human rights of those affected. Maintaining the rights and dignity of affected individuals as the key priority is essential for any response to climate-induced migration. Through concerted, rights-centered international cooperation, the global community can strive for effective, humane, and legally binding resolutions to the challenges of climate-induced migration.

It is crucial to highlight that establishing a human rights-based framework for climate-induced migration can follow two primary pathways: the development of regional regulations or the creation of a universally binding convention. While climate-induced migration is a global issue with far-reaching implications, regional frameworks may offer more immediate solutions in areas most affected by environmental changes. These regional arrangements could also act as catalysts for broader international cooperation, encouraging global consensus. Alternatively, a binding international legal framework, specifically addressing climate-induced migration, could be developed drawing on existing models like the Kampala Convention and the UN Guiding Principles on Internal Displacement rather than starting from scratch.

Additionally, any binding instrument—whether regional or universal in scope—must address the protection of both IDPs and cross-border migrants, as the rights of both groups remain inadequately protected under current frameworks. The Kampala Convention imposes an obligation upon state parties to protect IDPs within their jurisdictions. Extending its provisions to include cross-border migrants would require states to assume responsibility for individuals displaced by climate-related crises in other countries. This raises key questions about responsibility-sharing and what would motivate states to engage with such agreements. Given the current reluctance of many countries to enter into binding international frameworks on migration, the Kampala Convention offers a valuable model for rethinking how global cooperation on climate-induced migration might be structured.

While this study does not examine the detailed process through which a universally binding instrument might emerge, these debates—particularly those concerning state responsibility and the incentives required for international cooperation—remain important and warrant further examination. In the meantime, exploring the Guiding Principles and regional frameworks could provide a practical starting point for addressing the urgent issue of climate-induced migration. By building on existing models and ensuring human rights protections, the global community can work toward a comprehensive, legally binding response that addresses the complex challenges posed by climate change and migration.

Bibliography

Advisory Opinion OC-23/17, The Environment and Human Rights, November 15, 2017, Retrieved from https://www.refworld.org/jurisprudence/caselaw/iacrthr/2017/en/123157, on March 14, 2024.

African Union Convention for the Protection and Assistance of Internally Displaced Persons in Africa (Kampala Convention), opened for signature October 23, 2009 (entered into force December 6, 2012).

Alexander, H. and Simon, J. (2014). "Unable to return" in the 1951 Refugee Convention: Stateless refugees and climate change. *Florida Journal of International Law, 26*(3), 531–574.

Alvarado, L. J. (2007). Prospects and challenges in the implementation of indigenous peoples' human rights in international law: Lessons from the case of Awas Tingni v. Nicaragua. *Arizona Journal of International and Comparative Law, 24*(3), 609–643.

American Convention on Human Rights, opened for signature November 22, 1969, 1144 U.N.T.S. 123 (entered into force, July 18, 1978).

Amiott, J. (2002). Environment, equality, and Indigenous peoples' land rights in the Inter-American Human Rights System: Mayagna (Sumo) Indigenous Community of Awas Tingni v. Nicaragua. *Environmental Law, 32*(4), 873–903.

Bautista, J. J. E. (2019). Human rights as a protection mechanism for the environment: Is it possible to include IACHR's Advisory Opinion 23/17 in the Ecuadorian legal system? *USFQ Law Review, 6*(1), 79–98.

Bergova, I. (2021). Environmental migration and asylum: Ioane Teitiota v. New Zealand. *The Justice System Journal, 42*(2), 222–224.

Beyani, C. (2020). *A view from inside the kitchen of the Kampala Convention: The modernisation of the international legal regime for the protection of internally displaced persons* (LSE Legal Studies Working

Paper No. 17/2020). https://ssrn.com/abstract=3736788; http://dx.doi.org/10.2139/ssrn.3736788.

Campbell-Duruflé, C. and Atapattu, S. A. (2018). The Inter-American Court's Environment and Human Rights Advisory Opinion: Implications for international climate law. *Climate Law, 8*(3–4), 321–337.

Carême v France, App. No. 7189/21 (ECtHR, April 9, 2024).

Convention Relating to the Status of Refugees, opened for signature, July 28, 1951, 189 UNTS 137 (entered into force April 22, 1954).

Del Grande, A. (2021). Statelessness in the context of climate change: The applicability of the Montevideo criteria to "sinking states." *N.Y.U. Journal of International Law and Politics, 53*(3), 152–161.

Duarte Agostinho and Others v. Portugal and 32 others, App. No. 39371/20 (ECtHR, April 9, 2024).

European Convention on Human Rights (1950). European Treaty Series-No. 5. Retrieved October 20, 2024, from http://www.echr.coe.int/Documents/Convention_ENG.pdf

Fadeyeva v Russian Federation, App. No. 55723/00 (ECtHR, June 9, 2005).

Feria-Tinta, M. (2020). Climate change as a human rights issue: Litigating climate change in the Inter-American System of Human Rights and the United Nations Human Rights Committee. In I. Alogna, C. Bakker and J. P. Gauci (Eds.), *Climate change litigation: Global perspectives* (pp. 310–342). Brill.

Ferris, E. (2017). The relevance of the Guiding Principles on Internal Displacement for the climate change-migration nexus. In B. Mayer and F. Crépeau. (Eds.), *Research handbook on climate change, migration and the law* (pp. 108–130). Edward Elgar Publishing.

Foster, M. and McAdam, J. (2022). Analysis of "imminence" in international protection claims: Teitiota v New Zealand and beyond. *International and Comparative Law Quarterly, 71*(4), 975–982.

Gemenne, F. and Brücker, P. (2015). From the Guiding Principles on Internal Displacement to the Nansen Initiative: What the governance of environmental migration can learn from the governance of internal displacement. *International Journal of Refugee Law, 27*(2), 245–263.

Grossman, C. and Anaya, S. J. (2002). The case of Awas Tingni v. Nicaragua: A step in the international law of indigenous peoples. *Arizona Journal of International and Comparative Law, 19*(1), 1–15.

Guiding Principles on Internal Displacement, E/CN.4/1998/53/Add.2, July 22, 1998, Retrieved from https://www.unhcr.org/sites/default/files/legacy-pdf/47949b3f2.pdf, on March 14, 2024.

International Covenant on Civil and Political Rights, adopted December 19, 1966, 999 U.N.T.S. 171 (entered into force March 23, 1976).

Jegede, A. O. (2016). Rights away from home: Climate-induced displacement of indigenous peoples and the extraterritorial application of the Kampala Convention. *African Human Rights Law Journal, 16*(1), 58–82.

Koubi, V., Böhmelt, T., Spilker, G. and Schaffer, L. (2018). The determinants of environmental migrants' conflict perception. *International Organization, 72*(4), 905–936.

Kyoto Protocol to the United Nations Framework Convention on Climate Change, opened for signature March 16, 1998, 2303 U.N.T.S. 162 (entered into force February 16, 2005).

Kyrtatos v. Greece, App. No. 41666/98, (ECtHR, May 22, 2003).

Laczko, F. and Aghazarm, C. (Eds.). 2009. Migration, environment, and climate change: Assessing the evidence. International Organization for Migration.

Le Moli, G. (2020). The Human Rights Committee, environmental protection and the right to life. *International and Comparative Law Quarterly, 69*(3), 735–752.

López Ostra v Spain, App. No. 16798/90 (ECtHR, December 9, 1994).

McAdam, J. (2020). Protecting people displaced by the impacts of climate change: The UN Human Rights Committee and the principle of non-refoulement. *American Journal of International Law, 114*(4), 708–725.

Migrants in Countries in Crisis Initiative (2014). Retrieved March 14, 2024 from https://micicinitiative.iom.int/

Mladenov, M. and Serotila, I. (2022). Human rights' approach to environmental protection practice of the human rights committee. *LAW Theory and Practice, 39*(2), 52–64.

Nansen Initiative, *Protection Agenda* (2015). Retrieved from https://disasterdisplacement.org/wp-content/uploads/2015/02/PROTECTION-AGENDA-VOLUME-1.pdf; https://disasterdisplacement.org/wp-content/uploads/2015/02/PROTECTION-AGENDA-VOLUME-2.pdf; https://environmentalmigration.iom.int/nansen-initiative, on March 14, 2024.

Neef, A. and Benge, L. (2022). Shifting responsibility and denying justice: New Zealand's contentious approach to Pacific climate mobilities. *Regional Environmental Change*, *22*(94), 1–12.

New York Declaration for Refugees and Migrants. A/RES/71/1, October 3, 2016, Retrieved from https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_71_1.pdf, on March 14, 2024.

Ollino, A. (2020). Reflections on the Advisory Opinion on human rights and the environment and the notion of extraterritorial jurisdiction. *Die Friedens-Warte*, *93*(1/2), *56–69*.

Paris Agreement to the United Nations Framework Convention on Climate Change, opened for signature, April 22, 2016, 3156 UNTS 1 (entered into force November 4, 2016).

Protocol Relating to the Status of Refugees, opened for signature January 31, 1967, 606 UNTS 267 (entered into force, October 4, 1967).

Resolution 35/20 Human Rights and Climate Change, A/HRC/RES/35/20, July 7, 2017, Retrieved from https://documents.un.org/doc/undoc/gen/g17/184/52/pdf/g1718452.pdf?token=hVcUglvXCT27H2AF6V&fe=true, on March 14, 2024.

Resolution 41/21 Human Rights and Climate Change, A/HRC/RES/41/21, July 23, 2019, Retrieved from https://documents.un.org/doc/undoc/gen/g19/223/65/pdf/g1922365.pdf?token=g5z0Fyt7T86F7vInMR&fe=true, on March 14, 2024

Schloss, C. (2018). Cross-border displacement due to environmental disaster: A proposal for UN Guiding Principles to fill the legal protection gap. In S. Behrman and A. Kent (Eds.), In *Climate refugees: Beyond the legal impasse* (pp. 243–264). Routledge.

Sendai Framework for Disaster Risk Reduction 2015–2030. Retrieved from http://www.unisdr.org/files/43291_sendaiframeworkfordrren.pdf, on March 14, 2024.

Siwior, P. (2021a). The Inter-American Court of Human Rights Advisory Opinion OC-23/17 on the relationship between human rights and the environment. *Review of European and Comparative Law, 46*(3), 177–188.

Siwior, P. (2021b). The potential of application of the ECHR in climate change related cases. *International Community Law Review, 23*(2–3), 197–208.

Soares, A. S. (2023). Displaced by environmental disasters: Evaluating the Kampala Convention's (in)effectiveness ten years after it came into force. *Revista Catalana de Dret Ambiental, 14*(1), 1–48.

Sommario, E. (2021). When climate change and human rights meet: A brief comment on the UN Human Rights Committee's Teitiota decision. *Questions of International Law, 8*(77), 51–65.

Stratilati, E. M. (2019). The practice of the European Court of Human Rights on environmental issues. *Iustinianus Primus Law Review, 10*(2), 1–8.

Task Force on Displacement (2015). Retrieved from https://unfccc.int/sites/default/files/resource/2018_TFD_report_16_Sep_FINAL-unedited.pdf?, on March 14, 2024.

Teitiota v Chief Executive of the Ministry of Business, Innovation, and Employment (2013) NZHC 3125.

Teitiota v. The Chief Executive of Ministry of Business, Innovation, and Employment (2014) NZCA 173.

Teitiota v Chief Executive of the Ministry of Business, Innovation, and Employment (2015) NZSC 107.

Teitiota v New Zealand (2019) UNHRC, Comm No 2278/2016, UN Doc CCPR/C/127/D/2728/2016.

The Mayagna (Sumo) Awas Tingni Community v Nicaragua (2001) IACHR 9, IHRL 1462.

The Yakye Axa Indigenous Community v Paraguay (2005) IHRL 1509.

UN Human Rights Committee General Comment No. 36, Article 6 (Right to Life), September 3, 2019, Retrieved from https://www.refworld.org/legal/general/hrc/2019/en/123145, on March 14, 2024.

UN Refugee Agency, *Statelessness and Climate Change* (2021). Retrieved from https://www.unhcr.org/sites/default/files/legacy-pdf/618524da4.pdf, on October 20, 2024

Ungureanu, C. G. (2023). The European Court of Human Rights and the major arguments in environmental law. *European Journal of Law and Public Administration*, *10*(2), 1–9.

United Nations Framework Convention on Climate Change, opened for signature, June 4, 1992, 1771 U.N.T.S. 107 (entered into force March 21, 1994).

Verdu Baeza, J. (2023). Climate refugees, human rights and the principle of non-refoulement. *Paix et Securite Internationales Journal of International Law and International Relations*, *11*, 1–23.

Verein KlimaSeniorinnen Schweiz and Others v. Switzerland, App. no. 53600/20 (ECtHR, April 9, 2024).

Warsaw International Mechanism for Loss and Damage (2013). Retrieved March 14, 2024, from https://unfccc.int/topics/adaptation-and-resilience/workstreams/loss-and-damage/warsaw-international-mechanism#__Enhancing-knowledge-and-understanding-of-comprehensive-risk-management-approaches-to-address-loss-and-damage-associated-with-the-adverse-effects-of-climate-change-including-slow-onset-impacts-by-facilitating-and-promoting

Climate Migration as a Human Security Problem in Africa

Ishmael Adjei[*4] *and Sevilay Zehra Aksoy*[*5]

3.1 Introduction

Climate-driven forced displacement has started to turn into a major problem in many parts of the world (Clement et al., 2021; IOM, 2022; Teye and Nikoi, 2022; Cantor et al., 2024). However, the issues related to climate migration and its governance have been either ignored or side-lined within the international community. Africa, which is the main focus area of this study, continues to experience forced displacement and migration driven by climate change. This has placed the region on the agenda of major migration forums and discussion platforms. Still, despite the alarming concerns, what governments are doing falls far short of what is expected of them (Oakes et al., 2023; Ghosh and Orchiston, 2022). While climate migration remains high in the internal realm (Clement et al., 2021), it will not be surprising to witness spillovers and major cross-border issues if individual states fail to handle the related challenges. As projected by the World Bank Groundswell's report, without the adoption of appropriate measures (the worst-case scenario), climate change could cause approximately 216 million people to migrate globally by 2050 and then accelerate. Out of this number, sub-Saharan Africa is projected to be the sub-region that will have the highest number of climate migration crises in the future, amounting to 86 million people likely to be climate migrants (Clement et al., 2021). However, there is a gap between the current climate change crisis and policy engagement in addressing the issue at both global and regional levels. This study examines the issues associated with policy gaps and provides recommendations.

* Both authors contributed equally to this work.

4 Ph.D. in Political Science and International Relations, Social Sciences Institute, Dokuz Eylül University, Izmir, Türkiye.

5 Assoc. Prof. Dr., Department of Political Science and International Relations, Faculty of Business, Dokuz Eylül University, Izmir, Türkiye.

As several projections indicate, climate-related migration is expected to be a major migration challenge in Africa by 2050 (Clement et al., 2021). Climatic events such as drought, desertification, high temperatures, changes in rainfall patterns, flooding, and rise in sea levels already affect many people, especially the poor and vulnerable in climate change hotspots, forcing them to migrate. In the Sahel region, for example, pastoralists (livestock farmers) migrate southward to Western Africa to compete with communities with limited resources, resulting in conflicts and other forms of social violence. Similarly, in the East and Horn of Africa, climate change has increased drought, water crises, and food insecurity, influencing people's migration patterns in these regions (Folami and Folami, 2013; Olaniyan and Okeke-Uzodike, 2015; Issifu, 2022; Teye, 2022; Clement et al., 2021). However, policymakers in Africa generally pay scant attention to climate change's impact on the mobility of people (Ibrahim and Mensah, 2022). In other words, there are policy gaps in what African governments do and what is expected of them.

In this study, critical attention is paid to the impact of climate change on migration and the related human security concerns in Africa. The study also points out the challenges regarding climate migration governance and makes recommendations on how to fill policy gaps. The following questions guide the discussions in this study: (1) How does climate change affect migration in Africa, and what are the implications for human security? (2) Do migration governance mechanisms exist, especially for climate migration issues, and what are the challenges?

In answering these questions, this study applies a qualitative research approach, using both primary and secondary data sources. The primary sources are obtained from the African Union (AU) and other sub-regional organizations' migration policy frameworks; the International Organization for Migration's (IOM) policy and migration documents on Africa; and climate-mobility information from the Internal Displacement Monitoring Centre (IDMC). Secondary sources include reviews of the existing literature and other related internet sources on the subject.

3.2 Migration in Africa

Migration is a major and historical phenomenon in Africa, which has increased with dramatic changes in climate patterns. African migration takes many forms, notably internal, intra-regional, and international. Intertwined factors such as conflict, poor governance, social and economic challenges as well as climate change-related and other environmental problems influence these forms of migration. Irrespective of what influences people's decision to migrate, migration contributes to African states' development in many ways (IOM, 2022; IOM, 2020; Teye and Owusu, 2015; Teye et al., 2021; Awumbila et al., 2018). African migration is dominated by intra-regional migration that takes place largely among East, West, and Southern Africa. Migration trends include labor migration in the Western and Central areas, refugee mobility in the Eastern and Southern areas, and skilled worker migration from the East and West to Southern Africa. North Africans largely migrate to Europe and the Gulf states (IOM, 2020; IOM, 2022; Awumbila et al., 2018; Agoben, 2018).

Both internal and international migration affect state development. Migrants contribute to their origin/host countries and communities in many ways. However, the contribution of migration to development depends on the existing policies of each state (Mavroudi, 2022). This means that migration in Africa can have both positive and negative impacts, depending on how migration is governed in a country. It has the potential to reduce unemployment, promote rural development, and improve the urban infrastructure. Yet, it also poses issues such as brain drain, delayed development in critical sectors, loss of family cohesion, and urban overpopulation (Agoben, 2018; Adu Gyamfi et al., 2021).

While migration is an important phenomenon in Africa, it is often characterized by misconceptions. Most perceptions of African migration are based on stereotypes, without concrete evidence to support such claims. Common misconceptions include that African migrants mostly cross the ocean via irregular routes, that Africa has the largest migrant population, and that poor and low-skilled people emigrate from Africa (IOM, 2020; Flahaux and De Haas, 2016). However, these narratives do not accurately reflect the reality. Most African migrants use land borders and they are not only the poor who migrate. The better-off and highly skilled also migrate, including people such as doctors, nurses, engineers and academics (MIF, 2022). Actually, migration processes are expensive and, thus, the very poor cannot afford them. Also, a large number of global migrants originate from Asia (41%), whereas Africa only accounts for 14 percent of the global migrant population (IOM, 2020). African migration continues to be dominated by intra-regional movements (Flahaux and De Haas, 2016; IOM, 2020) and to be subject to several intercontinental restrictions (Flahaux and De Haas, 2016).

3.3 Climate Change as a Human Security Threat in Africa and Migration

At the turn of the twenty-first century, human security was described by the Japanese Prime Minister Obuchi Keizo as "the keyword to comprehensively seizing all of the menaces that threaten the survival, daily life, and dignity of human beings and to strengthening the efforts to confront these threats" (Obuchi, 1999). The concept of human security became popular in the post-Cold War era and found for itself a legitimate place in the discipline of International Relations with the deepening and broadening of security studies, that is, deepening in the sense of being more inclusive as to the subjects of security (individuals, groups as well as states) and broadening by paying increasing attention to non-violent sources of security threats such as environmental problems, mass movements of people, epidemics/pandemics, and so on (Paris, 2001; Ovalı, 2006). In the context of climate change, the International Panel on Climate Change (IPCC) has defined human security as "a condition that exists when the vital core of human lives is protected, and when people have the freedom and capacity to live with dignity" (Adger et al., 2015). In this definition, survival, freedom and dignity are highlighted as the key elements of human security. Therefore, anything that threatens these can be a source of insecurity for human beings.

Climate change may adversely affect the very core of people's lives by depriving them economically, endangering their health and threatening their survival, and by forcing them to migrate, which, instead of a dignified life, could lead to increasing insecurity for migrants as well as insecurities for their host communities/states (Adger et al., 2015). The latter insecurity may result from issues related to identity/ culture and competition for limited jobs. Migration in Africa has a complex relation with human security and is driven by interrelated factors such as poor governance, intra- and inter-state conflict, socioeconomic causes and climate crises (Bayar and Aral, 2019). Migration caused by the adverse effects of climate change is considered in this study to be forced migration, which threatens people's lives before, during and after their move, creating a serious human security problem.

The effects of climate change on Africa have started to increase disproportionately of the region's contribution to global greenhouse emissions. Although this contribution is less than three percent of the total global emissions, Africa remains one of the regions that is most vulnerable to the effects of climate change (Amakrane et al., 2023). Many people in the region are forced to migrate when facing climate events such as severe drought, desertification, hot temperatures, changes in rainfall patterns, flooding, and rise in sea levels (Clement et al., 2021; IOM, 2022; Teye and Nikoi, 2022; IDMC, 2023). For instance, according to the Internal Displacement Monitoring Centre (IDMC) report, disaster-related displacements in sub-Saharan Africa increased from 2.6 million in 2021 to over 7.4 million in 2022 (IDMC, 2023). In 2022, 2.4 million disaster-related displacements were recorded in Nigeria alone due to severe floods, while the above-average rains and floods also led to very high levels of displacement in Mali, Niger, Mauritania, Chad and South Africa (IDMC, 2023). Malawi, Madagascar and Mozambique were the most affected countries from tropical cyclones and tropical storms that hit in 2022 with around 700,000 people displaced in Southern Africa, with the storms also causing severe food insecurity and outbreaks of waterborne diseases such as cholera (IDMC, 2023). Furthermore, many in East Africa have been displaced by consecutive failed rainy seasons, desertification, and the consequences, such as famine and water scarcity (Terry and Rai, 2023).

According to the projections by the World Bank, those numbers are expected to rise even further. In the World Bank Groundswell Report, climate-induced migration is expected to turn into a major crisis in sub-Saharan Africa by 2050, likely to affect approximately 86 million people, representing 4.2 percent of the sub-Saharan African population. North Africa is also projected to have 19.3 million climate migrants, representing 9 percent of the North African population (Clement et al., 2021). These new challenges are likely to exacerbate the existing humanitarian issues in the region (IOM, 2020), since many African states' low level of industrialization and their dependency on agriculture for economic development make them particularly vulnerable to the effects of climate change, especially migration (Kumssa and Jones, 2010; Cabot, 2015; Ibrahim and Mensah, 2022).

Both slow—(such as severe droughts, desertification or rise in sea levels) and sudden-onset events (such as floods or hurricanes) have several effects on human security in Africa. The problem is more critical in high-drought countries in the East and Horn of African countries, such as Ethiopia, Somalia, Sudan, and countries in the Sahel region such as Mali, Niger, Chad and Burkina Faso (Teye, 2022). As a result of climate-related displacement, people lose their livelihoods because of their dependency on climate-sensitive resources. This, in turn, has negative implications for both human security and countries' development (Ibrahim and Mensah, 2022), including, but not limited to, decrease in food production (food insecurity), severe malnutrition, water shortages, economic challenges, and loss of lives (Amakrane et al., 2023). These challenges cause people in some areas to question their habitual status in their places of origin (Clement et al., 2021) and sometimes even force them to move out of their countries with no possibility of returning due to loss of lands and destruction of property (Cantor et al., 2024). This form of displacement and consequent migration has become a major concern for different states and non-state actors because of the unmeasurable human security implications associated with this phenomenon.

Most importantly, due to climate change, many communities and people on the continent suffer from food insecurity and water crises. This is largely associated with changes in agricultural output[6] and increasing vulnerability in climate hotspot areas in the Horn of Africa and West Africa, especially the Sahel region. Water crises are exacerbated by longer periods of droughts and insufficient water resources. The most climate-vulnerable in Africa are predominantly the poor in rural areas, as they heavily depend on climatic conditions for employment (in farming sectors) (Ibrahim and Mensah, 2022). Thus, changes in climatic conditions make it increasingly difficult for those people to sustain their livelihood (Ibrahim and Mensah, 2022; Rigaud et al., 2018; Clement et al., 2021; Vinke et al., 2022) and render the already existing human security-related issues worse, forcing people to migrate and resulting in conflicts in some places (Saraiva and Monteiro, 2023; Daoudy et al., 2022).

In some cases, migration triggers or influences conflicts because of the struggle for scarce resources (McLeman, 2011). For instance, in West Africa, there have been frequent conflicts between farmers and herders. As the activities of farmers and herdsmen are primarily dependent on climatic conditions, the adverse consequences of climate change often force them to migrate to find favorable locations for cultivating crops and searching for food for their livestock. This movement is often associated with competition

[6] What is meant by changes in agricultural output is the variations in agricultural production (low and insufficient food production) due to the adverse impact of climate conditions such as low rainfall, drought, and high temperature that affects crop yields and other farming activities.

for limited land resources, thereby instigating conflicts in the host states and communities (Issifu et al., 2022; Teye, 2022; Cabot, 2015).

According to Teye, climate migration in most African countries, which used to be seasonal and short-term movements of farmers from dry areas, has now become long-term or permanent due to the unpredictable and worsening climate conditions affecting people's livelihoods. In some cases, families send some of their members, especially adult males, to settle permanently in the urban centers and places where there are favorable climatic conditions to find jobs to support the left-behind family members through financial and food remittances (Teye, 2022). As people continue to move from rural areas to urban centers, many cities are experiencing an increase in urban population and pressure on already limited resources and infrastructure (Teye, 2022).

Expectedly, such migration exacerbates health insecurity in some communities. Some climate migrants, especially those who move to urban centers, live in slums, ghettos, and settlements with poor sanitary conditions (Prosper and Khan, 2018; Jarawura and Smith, 2015). This is a major problem due to the increasing urban population and the related high pressure on accommodation facilities in most African cities (Teye, 2022). Although for the vulnerable migration can sometimes be a coping and adaptation strategy, because of unplanned climate migration issues in most African states, migrants encounter several diseases and hazards that affect their health. For instance, climate migrants in the urban areas sometimes engage in survival activities, such as the collection of plastics and other recyclable materials. The act of gathering these waste products further causes health problems leading to poor sanitation conditions in places where the collected materials are kept before being sold to end users.[7]

Most of the African governments do not have the sufficient infrastructure, technological know-how, and human and economic resources to develop and improve the required adaptation capacities to be able to cope with the effects of such slow- and sudden-onset climate hazards (Teye and Nikoi, 2022). Finding sustainable solutions, in turn, is made difficult by the intertwined issues such as unrepresentative governments, absence of political will, widespread corruption, illiteracy and many other ills (Attoe, 2024).

---

7 Based on interview data collected for Ishmael Adjei's PhD thesis on climate migration in Ghana.

Given both the persistence of such structural domestic problems in many African states and the worsening conditions in the hotspot areas, there is an urgent need for coordination between and within states in Africa (and the rest of the world) to improve the adaptation capacities in question. An effective coordination depends primarily, in turn, on the existence at the regional and global levels of explicit norms and rules regulating the orderly movement of climate migrants.

3.4 The Absence of a Global Climate Migration Regime

Before looking into the state of climate-related migration governance in Africa, it may be illuminating to shed light on the prevailing outlook at the global level. Notwithstanding the existence of separate documents on the different aspects of climate-related migration, a coherent global protection regime for climate migrants has not been formed yet. The reasons for that can be better understood if the constituting elements of international regimes (institutions) are considered. In Krasner's standard definition, "regimes are sets of implicit or explicit principles, norms, rules, and decision-making procedures around which actors' expectations converge in a given area of international relations." For Krasner

> principles are beliefs of fact, causation, and rectitude. Norms are the standards of behavior defined in terms of rights and obligations. Rules are specific prescriptions or proscriptions for actions. Decision-making procedures are prevailing practices for making and implementing collective choice. (Krasner, 1982)

A regime on climate migration corresponding to the constituting elements in Krasner's definition does not exist at the global level, although a need for it is increasingly felt with the acceleration of climate change-related slow- and sudden-onset environmental problems. The absence of such a regime has several reasons. To start with, it is questionable whether states really have common interests to make regulations in an issue area that will give them certain obligations as well as rights. Climate change has an impact on almost every state, but not necessarily in a similar nature and/or scope. Thus, it is not clear whether state expectations converge with respect to the regulation of future climate migration. Certain regions are more prone to the negative consequences of climate change than others, and some have more adaptive capacity to deal with them, while others have less. Different needs, priorities and capacities make it hard for states to coalesce around a phenomenon which is not equally relevant and/or imminent for each of them.

Jakobsson describes climate migration as a creeping crisis, meaning that we are more likely to experience it more vividly and more forcefully later on, but the time for that is simply unpredictable. This inevitably contributes to the lack of political will on the part of governments. Till they are faced with the overwhelming *and* enduring reality (actually, the number of people displaced due to climate events is already greater than those displaced because of violence), the governments will keep on delaying and be content with limited measures and policies. They also have on their plates unresolved refugee problems related to military conflicts (Jakobsson, 2021), which are expected to rise further due to the increasing eruption of inter-state and intra-state violence worldwide (Foreign Affairs, 2024).

As to the first element of international regime, that is, principles (the facts of belief and causation), it is not clear whether it has crystallized with regard to climate migration. Although the reality of climate change is now an acknowledged fact, the causality between climate change and migration is not always straightforward. Not everyone affected by climate-related disasters migrates, or when they migrate, they may prefer to remain at home rather than cross borders. For instance, the EU future projections are such that the majority of movements will not be of the cross-border type. Thus, who should be covered by such a regime? Only the victims of climate-related events? What about those displaced due to natural disasters (such as earthquakes) that are not related to climate change? And how to distinguish regular economic migrants from climate migrants who, especially the poor in rural areas, also migrate for economic reasons? Also, should those people be treated as migrants or refugees (Jakobsson, 2018)? On the issue of migrants in general and of economic migrants in particular, there is already what Hollifield calls a "liberal paradox," that is, while the developed liberal states generally adopt a free market logic in trade and finance, the opposite is the case for migration, and has been increasingly so since the end of the Cold War, mostly on the grounds of national security and/or identity (Hollifield, 2000). Thus, in a world where the tendency is closing borders, especially with regards to unskilled labor, it is highly likely that states will shy away from agreeing to the principles of a protection regime for climate migrants, who apparently constitute the bulk of that labor population.

As principles are not settled, norms on state behavior, that is, states' rights and obligations, are yet to be put forward explicitly and clearly. In an issue area where common definitions of key terms are lacking or where causal relationships are vague, this is not surprising. Also, there is no international consensus as to the objectives to be achieved vis-à-vis climate migrants: short-term protection through humanitarian assistance, adaptation/resilience, or planned resettlement. In any case, each of these objectives is too complex to be covered under the umbrella of a single climate migration regime. There have been several global initiatives and documents, but they do not constitute a coherent framework and have not led to a general written agreement on the subject, e.g., the International Organization for Migration (IOM)'s definition of environmental migrants;[8] the reports of the United Nations Development Programme (UNDP) (UNDP, n.d.) and the Intergovernmental Panel on Climate Change (IPCC, n.d.); the UN Guiding Principles on Internal Displacement (UN, 2004); the United Nations Framework Convention on Climate Change (UNFCCC) negotiations and the 2010 Cancun Adaptation Framework (UNFCCC, 2010); the Nansen Initiative (IOM, n.d.); the Paris Agreement (Task Force for Displacement) (IOM, 2018); the Global Compact for Migration (GCM) (UN, 2019), and the Global Compact on Refugees (GCR) (UN, 2018). Such incoherence can be regarded as natural and, thus, expected given the heterogeneous and controversial nature of climate migration for the reasons already stated. Also, given the different needs of different types of climate migrants, it may be more appropriate and fairer to approach each group contextually than to treat them *en masse*, which, in turn, would lead to differentiated obligations or duties at the international and local levels and correspondingly different rights on the part of migrants (Draper, 2024).

Thus, given both the questionable existence of common interests at the global level concerning the phenomenon of climate migration in particular

---

[8] Environmental migrants are defined by the IOM as "persons or groups of persons who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad" (IOM, 2007).

and the increasing liberal paradox toward migration in general, those states already affected and most likely to be affected in the future (e.g., sub-Saharan Africa and atoll Pacific Islands) need to discover better ways of protecting their people (McAdam, 2012; Behrman and Kent, 2018; Jakobsson, 2022). Building the essential protection mechanisms might be more feasible at the regional level where, at least, the political hurdles such as political and cultural identity issues seem to be less troublesome. This fact is also acknowledged by the African Union in its revised Migration Policy Framework for Africa and Plan of Action (2018–2030), where it is underlined that "it is essential for Africa to chart and drive its own migration objectives and policies that address its migration realities in support of its development goals" in the face of poor global dynamics (AU, 2018b).

3.5 Migration Governance Framework in Africa and the Challenges

Migration governance in Africa is a complex topic that encompasses several regional economic communities and organizations such as the African Union (AU), the Economic Community of West African States (ECOWAS), and the Intergovernmental Authority for Development (IGAD) for the East African states (Musimwa, 2021; Dick and Schraven, 2018). The aforementioned organizations established principles, norms and rules guiding practices to govern migration within the continent, addressing concerns such as forced displacement, seasonal labor migration, and circular migration (Fioramonti and Nshimbi, 2016). The AU Commission regarded migration as a major agenda at the Union's 74th ordinary session in 2001, when the Council of Ministers underlined the need for migration policies vis-à-vis the regional developments and challenges. This session contributed to the development of the AU Migration Policy Framework for Africa (MPFA), which was adopted in 2006 in Banjul (the Gambia) (AU, 2018 a).

The African Union follows strategic guidelines and norms to facilitate migration governance, which involves engaging stakeholders, providing technical assistance, and capacity building (AU, 2022; AU, 2018 a). In addition, migration governance in Africa revolves around managing, controlling, and ascertaining up-to-date data on migration. Most countries govern migration through Interior and Foreign Affairs Ministries (IOM, 2020). Since migration challenges are not static, the AU recognizes the dynamism in the region and collaborates with sub-regional blocs to develop policy frameworks. Most importantly, the AU acknowledges the importance of migration for development in Africa, which is reflected in its revised "Migration Policy Framework for Africa and Plan of Action (2018–2030)." The AU includes a migration chapter in its 2063 Agenda that aims at inclusive and socio-economic development, and the Africa Continental Free Trade Agreement (AfCFTA), a free trade agreement aiming to reduce the trade barriers on the continent (AU, 2018 a).

While climate-related migration has received less attention on the migration agenda of the AU, it is important to note that the African Union (AU) has attempted to govern climate-related mobility through the African Union Convention for the Protection and Assistance of Internally Displaced Persons in Africa, also known as the Kampala Convention (2009). This Convention aims to ensure that those displaced in the region are assisted in resettling in accordance with human rights norms. It emphasizes the provision of humanitarian assistance to the needy, especially to climate-induced displaced populations (AU-Kampala Convention, 2009).

As stated in the Convention, parties are obligated to protect internally displaced persons (IDPs), particularly those affected by climate change: *States Parties shall take measures to protect and assist persons who have been internally displaced due to natural or human-made disasters, including climate change* (AU-Kampala Convention (2009)—Article 5(4)). Thus, the Convention emphasizes the protection of those displaced and migrating for climate-related reasons and has the potential to serve as the basis of a regional protection mechanism. African leaders' efforts to establish this Convention are significant, because the Kampala Convention provides protection for IDPs by creating a duty for the signatories. The Convention can be considered as an important milestone in African migration governance, as it reflects the concern of the AU to get climate-related mobility on the continent recognized by all the member states and to push them for actions.

Although the Convention was adopted in October 2009 and entered into force in 2012, its implementation and the level of commitment among member states have not been as strong as expected until now. Despite the fact that the Convention encourages the protection of climate migrants through humanitarian assistance, planned resettlement, engagement with the affected community, and promoting data gathering on displaced persons, African governments' efforts to date have fallen short of the measures needed to find lasting solutions for climate-related displacement and movement (Ibrahim and Mensah, 2022).

Furthermore, executing migration policies at national and subnational levels remains a difficulty because of the necessity for significant technical and financial support. Even though the AU has established a Migration Policy Framework for Africa (MPFA) to combat irregular migration, its effectiveness is hampered by inadequate institutional capacity. On the other hand, inadequate government institutions for orderly migration as well as socio-economic constraints in many African countries contribute to the popularity of irregular migration, especially among the youth. However, the tendency toward the closure of borders in the face of increasing populist demands in the Global North makes irregular migration not only an uncomfortable fact but also a dangerous venture (Hil, 2013). In general, migration governance in Africa is a dynamic and developing process that necessitates cooperation and support from both regional and international actors (Adeniran, 2020; Musimwa, 2021; Dick and Schraven, 2018). Otherwise, the constant efforts of especially the advanced industrial states to avoid irregular or illegal migration from Africa (Frasca, 2023) will remain inconsequential (Munoz et al., 2024).

Another challenge to migration governance in Africa has been the lack of political will. This has been observed from states' attitudes toward the signing and ratification of some agreements that regulate migration issues (Yusuf et al., 2018; Awumbila et al., 2018; Gazzotti et al., 2022). A typical example is the attitude toward the ratification and implementation of the African Free Movement Protocol (FMP). The FMP needs 15 ratifications to come into force. However, so far only four countries (Mali, Niger, São Tomé and Príncipe, and Rwanda) have ratified it. Although the FMP is an important protocol, states are reluctant to promote free movement because of sovereignty-related concerns (Hirsch, 2021). Another agreement that can facilitate movement of individuals, especially climate-related mobility, is the Kampala Convention. It is important to note that more than half of African states—28 out of 55—have ratified it since its adoption in 2012. However, the Convention's practical influence has been minimal due to its weak enforcement structure and ineffective binding mechanisms (Addadzi-Koom, 2023).

Some states are also concerned about security issues when dealing with intra-regional migration on the continent (IOM, 2022). This makes some states pay more attention to their domestic laws. In the case of ECOWAS, for example, although citizens in the sub-region are free to move within the bloc, movements are sometimes restricted by the laws or regulations of individual member states for security reasons (Garba and Yeboah, 2022; Awumbila et al., 2008; Hirsch, 2021).

Additionally, the regional migration governance system has inadequate funding and resources to promote adaptation programs and support people's coping strategies (Teye and Nikoi, 2022; Vinke et al., 2022). This can be attributed to inadequate institutional mechanisms at the regional level to raise funds and build capacities to ensure effective migration governance, especially climate-related migration. The absence of such institutional mechanisms makes governments in the region focus too much on donor partners' support, especially outside actors such as the EU (Kandilige et al., 2023; Dick and Schraven, 2018). However, over-dependence on external sponsorship often results in donor interests being given more attention than the genuine needs and interests of local stakeholders, and is an obstacle to achieving a mutual interest in migration governance in the region (Kandilige et al., 2023; Frasca, 2023).

Lastly, in the case of climate migration governance, the reluctance of states to show genuine concern for collective action may be attributed to the fact that not every state is equally vulnerable to climate-related problems and disasters in Africa—a situation that is also true for other countries, as explained in the previous section. Hence, not all governments may be willing to consider issues of climate-related migration and displacement as urgent. This perception has implications for climate migration governance in the region and is likely to negatively affect leaders' attitudes toward the establishment of swift measures based on effective cooperation and commitments.

However, the challenges faced by African governments should not pose insurmountable barriers to the establishment of regulatory frameworks. Since Africa is projected to host and/or send large numbers of climate migrants, as mentioned in the introduction, the African Union (AU) and various stakeholders need to make greater efforts to pay critical attention to climate-related mobility and displacement in the region by engaging in genuine communication to understand each other's concerns and challenges and address them effectively through institutional channels. The existing regional and international legal frameworks on migration and refugees can also be deployed as supporting mechanisms in this regard as their wording may enable their application to climate-related disasters with a view to protecting the vulnerable under certain circumstances (Cantor et al., 2024).

3.6 Conclusion: What Next?

The governance of migration in Africa has been associated with various cross-cutting dynamics. While migration policy has been on the continental political agenda for several decades, climate-related migration is a relatively new phenomenon. Climate migration and displacement, which are projected to rise considerably in the not-too-distant future, will exacerbate the existing challenges faced by many vulnerable people in Africa. However, there are still serious hurdles to overcome in tackling the emerging crisis. The regional institutional mechanisms are not sufficient to address this issue or, more accurately, the existing institutional capacities have not been fully utilized or further developed due to the lack of political will on the part of many African governments—a serious issue generally associated with the absence of representative governments and good governance at the domestic level. There is also a limited long-term regional policy framework to address the concerns of climate migrants and host community members, particularly their livelihood challenges. As observed in some earlier studies such as by Issifu et al. (2022), Olaniyan and Okeke-Uzodike (2015), and Bukari (2017), there are already existing conflicts between climate migrants and members of host communities due to competition for limited resources in some places. If the necessary political will to develop or enhance the adaptation capacities of the most vulnerable communities and to establish conflict resolution mechanisms does not appear on the horizon soon, such conflicts can be expected to turn bitter and more complex in the near future.

This study, therefore, argues that climate mobility is an existential threat to human security in Africa. Climate migrants are critically deprived of minimum rights that are essential for their subsistence, while they may also find themselves in conflicts with host community members in competition for limited resources and social amenities in many hot spot areas. However, notwithstanding the alarming nature of the problem, the *de facto* state of regional affairs is such that there is a gap between what governments are expected to fulfill and what they actually do to effectively address the human security issues in question. Since not all disasters may automatically result in legal international or cross-border protection for victims (Cantor et al., 2024), establishing the necessary protection mechanisms at the regional level can aid countries to address issues that threaten the security of these victims. Considering that the degree of being affected differs or that states may have different capacities to support their victims, an established partnership can be useful in assisting the most vulnerable.

Governments should pay considerable attention to the impact of climate change on migration in Africa. Governments and other relevant stakeholders should seek to develop adaptation and protection plans for different types of climate hazards and their victims, and to implement these plans by ensuring strong commitment and cooperation between state and non-state actors. Education and increasing the literacy rates should be among the top priorities, as they are key to raising awareness on the impacts of climate change and to establishing effective cooperation with local communities and authorities. The emphasis should be on decentralized and inclusive policies characterized by a more community-led approach. Domestic laws need to be more climate-friendly while climate migration policies in Africa should be carefully defined and managed by specific institutions. The latter is also particularly important to help gather accurate data on climate migrants, which is essential for multidimensional planning.

Finally, while effective cooperation among stakeholders at the national, regional and sub-regional levels is essential, it may need to be facilitated or reinforced by technical and financial support from international actors at different stages of the process. The cooperative models suggested for financing the mitigation efforts in the Global South through the partnership of the United States and China (Gallagher, 2023) could also be developed to enhance the adaptation/resilience capacities of the world's most vulnerable regions, including in particular sub-Saharan Africa. The ultimate long-term goal should be the creation of a sustainable institutional mechanism governing different aspects of climate migration with well-defined principles, norms, and rules as well as monitoring and sanctioning instruments against free riding. This goal needs to be realizable by a strong commitment to climate finance; investment in adaptation/resilience projects; and prioritization of the implementation of climate migration policy frameworks, all with a view to enhancing human security, which is increasingly challenged by climate change.

Bibliography

Addadzi-Koom, M. E. (2023). Breathing Life into the Kampala Convention: Towards Workable Enforcement Mechanisms. *Journal of African Law, 67*(3), 329–347.

Adeniran, A. I. (2020). *Migration Crises in 21st Century Africa: Patterns, Processes andProjections*. Palgrave Macmillan.

Adger, W. N., Pulhin, J. M., Barnett, J., Dabelko, G. D., Hovelsrud, G. K., Spring, O. U., &Vogel, C. H. (2014). Human security. C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, and L. L. White (Eds.). *Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (755–791), Cambridge University Press.

Adu Gyamfi, B., Kwarteng, C. T., & Appiagyei, E. (2021). Public policy and migration inAfrica: A multi-theoretical approach. A. Olayiwola and O. A. Sabella (Eds.), *African Migrants and the Refugee Crisis* (23–54), Springer.

Africa Union (2009). African Union Convention for the Protection and Assistance of InternallyDisplaced Persons in Africa (Kampala Convention). Retrieved from https://au.int/en/treaties/african-union-convention-protection-and-assistance-internally-displaced-persons-africa, on November 10, 2023.

Africa Union (AU) Commission (2018 a). Migration Policy Framework for Africa and Plan of Action (2018–2030): Executive Summary, Retrieved from https://au.int/sites/default/files/documents/35956-doc-au-mpfa-executive-summary-eng.pdf, on December 4, 2023.

Africa Union (AU) Commission (2018b). Migration Policy Framework for Africa and Plan of Action (2018–2030), Retrieved from https://au.int/sites/default/files/documents/35956-doc-2018_mpfa_english_version.pdf, on April 10, 2024.

Africa Union (AU) Information and Communication Directorate (2022). African Union workshop towards operationalization of the African Centre for the Study and Research on Migration in Mali. Retrieved from https://au.int/sites/default/files/pressreleases/42240-pdf, on January 11, 2024.

Agoben, T. T. (2018). Migration in Africa-Who Gains and Who Lose? The Prospects and Problems of Migration in Africa: For the Migrant and the African Continent. *SSRN Electronic Journal, 4*(3), 344–359. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3234602, on December 4, 2023.

Amakrane, K., Rosengaertner, S., Simpson, N. P., de Sherbinin, A., Linekar, J., Horwood, C., Jones, B., Cottier, F., Adamo, S. B., Mills, B., Yetman, G., Chai-Onn, T., Squires, J., S., Chewe, J., Frouws, B., & Forin, R. (2023). African Shifts: The Africa Climate Mobility Report, Addressing Climate-Forced Migration and Displacement; Africa Climate Mobility Initiative and Global Centre for Climate Mobility, *Global Centre for Climate Mobility*.

Attoe, A. D. (2024). Why Democracy Fails in Africa. *The Philosophical Forum*. *55*(2), 137–156.

Awumbila, M., Deshingkar, P., & Teye, J. (2018). Ghana-Migration Industry. *Centre for Migration Studies, University of Ghana*.

Awumbila, M., Manuh, T., Quartey, P., Tagoe, C. A., & Bosiakoh, T. A. (2008). Migrationcountry paper (Ghana). *Centre for Migration Studies, University of Ghana*.

Bayar, M., & Aral, M. M. (2019). An analysis of large-scale forced migration inAfrica. *International Journal of Environmental Research and Public Health, 16*(21), 1–16.

Behrman, S., & Kent, A. (2018). Overcoming the legal impasses? Setting the scene. S. Behrmanand A. Kent (Ed.), *Climate refugees: beyond the legal impasse*? (3–16). Routledge.

Bukari, K. N. (2017). *Farmer-herder relations in Ghana: interplay of environmental change, conflict, cooperation and social networks*. (Doctoral Thesis, Georg-August-Universitaet, Goettingen, Germany). https://www.proquest.com/docview/1951126907/C626F560BD5642E1PQ/1?accountid=10527.

Cabot, C. (2015). *Climate Change, Security Risks, and Conflict Reduction in Africa*. Springer-Verlag Berlin and Heidelberg GmbH & Company K. Cantor, D., Burson, B., Aycock, B., Tan, N. F., Anastasiou, T., Arnold-Fernandez, E., … & Wood, T. (2024). International Protection, Disasters and Climate Change. *International Journal of Refugee Law*, 36(1), 176–197.

Clement, V., Rigaud, K. K., De Sherbinin, A., Jones, B., Adamo, S., Schewe, J., Sadiq, N., & Shabahat, E. (2021). Groundswell Part 2: Acting on Internal Climate Migration. World Bank.

Daoudy, M., Sowers, J., & Weinthal, E. (2022). What is climate security? Framing risks aroundwater, food, and migration in the Middle East and North Africa. *WIREs Water, 9*(3), 1–17.

Dick, E., & Schraven, B. (2018). *Regional migration governance in Africa and beyond: aframework of analysis*. Discussion Paper, German Development Institute.

Draper, J. (2024). Climate change and displacement: Towards a pluralist approach. *European Journal of Political Theory, 23*(1), 44–64.

Fioramonti, L., & Nshimbi, C. C. (2016). Regional Migration Governance in the African Continent. Current state of affairs and the way forward, *Development and Peace Foundation*.

Flahaux, M. L., & De Haas, H. (2016). African migration: trends, patterns, drivers, *Comparative Migration Studies, 4*, 1–25.

Folami, O. M., & Folami, A. O. (2013). Climate change and inter-ethnic conflict in Nigeria. *Peace Review, 25*(1), 104–110.

Foreign Affairs. (2024). Why is violent conflict reaching record levels? A conversation with Comfort Ero. *Foreign Affairs*, March 21, 2024. Retrieved from https://www.foreignaffairs.com/podcasts/why-violent-conflict-reaching-record-levels, on April 10, 2024.

Frasca, E. (2023). Informal Agreements and Quasi-Legal Mechanisms in EU-Africa Cooperation on Migration: How the EU takes advantage of the GCM commitments. *Frontiers in Human Dynamics, 5(1)*, 1–14.

Gallagher, K. S. (2023). The Right Way for America and China to Cooperate on Climate: How the Two Powers Can Jointly Aid Poorer Countries. *Foreign Affairs*, August 3, 2023. Retrieved from https://www.foreignaffairs.com/united-states/right-way-america-and-china-cooperate-climate, on October 29, 2024.

Garba, F., & Yeboah, T. (2022). Free Movement and Regional Integration in the ECOWAS, Sub-Region. J. K. Teye (Ed.), *Migration in West Africa* (19–34). Springer.

Gazzotti, L., Mouthaan, M., & Natter, K. (2022). Embracing complexity in "Southern" migration governance. *Territory, Politics, Governance, 11*(4), 625−637.

Ghosh, R. C., & Orchiston, C. (2022). A systematic review of climate migration research: gaps in existing literature. *SN Social Sciences, 2*(47), 1–22.

Hil, R. (2013). Climate Change, Population Movements and Governance: Case Studies in Response Mechanisms. T. Cadman (Ed.), *Climate Change and Global Policy Regimes: Towards Institutional Legitimacy* (187–201). Palgrave Macmillan.

Hirsch, A. (2021). The African Union's Free Movement of Persons Protocol: Why has it faltered and how can its objectives be achieved? *South African Journal of International Affairs, 28*(4), 497–517.

Hollifield, J. F. (2000). Migration and the "New" International Order: The Missing Regime. B. Ghosh (Ed.), *Managing Migration: Time for a New International Regime?* (75–109). Oxford University Press.

Ibrahim, B., & Mensah, H. (2022). Rethinking climate migration in sub-Saharan Africa from the perspective of tripartite drivers of climate change. *SN Social Sciences, 2*(87), 1–24.

Intergovernmental Panel on Climate Change Reports. (n.d.). Retrieved from https://www.ipcc.ch/reports/, on October 24, 2024.

Internal Displacement Monitoring Centre (IDMC) (2023). Internal Displacement and Food Security. Retrieved from https://api.internal-displacement.org/sites/default/files/publications/documents/IDMC_GRID_2023_Global_Report_on_Internal_Displacement_LR.pdf#page=12, on October 31, 2024.

International Organization for Migration (IOM) (2007). Discussion note: Migration and the environment. Ninety-fourth session, MC/INF/288. Retrieved from https:// environmentalmigration.iom.int/sites/g/files/tmzbdl1411/files/MC_INF_288.pdf, on October 31, 2024.

International Organization for Migration (IOM) (2018). Implementation of the Workplan of the Task Force on Displacement under the Warsaw International Mechanism for Loss and Damage (WIM) United Nations Framework Convention on Climate Change (UNFCCC): Mapping Human Mobility (Migration, Displacement and Planned Relocation) and Climate Change in International Processes, Policies and Legal

Frameworks. Retrieved from https://unfccc.int/sites/default/files/resource/WIM%20TFD%20II.2%20Output.pdf, on October 29, 2024.

International Organization for Migration (IOM) (2020). Africa Migration Report: Challenging the Narrative. Retrieved from https://publications.iom.int/system/files/pdf/Africa-Migration-Report.pdf, on November 18, 2023.

International Organization for Migration (IOM) (2022). World Migration Report 2022. Retrieved from https://publications.iom.int/books/world-migration-report-2022, on December 4, 2023.

International Organization for Migration (IOM). (n.d.). Environmental Migration Portal: The Nansen Initiative. Retrieved from https://environmentalmigration.iom.int/nansen-initiative, on November 19, 2023.

Issifu, A. K., Darko, F. D., & Paalo, S. A. (2022). Climate change, migration and farmer–herder conflict in Ghana. *Conflict Resolution Quarterly*, (39), 421–439.

Jakobsson, E. (2018). The politics of climate change and migration. H. Heijne (Ed.), *Climate Change and Migration: Policy Approaches for a Sustainable Future* (7–48). European Liberal Forum.

Jakobsson, E. (2021). Political Attention in a Creeping Crisis: The Case of Climate Change and Migration. A. Boin, M. Ekengren and M. Rhinard (Ed.), *Understanding the Creeping Crisis* (131–147). Palgrave Macmillan.

Jakobsson, E. (2022). Lessons from the Past Momentum Going Forward: Norm Dynamics and the Process of Protection for Climate-Induced Migration and Displacement. S Behrman & A. Kent (Ed.), *Climate Refugees: Global, Local and Critical Approaches* (85–106). Cambridge University Press.

Jarawura, F. X., & Smith, L. (2015). Finding the Right Path: Climate Change and Migration in Northern Ghana. F. Hillmann, M. Pahl, B. Rafflenbeul, & H. Sterly (Eds.), Environmental Change, Adaptation and Migration (245–266). Palgrave Macmillan.

Kandilige, L., Teye, J., Talleraas, C., and Gopsill, A. (2023). National and International Migration Policy in Ghana. *EFFEXT Background paper, Chr. Michelsen Institute*.

Krasner, S. D. (1982). Structural Causes and Regime Consequences: Regimes as Intervening Variables. *International Organization*, *36*(2), 185–205.

Kumssa, A., & Jones, J. F. (2010). Climate change and human security in Africa. *International Journal of Sustainable Development & World Ecology, 17*(6), 453–461.

Mavroudi, E. (2022). Migration as a development strategy: Debating the role that migrants and those in diaspora can play. M. L. C. Markus (Ed.), *Handbook on Migration and Welfare* (488–503). Edward Elgar Publishing.

McAdam, J. (2012). *Climate Change, Forced Migration, and International Law*. Oxford University Press.

McLeman, R. (2011). *Climate change, migration and critical international security considerations*. International Organization for Migration. Retrieved from https://publications.iom.int/system/files/pdf/mrs42.pdf, on October 19, 2023.

Mo Ibrahim Foundation (MIF) (2022). Africa and Europe: Facts and Figures on African Migrations. Retrieved from https://mo.ibrahim.foundation/sites/default/files/2022-02/aef_summit_african-`migrations.pdf, on December 18, 2023.

Munoz, B., Alcock, C., & Mbaye, M. C. (2024). "Try or die"—one man's determination to the get to the Canary Islands. *BBC*. October 14, 2024. Retrieved from https://www.bbc.com/news/articles/c4g957x3g49o, on October 24, 2024.

Musimwa, A. O. (2021). Migration governance in Africa. *International Journal of Innovation and Applied Studies, 31*(4), 679–693.

Oakes, R., Van der Geest, K., Schraven, B., Adaawen, S., Ayeb-Karlsson, S., de Sherbinin, A., Etzold, B., Groth, J., Hermanns K., Lakeman S., Nawrotzki, R., Radamacher-Schulz, C., Romankiewic, C., Serraglio, D., Sterly, H., Thalheimer, L., Wiederkehr, C., & Williams, D. (2023). A future agenda for research on climate change and human mobility. *International Migration. 61*(5), 116–125.

Obuchi K. (1999). *Opening Remarks*. The Asian Crisis and Human Security. *Japan Centre for International Exchange, Tokyo*. Retrieved from https://jcie.org/wp-content/uploads/2022/08/AsianCrisisHumanSecurity_Speeches.pdf, on October 25, 2024.

Olaniyan, A., & Okeke-Uzodike, U. (2015). Desperate guests, unwilling hosts: climate change-induced migration and farmer-herder conflicts in southwestern Nigeria. *Conflict Studies Quarterly, 10*, 23–40.

Ovalı, A. Ş. (2006). Ütopya ile Pratik Arasında: Uluslararası İlişkilerde İnsan Güvenliği Kavramsallaştırması [Between Utopia and Practice: Conceptualization of Human Security in International Relations]. *Uluslararası İlişkiler, 3*(10), 3–52.

Paris, R. (2001). Human Security: Paradigm Shift or Hot Air? *International Security, (26)*2, 87–102.

Prosper, A. & Khan, A. (2018). Migration in Climate Change Hotspots: Opportunities and Challenges for Adaptation, *Collaborative Adaptation Research Initiative in Africa and Asia*. Retrieved from https://iess.ug.edu.gh/sites/iess.ug.edu.gh/files/Briefs/Migration%20Brief.pdf, on December 10, 2023.

Rigaud, K. K., de Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., Schewe, J., Adamo, S., McCusker, B., Heuser, S., & Midgley, A. (2018). Groundswell: Preparing for Internal Climate Migration. *World Bank*.

Saraiva, A., & Monteiro, A. (2023). Climate change as a risk to human security: a systematic literature review focusing on vulnerable countries of Africa-causes and adaptation strategies. *International Journal of Global Warming, 29*(4), 362–382.

Terry, K., & Rai, A. (2023). Amid Record Drought and Food Insecurity, East Africa's Protracted Humanitarian Crisis Worsens. *Migration Policy Institute*. January 18, 2023. Retrieved from https://www.migrationpolicy.org/article/east-africa-drought-food-insecurity-refugee-migration, on October 31, 2024

Teye, J. K. (2022). Migration in West Africa: An introduction. J. K. Teye (Ed.) *Migration in West Africa* (3–18), *Springer*.

Teye, J. K., & Owusu, K. (2015). Dealing with climate change in the Coastal Savannah Zone of Ghana: In situ adaptation strategies and migration. F. Hillmann, M. Pahl, B. Rafflenbeul, and H. Sterly (Ed.). *Environmental Change, Adaptation and Migration* (223–244). Palgrave Macmillan.

Teye, J. K., Jarawura, F., Lindegaard, L. S., Kleist, N., Ladekjær Gravesen, M., Mantey, P., & Quaye, D. (2021). Governing climate mobility: Scoping study of two localities in Ghana (Working Paper, No. 2021:10), *Danish Institute for International Studies (DIIS)*.

Teye, J. K., and Nikoi, E. G. (2022). Climate-induced migration in West Africa. J. K. Teye (Ed.), *Migration in West Africa* (79–105), *Springer*.

United Nations (2004). Guiding Principles on Internal Displacement. Retrieved from https://www.unhcr.org/fr-fr/en/media/guiding-principles-internal-displacement, on December 18, 2023.

United Nations (UN) (2018). Global Compact on Refugees. Retrieved from https://www.unhcr.org/media/global-compact-refugees-booklet, on October 29, 2024.

United Nations (UN) (2019). Resolution adopted by the General Assembly on December 19, 2018, 73/195. Global Compact for Safe, Orderly and Regular Migration. Retrieved from https://documents.un.org/doc/undoc/gen/n18/451/99/pdf/n1845199.pdf, on October 29, 2024.

United Nations Climate Change (n.d.). Taskforce on Displacement. Retrieved from https://unfccc.int/process/bodies/constituted-bodies/WIMExCom/TFD, on November 18, 2023.

United Nations Development Program (UNDP). (n.d.). Environmental Migration. Retrieved from https://sdgintegration.undp.org/environmental-migration-portal, on November 18, 2023.

United Nations Framework Convention on Climate Change (UNFCCC) (2010). Report of the Conference of the Parties on its sixteenth session, held in Cancun from November 29 to December 10, 2010. Retrieved from https://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf, on January18, 2024.

Vinke, K., Rottmann, S., Gornott, C., Zabre, P., Nayna Schwerdtle, P., & Sauerborn, R. (2022). Is migration an effective adaptation to climate-related agricultural distress in sub-Saharan Africa? *Population and Environment, 43*(1), 319–345.

Yusuf, A. S., Ahmad, A. A., & Wali, M. M. (2018). ECOWAS single currency and the political constraints. *International Journal of Academic Research in Business and Social Sciences, 8*(9), 537–546.

Possible Effects of Global Climate Change on Plant Health

Hüseyin Basım[9] *and Esin Basım*[10]

4.1 Introduction

Given that the global population is estimated to reach 9.7 billion in 2050 and 10.4 billion in 2100 (UNO, 2022), it is evident that climate change will continue to be the most significant problem that needs to be solved as a priority for all countries, as it poses a threat to the nutrition of this ever-increasing population in the world. Greenhouse gas emissions caused by human activities have unquestionably caused global warming, with the global surface temperature having increased by 1.1°C for the years 1850–1900 in 2011–2020 (IPCC, 2023). The ongoing increase in unsustainable energy consumption, land use and land use change, as well as global greenhouse gas emissions, is of particular concern. Continuing greenhouse gas emissions will lead to increased global warming, with the scenarios and modeling considered leading to a best estimate of a 1.5°C temperature increase in the near term. Any increase in global warming will intensify multiple, simultaneous dangers. Reducing greenhouse gas emissions could mean a noticeable global warming slowdown within two decades and atmospheric changes within years, research predicts (IPCC, 2023).

The current global CO_2 concentration is approximately 350 ppm, and in the coming years, this figure is likely to increase to 550–750 ppm (De, 2018). Doubling the CO_2 concentration can cause the temperature to increase by 2.3±1.6°C. If annual CO_2 emissions from 2020 to 2030 remain on average at the same level as 2019, the resulting cumulative emissions would reduce the temperature by almost 1.5°C, and cumulative emissions would reduce the temperature by more than 2°C. Today, all agricultural sectors are significantly

[9] Prof. Dr. Akdeniz University, Faculty of Agriculture, Department of Plant Protection, Antalya-TÜRKİYE, hbasim@akdeniz.edu.tr, ORCID ID: 0000-0002-8059-3680.

[10] Prof. Dr. Akdeniz University, Technical Sciences Vocational School, Department of Organic Agriculture, Antalya, Türkiye, esinbasim@akdeniz.edu.tr, ORCID ID: 0000-0001-9188-6609.

affected by the issue of climate change. Adverse effects on agricultural productivity are caused by increasing global surface temperature, changes in rainfall patterns, and the frequency of extreme weather events, as well as by the concentration of CO_2 in the atmosphere (Chakraborty and Newton, 2011). The impact of climate change on plant diseases is inevitable (Régnière, 2012). The changing climate is going to have consequences on all three elements of the disease triangle: the host plant, the pathogen and the environment (Pachauri et al., 2014). It is important to note that plant-parasite interactions are affected by rising temperature and increasing CO_2 concentrations (Lopez-Gresa et al., 2012).

Therefore, it is imperative to update disease management strategies to ensure sustainable food production in a changing climate. Plant diseases are of vital importance in crop production (Agrios, 2005). Plant disease outbreaks pose increasing risks to global food security, crop production, and biodiversity in many parts of the world (Chakraborty and Newton, 2011; Fones et al., 2020; Ristaino et al., 2021; Tripathi, Tiwari and Behera, 2022). The prediction of the effects of climate change on plant diseases is a complex undertaking. This is due to the fact that plants, pathogens, and the environment are factors that must be evaluated from a multitude of perspectives. Several factors contribute to the occurrence and spread of diseases caused by microorganisms. These factors include the distribution and abundance of different types of microorganisms, their ability to survive and cause harm, the way they interact with the environment, the way they interact with plants, and the conditions of their environment. For instance, certain microorganisms inhabiting the soil have the capacity to cause disease outbreaks when the conditions are conducive for them to multiply and suitable hosts are present (Cheng, Zhang and He, 2019; Trivedi et al., 2020). Climate change may indirectly impact plant–pathogen interactions through changes in biochemical, physiological, ecological, and evolutionary processes of the plant host and/or pathogen (Velasquez, Castroverda and He, 2018; Cheng, Zhang and He, 2019; Desaint et al., 2021; Trivedi et al., 2022). Climate change has the potential to directly affect the plant development, photosynthesis, leaf area, sugar content, yield, and immune responses of plants (Cheng, Zhang and He, 2019; Sparks et al., 2014; Castroverde and Dina, 2021; Saijo and Loo, 2020).

For plant diseases that negatively affect plant health to occur and cause epidemics, disease-causing pathogens such as bacteria, fungi, and viruses that can cause disease to the plant, a host plant that is susceptible to the disease, and suitable environmental conditions must be present and all these conditions must be continuous. It is important to note that, should one of these factors be absent, the plant will not be affected by the disease (Agrios, 2005). If suitable environmental conditions are present in a changing global climate, an increase in plant diseases and consequent loss of yield and quality may be inevitable. To date, only limited data has been collected on the effects of emerging global climate change on plant diseases (Harvell et al., 2002; Garret et al., 2006).

In order to ensure yield and quality by controlling these biotic factors affecting plant health, the use of biopesticides instead of chemical pesticides and microbial and organic fertilizers instead of inorganic fertilizers is vital, with a view to reducing carbon emissions. It is of great importance that all measures are seriously taken into consideration by all countries to reduce carbon emissions resulting from crop production, and that they commit to reducing the current global temperature increase within the framework of the Green Agreement in the short term by 2030 and in the medium term by 2050 (Fetting, 2020). It is planned to significantly reduce the use of pesticides and inorganic fertilizers in agricultural production by 2030, as well as to increase organic agricultural production areas instead of current agricultural systems and to ensure sustainable agricultural production in the face of climate change (Fetting, 2020).

This study aims to discuss the possible effects of global climate change on plants and plant diseases.

4.2 Effects of Climate Change on Crop Production

Since prehistoric times, humans have utilized plants for a variety of purposes, including food, shelter, tools, medicine, clothing, and fuel. Our relationship with plants has always been close, from gathering wild ones to modern bioengineering methods. However, the world's rapidly changing climate is affecting plant production, which ultimately impacts us. The healthy development of plants is dependent on various climatic factors including temperature, light, carbon dioxide (CO_2), precipitation, and humidity. This dependency makes plant production difficult and highly sensitive to changes in temperature (Hatfield and Prueger, 2015).

Climate change and food security are two crucial problems of the twenty-first century. Around 815 million people are affected by malnutrition, which highlights the problems of sustainable development with the aim of eradicating hunger by 2030(Richardson et al., 2018). Severe weather conditions have been shown to have a notable impact on food security and agricultural output. It has been reported that increases in temperature around the world significantly reduce crop production (Ito, Vasconcelos and Feeley, 2018). As a consequence of climate change, it is anticipated that by the conclusion of this century, there will be a decline in global crop production, attributable to an increase in temperatures of 2.6°C to 4°C. This decrease in crop productivity represents a significant challenge to food security, particularly in light of the rapidly expanding global population (Rogelj et al., 2016). The population is expected to reach approximately 9 billion in 2050, resulting in an estimated rise in food requirements of approximately 85 percent (FAOSTAT, 2017). The generation of agricultural products is becoming increasingly challenging due to the effects of climate change (Reckling et al., 2018). Climate change-induced factors such as droughts, heavy rains, temperature fluctuations, salinity, and insect pests are expected to decrease plant productivity, resulting in an increased risk of hunger (Dhankher and Foyer, 2018).

The necessity to enhance the food security of 9.5 billion people, more than 86 percent of whom will live in underdeveloped countries by 2050 (UNDESA, 2013), makes it inevitable for biological and food systems to adapt to increasingly changing climate events (IPCC, 2012). According to the Intergovernmental Panel on Climate Change (IPCC), climate change has caused a 30 percent increase in atmospheric CO_2 and a 0.3 to 0.6°C increase in temperature (Chakraborty, Tiedemann and Teng, 2000). It is stated that if the current CO_2 concentration doubles from approximately 350 ppm to 550–750 ppm, it will cause the temperature to increase by 2.3±1.6°C (De, 2018; Kaur et al., 2023). The increase in global temperature is predicted to cause plants to change their phenology, increase their respiration rates, decrease their pollen, and ultimately reduce the biomass and productivity of plants (Ahmed, 2018). Since the world's main plant agricultural products are wheat, rice, corn, and soybeans, 67% of people's caloric needs are thought to be under threat from climate change. In case of a 1°C increase in temperature, global wheat production will probably decrease by around 6% on average, rice by 3%, corn by 7.4%, and soybean by 3.1% (Zhao et al., 2017).

Increasing CO_2 concentrations predicted for the mid-twenty-first century to 550 ppm will increase photosynthetic activity in plants. High CO_2 levels can increase carbon absorption and water use by 38% in C3 plants such as rice, soybeans, and wheat, and reduce photorespiration (McGrath and Lobell, 2013). Such plant species tend to be more photosynthetic at temperatures above 25°C and increasing CO_2 levels (Kimball, 2010). C4 plants, such as corn and sorghum, may not directly respond to increased CO_2 levels with photosynthetic activity (Leakey, 2009). By 2080s, rising CO2 levels will increase corn, soybean, rice, and wheat yields increase by 7%, 24%, 16% and 17.5%, respectively, in some parts of the world (Parry et al., 2004).

4.2.1 Effects of Temperature on Plant Pathogens

Hosts and pathogens have co-evolved over time in a constant struggle for resistance. Environmental factors play a crucial role in both the microbial pathogenesis process and host immunization. Fluctuating temperatures facilitate microbial colonization and overcome host inhibition mechanisms. Unlike mammals, which maintain a constant body temperature, the plant's internal temperature fluctuates daily. Epidemic diseases can spread faster in hot climates (Robinet et al., 2011). Generally, fungi engage in various parasitic interactions with their host plants. Environmental conditions, such as temperature and humidity, significantly impact the development of fungal diseases in plants and pathogens as they both require a specific minimum temperature to grow. Any temperature change can significantly affect the reproduction, infection rate, penetration, infection cycle, distribution, and off-season survival of the fungus. Sudden temperature changes can awaken dormant strains of pathogens, causing outbreaks in new regions and hosts. The susceptibility of grain crops to rust infections can be influenced by temperature. The stripe rust pathogen (*Puccinia striiformis*) was able to show high virulence at high temperatures, making wheat or oats more vulnerable (Mboup et al., 2012; Mari and Martini, 2015). Yellow rust in wheat started to appear in late December due to the favorable climate brought by increasing temperatures (Prashar et al., 2007; Jindal, Mohan and Pannu, 2012). During high-temperature conditions, the powdery mildew disease can cause significant crop losses in winter wheat in China (Tang et al., 2017). Concerns have risen regarding the blast and sheath blight disease in rice and late blight disease in potatoes due to increasing temperatures and CO_2 concentrations

(Kobayashi et al., 2006). It has been observed that chickpea varieties resistant to *Fusarium* wilt have a higher risk of dry root rot when temperatures exceed 33°C (Dixon, 2012). Temperature changes create greater possibilities for the overwintering of fungi, which promotes the emergence of virulent genotypes of the pathogen (Kocmankova et al., 2009). In places where production is poor, if seed spraying is done incorrectly, and in changing climatic conditions, blight diseases common in carnal strawberries and wheat may be important (Oereke, 2006; Gautam and Bhardwaj, 2011).

The frequency with which bacterial pathogens such as *Ralstonia solanacearum*, *Acidovorax avenae*, and *Burkholderia glumea* cause disease in plants is greatly affected by temperature. Moreover, these bacterial pathogens can develop in places where heat-related diseases have not yet been reported (Kudela, 2009). While high temperatures generally decrease the virulence of most pathogenic bacteria, this is not the case for soft rot bacteria (*Erwinia carotovora* subsp. *carotovora*). This type of bacteria, which produces large amounts of rRNA, N-acyl homoserine lactone, and extracellular proteins, is commonly found in Chinese cabbage and celery stalks. Soft rot bacteria cause maceration, as noted by Hasegawa et al. in 2005. The prevalence of viruses and vector-borne diseases is affected by temperature. When winter conditions are mild, aphids have a higher survival rate, which leads to an increase in the frequency of viral diseases in sugar beet and potato. This also causes the Barley Yellow Dwarf Virus to spread more widely (Thomas, 1989; Mackerron et al., 1993).

Future projections show that in 2020, 2050, and 2080, the favorable regions for the occurrence of the Black Sigatoka disease (*Mycosphaerella fijiensis*) of bananas will decrease significantly, but the disease will still be favorable for its occurrence in some regions (Ghini et al., 2007). The resistance of plants to diseases may vary depending on temperature changes and overall disease development may be affected. It has been discovered that rising temperatures lead to a reduction in resistance against various plant diseases, such as leaf rust (*Puccinia recondita*) in wheat, black sap (*Phytophthora nicotianae*) in tobacco, heather (*Orobanche cumana*) in sunflower, and bacterial blight (*Xanthomonas oryzae* pv. *oryzae*) in rice (Gregory, Johnson and Newton, 2009).

Climate warming can have significant impacts on pathogen population dynamics. A decrease in daily temperature shortens the duration of infection of the coffee leaf rust pathogen *Hemileia vastatrix*, leading to rust epidemics in Central America (Gautam and Bhardwaj, 2011). Increasing temperatures shorten the incubation period of the pathogen, causing the population of the pathogen to increase in one season. Depletion of natural resources and degradation of the natural environment have led to the degradation of agro-ecosystem diversity. Emerging evidence shows that by influencing and manipulating soil and plant microbiomes, plant physiology, and the immune system, it affects the host, pathogen, and environmental conditions, which are key factors in the disease triangle. For instance, in soils that are naturally resistant to diseases, the microorganisms that are present can reduce the incidence of diseases even when the pathogen is present, the host is susceptible, and the environment is suitable for the disease to spread. If we take into account the role of microorganisms, we can make more accurate predictions, monitor and manage disease outbreaks more effectively. By improving land management practices, we can enhance the health of soil and influence the diversity and functions of soil microbial communities. This can help in augmenting the microbiomes that are capable of suppressing diseases.

High humidity increases the disease severity of the potato blight pathogen (*Phytophthora infestans*). Increasing average winter temperatures increase the risk of the fungal pathogen, *Phytophthora* spp. It causes excessive tree mortality in North America (Gustafson et al., 2022). According to a study by Barbeito et al. (2013), pine trees are more susceptible to the snow blight disease (*Phacidium infestans*) when there is early snowmelt. The occurrence of pests and pathogens in natural and agricultural ecosystems can be affected by changes in global temperatures, which can increase the risk of exposure to new pathogens. Global warming is expected to increase the abundance of soil-borne fungal plant pathogens, leading to significant consequences (Delgado-Baquerizo et al., 2020). As temperatures rise, it is expected that new pathogen species will emerge, which will be better adapted to the environment and more virulent. This shift in the pathogen population is expected to increase the severity of diseases caused by *Fusarium* head blight in wheat. The more benign *Fusarium culmorum*, which prefers cool and wet conditions, is expected to be replaced by the more aggressive *Fusarium graminearum*, which prefers hot and humid conditions (Parikka, Hakala and Tiilikkala, 2012). Similarly, new strains of *Puccinia striiformis*, which are more aggressive and temperature-tolerant, have replaced the older strains, causing significant outbreaks of wheat rust in the United States, Australia, and Europe (Walter et al., 2016; Vidal et al., 2022). As temperatures rise, wheat black rust disease agent *Puccinia graminis* f.sp. *tritici*'s currently limited overwintering requirements may increase the pathogen's range of infection (Ma et al., 2015). On the other hand, local extinctions of the rust pathogen *Triphragmium ulmarie* infecting *Filipendula ulmaria* (meadowsweet) have been reported, in parallel with steady increases in summer temperatures over 30 years (Zhan, Ericson and Burdon, 2018). *Phytophthora infestans* is expected to be little affected by rising temperatures due to its low thermal preferences (Sparks et al., 2014).

The reason why plants are more prone to diseases at higher temperatures is not fully understood (Cohen and Leach, 2020; Newbery, Qi and Fitt, 2016; Fischer et al., 2020). However, high temperatures can weaken plant immunity, which leads to an increase in pathogen infection (Cheng, Zhang and He, 2019). In *Arabidopsis*, salicylic acid production, which is a crucial hormone for plant defense, is hindered at high temperatures due to the lack of activation of key immune transcription factors such as CBP60g (Kim et al., 2022; Castroverde and Dina, 2021). The CBP60g family of transcription factors is found in many plant species and plays a role in regulating plant immunity in response to changes in temperature (Zheng, Majsec and Katagiri, 2022). Understanding this process can help us better understand how temperature affects plant diseases. Studies have shown that higher temperatures in rice can increase the susceptibility of the plant to bacterial blight disease by activating genes associated with abscisic acid biosynthesis (Cohen et al., 2017). Similarly, increased temperatures can also lead to the activation of genes associated with jasmonic acid biosynthesis and signaling, making the plant more susceptible to *Magnaporthe oryzae* infection (Qiu et al., 2022).

4.2.2 Effects of Carbon Dioxide on Plant Pathogens

Increased levels of carbon dioxide (CO_2) in the atmosphere have different effects on plants and plant pathogens (Eastburn, McElrone and Bilgin, 2011). On the positive side, higher CO_2 concentrations can enhance plant growth, photosynthesis, leaf area, sugar content, and crop yield (Vary et al., 2015). However, increased CO_2 levels can also facilitate the rapid growth and sporulation of plant pathogenic fungi, which can lead to disease outbreaks (Chakraborty and Datta, 2003). Changes in the occurrence of different diseases such as brown spots, downy mildew, and sudden death have been observed in soybeans due to high CO_2 concentrations (Eastburn et al., 2010).

Additionally, high CO_2 levels can increase the virulence of some plant pathogens, such as *Fusarium graminearum* (Vary et al., 2015), while having little effect on others such as *Peronospora manshurica*, which demonstrates a low severity of the disease (Eastburn, McElrone and Bilgin, 2011). Bacterial wilt and spot infections in pepper have further increased due to high ambient CO_2 concentrations (Shin and Yun, 2010). Additionally, increased CO_2 has been shown to have a significant impact on disease development in controlled environments. It has been reported that blast and sheath blight infection in rice increases when the CO_2 concentration of 200–280 µmol mol–1 is increased above ambient values (Kobayashi et al., 2006). A study by Trebicki et al. (2015) found that elevated levels of CO_2 (650 mol mol-1) led to an increase in the incidence of barley yellow dwarf disease and *BYDV-PAV* titer. It's worth noting though that disease symptoms are not always associated with high virus titers. In fact, despite having a high viral titer, there was little effect on symptoms after *Nicotiana benthamiana* plants were inoculated with *PVX* and *CMV* under higher CO_2 conditions (Del Torro et al., 2015). Studies have shown that high levels of CO_2 can decrease the resistance of tobacco plants to *PVY* and of tomato plants to both *YLCV* and *TMV* (Huang et al., 2012; Zhang et al., 2015; Garrett et al., 2006).

The difference in disease incidence in conditions where carbon dioxide (CO_2) concentration increases suggests pathogen- and host-dependent responses to CO_2. According to recent studies, high levels of CO_2 in the atmosphere can worsen the effects of powdery mildew caused by *Sphaerotheca fuliginea* on cucurbits (Khan and Rizvi, 2020), as well as head blight caused by *Fusarium* spp. and spot disease caused by *Septoria tritici* on wheat (Matros et al., 2006). However, it can also lead to decreased susceptibility to the downy mildew pathogen *Peronospora manshurica* in soybean, as found in a study by Huang in 2012 (Huang et al., 2012). Similarly, changes in leaf surface properties caused by high CO_2 application increased rust disease in poplar trees (Zhang et al., 2015), but reduced the disease severity of brown spot disease in maple trees (Coakley, Scherm and Chakraborty, 1999). Atmospheric carbon dioxide (CO_2) levels can have an impact on the immune responses and hormone levels of plants, which in turn can affect their interactions with pathogens. The increased basal expression of jasmonic acid-responsive genes under high CO_2 has been reported to increase resistance to the necrotrophic leaf pathogen *Botrytis cinerea* but decrease resistance to the Tomato hemi-biotrophic leaf pathogen *Pseudomonas syringae* pv *tomato* (Olsen et al., 1990).

Infection of the barley yellow dwarf virus (BYDV) and its aphid vector, *Rhopalosiphum padi*, has been reported to increase the above-ground nitrogen content of wheat grown under high CO_2 compared to uninfected plants, thereby reducing vector performance (Trębicki et al., 2016). High CO_2 affects the outcome of plant–pathogen interactions.

4.2.3 Effects of Moisture on Plant Pathogens

Moist conditions are favorable for the growth and spread of bacterial and fungal diseases. Bacteria require moisture to penetrate and grow while fungal spores need moisture for germination and infection initiation. The germination of spores, bacterial growth, and initiation of infection all require moisture. Climate change models predict that precipitation events will become more frequent and intense as temperatures rise, leading to more water vapor in the atmosphere. Plant canopies retain moisture in the form of leaf wetness and relative humidity (RH) for extended periods, promoting pathogen infections such as late blights and vegetable root diseases (Coakley, Scherm and Chakraborty, 1999).

High humidity can create an environment that is conducive to the growth of soil-borne pathogens such as *Phytophthora*, *Pythium*, *Rhizoctonia solani*, and *Sclerotium rolfsii*. On the other hand, drought stress can have an impact on the emergence of viral diseases such as *Beet yellow virus* (*BYV*) and *Maize dwarf mosaic virus* (*MDMV*) (Olsen et al., 1990; Clover et al., 1999). It has been revealed that low soil moisture reduces infections of tomato bacterial wilt, and *Ralstonia solanacearum* (Islam and Toyota, 2004). In apples, fungal pathogens thrive in drier rainy seasons and hotter summers, leading to an increased incidence of cancer (Paul, 2000). It has been observed that the incidence of apple scab disease caused by *Venturia inaequalis* has decreased due to the reduced rainfall in March and April. The maturation of fungal spores during the winter months requires a specific level of rainfall, and the decrease in rainfall has resulted in a decline in the disease. The abundance and infectivity of plant pathogens are affected by changes in relative humidity and soil moisture levels, which are significant factors. Changes in moisture levels due to climate may impact plant disease epidemics. Fungal diseases often require high humidity for spore germination and the infection of host plants (Romero et al., 2022).

High humidity increases pathogen virulence in airborne plant tissues. *Sclerotinia sclerotiorum* is a pathogen that affects lettuce (Mamo et al., 2021). Increased humidity leads to higher infection rates by the stem rot pathogen *Phytophthora sojae* (Tada et al., 2021). The expression of bacterial effectors that alter plant immune response is humidity-dependent and occurs in the apoplast of Arabidopsis leaves. It promotes the formation of *Pseudomonas syringae* (Xin et al., 2016) and causes a decrease in food quality (Andersen, Madden and Paul, 2015; Qiu et al., 2016). In contrast, *Magnaporthe oryzae*, the causative agent of rice blast disease, and *Streptomyces* spp., the causative agent of potato bacterial scab, low humidity conditions increase the number of pathogens and disease severity (Johansen, Dees and Hermansen, 2015; Bidzinski et al., 2016). Recent analyses show that a general increase in relative humidity may increase the incidence of fungal diseases in general (Romero et al., 2022).

The impact of drought on the prevalence and severity of pathogen infections differs significantly (Wakelin et al., 2018). Some plant diseases, such as pea root rot, onion white rot, brassica blackleg, and the vine black leg disease, tend to worsen as droughts become longer and more frequent. However, droughts can reduce the severity of kiwifruit *Sclerotinia* rot (*Sclerotinia sclerotiorum*) and the radiata pine red needle casting disease (*Phytophthora pluvialis*) (Wakelin et al., 2018).

Similar results have been reported for the bacterial pathogen *Xylella fastidiosa* in grapes (Choi et al., 2013). Drought-induced changes in the direction and strength of plant–pathogen interactions may alter disease range expansions in response to climate change (Suffert et al., 2018). In arid regions, drought and high tree mortality rates can hasten the decline in pine rust at lower elevations. Conversely, lower alternative host occurrence at higher elevations can reduce the probability of infection, even amidst increasingly favorable climatic conditions. Drought conditions may lead to the emergence of new pathogens that can tolerate harsh environmental conditions and exploit changes in plant physiology that occur in response to stress. An example is the dry root rot fungal pathogen *Macrophomina phaseolina*, which can infect chickpea plants more easily during a drought (Rai, Irulappen and Muthappa, 2021).

Drought-induced reduction of basal plant immune responses increased susceptibility to the yellow vein virus and symptoms of the yellow vein disease in potato plants (Vasquez et al., 2022).

4.3 Conclusion

Today, the effects of global climate change on food supply and quality have been scientifically demonstrated by many studies. Reduced agricultural productivity may be caused by rising temperatures, changing rainfall patterns, extreme weather events, and water scarcity, while plant diseases account for about 10 percent of decline in global food production and affect food security (Strange and Scott, 2005).

Plant diseases are a global concern and significantly impact food crop production, as well as the social and political stability of nations. A notable example is the Irish potato famine of the nineteenth century. In 1845, the pathogen *Phytophthora infestans* devastated the potato crop, resulting in the Irish Famine in the following years. This disaster led to over 2 million deaths and mass migration from Ireland (Bourke, 1964).

The recent outbreaks of coffee rust, caused by the fungus *Hemileia vastatrix* in Central America in 2012, highlight how emerging endemic plant diseases and climate change can displace communities. In some areas of Central America, coffee yields have dropped by more than 50 percent, resulting in over 400,000 coffee workers in Honduras, El Salvador, and Guatemala losing their livelihoods. This loss has led to increases in hunger, poverty, and migration (Sieff, 2019).

Disease control measures, especially chemical ones, can lead to social and economic negativities as well as direct losses and chemical residues that disrupt the food chain. New disease management approaches are urgently needed to prevent crop losses. Biopesticides and host plant resistance can contribute significantly to creating sustainable plant crop production systems and mitigating climate change, thus ensuring global food security (Legreve and Duveiller, 2010).

In light of the ongoing climate change, it is imperative that current strategies for protecting plant health be adapted accordingly. Additionally, the digital and precision agriculture, plant biotechnology, and the widespread use of biopesticides should be developed. Furthermore, weather forecast-based disease prediction and early warning systems should be implemented. It is essential to accelerate the breeding of disease-, pest- and drought-resistant plants and to expand breeding studies using modern nucleic acid-based methods. Consequently, there is a necessity to fund and disseminate scientific studies that explore the effects of climate change on host physiology, the pathogen life cycle, and host–pathogen interactions.

Bibliography

Agrios, G. N. (2005). *Plant Pathology*. (5th ed.) San Diego, Elsevier.

Ahmed, B. (2018). Who takes responsibility for the climate refugees? *Int. J. Cli. Change Str. and Management*. 10(1), 5–26.

Andersen, K. F., Madden, L. V. and Paul, P. A. (2015). *Fusarium* head blight development and deoxynivalenol accumulation in wheat as influenced by post-anthesis moisture patterns. *Phytopathology* 105, 210–219.

Barbeito, I., Brücker, R. L., Rixen, C. and Bebi, P. (2013). Snow fungi-induced mortality of *Pinus cembra* at the alpine treeline: evidence from plantations. *Arct. Antarct. Alp. Res*. 45, 455–470.

Bidzinski, P., Ballini, E., Ducasseet, A. et al. (2016). Transcriptional basis of drought-induced susceptibility to the rice blast fungus *Magnaporthe oryzae*. *Front. Plant Sci.* 7, 1558.

Bourke, P. M. A. (1964). Emergence of potato blight, 1943–46. Nature 203, 805–808.

Castroverde, C. D. M. and Dina, D. (2021). Temperature regulation of plant hormone signaling during stress and development. *J. Exp. Bot.* 72(21), 7436–7458.

Chakraborty, S., Tiedemann, A. V. and Teng, P. S. (2000). Climate change: potential impact on plant diseases. *Environ. Pollution* 108, 317–326.

Chakraborty, S. and Datta, S. (2003). How will plant pathogens adapt to host plant resistance at elevated CO_2 under a changing climate. *New. Phytol*. 159,733–742.

Chakraborty, S. and Newton, A. C. (2011). Climate change, plant diseases and food security: An overview. *Plant Pathol*. 60, 2–14.

Cheng, Y. T., Zhang, L. and He, S. Y. (2019). Plant–microbe interactions facing environmental challenge. *Cell Host Microbe* 26, 183–192.

Choi, H.-K., Iandolino, A., da Silva, F. G. and Cook, D. R. (2013). Water deficit modulates the response of *Vitis vinifera* to the Pierce's disease pathogen *Xylella fastidiosa*. *Mol. Plant Microbe Interact*. 26, 643–657.

Clover, G. R. G., Smith, H. G., Azam-Ali, S. M., Jaggard, K. W. (1999). The effects of drought on sugar beet growth in isolation and in combination with beet yellows virus infection. *J Agric Sci. 133*(3), 251–261.

Coakley, S. M., Scherm, H., Chakraborty, S. (1999). Climate change and plant disease management. *Annu. Rev. Phytopathol. 37*(1), 399–426.

Cohen, S. P., Liu, H., Argueso, C. T., Pereiraet, A. et al. (2017). RNA-seq analysis reveals insight into enhanced rice Xa7-mediated bacterial blight resistance at high temperature. *PLoS One* 12, e0187625. https://doi.org/10.1371/journal.pone.0187625.

Cohen, S. P.and Leach, J. E. (2020). High temperature-induced plant disease susceptibility: more than the sum of its parts. *Curr. Opin. Plant Biol.* 56, 235–241.

De, L. C. (2018). Impact of climate change on floriculture and landscape gardening. *Int J Agric Sci. 10*(11), 6253–6256.

Delgado-Baquerizo, M., Reich, P. B., Trivedi, C., Eldridge, D. J. et al. (2020). Multiple elements of soil biodiversity drive ecosystem functions across biomes. *Nat. Ecol. Evol.* 4, 210–220.

Del Toro, F. J., Aguilar, E., Hernandez-Walias, F. J., Tenllado, F. et al. (2015). High temperature, high ambient CO_2 affect they interactions between three positive-sense RNA viruses and a compatible host differentially, but not their silencing suppression efficiencies. *PLoS One 10*(8), e0136062. doi:10.1371/journal.pone.0136062.

Desaint, H., Aoun, N., Deslandes, L., Vailleau, F., Roux, F., Berthomé, R. (2021). Fight hard or die trying: when plants face pathogens under heat stress. *N. Phytol.* 229, 712–734.

Dhankher, O. P., Foyer, C. H. (2018). Climate resilient crops for improving global food security and safety. *Plant Cell Environ.* 41, 877–884.

Dixon, G. R. (2012). Climate change—impact on crop growth and food production and plant pathogens. *Can J Plant Pathol.* 34, 362–379.

Eastburn, D. M., Degennaro, M. M., Delucia, E. H., Dermody, O., Mcelrone, A. J. (2010). Elevated atmospheric carbon dioxide and ozone alter soybean diseases at SoyFACE. *Glob Chang Biol.* 16, 320–330.

Eastburn, D. M., McElrone, A. J., Bilgin, D. D. (2011). Influence of atmospheric and climatic change on plant–pathogen interactions. *Plant Pathol.* 60, 54–69.

FAOSTAT (2017). Available online: http://www.fao.org/faostat/en/#data (accessed on August 2, 2017).

Fetting, C. (2020). "The European Green Deal," ESDN Report, December 2020, ESDN Office, Vienna, 22 pp.

Fisher, M. C., Gurr, S. J., Cuomo, C. A., Blehert, D. S., Jin, Het al. (2020). Threats posed by the fungal kingdom to humans, wildlife and agriculture. *mBio Asm. 11*(3), e00449-20. https://doi.org/10.1128/mBio.00449-20.

Fones, H. N., Bebber, D. P., Chaloner, T. M., Kay, W. T., Steinberg, G., Gurr, S. J. (2020). Threats to global food security from emerging fungal and oomycete crop pathogens. *Nat. Food* 1, 332–342.

Garrettt, K. A., Dendy, S. P., Frank, E. E., Rouse, M. N., Travers, S. E. (2006). Climate change effects on plant disease: genomes to ecosystems. *Annual Review of Phytopathol*. 44, 489–509.

Gautam, H. R., Bhardwaj, M. L. (2011). Better practices for sustainable agricultural production and better environment. *Krukshetra, 59*(9), 3–7.

Ghini, R., Hamada, E., Gonclaves, R. R., Gasparotto, L., Pereira, J. C. R. (2007). Analise de risco das mundan caslimatic as globaissobre a sigato—kanegra da bananeira no Brasil. *Fitopathol Brasil. 32*(3), 197–204.

Gregory, P. J., Johnson, S. N., Newton, A. C. (2009). Ingram JSI. Integrating pests and pathogens into the climate change/food security debate. *J Exp Bot*. 60, 2827–2738.

Gustafson, E. J., Miranda, B. R., Dreaden, T. J., Pinchot, C. C. and Jacobs, D. F. (2022). Beyond blight: *Phytophthora* root rot under climate change limits populations of reintroduced American chestnut. *Ecosphere* 13, 18.

Harvell, C. D., Mitchell, C. E., Ward, J. R., Altizer, S., Dobson, A. P., Ostfeld, R. S., Samuel, M. D. (2002). Climate warming and disease risks for terrestrial and marine biota. *Science*. 2296, 2158–2162.

Hasegawa, H., Chatterjee, A., Cui, Y., Chatterjee, A. K. (2005) Elevated temperature enhances virulence of *Erwinia carotovora* subsp. *carotovora* strain EC153 to plants and stimulates production of the quorum sensing signal, N-Acyl homoserine lactone and extracellular proteins. *Appl Environ Microbiol. 71*(8), 4655–4663.

Hatfield, J. L., Prueger, J. H. (2015). "Temperature extremes: Effect on plant growth and development" *Weather and Climate Extremes*. 10, 4–10.

Huang, L., Ren, Q., Sun, Y., Ye, L., Cao, H., Ge, F. (2012). Lower incidence and severity of tomato virus in elevated CO_2 is accompanied by modulated plant induced defence in tomato. *Plant Biol*. 14, 905–913.

IPCC (2012). Changes in Climate Extremes and their Impacts on the Natural Physical Environment Field, C. B., V. Barros, T. F. Stocker, D.

Qin, D. J. Dokken, K. L. Ebi, M. D. Mastrandrea, K. J. Mach, G.-K. Plattner, S. K. Allen, M. Tignor, and P. M. Midgley (Eds.). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 8RU England, 582 pp.

IPCC (2023). Summary for Policymakers. H. Lee and J. Romero (Eds.), *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (35–115), Geneva, Switzerland.

Islam, T. M., Toyota, K. (2004). Effect of moisture conditions and pre-incubation at low temperature on bacterial wilt of tomato caused by *Ralstonia solanacearum*. *Microbes Environ. 19*(3), 244–247.

Ito, R., Vasconcelos, H. L., Feeley, K. J. (2018). Global climate change increases risk of crop yield losses and food insecurity in the tropical Andes. *Glob. Chang. Biol*. 24, e592–e602.

Jindal, M. M., Mohan, C., Pannu, P. P. S. (2012). Status of stripe rust of wheat in Punjab during 2011–2012 season. In: Proceedings of brain storming session. Department of Plant Pathology PAU, Ludhiana. 56 pp.

Johansen, T. J., Dees, M. W. and Hermansen, A. (2015). High soil moisture reduces common scab caused by *Streptomyces turgidiscabies* and *Streptomyces europaeiscabiei* in potato. *Acta Agric. Scand B Soil Plant Sci*. 65, 193–198.

Kaur, H., Kaur, H., Kaur, H., Srivastava, S. (2023). The beneficial roles of trace and ultratrace elements in plants. *Plant Growth Regul*. 100, 219–236.

Khan, M. R. and Rizvi, T. F. (2020). Effect of elevated levels of CO_2 on powdery mildew development in five cucurbit species. *Sci. Rep*. 10,4986. https://doi.org/10.1038/s41598-020-61790-w.

Kim, J. H., Castroverde, C. D. M., Huang, S., Liet, C. et al. (2022). Increasing the resilience of plant immunity to a warming climate. *Nature* 607, 339–344.

Kimball, B. A. (2010). Lessons from FACE: CO_2 effects and interactions with water, nitrogen and temperature. Hillel D., Rosenzweig C. (Eds.) *Handbook of climate change and agroecosystems: impacts, adaptation, and mitigation*. London, Imperial College Press, 87–107 pp.

Kobayashi, T., Ishiguro, K., Nakajima, T., Kim. H. Y., Okada, M., Kobayashi, K. (2006). Effects of elevated atmospheric CO_2 concentration on the infection of rice blast and sheath blight. *Phytopathol*. 96, 425–431.

Kocmankova, E. M., Trnka, J., Juroch, M., Dubrovsky, D., Semeradova, M., Monzy, Zalaud, Z (2009). Impact of climate change on the occurrence and activity of harmful organisms. *Plant Prot Sci*. 45, 48–52.

Khan, M. R.and Rizvi, T. F. (2020). Effect of elevated levels of CO_2 on powdery mildew development in five cucurbit species. Sci. Rep. 10, 4986. https://doi.org/10.1038/s41598-020-61790-w

Kudela, V. (2009). Potential impact of climate change on geographic distribution of plant pathogenic bacteria in Central Europe. *Plant Prot. Sci*. 45, 527–532.

Leakey, A. D. B. (2009). Rising atmospheric carbon dioxide concentration and the future of C4 crops for food and fuel. *Proc. R. Soc. B*. 276, 2333–234.

Legreve, A., Duveiller, E. (2010). Preventing potential diseases and pest epidemics under a changing climate. M. P. Reynolds (Ed.) *Climate Change and Crop Production*. Wallingford, UK: CABI Publishing, 50–70.

Lopez-Gresa, M. P., Torres, C., Campos, L., Lison, P., Rodrigo, I., Belles, J. M. (2012). Identification of defence metabolites in tomato plants infected by the bacterial pathogen *Pseudomonas syringae*. *Environ. Exp. Bot*. 74, 216–228.

Ma, L., Qiao, J., Kong, X., Zou, Y., Xu, X., Chen, X., Hu, X. (2015). Effect of low temperature and wheat winter-hardiness on survival of *Puccinia striiformis* f. sp. *tritici* under controlled conditions. *PLoS ONE* 10, e0130691. DOI:10.1371/journal.pone.0130691.

Mackerron, D., Boag, B., Duncan, J. M., Harrison, J. G., Woodford, J. A. T. (1993). The prospect of climate change and its implications for crop pests and diseases. D. Ebbels (Ed.), *Plant Health and the European Single Market*. Farnham: British Crop Production Council, 181–193 pp.

McGrath, J. M. and Lobell, D. B. (2013). Regional disparities in the CO_2 fertilization effect and implications for crop yields. *Environ. Res. Lett*. 8, 14054–14063.

Mamo, B. E., Eriksen, R. L., Adhikari, N. D. et al. (2021). Epidemiological characterization of lettuce drop (*Sclerotinia* spp.) and biophysical features of the host identify soft stem as a susceptibility factor. *PhytoFrontiers* 1, 182–204.

Mari, M. and Martini, C. (2015). Possible effects of climate changes on plant diseases. Proceedings 50" Croatian and 10th International Symposium on Agriculture. Opatija. Croatia. 37–4 l.

Matros, A., Amme, S., Kettig, B., Buck-Sorlin, G. H., Sonnewald, U., Mock, H. P. (2006). Growth at elevated CO_2 concentrations leads to modified profiles of secondary metabolites in tobacco cv. SamsunNN and to increased resistance against infection with potato virus Y. *Plant Cell Environ. 29*(1), 126–137.

Mboup, M., Bahri, B., Leconte, M., DeVallavieille, P. C., Kaltz, O., Enjalbert, J. (2012). Genetic structure and local adaptation of European wheat yellow rust populations: The role of temperature specific adaptation. *Evol Appl. 5*(4), 341–352.

Newbery, F., Qi, A.and Fitt, B. D. L. (2016). Modelling impacts of climate change on arable crop diseases: progress, challenges and applications. *Curr. Opin. Plant. Biol*. 32, 101–109.

Oereke, E. C. (2006). Crop losses to pests. *J Agric Sci*. 144, 31–43.

Olsen, A. J., Pataky, J. K., D'arcy, C. J., Ford, R. E. (1990). Effects of drought stress and infection by Maize Dwarf Mosaic Virus (MDMV) in Sweet Corn. *Plant Dis*. 74, 147–51.

Pachauri, R. K., Allen, M.R., Barros, V. R., Broome, J., Cramer, W., Christ, R., Church, J. A. et al. (2014). Climate change 2014: Synthesis report. R. Pachauri and L. Meyer (Eds.), *Contribution of working groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change* (151), Switzerland, Geneva.

Parikka, P., Hakala, K. and Tiilikkala, K. (2012). Expected shifts in *Fusarium* species' composition on cereal grain in Northern Europe due to climatic change. *Food Addit. Contam. A* 29, 1543–1555.

Parry, M. L., Rosenzweig, C., Iglesias, A., Livermore, M., Fischer, G. (2004). Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Glob. Environ. Change* 14, 53–67.

Paul, N. D. (2000). Stratospheric ozone depletion, UV-B radiation and crop disease. *Env Pollut. 108*(3), 343–355.

Prashar, M., Bhardwaj, S. C., Jain, S. K., Datta, D. (2007). Pathotypic evolution in *Puccinia striiformis* in India during 1995–2004. *Austral J Agric Res.* 58, 602–604.

Qiu, J. B., Dong, F., Yu, M. Z., Xu, J. H. and Shi, J. R. (2016). Effect of preceding crop on *Fusarium* species and mycotoxin contamination of wheat grains. *J. Sci. Food Agric*. 96, 4536–4541.

Qiu, J., Xie, J., Chen, Y., Shen, Z. et al. (2022). Warm temperature compromises JA-regulated basal resistance to enhance *Magnaporthe oryzae* infection in rice. *Mol. Plant* 15, 723–739.

Rai, A., Irulappan, V.and Muthappa, S. K. (2021). Dry root rot of chickpea: a disease favored by drought. *Plant Dis. 106*(2), 346–356. Régnière, J. (2012). Invasive species, climate change and forest health. T. Schlichter and L. Montes (Eds.) *Forests in Development: A Vital Balance* (27–37), Springer, Dordrecht.

Reckling, M., Döring, T. F., Bergkvist, G., Chmielewski, F., Stoddard, F., Watson, C., Seddig, S., Bachinger, J. (2018). Grain legume yield instability has increased over 60 years in long-term field experiments as measured by a scale-adjusted coefficient of variation. *Asp. Appl. Biol*. 138, 15–20.

Régnière, J. (2012). Invasive species, climate change and forest health. T., Schlichter, L., Montes, (Eds.). *Forests in Development: A Vital Balance*. Springer, Dordrecht. 27–37 pp.

Richardson, K. J., Lewis, K. H., Krishnamurthy, P. K., Kent, C., Wiltshire, A. J., Hanlon, H. M. (2018). Food security outcomes under a changing climate: Impacts of mitigation and adaptation on vulnerability to food insecurity. *Clim. Chang.* 147, 327–341.

Ristaino, J. B., Anderson, P. K., Bebber, D. P., Brauman, K. A. et al. (2021). The persistent threat of emerging plant disease pandemics to global food security. *Proc. Natl Acad. Sci. 118*(23), e2022239118.

Robinet, C., Van Opstal, N., Baker, R., Roques, A. (2011). Applying a spread model to identify the entry points from which the pine wood nematode, the vector of pine wilt disease, would spread most rapidly across. *Europe. Biol Invasions*.13, 2981–2995.

Rogelj, J., Den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., Schaeffer, R., Sha, F., Riahi, K., Meinshausen, M. (2016). Paris Agreement climate proposals need a boost to keep warming well below 2 °C. *Nature*, 534, 631.

Romero, F., Cazzato, S., Walder, F. et al. (2022). Humidity and high temperature are important for predicting fungal disease outbreaks worldwide. *N. Phytol*. 234, 1553–1556.

Saijo, Y. and Loo, E. P. (2020). Plant immunity in signal integration between biotic and abiotic stress responses. *N. Phytol*. 225, 87–104.

Shin, J. V., Yun, S. C. (2010). Elevated CO_2 and temperature effects on the incidence of four major chili pepper diseases. *Plant Pathol J*. 26,178–184.

Sieff, K. (2019). The migration problem is a coffee problem. Washington Post, June 11, 2019. https://www.washingtonpost.com/world/2019/06/11/falling-coffee-prices-drive-guatemalan-migration-united-states/. Accessed October 7, 2019.

Sparks, A. H., Forbes, G. A., Hijmans, R. J. and Garrett, K. A. (2014). Climate change may have limited effect on global risk of potato late blight. *Glob. Chang. Biol*. 20, 3621–3631.

Strange, R. N. and Scott, P. R. (2005). Plant disease: a threat to global food security. *Annu Rev Phytopathol*. 43, 83–116.

Suffert, F., Goyeau, H., Sache, I., Carpentier, F., Gelisse, S., Morais, D., Delestre, G. (2018). Epidemiological trade-off between intra and inter annual scales in the evolution of aggressiveness in a local plant pathogen population. *Evol Appl*. 11, 768–780.

Tada, T., Tanaka, C., Katsube-Tanaka, T. and Shiraiwa, T. (2021). Effects of wounding and relative humidity on the incidence of *Phytophthora* root and stem rot in soybean seedlings. *Phsiol. Mol. Plant Pathol*. 116, 101737. https://doi.org/10.1016/j.pmpp.2021.101737

Tang, X., Cao, X., Xu, S., Jiang, Y., Luo, Y., Ma, Z., Fan, J., Zhou, Y. (2017). Effects of climate change on epidemics of powdery mildew in winter wheat in China *Plant Dis*. 101, 1753–1760

Thomas, T. (1989). Sugar beet in the greenhouse-a global warning. *Brown Sugar* 59, 24–26.

Trebicki, P., Nancarrow, N., Cole, E., Bosque-Perez N. A., Constable, F., Freeman, A. J., Rodoni, B., Yen, A. L., Luck, J. E., Fitzgerald, G. J. (2015). Virus disease in wheat predicted to increase with a changing climate. *Glob. Clim. Chang*. 21, 3511–3519.

Trebicki, P., Vandegeer, R. K., Bosque-Pérez, N. A. et al. (2016). Virus infection mediates the effects of elevated CO_2 on plants and vectors. *Sci. Rep*. 6, 22785. DOI: 10.1038/srep22785

Tripathi, A. N., Tiwari, S. K. and Behera, T. K. (2022). Postharvest diseases of vegetable crops and their management in postharvest technology. MD. Ahiduzzaman (Ed.), *Postharvest Technology Recent Advances, New Perspectives and Applications*. (1–17), IntechOpen, DOI: 10.5772/intechopen.101852.

Trivedi, P., Leach, J. E., Tringe, S. G., Sa, T. and Singh, B. K. (2020). Plant–microbiome interactions: from community assembly to plant health. *Nat. Rev. Microbiol.* 18, 607–621.

Trivedi, P., Batista, B. D., Bazany, K. E. and Singh, B. K. (2022). Plant–microbiome interactions under a changing world: responses, consequences and perspectives. *N. Phytol.* 234, 1951–1959.

United Nations Department of Economic and Social Affairs (UNDESA). (2013). World Population Prospects: The 2012 Revision. New York. Date accessed September 27, 2016. http://esa.un.org/wpp/Documentation/pdf/ WPP2012_Volume-I_Comprehensive-Tables.pdf

UNO (2022). *World population prospects report*, Retrieved from https://population.un.org/wpp/, on January 10, 2023.

Vasquez, D. F., Hernandez, A., Torreset, D. et al. (2022). Drought as a modulator of plant–virus–vector interactions: effects on symptom expression, plant immunity and vector behaviour. *Plant Pathol.* 71, 1282–1292.

Vary, Z. E., Mullins, J. C., McElwain, Doohan, F. M. (2015). The severity of wheat diseases increases when plants and pathogens are acclimatized to elevated carbon dioxide. *Glob Chang Biol.* 21, 2661–2669.

Velasquez, A. C., Castroverde, C. D. M. and He, S. Y. (2018). Plant–pathogen warfare under changing climate conditions. *Curr. Biol.* 28, R619–R634.

Vidal, T., Boixel, A-L., Maghrebi, E., Perronne, R., du Cheyron, P. et al. (2022). Success and failure of invasive races of plant pathogens: the case of *Puccinia striiformis* f. sp. *tritici* in France. Plant. Pathol. 71, 1525–1536.

Wakelin, S. A., Gomez-Gallego, M. and Jones, E. et al. (2018). Climate change induced drought impacts on plant diseases in New Zealand. *Australas. Plant Pathol.* 47, 101–114.

Walter, S., Ali, S., Kemen, E. et al. (2016). Molecular markers for tracking the origin and worldwide distribution of invasive strains of *Puccinia striiformis. Ecol. Evol.* 6, 2790–2804.

Xin, X.-F., Nomura, K., Aung, K. et al. (2016). Bacteria establish an aqueous living space in plants crucial for virulence. *Nature* 539, 524–529.

Zhan, J., Ericson, L. & Burdon, J. J. (2018). Climate change accelerates local disease extinction rates in a long-term wild host–pathogen association. *Glob. Chang. Biol*. 24, 3526–3536.

Zhang, L., Gua, L., Ringler, P., Smith, S., Rushton, P. J., Shen, Q. J. (2015). Three WRKY transcription factors additively repress abscisic acid and gibberellin signaling in aleurone cells. *Plant Science* 236, 214–222.

Zhao, C., Liu, B., Piao, S., Wang, X. et al. (2017). Temperature increase reduces global yields of major crops in four independent estimates. *PNAS*, *114*(35), 9326–9331.

Zheng, Q., Majsec, K. and Katagiri, F. (2022). Pathogen-driven coevolution across the CBP60 plant immune regulator subfamilies confers resilience on the regulator module. *N. Phytol*. 233, 479–495.

PART II

Local Mitigation Strategies

Priorities in Türkiye's Climate Policy Within the Framework of Medium-Term Programs

Pelin Demircan Yıldırım[11]

5.1 Introduction

Today, the natural balance and systems on Earth are undergoing significant changes with the acceleration of human mobility and the industrial market. Climate change is a universal reflection of this change. While the complex balances of nature have evolved with a number of factors affecting our planet, human intervention and global activities have had an upsetting effect on this balance.

As the effects of climate change become more evident, this is not only a scientific fact but also an increasingly apparent reality that seriously threatens humanity. The disruption of the balance of nature, the damage to ecosystems and the more frequent and severe climate events demonstrate the necessity for the creation of conditions that allow for urgent action for the purpose of establishing a sustainable future. Therefore, this study aims to examine the role of Türkiye in tackling this global issue within the scope of the Medium-Term Program [MTP][12] and to analyze important policy steps toward a solution.

In this study, data were collected using qualitative research methods and document analysis techniques. In accordance with the purpose of the study, 18 MTP documents, ranging from the 2006–2008 MTP to the 2024–2026 MTP, available on the website of the Presidency Strategy and Budget Directorate, were analyzed. Data analysis was conducted using the content analysis method and the documents were analyzed through Maxqda software. According to the results of the data analysis, six main themes were identified based on

11 Dr. Burdur Mehmet Akif Ersoy University, Faculty of Economics and Administrative Sciences, pdemircanyildirim@mehmetakif.edu.tr ORCID: 0000-0003-3300-5783

12 The Medium-Term Program (MTP) is the main policy document prepared annually by the Presidential Strategy and Budget Directorate and the Ministry of Treasury and Finance, covering a three-year period. The MTP is a document that includes economic indicators such as macro policies, targets, budget balance, borrowing status and appropriation proposal ceilings of public administrations and initiates the preparation process of the central government budget (OVP, 2023). For detailed information, see the section titled "Türkiye's Medium-Term Programme and Its Importance in Combating Climate Change."

the 18 public documents analyzed: "environmental protection and infrastructure," "energy and transportation," "agriculture and water resources," "green finance and financial adaptation," "national climate change strategy" and "green transformation and sustainability." Focusing on these themes, a total of 260 codes and sub-codes were assigned.

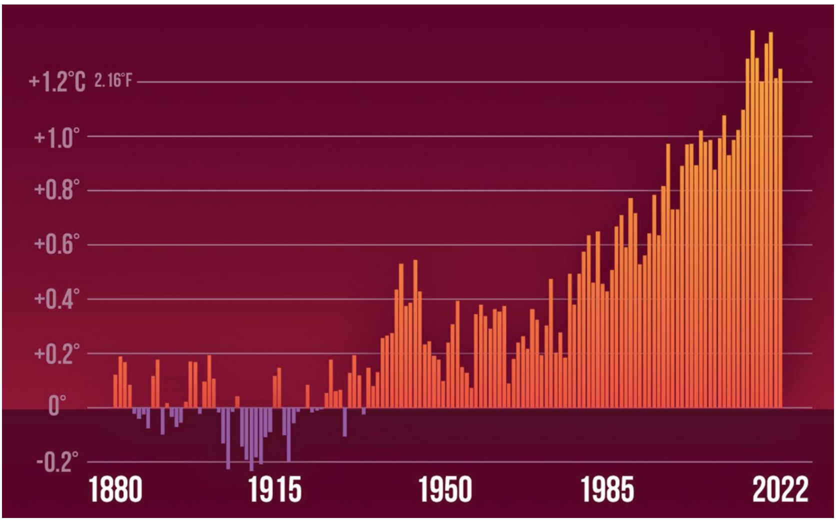
According to the research findings, Türkiye's climate change mitigation strategies have been implemented with increasing capacity over the years, improving the country's ability to effectively address climate change challenges. These comprehensive policy plans have contributed to Türkiye's progress in taking important steps toward a sustainable future. However, more sustainable policies and increased resource allocation, especially in environmental protection infrastructure, agriculture and water resources, will support the success of these policies. Furthermore, in order to steer Türkiye's climate change policies toward a more sustainable future, policies aimed at strengthening social participation, making targets more clear and measurable, and increasing education and awareness are recommended.

In this study, the main research question is formulated as "What are Türkiye's priorities in terms of climate policy?" within the framework of Türkiye's Medium-Term Programme (MTP). Accordingly, the study aims to provide important implications for policy makers and researchers by analyzing the effectiveness of Türkiye's climate policies on a scientific basis.

5.2 Climate Change: A Global Threat

Climate change refers to long-term changes in temperature and weather patterns, which have been recognized as a major threat to planet Earth and humanity. Besides natural factors, such as changes in solar activity or major volcanic eruptions, human activity, particularly the burning of fossil fuels such as coal, oil and gas (Carbonbrief, 2021), has become one of the main causes of climate change since the 1800s. The combustion of fossil fuels results in the emission of greenhouse gases (e.g., carbon dioxide, methane) into the atmosphere, forming a layer that traps the sun's heat thus leading to an increase in global temperatures (UN, 2023). When we analyze the amount of greenhouse gas emissions, China, the United States, India, EU countries, Russia and Brazil were the world's top six greenhouse gas emitters in 2022, whereas Türkiye ranks 14th (European Commission, 2023). Therefore, the extent of climate change in the coming years will depend primarily on the amount of greenhouse gases emitted on a global scale and the sensitivity of the world climate to these emissions (World Bank, 2023).

The global climate continues to change rapidly compared to the rate of natural changes in climate throughout Earth's history. Trends in global average temperature, sea-level rise, upper ocean heat content, melting land ice, polar sea ice and other climate variables provide consistent evidence that the planet is warming (World Bank, 2023). This evidence has serious implications not only for the environment, but also for the economy, health, quality of life and the general well-being of societies (IPCC, 2023; UN, no date; European Commission, no date; U.S. Environmental Protection Agency, 2016). While climate change affects our health, food security, housing and overall security, people living in underdeveloped or developing countries may become even more vulnerable to climate impacts. It is predicted that some communities in particular will be forced to relocate as a result of sea-level rise and that famines will occur due to prolonged droughts, while the number of people displaced by weather-related events will, according to these predictions, also increase in the future. This has led to the emergence of so-called eco-anxiety in many people, caused by contemplating the effects of climate change (Kaddo, 2016; Usher et al., 2019; Dodds, 2021; WHO, 2023). Consequently, the impact of climate change is experienced in diverse ways by individuals across the world.



Picture 5.1: Global Average Temperature Anomalies.
Source: World Bank (2023).

The aforementioned graph illustrates global average temperature anomalies, indicating that the global average temperature has increased by about 1°C since the 1880s. Today, it has been proven that an increase in global surface temperature from 1°C to 2°C will irreversibly deteriorate the global climate, which will manifest in the form of a rise in sudden and extreme climate events, which will become commonplace and usual, having detrimental impacts on ecosystems. While 2°C represents the danger limit for humanity and all other living beings, the international community continues its efforts to limit the increase in temperature to 1.5°C, which is recognized as a precautionary limit to stop global warming (Ministry of Environment, Urbanization and Climate Change, no date). In this context, societies recognize the need to find common solutions to combat climate change. In this regard, the EU plays a leading role in international climate negotiations, formulating and implementing policies and strategies (Cifuentes-Faura, 2022). The Framework Convention on Combating Climate Change [UNFCCC], which came into force in 1994 under the umbrella of the United Nations, the Kyoto Protocol, which came into force in 2005, and most recently the Paris Agreement, which came into force in 2016, are carried out in this context. The importance of these agreements is that they ensure international cooperation in combating global climate change and direct countries toward common goals. Türkiye's accession process is a process that takes into account the special conditions of the country and enables it to determine its own mitigation commitments, especially within the scope of the UNFCCC and the Paris Agreement. The Kyoto Protocol is an agreement that aims to reduce greenhouse gas emissions as part of the UNFCCC. Türkiye became a party to the Kyoto Protocol on August 26, 2009, and accepted the reduction commitment set by the Doha Amendment. The Paris Agreement is an international climate agreement that entered into force in 2020 and aims to keep global warming below 1.5–2°C. It allows countries to submit their own mitigation commitments and review them regularly. Türkiye has also become a party to the Paris Agreement and set its own mitigation targets (Ministry of Foreign Affairs, no date).

Türkiye is taking important steps toward developing a comprehensive policy and action plan to tackle climate change. In this context, the government has identified and implemented targets and strategies. These policies and measures adopt sustainability principles in various sectors such as energy, transportation, industry, agriculture and forestry and aim to play an effective role in combating climate change.

5.3 Climate Change and Türkiye

Türkiyes extensive coastline, arid regions and mountainous terrain are particularly vulnerable to the impacts of climate change, including floods, droughts, extreme weather events and sea-level rise. According to the report "Climate Change 2022: Impacts, Adaptation and Vulnerability," published by The Intergovernmental Panel on Climate Change (IPCC), Türkiye is the most vulnerable country in Europe to extreme weather events (IPCC, 2022). According to the IPCC Fourth Assessment Report, the overall temperature increase in the Mediterranean Basin is expected to reach 1°–2°C, drought will become more pronounced in large geographical areas, and the frequency of heat waves and extremely hot days will increase, especially in inland regions. Various scientific modeling studies on Türkiye's climate reveal a similar picture. The average annual temperature across Türkiye is projected to increase by 2.5°–4°C within the coming decades. This increase is estimated to exceed 4°C in the Aegean and Eastern Anatolia Regions and 5°C in the interior regions (Ministry of Environment, Urbanization and Climate Change, 2012 a). The IPCC report and national/international scientific studies show that Türkiye will face a climate with higher temperatures, drier conditions and increased precipitation uncertainty in the near future. In this context, climate change has serious impacts in many fields in Türkiye, from water resources to the agricultural sector, from coastal regions to rural development and adaptation. It is important to note that the increase in winter precipitation in the form of rain, due to temperatures, snowmelt and changes in precipitation distribution, make the management of water resources challenging. In the agricultural sector, changes in temperature and precipitation patterns increase the spread of harmful organisms and negatively affect production. Water and soil resources, which are important for food security, are vulnerable to climate change. Events such as erosion, flooding and inundation in coastal areas can damage settlements and infrastructure. Significant surface water loss is expected, especially in water resource critical areas such as the Gediz and Büyük Menderes Basins (Ministry of Environment, Urbanization and Climate Change, 2012 a). In terms of rural development and adaptation, Türkiye, with limited capacity to cope with the impacts of climate change, has to deal with the decline in water resources, changes in agricultural activities and climatic uncertainties in general. In this context, sustainable agricultural practices, water management policies and measures to be taken in coastal areas are critical for food security and development in the country (Ministry of Environment, Urbanization and Climate Change, 2012 a).

Türkiye's National Climate Change Strategy Document, which was approved by the High Planning Council and entered into force on May 3, 2010, states that

> Türkiye's national vision in the context of climate change is to become a country that has integrated climate change policies with development policies; has expanded energy efficiency; has increased the use of clean and renewable energy resources; actively participates in the fight against climate change within the framework of its special conditions; and is able to offer high quality of life and welfare to all its citizens with low carbon intensity. (Ministry of Environment, Urbanization and Climate Change, 2012b)

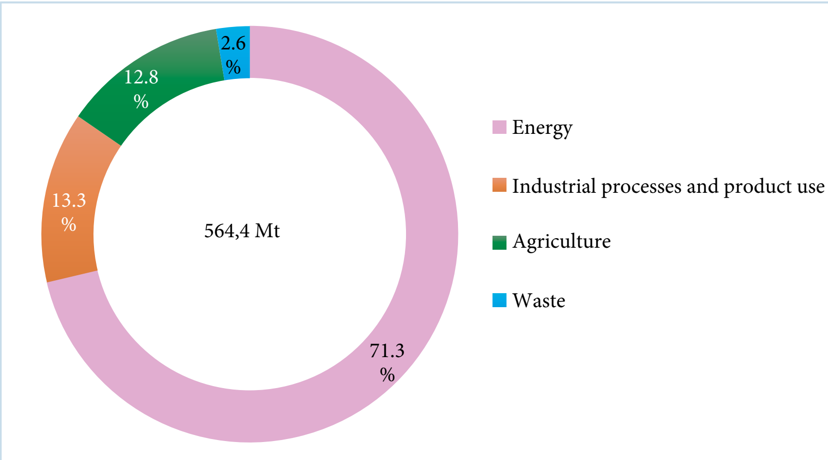
One of the basic principles of the National Climate Change Strategy Document is to contribute to the global policies and measures taken to reduce greenhouse gas emissions, within the limits of its own capabilities, without interrupting a development program in line with the principles of sustainable development, and to aim to limit the rate of increase in greenhouse gas emissions (Ministry of Environment, Urbanization and Climate Change, 2012b). However, Türkiye's greenhouse gas [GHG] emission performance is not satisfactory. According to the Türkiye 2023 GHG Emission Inventory Report, Türkiye's total GHG emissions in 2021 are 564.4 Mt CO_2 equivalent. This represents a 7.7 percent increase compared to the 523.9 Mt CO_2 equivalent recorded in 2020 (TÜİK, 2023).

Table 5.1: Greenhouse Gas Emissions by Sectors (CO_2 Equivalent), 1990–2021

(Million tonnes)					
Year	**Total**	**Energy**	**Industrial processes and product use**	**Agriculture**	**Waste**
1990	219.5	139.5	22.9	46.1	11.1
2000	298.9	216.0	26.2	42.3	14.3
2010	398.8	287.9	49.1	44.4	17.4
2016	501.1	361.7	63.8	58.9	16.7
2017	528.6	382.4	66.6	63.3	16.3
2018	523.1	373.4	67.7	65.3	16.6

(Million tonnes)					
Year	**Total**	**Energy**	**Industrial processes and product use**	**Agriculture**	**Waste**
2019	508.7	365.6	59.0	68.0	16.1
2020	524.0	366.6	68.0	73.2	16.3
2021	564.4	402.5	75.1	72.1	14.7
Change compared to 1990–2021 (%)	157.1	188.4	228.7	56.5	32.6
Change compared to 2020–2021 (%)	7.7	9.8	10.6	–1.5	–9.9

Source: TÜİK (2023 a).



Graph 5.1: Greenhouse Gas Emission Rates by Sectors (2021).
Source: TÜİK (2023b).

As shown in the aforementioned graph, the largest share in total greenhouse gas emissions in 2021 by CO_2 equivalent was attributed to energy-related emissions with 71.3 percent. This share was followed by industrial processes and product use with 13.3 percent, agriculture with 12.8 percent and the waste sector with 2.6 percent (TÜİK, 2023). Consequently, it has a significant impact on global warming and climate change due to the increase in greenhouse gases, which has a negative effect on Türkiye.

5.4 Türkiye's Medium-Term Program and Its Importance in Combating Climate Change

Combating climate change is considered to be a fundamental element of Türkiye's commitment to building a sustainable future. In this context, Türkiye has implemented a series of policies, strategies and projects. These policies and measures adopt sustainability principles in various sectors such as energy, transportation, industry, agriculture and forestry. In line with the aim to combat climate change, the Medium-Term Programme (MTP), which is prepared every year by the Ministry of Treasury and Finance and the Presidency's Presidency of Strategy and Budget with a three-year perspective, is formalized by Presidential Decree. Between 2006 and 2026, 19 MTPs have been published in Türkiye, each for three years (Ministry of Environment, Urbanization and Climate Change, no date) programme.

The Medium-Term Programme is "a programming tool that initiates the budget process and guides resource allocations by setting out public policies and practices on the basis of the policies and priorities in the Development Plan" (OVP, 2017). It is also "a basic policy document containing macro policies, principles, targets and indicative basic economic aggregates, total revenue and expenditure forecasts for the next three years, budget balance and borrowing status, and appropriation proposal ceilings of public administrations" (OVP, 2023). In the MTP, macroeconomic targets and policies are further progressed by evolving over time and increasing budget allocations. Growth, employment, price stability, balance of payments, public finance, disaster management, digital transformation and sectoral policies are included in the MTP. MTPs analyze the global, regional and national economic situation in detail; the macroeconomic targets and policies to be pursued in economic and social areas are announced to the public on the basis of these analyses. In this context, the main targets of Türkiye, particularly with regard to combating climate change, have been established as of 2022 under the title of "green transformation." (OVP, 2022). The government aims to support green transformation policies by providing measurable resources to effectively address climate change. In this context, this study aims to examine Türkiye's efforts in this regard within the scope of the MTP, examining the policies outlined in the program.

5.5 Method

This section includes explanations on the design of the study, the identification of the study group and the data collection process.

a. Research Model

In this study, the document analysis technique was employed as a data collection method within the qualitative research framework. Document analysis is a qualitative research method used to analyze and evaluate the content of written documents (printed and electronic) carefully and systematically (Wach, 2013). Like other methods in the context of qualitative research, document analysis involves a process of rigorous examination and interpretation of data. This process aims to make sense, to create an understanding of the subject matter and to develop empirical knowledge (Juliet and Strauss, 2008). In the process of document analysis, researchers can use a variety of sources such as articles, theses, dissertations, books, meeting minutes, official sources, lesson or unit plans as written materials (Yıldırım and Şimşek, 2011). In this context, the study covers Türkiye's MTP documents starting from the 2006 to 2008 MTP, moving periodically forward up to the 2024–2026 MTP.

b. Population and Sample

The study focuses on the policies on combating climate change in the MTP. In this context, the study includes 18 MTP documents ranging from the 2006–2008 MTP to the 2024–2026 MTP. These documents are available on the website of the Presidency Strategy and Budget Directorate.

c. Data Analysis

The data analysis in this study was based on content analysis. Content analysis is based on collecting similar qualitative data around certain concepts, categories and themes, organizing and interpreting this information in a way that the reader can understand (Yıldırım and Şimşek, 2011). Within the scope of the research, the data analysis process was based on Saldana's (2019) "data/code-subcode/category/theme" approach. In the first stage of the analysis process, the documents were transferred to the Maxqda program and the data were examined one by one. The places that were not relevant to the research were excluded from the codes. Subsequently, the important elements of the subject were coded in detail and some codes were divided into sub-codes. The coded data were then divided into main categories, before these categories were combined to, identify the main themes. At the end of the analysis process, the findings were presented in quotations, taking into account the frequency of repetition, using visual tools.

5.6 Findings

In this part of the research, the analysis of the data obtained as a result of the document analysis conducted with the perspective of determining Türkiye's priorities regarding climate policies and the findings that emerged was focused on. According to the data analysis, six main themes, namely *environmental protection and infrastructure*, *energy and transportation*, *agriculture and water resources*, *green finance and financial adaptation*, *national climate change strategy* and *green transformation and sustainability*, were identified as a result of the analysis of 18 public documents. These themes were assigned 260 codes and sub-codes.

a. Environmental Protection and Infrastructure

The codes and frequencies generated for the theme of environmental protection and infrastructure are shown in Figure 5.1.

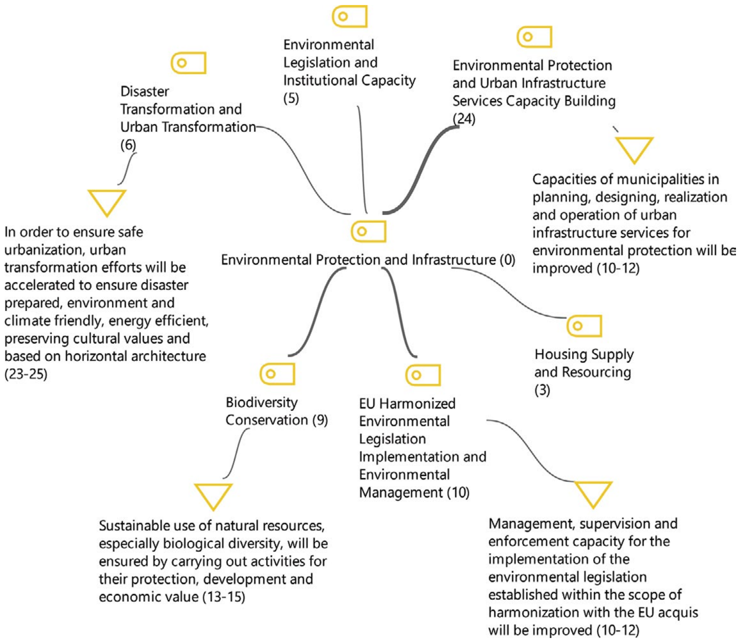


Figure 5.1: Codes Related to the Theme of Environmental Protection and Infrastructure.
Source: Created by Author.

According to the data obtained from the documents, the most emphasized objectives in the environmental protection and infrastructure theme are "capacity building for environmental protection and infrastructure services," "implementation of EU harmonized environmental legislation and environmental management" and "protection of biodiversity."

For the code on environmental legislation and institutional capacity, the following target has been set in MTP 12–14: "The capacities of all relevant institutions will be improved to ensure effectiveness in the implementation of environmental legislation."

For the housing supply funding code, the MTP 11–13 emphasizes that "capital market instruments will be developed to provide sufficient resources for housing supply and demand."

b. Energy and Transportation

The codes and frequencies generated for the Energy and Transportation theme are shown in Figure 5.2.

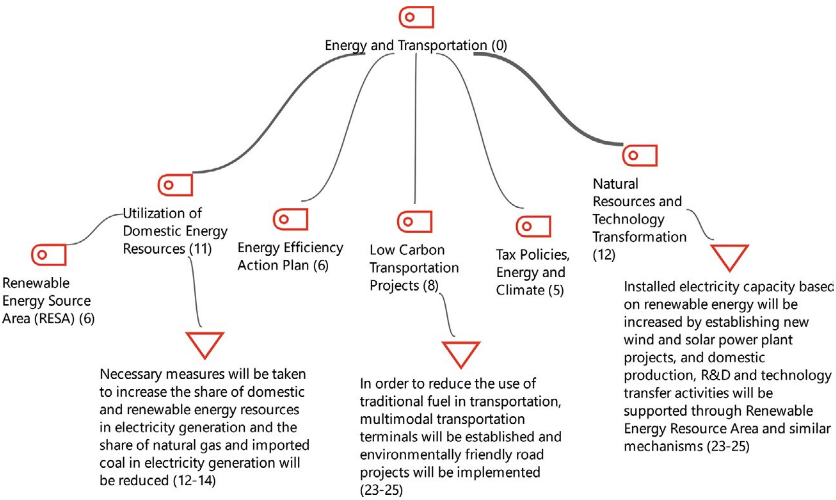


Figure 5.2: Codes Related to the Theme of Energy and Transportation.
Source: Created by Author.

According to the data obtained from the documents, the most emphasized targets in the energy and transportation theme are "natural resources and technology transformation," "use of domestic energy resources" and its sub-codes "renewable energy resource area (resa)" as well as "low-carbon transportation projects."

For the energy-efficiency action plan code, the MTP 24–26 sets the target as "the new energy efficiency strategy document and the 2nd national energy efficiency action plan will be implemented."

For the energy and climate code for tax policies, MTP 14–16 emphasizes that "priorities for combating climate change and saving energy consumption will be taken into account in the determination and implementation of tax policies."

c. Agriculture and Water Resources

The codes and frequencies generated for the themes of agriculture and water resources are shown in Figure 5.3.

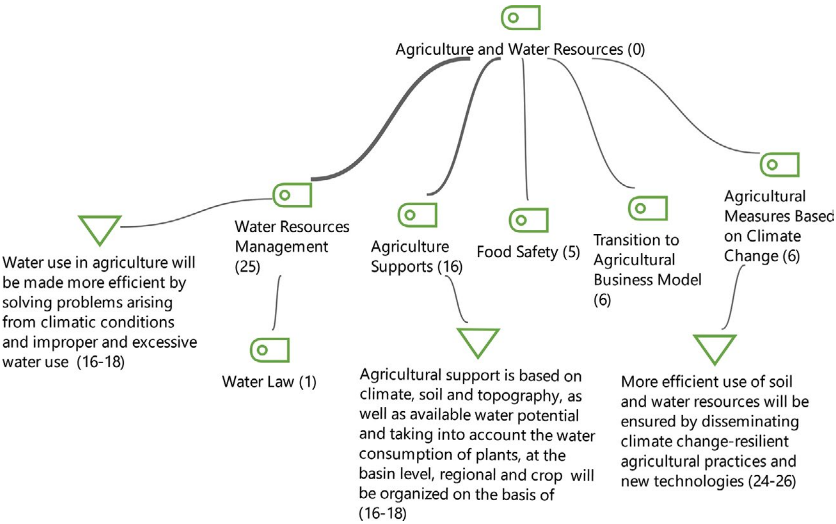


Figure 5.3: Codes Related to the Theme of Agriculture and Water Resources.
Source: Created by Author.

According to the data obtained from the documents, the most emphasized targets in the theme of agriculture and water resources are "water resources management" and its sub-codes "water law" and "agricultural supports."

For the code of transition to an agricultural enterprise model, MTP 10–12 set the following target: "In order to overcome the scale problem in agricultural enterprises, fragmentation of agricultural lands through inheritance will be prevented and land consolidation efforts will be accelerated."

For the food safety code, MTP 06–08 emphasized that "within the framework of the principle of food safety from farm to table, the production conditions of enterprises in agricultural products and public inspection conditions in food products will be improved."

d. Green Financing and Financial Compliance

The codes and frequencies generated for the theme of green financing and financial alignment themes are shown in Figure 5.4.

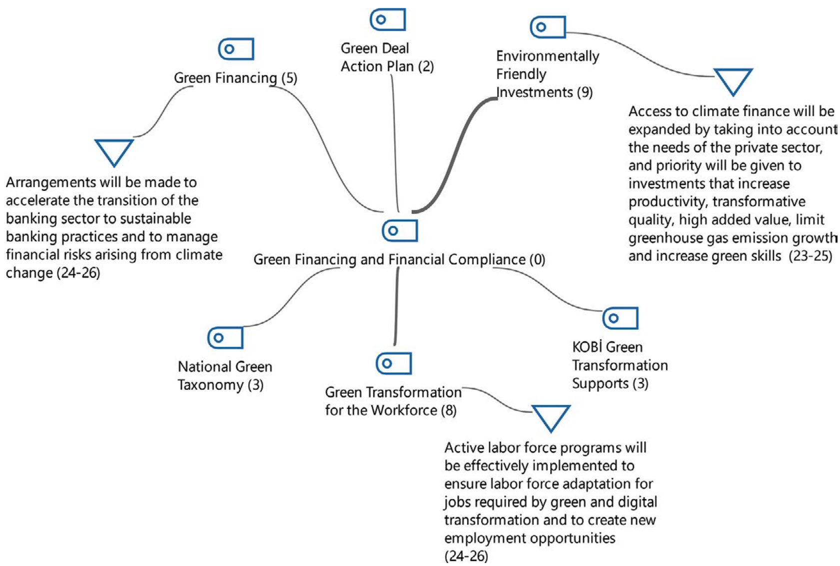


Figure 5.4: Codes Related to the Theme of Green Financing and Financial Compliance. *Source*: Created by Author.

According to the data obtained from the documents, the most emphasized targets in the theme of green financing and green adaptation are "environmentally friendly investments," "green transformation for labor force" and "green financing" codes.

Regarding the code for green transformation supports for small and medium-sized enterprises (KOBİ), the MTP 23–25 states that

> support mechanisms will be developed to facilitate the adaptation of firms, especially exporting KOBİ, to green transformation, and the capacity to measure, analyse and manage environmental and social risks in the value chain of the products and services produced will be improved.

For the national green taxonomy code, the target for MTP 24–26 is set as "legislative work will be carried out to establish a National Green Taxonomy in line with international taxonomy examples, especially the European Union taxonomy, and in line with Türkiye's needs."

For the Green Deal code, the MTP 24–26 emphasized that "the Green Deal Action Plan will be updated in order to increase competitiveness in export markets, particularly in the EU, and to enhance Türkiye's position in supply chains."

e. National Climate Change Strategy

The codes and frequencies generated for the theme of national climate change strategies are shown in Figure 5.5.

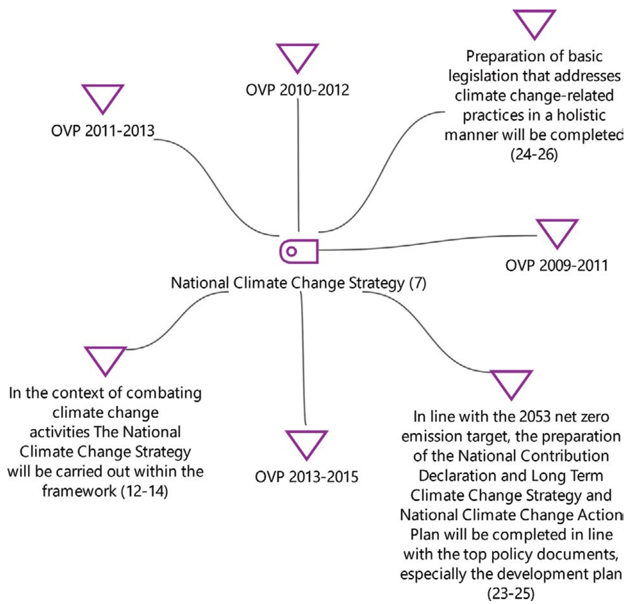


Figure 5.5: Codes Related to the Theme of National Climate Change Strategy.
Source: Created by Author.

According to the data obtained from the documents, the theme of the national climate change strategy was emphasized in the MTP documents, which were set as targets.

f. Green Transformation and Sustainability

The codes and frequencies generated for the green transformation and sustainability themes are shown in Figure 5.6.

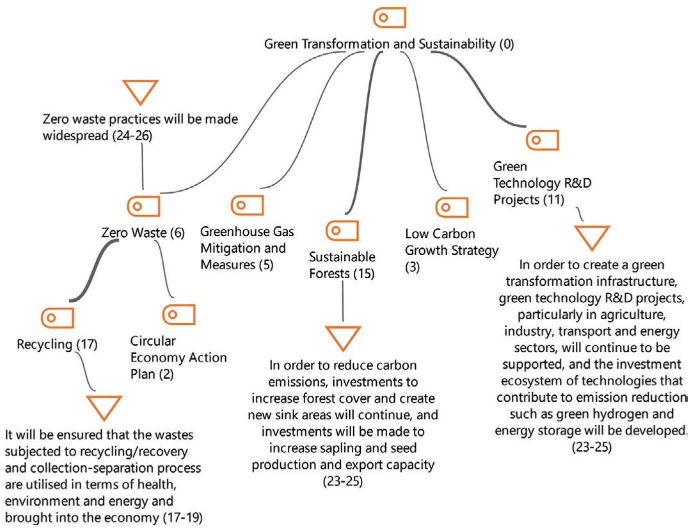


Figure 5.6: Codes Related to the Theme of Green Transformation and Sustainability. *Source*: Created by Author.

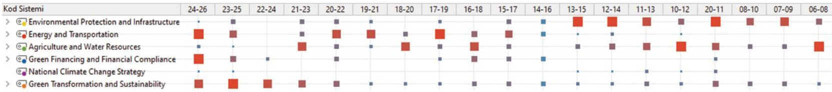
According to the data obtained from the documents, the most emphasized targets in the green transformation and sustainability theme are "recycling," "sustainable forests" and "green R&D projects," which are sub-codes of the "zero waste" code.

For the code of greenhouse gas mitigation and measures, the MTP 8–10 sets the target as "measures will be taken to mitigate greenhouse gases and eliminate the possible effects of climate change."

For the low-carbon growth strategy code, MTP 23–25 emphasizes that "road maps will be prepared and practices will be encouraged for the transition of sectors to low carbon production within the framework of the best available techniques and best environmental practices."

In MTP 24–26 regarding the subcode of a Circular Economy Action Plan, the target is set as follows:

> The National Circular Economy Action Plan will be prepared by making an impact assessment regarding the harmonization with the legislation under preparation within the framework of the EU's circular economy policies, material recovery and waste management will be prioritized by prioritizing resource efficiency within the framework of sustainable production and consumption approach, and industrial symbiosis practices will be encouraged.



Picture 5.2: Position of Themes in the Medium-Term Program.
Source: Created by Author.

Picture 5.2 highlights the frequency of repetition of themes (policies) generated as a result of document analysis in MTPs by years. Policies related to the theme of environmental protection and infrastructure were addressed more intensively starting from the 2006–2008 MTP to the 2013–2015 MTP. Policies on the energy and transportation theme have been included more frequently since 2015, but have generally focused on future-oriented studies. It has been observed that policies on agriculture and water resources are addressed in a fragmented manner without continuity in the MTP documents. Regarding the themes of green finance and financial adaptation, MTPs emphasized forward-looking policies. The theme of national climate change strategy has been included in policy documents at certain intervals. The theme of green transformation and sustainability has been given more space in MTPs in post-2020 policies, which shows that it has an important place in future-oriented policy targets.

5.7 Conclusion

Türkiye's strategies to combat climate change have been strengthened over the years to move toward a sustainable future and many priority policy areas have been identified in this context. These priority areas are shaped under headings that strengthen Türkiye's commitment to achieving its climate goals and provide a comprehensive roadmap for the country's environmental and economic sustainability. In the areas of energy and transport, policies to increase the use of domestic and renewable resources, low-carbon transport projects and steps to integrate natural resources with technology stand out; more resources are allocated to these areas. For example, in the field of energy, various projects have been conducted to increase the use of renewable energy sources such as solar and wind energy. Within the scope of these projects, solar and wind power plants are established, energy-efficiency studies are carried out for buildings and the use of energy-efficient devices is encouraged. In addition, policies are aimed at bringing natural resources into production with the help of technology; ensuring the transition to sustainable transportation systems for railway, transportation and maritime trade; supporting the use of domestic energy resources; exploring new resources and bringing them into the economy; and considering combating climate change and energy saving in determining tax policies. Therefore, these policies are an important step in combating climate change and can contribute to reducing environmental impacts. In addition, it is important to support these policies with enforceability, cooperation and technological innovation. Furthermore, priority is given to environmentally friendly investments, regulations to eliminate climate change-related risks and R&D investments. Increasing such investments can contribute to both reducing environmental impacts and creating new economic opportunities. In particular, R&D efforts in renewable energy sources and energy-efficiency technologies can accelerate the transformation of the energy sector and reduce carbon emissions. Measures are taken for a fair transition to green transformation for SMEs and the labor force and social policies are established to provide environmentally friendly green jobs and professional standards. In this context, the Small and Medium Enterprises Development Organization offers grants and loans to support SMEs' investments in areas such as energy efficiency, renewable energy investments and waste management through green transformation support programs. In addition, with technical support, The Türkiyes Green Industry Project will ensure the green transformation of the industrial sector (Small and Medium Enterprises Development Organization [SMEDO], 2023). Policies are aimed at expanding zero waste practices, recycling and reintroducing waste into the economy, taking measures to reduce greenhouse gases, investing, afforesting and working for sustainable forests, and supporting R&D projects with green technology by ensuring the transition of sectors to low-carbon production through green transformation. These policies include positive steps toward environmental sustainability and combating climate change. In particular, zero waste can ensure more efficient use of resources, while recycling can contribute to the economy by reducing the damage caused by waste to nature (Greyson, 2007). Despite the limited targets set for agriculture and water resources over the years, emphasis was placed on legal arrangements for the use of water and policies for the efficient use and management of land and water. Emphasis on these policies is crucial for the sustainable management and utilization of agricultural and water resources. The use of water is becoming increasingly critical, particularly because of factors such as drought. In this context, legal arrangements need to ensure the fair and efficient use of these resources. Policies for the efficient use and management of land and water are essential to increase agricultural productivity, reduce environmental impacts and ensure the sustainability of water resources. Through these policies, the agricultural sector can be made more productive and the environmental balance can be maintained by preventing overuse and pollution of water. In addition, policies were included to provide R&D support for agricultural enterprises and to mitigate the potential impacts of climate change on the agricultural sector and to protect farmers from negative impacts. Food and Agriculture Organization [FAO]'s projects on agricultural resources are extremely important. In this framework, many projects such as "Sustainable Land Management and Climate Friendly Agriculture," "Protect Your Food," "Support to the development of a national e-agriculture strategy," or "Integrated Land Use Planning for Food Security by Improving Climate Resilience and Ecosystem Management (ILUP)" draw attention (FAO, 2024). These comprehensive policy plans include important steps to reduce greenhouse gas emissions, enhance environmental sustainability and build capacity to cope with climate change impacts. However, effective implementation of these policies requires a continuous monitoring and evaluation process.

In line with the data obtained from the MTPs, this study offers several recommendations for Türkiye to further strengthen its climate policies and focus on a sustainable future. It has been observed in the Medium-Term Program documents that policies and budgets allocated for environmental protection, infrastructure, agriculture and water resources are limited. Most of the negative impacts of climate change are known to affect the environment, agriculture and water resources. In this context, in addition to the targets set in the MTPs for these themes, there is a need to strengthen policies and increase the budget. For environmental protection and infrastructure, it is recommended to improve air quality, increase green areas and design low-carbon urban models with economic integrity that are compatible with the impacts of climate change, and to establish urban green infrastructure systems to control flood waters. If necessary measures are not taken, worsening air quality in particular can lead to an increase in respiratory diseases and damage to ecosystems. It is also crucial to create green infrastructure systems to control flood waters in cities, adapting to the impacts of climate change. Otherwise, situations such as flood disasters due to heavy rainfall may occur more frequently and severely, resulting in serious loss of life and property. Water consumption for agriculture needs to be reduced and rain harvesting should be used, especially for irrigation. Furthermore, the method of collecting water from precipitation should be used as an alternative to groundwater. Also, traditional irrigation methods in agriculture, which cause soil destruction, need to be abandoned, and modern agricultural and technological methods, such as restorative agriculture and vertical farming, must be introduced to restore organic matter to the soil. In this context, impacts of the global climate crisis on agriculture and water resources can be substantial. It is especially important to reduce water consumption and manage water resources in a sustainable manner. Failure to do so may result in a decline in agricultural productivity, the destruction of soil and scarcity of water resources. In this case, food security and the safe/healthy use of water resources can be jeopardized. Reductions in water and food resources can consequently lead to the migration of local communities and conflict over resources. Productivity declines in the agricultural sector and the impacts of natural disasters can lead to economic losses and increased unemployment. In addition, the effects of natural disasters, such as droughts, may become more visible. Therefore, timely and effective implementation of measures to be taken on these issues is of utmost importance.

Finally, recommendations include increasing community participation, establishing more specific and measurable targets, and strengthening education and awareness programs. These policy recommendations require the participation not only of the state, but also of all segments of society and the private sector. Such cooperation and participation will significantly contribute to the successful implementation of Türkiye's strategies to combat climate change.

Bibliography

Carbonbrief (October 5, 2021). *Emissions*. Analysis: Which countries are historically responsible for climate change? Retrieved from https://www.carbonbrief.org/analysis-which-countries-are-historically-responsible-for-climate-change/, on March 4, 2024

Cifuentes-Faura, J. (2022). European Union policies and their role in combating climate change over the years. *Air Qual Atmos Health* 15, pages 1333–1340. https://doi.org/10.1007/s11869-022-01156-5

Dodds, J. (August 2021). The psychology of climate anxiety. *BJPsych Bulletin*, *45*(4), pages 222–226. https://doi.org/https://doi.org/10.1192/bjb.2021.18

European Commission (2023). *Ghg Emıssıons Of All World Countrıes*. Jrc Scıence For Polıcy Report.

European Commission (no date). January 22, 2023 on the date Consequences of climate change, Retrieved from https://climate.ec.europa.eu/climate-change/consequences-climate-change_en, on March 8, 2024

FAO.(2023). *Programs and Projects*. Retrieved from https://www.fao.org/turkiye/programmes-and-projects/project-list/tr/ on March 10 2024

Greyson, James.(2007). An economic instrument for zero waste, economic growth and sustainability. *Journal of Cleaner Production* 15(13–14). Pages 1382–1390. https://doi.org/10.1016/j.jclepro.2006.07.019

IPCC (2022). *Climate change 2022: Impacts, adaptation and vulnerability*. Retrieved from https://www.ipcc. on December14, 2023.

IPCC (2023). *Summary for Policymakers. In: Climate Change 2023: Synthesis Report*. Geneva: IPCC. https://doi.org/10.59327/IPCC/AR6-9789291691647.001

Juliet, C., & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for.* Thousand Oaks: SAGE. https://doi.org/https://doi.org/10.4135/9781452230153

Kaddo, Jameel R. (2016). *Climate Change: Causes, Effects, and Solutions. A with Honors Projects*. 164, Retrieved from http://spark.parkland.edu/ah/164 on March 19, 2023.

Ministry of Environment, Urbanization and Climate Change. no date). *Basic Concepts: What 1.5°C, 2°C defines global warming?* December 13, 2023 on the date Ministry of Environment, Urbanization and Climate Change Climate Change Directorate : https://iklim.gov.tr/sss/temel-kavramlar

Ministry of Environment and Urbanization. (2012 a). *Türkiye Climate Change Adaptation Strategy and Action Plan 2011–2023*. Ankara.

Ministry of Environment and Urbanization. (2012b). *Climate Change Action Plan 2011–2023*.

Ministry of Foreign Affairs (no date). Combating climate change, Retrieved from https://www.mfa.gov.tr/sub.tr.mfa?6f41190c-6742-405 a-9 e5a-784385301607 on March 10, 2024.

OVP (2017). *Medium-Term Programme 2018–2020*.

OVP (2022). *Medium-Term Programme 2023–2025*.

OVP (2023). *Medium-Term Programme 2024–2026*.

Presidential Strategy and Budget Directorate. no date). *Plans and Programs*. Retrieved from https://www.sbb.gov.tr/orta-vadeli-programlar/, on January 16, 2024.

Saldana, J. (2019). *Coding Handbook for Qualitative Researchers*. (A. Tüfekçi Akcan, & S. Şad, Dü) Pegem Academy.

SMEDO (2024). Green Transformation in Industry, Retrieved from https://www.kosgeb.gov.tr/site/tr/genel/detay/8874/sanayide-yesil-donusum, on March 10, 2024.

TÜİK (2023 a). *Greenhouse Gas Emission Statistics, 1990–2021*. https://data.tuik.gov.tr/Bulten/Index?p=Sera-Gazi-Emisyon-Istatistikleri-1990-2021-49672&dil=1, Access Date: January 20, 2024.

TÜİK (2023b). *Greenhouse Gas Emission Rates by Sectors, 2021* https://data.tuik.gov.tr/Bulten/Index?p=Sera-Gazi-Emisyon-Istatistikleri-1990-2021-49672&dil=1, Access Date: January 28, 2024

UN (2023). *Science: What Is Climate Change?* December 13, 2023 on the date United Nations: https://www.un.org/en/climatechange/what-is-climate-change.

UN (no date). *Climate Action*. January 22, 2023 on the date Causes and Effects of Climate Change: https://www.un.org/en/climatechange/science/causes-effects-climate-change

U.S. Environmental Protection Agency (2016). *Climate change indicators in the United States, Fourth edition*. Retrieved from https://www.epa.gov/sites/default/files/2016-08/documents/climate_indicators_2016.pdf on March 15 2023.

Usher, K., Durkin, C., & Bhullar, N. (2019). Eco-anxiety: How thinking about climate change-related environmental decline is affecting our mental health. *International Journal of Mental Health Nursing*, *28*(6), p. 1233–1234. https://doi.org/10.1111/inm.12673

Wach, E. (2013). Learning about Qualitative Document Analysis. *IDS Practice Papers*.

WHO (2023, Oktober 12). *Climate Change*. Retrieved from https://www.who.int/news-room/fact sheets/detail/climate-change-and-health on March 17,2023.

World Bank (2023). *What is Climate Change? Understanding the Big Picture*. Aralık 13, 2023 tarihinde Climate Change Knowledge Portal: https://climateknowledgeportal.worldbank.org/overview#:~:text=Climate%20change%20is%20the%20significant,change%20from%20natural%20weather%20variability.

Yıldırım, A., & Şimşek, H. (2011). *Qualitative Research Methods in Social Sciences*. Ankara: Seçkin Publishing.

The European Green Deal: Leverage or Obstacle for EU–Türkiye Relations?

Yaşar Aydın[13] *and Bettina Emir*[14]

6.1 Introduction

The European single market as a whole and most of the European Union's (EU) national economies, like Germany, are closely interconnected with Türkiye. Despite political differences between Türkiye and the EU as well as Türkiye and Germany, bilateral and multilateral trade set new records in 2023. Nevertheless, there are numerous challenges that could curb Turkish European trade. One of these, which we will focus on in this chapter, is the European Green Deal (hereafter EGD).

The EGD has implications not only for the climate, but also for the EU's relations with many other countries, including Türkiye. It requires the greening of the Turkish economy if the volume of trade is to be maintained at a high level. It thus forces and encourages Turkish businesses to face the challenges but also the new opportunities that decarbonization brings, and it affects trade- and political relations with the European Union. In the process, longstanding unresolved issues such as the modernization of the EU-Türkiye Customs Union (CU) (Aydın, 2020), that could potentially form a framework in which the new regulations are embedded, return to the political agenda—as well as the obstacles that have so far prevented this modernization.

---

[13] Yaşar AYDIN is based at the *Centre for Applied Turkey Studies (CATS)* at the *Stiftung Wissenschaft und Politik/German Institute for International and Security Affairs in Berlin (SWP)*. https://orcid.org/0000-0001-5354-2389.

[14] Bettina EMİR is based at the *Centre for Applied Turkey Studies (CATS)* at the *Stiftung Wissenschaft und Politik/German Institute for International and Security Affairs in Berlin (SWP)*. https://orcid.org/0009-0000-9969-2315.

This chapter[15] outlines the current state of play in Türkiye and assesses whether the EGD is a potential barrier to trade or an incentive for cooperation. The discussion of the EGD is preceded by a brief outline of the trade between the EU and Türkiye.

6.2 EU–Türkiye Trade

The volume of EU–Türkiye trade in 2022 amounted to US$207.9 billion, US$103.5 billion of which were Turkish exports to the EU. The trade between Germany and Türkiye was worth about US$49.8 billion in 2023. Given that Türkiye's total trade volume amounted to US$617 billion in 2022, the trade with the EU accounts for a third of Türkiye's total trade. Moreover, trade with the EU is much more balanced, in contrast to Türkiye's significant trade deficit. Forty percent of Türkiye's exports go to the EU, while 25 percent of Türkiye's imports come from the EU (Aydın/Bastian/Schneider, 2024).

The main export sectors to the EU include the automotive, energy, textile, steel and household goods industries. In particular, companies in the automotive, textile and steel sectors are well integrated into the European single market. In addition, the country at the crossroads of Europe, Asia and Africa stands out as an attractive production location for thousands of European companies. Turkish companies are part of European value and supply chains.

Türkiye is also an attractive country for foreign direct investments. Therefore, a possible collapse of the Turkish banking system could also have a destabilizing effect on the European economy. European banks—especially

[15] This chapter is an outcome of an ongoing research project, part of a work in progress. The first outcome of our research was the CATS Network Perspectives "What Are the Implications of the European Green Deal for EU–Turkey Relations?" (Berlin: Stiftung Wissenschaft und Politik), 07.11.2023, retrieved from https://tinyurl.com/4ancba79 on March 15, 2024).

This work in progress is based on a wide range of empirical material, including official documents, statistical data, media reports and our own data collection of qualitative interviews. Within this framework, a total of 16 expert interviews were conducted between November 2023 and May 2024 with experts and stakeholders from politics, business and bureaucracy in Berlin, Brussels, Istanbul and Ankara. The sources of these interviews are cited anonymously. For the semi-structured interviews, the documentary method was used (cp. Nohl, 2017).

Spanish, French and Italian banks—have accumulated exposures of more than €100 billion. Spanish banks alone have invested €80 billion in the Turkish banking sector (cp. Suárez, 2021). So, in addition to trade relations and close cooperation in the production of goods, the EU and Türkiye are also linked in the financial sector. It is against this background that we would now like to take a look at the impact of the EGD on the interlinked relationships.

6.3 The European Green Deal—Goals and Measures

In December 2019, the European Commission launched the EGD with the aim of achieving climate neutrality in production across EU countries by 2050. To counteract potential competitive advantages for companies located in non-EU countries with lower environmental standards, a package of policy measures has been introduced to encourage CO_2 emission reductions that align with the EU's green transition goals as outlined in the European Green Deal. Since Türkiye ratified the Paris Climate Agreement on October 7, 2021, and committed itself to climate neutrality by 2053, these mechanisms also encourage emissions reduction in Türkiye (Kaya, 2023). However, the goal of decarbonization will also impose costs on businesses, and, therefore, could have a constraining effect on EU-Türkiye trade (Bennett, 2021).

The EGD aims at achieving climate neutrality, a state where the net greenhouse gas emissions resulting from human activities are balanced out by removing or offsetting an equivalent quantity of emissions from the atmosphere. On the way there, emissions shall be reduced by at least 55 percent by 2030 compared to 1990 levels and by 90 percent by 2040 according to the European Commission (2019). The green transition and the digital transition are often addressed together as "twin transitions" (Joint Research Center, 2022) as they influence each other and both profoundly transform economy and society. Besides the green and digital technologies that are required, there is a need for social acceptance which is more likely to be achieved, if the changes are perceived as fair and manageable. Jobs will be shifting between growing and declining sectors; new skills are required and the investments into new technologies and training need to be financed. As such, the transition offers both a path toward innovation, new fields and markets, such as renewable energies, but it also forces companies and businesses to invest and thus creates considerable costs (Viola, 2023).

In an entirely free market, this might lead to competitive disadvantages for European companies that need to follow stricter regulations compared to actors outside of Europe who are allowed to produce with higher emissions, less investments into decarbonization and who could thus offer cheaper prices. The *Carbon Border Adjustment Mechanism* (CBAM) is also thought to avoid "carbon leakage": European companies moving carbon-intensive production abroad to other countries, undermining the European climate ambitions (European Commission, no release date).

In order to counterbalance these potentially negative effects, the Green Deal entails the CBAM (European Commission), that imposes charges on imported goods based on their embedded carbon emissions.[16] It also considers the prices for the emission of greenhouse gases that have already been paid in the country of production. If, for example, cement as a carbon-intensive product is imported to the EU from a country without any pricing for greenhouse gas emissions, the importer has to pay taxes that shall be equivalent to the domestic production within the EU. In case the cement comes from a country with an *Emissions Trading System* (ETS) in place and a certain amount has already been paid for the emissions, it will only be the difference between the costs in the country of production and the costs for the same emissions within the EU that are charged when the product enters the union (Federal Ministry for Economic Relations and Climate Action, no release date).

For the start, the CBAM will only apply to carbon-intensive products with a high risk of carbon leakage. In addition to cement, these include iron and steel, aluminium, fertilizers, electricity and hydrogen. By 2030, further products may be included. "With this enlarged scope, CBAM will eventually—when fully phased in—capture more than 50 percent of the emissions in ETS covered sectors" (European Commission, 2024). The CBAM is introduced in multiple steps to allow for a manageable transition. In October 2023 the transitional phase started and it will last until the end of 2025. During this time, importers shall align the reporting of emissions with the requirements of the EU, but there are no payments to be made yet.

One legal issue that needs to be resolved is whether the CBAM can be regarded as an obstacle to trade that violates the most-favored nation-rule

[16] As such, it complements the Emissions Trading System (ETS) of the EU, which aims to encourage European producers to reduce emissions by increasing CO_2 prices.

(MFN) of the World Trade Organization (WTO), which, generally speaking, is intended to ensure that all members of the WTO treat each other equally. Exceptions are only allowed in special cases, such as free trade agreements or customs unions, which allow for advantages to be granted to each other by the contracting parties. Also, developing countries may receive preferential treatment under certain conditions (World Trade Organization, no release date). Given that the least developed countries have fewer resources to reduce greenhouse gas emissions, this might, as some experts argue, lead to higher carbon adjustment prices at the border and could potentially put them in a disadvantaged trading position, which would be regarded as inconsistent with the basic principles of the WTO (Le Blanc and Mendoza, 2023).

6.4 Türkiye's Decarbonization Efforts

The Paris Agreement was adopted in 2015 and ratified in 2016. Its overarching goal is to hold "'the increase in the global average temperature to well below 2°C above pre-industrial levels' and pursue efforts 'to limit the temperature increase to 1.5°C above pre-industrial levels.'" (United Nations Framework Convention on Climate Change [UNFCCC], no release date). The support a country receives to meet climate targets depends on how its level of development is assessed. Türkiye signed the agreement in 2016 with the status of a developed country in the UN climate convention. However, it took another five years until the Turkish Parliament officially ratified the agreement on October 7, 2021, and approved the goal of becoming climate neutral by 2053.

Türkiye has insisted on being considered a developing country in this context, arguing that it is less economically developed than developed countries and therefore has fewer resources and capacity to make strong commitments to reduce emissions without jeopardizing its economic development. Following this argumentation, when ratifying the Paris Agreement, the Turkish Parliament appended a declaration asserting that Türkiye would adhere to the climate treaty as a developing country, despite its classification as a developed nation (Climate Home News, 2021).

A strong motivation for the longstanding demand to be re-classified as a developing country was the entitlement to funds and technological aid. In due course, a Franco-German guarantee of US$3.2 billion in financial support for Türkiye seems to have proved decisive (Weise, 2021). However, it is important to note that the ratification of the Paris Climate Agreement was not solely influenced by pressure from the EU. The motivation to decarbonize also played a significant role. TÜSİAD, for instance, as a strong and influential business organization, has been in favor of the Paris Agreement. TÜSİAD suggests supporting the approach to carry out economic activities with awareness of environmental issues (Numanoğlu and Sabuncu, 2016). In Germany, Türkiye had been criticized for its hesitation, so the signing of the agreement was celebrated as a clearer signal of its will to protect the climate.

Nevertheless, there is no doubt that the CBAM regulation will be a serious challenge for Türkiye because it is, along with Russia, the UK, China and Ukraine, one of the largest exporters of products which are covered by the carbon adjustment regulation (Le Blanc and Mendoza, 2023).

Besides ratifying the Paris Agreement in parliament, and committing to achieve carbon neutrality by 2053, Türkiye has taken concrete strides in climate policy since 2021, such as announcing the Green Deal Action Plan (Turkish Ministry of Trade, 2021). Corresponding to this,

> a series of initiatives aimed at promoting low-carbon production are in progress in the country. These include the establishment of a national ETS, the formulation of strategic roadmaps for low-carbon growth in relevant industries, alignment with newly developing EU sustainable product standards and the augmentation of research and development incentives. (Güçlü, 2023)

Another step is the draft Carbon Market Regulation in November 2023. This regulation introduces a national ETS in "response to the EU's carbon border tax, aiming to address mounting concerns and pressures from Turkish exporters" (Aşan, 2023). Türkiye plans to start a pilot phase of its ETS in 2025 for certain industries such as cement. As of 2026, the implementation will start and financial obligations will be introduced. The full implementation phase is scheduled for 2027 to 2034 (Eurometal 2024).

Furthermore, on August 18, 2023, a draft Climate Change Law was published, which will set the legislative framework for Türkiye's climate policies. The Climate Change Law entails specific strategies to mitigate the impact of climate change. This includes strengthening local administration roles, incorporating climate considerations into infrastructure projects, and promoting renewable energy and energy efficiency. At the heart of the Act is the establishment of a highly detailed ETS, outlining market operations, authority responsibilities and data submission requirements. In addition, as highlighted by expert observers, the law emphasizes accountability and enforcement mechanisms, including audit authority and penalty enforcement, positioning Türkiye "as an active participant in the global fight against climate change" (Levi, Ayhan and Baysal, 2024).

In the meantime, the draft law has been criticized for its "ineffective design, particularly regarding the non-binding cap." It is argued that the law is lacking a well-defined mechanism for its application, "a clear delineation of responsibilities among relevant ministries and other public authorities," which jeopardizes the enforceability and accountability of the targets set previously (Ibid.).

Experts see "significant limitations in terms of its scope, the absence of an agenda for coal phaseout, the lack of well-defined and binding emissions reduction targets" in the proposed legislation. They criticize the proposed ETS for having "unclear implementation procedures and responsibility for execution, inadequate input from scientific experts, and limited civil society involvement" (Ibid.).

Türkiye is in the process of developing a prototype of its own domestic ETS, with an anticipated operational launch date of 2025. The initial phase was marked by the establishment of a Monitoring-Reporting-Verification (MRV) system in 2015. On October 15, 2024, the pilot phase of the Turkish ETS shall start with the announcement of national allowance allocations. Finally, the start of the first implementation phase is scheduled for October 15, 2026. The ETS obliges installations in electricity, iron-steel, aluminium, cement, glass, ceramics, lime, mineral, wool, paper, refinery products, and chemicals to report their emissions to the Turkish Ministry of Environment, Urbanization, and Climate Change (Aşıcı, 2024).

6.5 Possible Obstacles and Risks

The EGD does not enter an area of trade relations free of conflict. European decision-makers and economic actors complain over the inadequate functioning of the market economy in Türkiye and over the lack of transparency, e.g., in public procurement, suggesting that domestic and foreign bidders are not treated equally.[17] Investors are concerned about the democratic back-

[17] Interview in Berlin, August 2023.

sliding, the deterioration of the rule of law and deficient predictability of the government's economic policies. For example, in January 2022, without prior notice the government decided that companies have to convert a quarter of their export revenues into Turkish lira—the exchange rate being set daily by the central bank. In April 2022, the percentage was raised to 40 percent, aiming to stabilize Türkiye's foreign exchange reserve. Another example mentioned in our interviews was public procurement procedures in which local Turkish companies can receive a price advantage of up to 15 percent from the awarding authority.[18] All this creates a lack of trust and an unfavorable investment climate, making European companies reluctant to enter the Turkish market. On the other hand, the restrictive visa policies of EU countries are perceived as a serious obstacle to closer ties; delays in issuing visas to Turkish company representatives, lorry drivers and representatives of business organizations are not in the interest of trade.

Both the EU and Germany expect Türkiye to take the first step as a sign of goodwill. Türkiye, on the other hand, expects an approach from both sides in order to find solutions together.[19] Consequently, a state of impasse has been reached, characterized by the absence of progress, from which neither party is able to extricate itself. In this respect, the main challenge is to get EU–Türkiye relations and negotiations moving again with the Green Deal, which requires action and coordination on both sides, and to break the deadlock in political relations.

Despite this deadlock, economic relations are running at full speed. As demonstrated in the previous subchapter on "EU–Türkiye Trade," multilateral trade is at a high level and has been growing steadily for years. German companies, for instance, that have already established a presence in Türkiye, are very satisfied overall (cp. Aydın/Bastian/Schneider, 2024). The biggest obstacle, which also deters new companies, is the lack of legal certainty and rule of law as well as the unpredictability of economic policy.

Türkiye's designed ETS has been the subject of criticism on the ground that it employs a single criterion to determine the scope of installations, namely installations emitting more than 500 ktCO_2e, which will be covered under

18 Interview in Berlin, August 2023, cp. also Reuters 2022 and ITA 2024.

19 Interviews in Ankara, Berlin, Brussels and Istanbul between May 2023 and November 2024.

the Turkish ETS. "Using a single emission-based criterion may lead to biased installation selection," clarifies Ahmet Atıl Aşıcı (ibid.). He also stresses that the ETS is not the solitary tool for decarbonizing economies. In the Turkish case, fossil fuel subsidies, tax breaks and special treatment for some industries in Türkiye are counterproductive policies that threaten the effectiveness of the ETS and need to be limited (Ibid.).

Meanwhile, there are doubts in the EU as to whether there is a clear political will in Türkiye for rapid implementation.

6.6 Conditions for a Success Story

The future of EU–Türkiye trade depends first and foremost on the modernization of the EU–Türkiye CU in order to realize the trade potential. Many economic actors believe that successful alignment with the CBAM and implementation of the ETS will deepen the harmonization of the economic and trade systems of Türkiye and the EU, thereby bringing Türkiye closer to the EU.

In this context, it is a positive development that the Türkiye report by the EU Commission and the External Action Service of November 29, 2023, recommends entering into negotiations with Türkiye to modernize the EU–Türkiye CU. Modernizing and expanding the CU to include agricultural products and services (including e-commerce) also promises trade growth for German and Turkish companies. It should be noted that there would also be potential for cooperation within the framework of the EU's Common Foreign and Security Policy.

In any case, the ETS, when it is ready, and the CBAM will have to be combined. This is a challenging issue, given that the ETS measures and reports a company's total CO_2 emissions. If a company emits less than it has received through ETS allowances, it can sell on the remainder, which is intended to incentivize reductions. However, the CBAM is not based on the company and its emissions, but on the CO_2 price for a specific product. Consequently, the ETS will need to be linked with the CBAM, a process that will require substantial coordination of measurements and calculations, resulting in a significant investment of time and resources. According to the EU, there are others who would be first in line.

Türkiye's top business organization, TÜSİAD, takes a positive view of the future development of economic relations in light of the EGD. According to them, efforts for the establishment of a Turkish ETS system and the ratification of the Paris Agreement are the right steps, it is a process that can provide Türkiye with an advantage.[20] Importantly, there is a green consensus action plan in Türkiye, which extends beyond the scope of the CBAM, namely applications such as digital product passports which will be introduced, or a Data Act which has already been introduced. Furthermore, there is work on Trade Secrets Legislation in Türkiye. The fact that Türkiye's Green Deal system is progressing in a healthy way will be beneficial and Türkiye is in an advantageous position compared to other countries in this regard.[21]

6.7 Outlook and Take-Aways

Reading the documents on the EGD, assessing Türkiye's efforts to harmonize national regulations with the CBAM or to introduce a national ETS, as well as evaluating the assessments of economic actors, provides evidence that the EGD not only poses challenges to the Turkish economy and EU-Türkiye trade, but also opens up opportunities. The transition to a low-carbon economy is forcing companies and businesses to invest, incurring significant costs and driving them toward innovation, new sectors and markets, such as renewable energy.

The evidence from business stakeholders and experts is that large companies in Türkiye are embracing the challenge and opportunity of decarbonization with confidence. Small and medium-sized enterprises are more likely to struggle, for a variety of reasons. While the Turkish state is preparing a new climate change law and a prototype emissions trading scheme, the EU considers the process too slow and lacking ambition.

The European market is crucial for Turkish exports. Energy-intensive industries such as cement and steel are under pressure to reduce emissions to avoid taxation under the EU's CBAM. This is not only a challenge, but also a potential area for cooperation. In the (renewable) energy sector, for example, European companies are competing in the growing Turkish market. Türkiye has great potential to further increase the share of renewable energy in energy production.

---

[20] Interview with representatives of TÜSİAD. With regard to TÜSİAD's position on the EGD, cp. the associations research report, TÜSİAD 2021.

[21] Author's expert interviews with actors from the economic field.

However, the EGD is also perceived—not only in Türkiye, but in several other countries—as a unilateral trade barrier that goes against the spirit of the EU-Türkiye Customs Union. In order to overcome this problem, the interviewed Turkish experts and stakeholders propose, among other things, to integrate the requirements of the EGD into a modernized EU-Türkiye Customs Union. However, due to the generally strained relationship, the EU is critical of such a step.

In conclusion, the EGD presents both challenges and opportunities for the Turkish economy and for Türkiye-EU economic relations. It is a challenge for the global competitiveness of Turkish products, especially in energy-intensive sectors, as it is difficult to integrate unilateral regulations into a strained bilateral relationship. However, the EGD is also an opportunity for Türkiye, as it will initiate the necessary policy and technological upgrades in Turkish industry, provide incentives to transform the energy used by these sectors into clean energy, and help reduce dependence on Russia through energy transition and decarbonization.

Politically, the EGD can provide a new framework for action in bilateral and multilateral relations, allowing for a revitalization of relations and a structured partnership between Ankara and Brussels, strengthening a partnership that could act as a catalyst for the modernization of the EU, to the benefit of both sides.

Bibliography

Aydın, Yaşar (2020). Modernisation of the EU–Turkey Customs Union, Centre for Applied Turkey Studies, Working Paper No. 3 (Berlin: Stiftung Wissenschaft und Politik). Retrieved from https://tinyurl.com/2a8h6c42 on March 24, 2024.

Aydın, Yaşar; Bastian, Jens, and Schneider, Maximiliane (2024). Visualising the Dynamics and Potential of Economic Relations between Germany and Turkey. CATS Network Mapping (Berlin: Stiftung Wissenschaft und Politik). Retrieved from https://tinyurl.com/mr448fxk, on April 2, 2025.

Aşan, Dilek (July 29, 2023). AB sınırda karbon düzenleme mekanizması ve Türkiye uygulama takvimi. Retrieved from https://tinyurl.com/52v3srx9, (LinkedIn), on March 31, 2024.

Aşıcı, Ahmet Atıl (February 2024). A preliminary analysis of the Turkish Emissions Trading System. IPC—Mercator Analysis (Istanbul: Istanbul Policy Center), 4–6. Retrieved from https://tinyurl.com/yefxhdpd, on April 5, 2024.

Bennett, Vanora (July 29, 2021). Turkish exporters could face steep extra costs under new EU carbon rules, *European Bank of Reconstruction and Development* (Website), Retrieved from https://tinyurl.com/2p8y5zec on March 24, 2024.

Blanc, Bart Le and Mendoza, Isaac de Leon (February 2023). Potential conflicts between the European CBAM and the WTO rules. *Norton Rose Fulbright*. Retrieved from https://tinyurl.com/56en3udb on March 25, 2024.

CATS Network Perspectives (November 7, 2023). What are the implications of the European Green Deal for EU-Turkey relations? (Berlin: Stiftung Wissenschaft und Politik). Retrieved from https://tinyurl.com/4ancba79 on March 15, 2024.

Climate Home News (2021). Turkey ratifies the Paris Agreement after approving a 2053 net zero goal. Retrieved from https://tinyurl.com/4pcwbacy on March 15, 2024.

Eurometal (2024). Pilot phase of Turkey's ETS on track for 2025 launch: official. Retrieved from https://tinyurl.com/3dkr4czk, on April 3, 2025.

European Commission (2019). The European Green Deal, Retrieved from https://tinyurl.com/4u29w7y9 on March 8, 2024.

European Commission (2021). Carbon leakage. Retrieved from https://tinyurl.com/bdzd5yrn on March 24, 2024.

European Commission (November 4, 2024). Carbon Border Adjustment Mechanism. Retrieved from https://tinyurl.com/72c22et5 on March 8, 2024.

Federal Ministry for Economic Relations and Climate Action (2024). The EU emissions trading system—essential for the energy transition. Federal Ministry for Economic Relations and Climate Action. Retrieved from https://tinyurl.com/ya7w965b on March 24, 2024.

Güçlü, Bahar (November 7, 2023). What are the implications of the European Green Deal for EU-Turkey relations? CATS Network Perspectives (Berlin: SWP—Stiftung Wissenschaft und Politik). Retrieved from https://tinyurl.com/4ancba79 on March 31, 2024.

ITA (2024). Turkey—Country Commercial Guide: Selling to the Public Sector. International Trade Administration. Retrieved from https://tinyurl.com/yc6fjduj on December 10, 2024.

Kaya, Nuran Erkul. (November 22, 2023). Turkey to become party to Paris Climate Agreement on November 10. Anadolu Janis. Retrieved from https://tinyurl.com/45w44sr5 on March 24, 2024.

Joint Research Center (June 29, 2022). The twin green & digital transition: How sustainable digital technologies could enable a carbon-neutral EU by 2050 (Brussels: European Commission). Retrieved from https://tinyurl.com/3huyv7zk, on March 24, 2024.

Levi, Selin, Ayhan, Sinem and Baysal, Başar (2024, March). Strengthening Türkiye's climate change legislation: A comparative examination with Germany's federal climate change act. IPC–Mercator Analysis. Retrieved from https://tinyurl.com/yc87w567 on March 25, 2024.

Mathiesen, Karl (October 8, 2021). Europe offered Turkey cash to join Paris climate accord. Politico. Retrieved from https://tinyurl.com/46ry9t5a on March 15, 2024.

Nohl, Arnd-Michael (2017). Interview und Dokumentarische Methode: Anleitungen für die Forschungspraxis. Springer VS.

Numanoğlu, Nurşen and Sabuncu, Tanyeli Behiç (ed.). (2016). Addressing Climate Change from an Economic Policy Perspective. TÜSİAD Report No. T/2016, 12–583 (Istanbul: TÜSİAD). Retrieved from https://tinyurl.com/yzbjrxm8, on April 17, 2024.

Reuters (2022). Turkish cenbank raises mandatory exporters' FX revenue conversion rate to 40%. April 15, 2022. Retrieved from https://tinyurl.com/254n934n, on December 10, 2024.

Suárez, Mónica (2021). BBVA launches a takeover bid to buy 100% of the Turkish bank Garanti, 15.11.2021, retrieved from https://tinyurl.com/mt9nusp8, on April 3, 2025.

Turkish Ministry of Trade (2021). Green Deal Action Plan 2021 (in Turkish). Retrieved from https://tinyurl.com/4y7c2xf8, on December 10, 2024.

TÜSİAD (2021). Avrupa Yeşil Mutabakatı Döngüsel Ekonomi Eylem Planı Türk İş Dünyasına Neler Getirecek? Retrieved from https://tinyurl.com/24cr9ba2 on 10.12.2024.

United Nations Framework Convention on Climate Change (UNFCCC). The Paris Agreement. Retrieved from https://tinyurl.com/ym2azm4u on March 15, 2024.

Viola, Roberto (February 6, 2023). Twin transition as a driving force for a fair and prosperous future. *The European Files*. Retrieved from https://tinyurl.com/bdhc9v8b on March 24, 2024.

Weise, Zia (November 6, 2021). EU's looming carbon tax nudged Turkey toward Paris climate accord, envoy says. Politico. Retrieved from https://tinyurl.com/2pzswzr8 on March 12, 2024.

World Trade Organization (2024). Principles of the trading system. Retrieved from https://tinyurl.com/4yp5x9bh, on April 17, 2024.

Climate-Resilient / Friendly City and Sustainable Urban Development

Ahmet Özaslan[22] and Hüseyin Gül[23]

7.1 Introduction

Covering less than 3 percent of land area on Earth, cities consume 80 percent of all energy, and 75 percent of all natural resources produced in the world, furthermore, they emit approximately 75 percent of global carbon emissions (UNDP, 2024; Shirgir, Kheyroddin and Behzadfar, 2019). It is predicted that more than 70 percent of people living on Earth will reside in urban areas by 2050. According to the United Nations Environment Program (UNEP) (2021), it is probable that global warming will reach a level of around 2.7°C by the end of this century. As reported by the Intergovernmental Panel on Climate Change (IPCC) (2023), global warming and climate change have drastically intensified in recent decades, with extreme climate events and adverse consequences, losses and damage to nature, human life and livelihoods around the globe. At present, approximately 60 percent of cities with a population of 500,000 inhabitants or more are at high risk of exposure to natural disasters such as tornadoes, droughts, floods, earthquakes, rising sea levels, water scarcity, landslides and volcanic eruptions, and this figure is increasing (UN, 2018). Consequently, as these represent major threats to urban areas, it is imperative to build the capacity of cities and create sustainable, resilient urban systems to address and resist the problems faced.

Stressors and shocks caused by climate change have widespread adverse direct impacts on people, societies, economies, and ecosystems, affecting cities and all other types of human habitats with regard to health, livelihoods, environment and quality of life. The future sustainability of cities is closely related to types of clean energy sources used, the extent of global carbon

[22] Dr., Independent Researcher, Political Science and Public Administration, Email: ahmetozaslan07@hotmail.com, ORCID: 0000-0002-0832-7337.

[23] Prof. Dr., Süleyman Demirel University, Department of Political Science and Public Administration, E-mail: huseyingul@sdu.edu.tr, ORCID: 0000-0001-6901-541X.

emission reduction, and the overall development of sustainable solutions to climate change (UNDP, 2024). Taylor (2017) asserts that cities are major contributors to the issue of climate change: "Without cities there would be no anthropogenic climate change [...] and understanding cities is totally central to researching anthropogenic climate change." Thus, climate science and policy are important subjects for urban studies. In this regard, sustainable city approaches, especially climate-resilient city approach, have gained importance over the last few decades. In addition to global efforts to tackle climate change, the development of regional and local solutions requires city governments to approach the environment with climate-resilient city and sustainable development perspectives. Thus, cities, which are both culprits and victims of climate change and are most deeply impacted by it, have a critical role to play in the fight against climate change.

According to the UN Framework Convention on Climate Change (UNFCCC) (2015), meeting the needs of a rapidly growing urban population and developing a sustainable urban infrastructure is predicted to require an investment of 6 trillion US$ by 2030. Designing a sustainable and resilient new urban world and involving cities in the fight against climate change will determine the success or failure of the global path to climate-resilient cities, and zero- or low-emission development. The 2030 Agenda for Sustainable Development through Sustainable Development Goals (UN, 2015), Habitat Program (UN-HABITAT) through Medellin Collaboration on Urban Resilience, HABITAT III, City Climate Leadership Group (C40), Global Covenant of Mayors for Climate and Energy, and UN-HABITAT's Cities Resilience Profiling Programs are all global initiatives with the goal of addressing climate-related challenges urban areas face today. In 2015, more than 400 city mayors gathered during the Paris climate conference, and requested closer involvement in climate negotiations because the implementation of any global agreements would not be successful without the leading role of cities in combating the causes and consequences of global warming and climate change at global, national and local levels (Heikkinen, Ylä-Anttila and Juhola, 2018; Sancino et al., 2021; Tollin, 2015).

Making cities climate resilient is one of the key areas requiring urgent policy development. In this regard, mitigation and adaptation strategies constitute the most important part of a climate-resilient city approach. These strategies play a pivotal role in tackling the impacts of climate change, slowing down the rate of global warming, and mitigating the severity of climate change impacts. Adaptation and mitigation strategies, as the major responses to climate change, are essential constituents of climate-compatible, resilient and sustainable urban development (Xiao, Xinhu Li and Wang, 2011). Accordingly, this struggle and related strategies rely on the components of both resilience and sustainability perspectives.

In order to address the challenges and risks caused by climate change, significant changes need to be made in the planning and management of cities (Tekin, 2023). In this regard, contemporary urban governance and planning has an important role to play in the construction of climate-resilient or friendly cities in order to cope with climate change and its consequences. Implementation methods often consist of measures to improve or strengthen the spatial, environmental and socioeconomic aspects of urban areas and life. It is possible to address common aspects of the relationship between a climate-resilient city approach and sustainable urban development, growth and regeneration from a multidimensional perspective, as all the relevant approaches contain components that support and complement each other. Within the scope of this study, the importance of sustainable urban development and resilient city policies are discussed on the basis of a literature review, with a view to managing cities in a more resilient and climate-friendly manner in the face of shocks or stresses resulting from climate change.

7.2 Climate Change and Cities

Climate change refers to significant variance of temperatures on Earth over a longer-term trend compared to average weather conditions and short-term natural weather variability (World Bank, 2024). There are also extreme and unprecedented forms of climate change, which are referred to as catastrophes. Climate change as a catastrophe occurs “when the climate system is forced to cross some threshold, triggering a transition to a new state at a rate determined by the climate system itself and faster than the cause” (NRC, 2002). There are many recent extreme weather events that are examples of such catastrophic climate change.

> [...] It is now an established fact that human-induced greenhouse gas emissions have led to an increased frequency and/or intensity of some weather and climate extremes since 1850, in particular for temperature extremes. Evidence of observed changes and attribution to human influence has strengthened for several types of extremes, in particular for extreme precipitation, droughts, tropical cyclones and compound extremes (including fire weather). (IPCC, 2021)

Extreme weather events have also been adversely impacting urban areas and people's well-being, inflicting damages and losses (Lomba-Fernández, Hernantes and Labaka, 2019).

During the last century, the carbon cycle has been disrupted and continues to be disrupted in the twenty-first century for reasons such as the extensive use of fossil fuels, overproduction, or urban and population growth. As a result of these factors, carbon dioxide, along with other greenhouse gases such as methane and fluorinated gases, has accumulated in the atmosphere, leading to the creation of a greenhouse effect, global warming, and thus a change in climate (Duman and Bilgili, 2022). The issue of climate change has become increasingly severe, as it has intensified its impact on all aspects of human and natural lives at every scale.

The impacts of climate change on human settlements are divided into two categories: direct and indirect. Direct impacts refer to settlement processes that are directly affected by climate and weather conditions, while indirect impacts refer to other already present socioeconomic processes. These effects could be observed in a number of areas, including institutional health systems, buildings and other built structures, transportation infrastructure, solid waste and water management, surface drainage systems, urban green areas, energy supply and consumption, local/regional economic activities and the level of exposure of disadvantaged groups to climate change. Therefore, the effects of climate change, especially on urban areas, have become critical both socio-economically and environmentally in terms of urban safety and protection from disasters (Hungarian Ministry of Interior et al., 2011). Prasad et al. (2009) classified the effects of climate change into three groups: Environmental, economic and social impacts. These are as follows:

> *Environmental Impact:* Consequences related to coastal and marine systems, forest cover, biodiversity, and other environmental assets.
> *Economic Impact:* Dimensions such as threats to water security, impacts on agriculture and fisheries, disruption of tourism and decreased energy

security, all of which negatively affect the Gross Domestic Product (GDP).

Social Impact: Consequences such as population displacement, increased health problems, decrease in livelihoods and quality of life.

Rising global concerns about the negative impacts caused by climate change have paved the way for climate-based negotiation efforts between international organizations and countries. At the UN Environment and Development Conference held in Rio de Janeiro in 1992, the UNFCCC was signed, and the Global and Local Agenda 21 were adopted. The Convention recognized that human-induced interference with the climate system has contributed to the build-up of greenhouse gases in the atmosphere, and that this increase had to be stabilized at a certain level in order to prevent a further worsening of the climate crisis. Such stability would allow ecosystems to naturally adapt to climate change, reduce stress on food production, and help economic development to progress sustainably (UN, 1992). Another international protocol was adopted in Kyoto in 1997 and entered into force in 2005 as a result of the efforts by the United Nations and other international organizations, aiming to reduce global greenhouse gas emissions by at least 5 percent compared with 1990 levels by 2012 (UN, 2002). Since then, the goal of reducing greenhouse gas emissions has been pursued at subsequent COP meetings.

The UN Sustainable Development Goals, known as Agenda 2030, were adopted on May 27, 2015, including 17 goals and 169 targets. The issue of combating global climate change is set out in goals 6, 11, 13, 14 and 15. It could be argued that the main emphasis of climate change within these goals is the creation of a framework based on environmentally based issues such as the protection of the ecosystem and biological diversity, resilient cities, effective use of natural resources, or drought and desertification, without compromising the goal of sustainable development (UN, 2015).

In addition to these international efforts, the Paris Agreement was signed in 2015. The main goal of this Agreement is to enhance resilience against the negative effects of climate change, achieve development with reduced greenhouse gas emissions, stabilize the financial flow for the fight against climate change, keep global warming below 2°C, or even limit it to 1.5°C if possible (Koçak and Bozyurt, 2021). In this Agreement, implementation processes and measures regarding national contributions, mitigation and adaptation strategies, losses, damages, and technology use and transfer, among others, have been determined to combat climate change (Dışişleri Bakanlığı, 2024). In short, it could be argued that with this Agreement, despite its promised long-term goals, international awareness has been raised toward reducing climate change and greenhouse gas emissions, and that a road map for decreasing or halting negative effects has been determined (CLC, 2020).

7.3 Relationship Between Climate Resilience and Strategies to Combat Climate Change

The concept of resilience, as employed in disciplines such as ecology, sociology, geography, urban studies, public policy, architecture and economics, is a fundamental construct referring to the capacity of a system to reduce and prevent risks and threats arising from factors such as climate change, natural disasters, economic crises, urbanization, migration and globalization (Bilgili and Yıkıcı, 2022). The concept of resilience to climate change pertains to the capacity of humans, human systems and ecosystems to withstand and adapt to shifting global climates and their attendant repercussions (Shirgir, Kheyroddin and Behzadfar, 2019). A city's ability to withstand climate stress or crises, and to recover from disasters, depends on its capacity as a system to survive and adapt to damages, thriving by taking advantage of opportunities in response. Building climate resilience necessitates a comprehensive societal and governance initiative at all levels, ranging from the local to the global. All stakeholders, private and civic organizations, public agencies and citizens need to collaborate to establish an enabling urban system or any ecosystem that will fortify its climate resilience (CLC, 2020).

The most important strategies of climate-resilient city policies are reducing or mitigating the harmful impact of climate change on cities and adapting to the already emerging consequences of climate change (Tuğaç, 2021). *Mitigating climate change* consists of measures that reduce greenhouse gas emissions resulting from human activities in urban areas, or expand carbon sink areas in cities, among others. The scope of increasing carbon reduction in general includes the transition from fossil fuels to renewable energy sources, afforestation and reforestation. *Adaptation to climate change* encompasses interventions that prevent, diminish, or halt current and expected damage and losses caused by climate change. Adaptation strategies include building dams and polders against rising sea levels, taking advantage of natural and artificial shade to reduce urban heat increase, and exhibiting conscious behavior in times of shocks and crises (CLC, 2020).

To summarize, mitigation strategies represent one-half of the battle against climate change; the other half is adaptation to it (Tuğaç, 2021). While the effects of climate change mitigation strategies may be global and widespread, adaptation strategies have to be more tailored toward local needs and characteristics, and carried out at the local level. In general, adaptation strategies are used for short-term exposure to shocks, stresses, crises, and disasters. Although there are minor differences in action between both of these strategies, they aim to control, alleviate, and balance climate change and its impact, ensuring the habitability and safety of the planet for future generations in the context of principles of sustainability and resilience (Shirgir, Kheyroddin and Behzadfar, 2019).

7.4 Climate-Friendly/Resilient City Approach

The concept of resilience has been applied in various fields and contexts as in the cases of engineering resilience, ecological resilience and socio-ecological resilience (Özaslan and Gül, 2023). It is also possible to extend this variation by including "epidemical resilience" or "resilience to natural disasters or pandemics" (Negiz and Savaş Yavuzçehre, 2021). The prevailing idea in all of these concepts is that socio-ecological resilience provides a better conceptual base for urban resilience (Sharifi and Yamagata, 2016). Socio-ecological resilience works as a mechanism of sustainability and emphasizes the need to understand the development and evolution of complex adaptive systems, the role of disruption, and the triggering forces for the collapse of complex systems (Childers et al., 2015).

Although the concept of a climate-resilient city has attracted widespread attention from academics and policy makers, theoretical and empirical research in this area is still inadequate. Quantitative evaluations on the concept of climate-resilient cities and its effectiveness are also limited in the literature (Liang, 2021). Current related research focuses on the evaluation of the characteristics, planning and construction of climate resistant cities.

Definitions for climate-resilient cities and the description of their characteristics are discussed in the related literature extensively. Besides, planning and building climate-resilient cities is studied from perspectives such as urban governance, urban and regional planning, disaster prevention and control in urban areas, among others. Similarly, this paper also presents a detailed review of the literature on a climate-resilient city perspective in order to construct its theoretical and conceptual base.

The concept of a resilient city refers to the ability of a city to maintain its desired functions at all times in the face of a shock or crisis, to adapt to climate change, and to quickly overcome obstacles that limit its adaptive capacity and bounce back (Meerow, Newell and Stults, 2016). Therefore, a city's resilience depends on its ability to absorb, recover and prepare for future shocks and crises. Such cities promote sustainable and inclusive growth, urban safety and livability, quality of life through their capacity for flexibility, adaptability, resilience, and diversity (OECD, 2016). The principle of urban resilience points to the necessary updating of planning and urban management schemes in line with proactive strategies to reduce risk, damage and loss, and adapt to environmental, management and socioeconomic changes (Poli, Ravagnan and Ricci, 2022).

Climate resilience is a state that strengthens the sustainability of a socio-ecological system, and that ensures the preparedness and agility of a system to respond to the consequences of climate change. This state or condition is based on the capacity of a system to absorb stress and maintain normal functioning, as well as adapt and reorganize in the face of pressures imposed by climate change (Shirgi, Kheyroddin and Behzadfar, 2019). The concepts of climate and city are often used together with the concepts of a resilient, ecological, green, sustainable or environmentally friendly city. In summary, a climate focused, friendly or resilient city is one in which urban development and planning, governance, growth policies, urban services and programs do not damage the environment—rather, they mitigate or halt the harmful effects of climate change gradually, and maintain the sustainability of the system (Tekin, 2023). Henstra (2012) lists a series of measures related to effective urban climate adaptation policy for climate-resilient cities. These are as follows:

- Hazard, vulnerability and risk assessment
- Increasing public awareness, and knowledge of weather-related risks

- Risk-avoiding land use planning
- Protection of infrastructure
- Emergency management

In short, the main goal in climate resistant cities is to prepare them for possible future climate-related stresses and shocks, building up strong capacities for cities to deal with the harmful effects of climate change. Climate resistant city policies involve both reducing or halting the adverse effects of climate change on cities and finding solutions to the issue of climate change by preparing cities and urban residents for the undesired and detrimental consequences of climate change and other stresses, risks, crises and disasters that exist, have occurred or may occur (Duman and Bilgili, 2022).

7.5 Importance of Sustainable Urban Development in Combating Climate Change

The challenge of securing necessary resources, providing a life worthy of human dignity for citizens, and protecting them from risk and harm are all challenges that must be met. In order to address these challenges, there is a necessity to prepare comprehensive urban planning that involves climate action plans, and to enhance urban management systems so as to minimize climate impacts (Xiao, Xinhu Li and Wang, 2011). Cities are both culprits as major contributors to and victims of climate change, and, as such, should be considered key actors in the development of sustainable solutions to climate change. Cities have many potentials to generate solutions that are required to prevent climate change, thereby reducing, mitigating and halting the damage and losses that are caused by it. Urban energy systems, renewable energy, energy-efficient buildings, sustainable transportation, urban planning for green areas, waste management and behavioral patterns among urban residents are some of the tools, methods and strategies used to fight climate change in urban areas (Uncu, 2019). Good urban governance, sustainable planning and climate action plans are seen as necessary to mitigate and adapt to climate change, based on the following measures (Shalaby and Aboelnaga, 2017):

- Increased use of renewable energy
- Development of sustainable urban transportation systems
- Resettlement of urban populations susceptible to climate change risks

- Controlling urban growth patterns through land use and zoning regulations
- Increasing citizen involvement in urban planning and tackling climate change
- Strengthening and constructing climate and disaster resilient settlements
- Identifying climate-resilient areas and alternative areas appropriate for urban growth
- Developing measures for and construction of climate-resilient infrastructure (e.g., building and improving embankments and developing or conserving sponge areas)

Participatory, open and collaborative public governance of urban areas is a critical factor in developing effective networks and solutions to combat climate change. Urban governance and planning are directly connected to several key areas, including city form, land use and zoning, or transportation systems, as well as sustainable and climate-resilient urban development (Sınmaz, 2013). To overcome the challenges in building sustainable settlements, participatory urban governance helps to identify common urban development priorities. These priorities should be consistent with shared and differentiated responsibilities of countries (and cities) in the fight against climate change (UN, 2013). Sustainable and climate-resilient urban development or growth plans are critical to improving urban living standards and supporting climate-based urban resilience (Asian Development Bank, 2013). Newman, Rauland and Holden (2011), along with Jabareen (2006), propose to evaluate sustainable urban form via concepts such as compact, mixed and dense use of urban land and settlement, sustainable urban transportation, afforestation and greening, passive solar design, increased utilization of renewable energy, carbon neutrality, and eco-efficiency.

Urban development is an urban policy tool with the potential to facilitate the implementation of urban policies for climate change. Interventions inherent in urban development or renewal processes can be used to improve city life and thereby change the form and settlement of cities in a climate-friendly and resilient way (Balaban and Puppim de Oliveira, 2014). The conceptual overlap of urban development models from past to present is an indicative of their support for holistic harmony. However, it can be seen that the criteria, indicators, policies, land uses, technology and information systems, ecosystem and resource uses that support the formation of urban development approaches over time vary according to their purpose (Erdem, 2022). New approaches to urban transformation, growth, development, regeneration or renewal have emerged in recent decades, including, but not limited to, "eco-city," "compact city," "smart city" (Tuğaç, 2018; 2022), "green city," "livable city," "sustainable city," "low-carbon cities," and "digital or smart city" (Sınmaz, 2013; Sulak, 2018). Furthermore, a range of climate-based strategies have been developed in order to address the issue of climate change. These include urban or climate action planning, as well as urban development strategies such as sponge cities, carbon capture technologies, green infrastructures, sustainable rain or surface drainage systems, and others (Xu, Liu and Ding, 2021). Sustainable and resilient city models in the face of climate change seek to mitigate or halt adverse consequences by enhancing city structures in a climate-compatible manner; aiming to strengthen urban capacity to return to the state previously experienced before the problem occurred, and to ensure sustainability (Duman and Bilgili, 2022).

The objective of enhancing the health and livability of urban areas is inherently aligned with the concept of sustainability. Economic, environmental, social, and governance dimensions of sustainability contribute to the development of more climate-resilient forms of cities through enhanced disaster risk management and adaptation systems. This also contributes to the long-term preservation of urban safety, quality of life, and environmental biodiversity of a city or community. Consequently, this enables a multidimensional perspective on the common aspects of the relationship between resilient, climate-resilient, and sustainable cities (Özaslan and Gül, 2023). The sustainability approach is intended for the achievement of long-term goals, whereas the resilience approach is employed in order to counteract shocks and swiftly return to the pre-crisis state by making quick decisions and taking speedy actions with a view to preserving and maintaining the system (Shirgir, Kheyroddin and Behzadfar, 2019). Considered from an urban-climate perspective, the vision of a climate-resilient city involves creating livable cities with clean air and green spaces, sustainable transportation, a vibrant and healthy urban lifestyle, effective solid waste and sewer water management, and safe living areas, among other factors (Tekin, 2023). In this context, the importance of environment-based urban growth approaches, developed with consideration for climate change and the harmony and sensitivity of a city with its environment, becomes evident.

Tuğaç (2018) asserts that it would be more appropriate to choose an eco-compact city approach when including climatic factors in urban governance, planning and design. Maltaş Erol and Görmez (2021) point out that walkability is an important tool in creating a resilient and sustainable city. Because walkability offers a cheap, easy and socially equitable transportation opportunity, it shares common ground with urban resilience. In particular, the widespread use of bicycles in urban transportation or the use of electric public transportation will facilitate a low-carbon lifestyle, and the establishment of a climate-friendly or resilient city (Tekin, 2023). Smart cities are very effective in combating climate change by making use of smart innovative tools in transportation, infrastructure, security and environment. These cities have considerable potential in this regard. The utilization of smart city strategies and policies for the purpose of safeguarding the environmental sustainability of urban areas is a far more efficacious approach when compared with conventional planning methodologies (Sezgin, 2023). Nevertheless, the fact that a city is considered to be "smart" does not automatically imply that it is "sustainable," since the connections between urban smart applications and sustainable cities are fragmented, and sustainability and human-centeredness are not always given due consideration seriously in smart city models (Gül, 2019). Further research is required, especially in areas such as green mobility, carbon footprint tracking and measurement, urban biodiversity, energy consumption or conservation, as well as waste and water management (Fallmann and Emeis, 2020).

The idea of sustainable urban development and regeneration, which has an important place in contemporary urban management and planning to combat climate change and natural disasters, will facilitate the construction of climate-friendly/resilient cities with planning and design principles for the comprehensive improvement of spatial, environmental, economic and social aspects (Özaslan and Gül, 2023). Therefore, climate-friendly/resilient urban planning plays an important role in mitigating and adapting to climate change (Fallmann and Emeis, 2020). Yet, it would be difficult to adapt a climate-friendly/resilient city approach in urban planning if a perspective of green infrastructure is not sufficiently integrated into climate-resilient urban planning or climate action planning processes. Climate change issues have a significant impact on the promotion of climate-friendly and green infrastructure in strategic urban development processes (Tekin, 2023). The

UNFCCC (2015) has taken several initiatives to build green infrastructure and climate-resilient cities, as well as to adapt to the harmful effects of climate change and prepare for the future, as outlined later:

- Support of ecosystem services
- Sustainable urban drainage systems
- Resilient food and agricultural systems
- Adaptation of housing and urban settlements
- Solidification of the knowledge base for compliance
- Establishment of economic and livelihood resilience
- Formation of research and development partnerships
- Integration of adaptation into planning at the local level
- Private sector participation and investment in adaptation strategies
- Climate resilience in transportation and telecommunication systems
- Development of data-based and natural solutions for climate resilience in cities

7.6 Conclusion

Cities have undergone changes from the past to the present and continue to do so. They are dynamic and complex systems with integrated economic, social, environmental and governance dimensions. Urban landscapes are subject to change due to a variety of factors, including population growth, urbanization, migration and urban development. High urbanization rates create significant spatial, environmental, social and economic challenges for cities and city governments with implications for the quality of urban life. While urban growth directly affects socioeconomic urban structure and life, especially fossil fuel consumption and excessive use of natural resources and land also inflict great damage to both natural and built urban environment. The most significant cause of this damage is the increase in the rate of carbon dioxide emissions released into the atmosphere, generating greenhouse gas effects. Carbon dioxide and other greenhouse gas emissions have a detrimental effect on the world's climate, resulting in an increase in the frequency of natural disasters and catastrophes. These include drought, tornadoes, floods, rising sea levels, water scarcity, fires, storms and landslides.

Cities are both the cause of climate change and the urban areas with the highest potential for solutions to this problem. It is vital to continue this endeavor in urban areas, given that cities are home to the majority of the global population and must provide healthy and livable environments for their residents. Acceptance of climate change and increased efforts to find solutions to create livable, safe and sustainable spaces worthy of human dignity provide an opportunity for a city vision that will shape the planning and governance of future cities. In order to make adequate use of this window of opportunity, a climate-friendly/resilient city perspective needs to be adopted, pursued and used as a basis for urban planning, climate action plans, and effective urban governance. Climate-friendly/resilient city policies and strategies would increase the resilience, adaptability, agility and strength of cities against the adverse impacts of climate change.

There are, of course, other valuable sustainable approaches to the city, such as the concepts of a compact city, an eco-city, a green city, a smart city, a sustainable city and low-carbon cities, among others. What is important from the perspective of a climate-friendly/resilient city is the identification and adoption of ways to combat, mitigate and adapt to climate change and its consequences. Greenhouse gas reduction, carbon tracking and carbon capture technologies and strategies, as well as adaptation strategies are essential in the fight against climate change-related stresses or shocks faced by cities. A climate-friendly/resilient city approach also offers such policy alternatives as increased use of renewable energy, green infrastructure, afforestation, efficient and compact land use, protection of biodiversity, ensuring blue-brown land balance, increased use of smart city policies, sustainable and smart urban transformation, or increased urban public involvement, among others. The critical aspect of climate-resilient city policies is related to improving existing opportunities to both adapt to climate change and mitigate its adverse impacts. Besides, climate-resilient city policies recognize the importance of integrating a sustainable city perspective and considering socioeconomic and environmental urban aspects in urban governance, planning, development and regeneration. In this regard, climate action plans should be considered as a pivotal part of a climate-resilient city perspective.

Urban development and planning are also closely linked to the climate-resilient city approach, as uncontrolled urban sprawl increases the intensity of pressure on the built urban environment and triggers expansion toward the urban periphery by increasing environmental degradation. Intensive construction and intense urban growth, which disrupt the ecological balance in urban areas opened to new settlements, result in the destruction of biodiversity, water resources and forest areas. Viewing urban land as the main means of generating rent tends to ignore the issue of sustainability of the natural and urban environment. New urban development areas with dense populations not only degrade the natural environment but also bring with them problems such as inadequate infrastructure and transport networks, low energy efficiency, or a lack of green space and climate-resilient urban transformation. Consequently, the design of climate-resilient urban policies should be such that they assist in the management of problems associated with urban growth, while simultaneously increasing compliance with sustainability principles.

Bibliography

Asian Development Bank (2013). *Moving from Risk to Resilience Sustainable Urban Development in The Pacific*. Asian Development Bank, Manila.

Balaban, O. & Puppim de Oliveira, J. A. (2014). Understanding the links between urban regeneration and climate-friendly urban development: Lessons from two case studies in Japan. *Local Environment, 19*(8), 868–890.

Bilgili, Y. & Yıkıcı, A. (2022). Kentsel Katı Atık Yönetim Türlerinin Kentsel Direnç Üzerindeki Etkisi. In: N. Bektaş (Ed.), *Çevre, İklim ve Afet: Dirençli Şehirler İçin Yol Haritası* (Cilt: 3, pp. 507–521). Nobel Yayıncılık, Ankara.

CLC (Centre for Livable Cities and Urban Land Institute) (2020). *Building Climate Resilience in Cities Worldwide: 10 Principles to Forge a Cooperative Ecosystem*. Centre for Livable Cities and Urban Land Institute, Singapore.

Childers, D. L., Cadenasso, M. L., Grove, J. M., Marshall, V., McGrath, B. & Pickett, S. T. A. (2015). An Ecology for Cities: A Transformational Nexus of Design and Ecology to Advance Climate Change Resilience and Urban Sustainability. *Sustainability, 7*, 3774–3791.

Csete, M. & Horváth, L. (2012). Sustainability and Green Development in Urban Policies and Strategies. *Applied Ecology and Environmental Research, 10*(2), 185–194.

Dışişleri Bakanlığı (2024). Paris Anlaşması. Retrieved from https://www.mfa.gov.tr/paris-anlasmasi.tr.mfa, on August 20, 2023.

Dumanlı, Y. & Bilgili, A. (2022). Kentlerin İklim Değişikliği Üzerine Etkisi: İklim Değişikliği İle Mücadelede Kentlerin Önemi ve Başarılı Uygulama Örnekleri. In: H. Ateş (Ed.), *Dirençli Şehirler İçin Vizyoner Yönetim* (Cilt: 1, pp. 119–136). Nobel Yayıncılık, Ankara.

Erdem, N. (2022). Dirençli Kent ve Kompakt Kent Modellerinin Sürdürülebilirlik Çerçevesinde Değerlendirmesi. *Eurasian Journal of Forest Science, 10*(3), 183–206.

Fallmann, J. & Emeis, S. (2020). How to Bring Urban and Global Climate Studies Together with Urban Planning and Architecture? *Developments in the Built Environment 4*, 2–9.

Gül, H. (2019). Sürdürülebilir Akıllı Kent Yönetimi ve Politikaları. In H. Sağır (Ed.), *Küreselleşme ve Dönüşen Kent* (pp. 97–118). Orion Kitabevi, Ankara.

Heikkinen, M., Ylä-Anttila, T. & Juhola, S. (2018). Incremental, Reformistic or Transformational: What Kind of Change do C40 Cities Advocate to Deal with Climate Change? *Journal of Environmental Policy & Planning, 21*(1), 90–103.

Henstra, D. (2012). Toward the Climate-Resilient City: Extreme Weather and Urban Climate Adaptation Policies in Two Canadian Provinces. *Journal of Comparative Policy Analysis: Research and Practice, 14*(2), 175–194.

Hungarian Ministry of Interior—VATI Hungarian Nonprofit Ltd. for Regional Development and Town Planning (2011). *Climate-Friendly Cities—A Handbook on the Tasks and Possibilities of European Cities in Relation to Climate Change*. Hungarian Ministry of Interior—VATI, Budapest.

IPCC (2021). *Climate Change 2021: The Physical Science Basis*. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change-IPCC. Cambridge University Press, Cambridge, UK and New York, NY, USA.

IPCC (2023). Summary for Policymakers. In: H. Lee & J. Romero (Eds.), *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1–34). IPCC, Geneva, Switzerland.

Jabareen, Y. (2006). Sustainable Urban Forms Their Typologies, Models, and Concepts. *Journal of Planning Education and Research*, (26), 38–52.

Jabareen, Y. (2013). Planning the Resilient City: Concepts and Strategies for Coping with Climate Change and Environmental Risks. *Cities, 31*, 220–229.

Koçak, H. & Bozyurt, O. (2021). Küresel İklim Değişikliğine Yönelik Çözüm Odaklı Yaklaşımlar. *Journal of Social, Humanities and Administrative Sciences, 7*(47), 2468–2479.

Liang, Z. (2021). Assessment of the Construction of a Climate Resilient City: An Empirical Study Based on the Difference in Differences Model. *Int. J. Environ. Res. Public Health, 18*(2082), 1–20.

Lomba-Fernández, C., Hernantes, J. & Labaka, L. (2019). Guide for Climate-Resilient Cities: An Urban Critical Infrastructures Approach. *Sustainability, 11*(17), 1–19.

Maltaş Erol, A. & Görmez, K. (2021). Yürünebilirliğin Kentsel Dirence Etkisi: Eskişehir Karapınar Mahallesi Örneği. *Eskişehir Osmangazi Üniversitesi Sosyal Bilimler Dergisi, 22*(2), 441–459.

Meerow, S., Newell, J. P. & Stults, M. (2016). Defining Urban Resilience: A Review. *Landscape and Urban Planning, 147*, 38–49.

Negiz, N. & Savaş Yavuzçehre, P. (2021). *Viral Çağda Kent ve Kentsel Bağışıklık*. Gazi Kitabevi, Ankara.

Newman, P., Rauland, V. & Holden, D. (2011). Creating Resilient Cities: How A New Generation of Tools Can Assist Local Governments in Achieving Carbon Their Abatement Goals. *5th State of Australian Cities National Conference*, November 29–December 2, Melbourne, Australia.

NRC (National Research Council) (2002). *Abrupt Climate Change: Inevitable Surprises*. National Academy Press, Washington, DC.

OECD (2016). *Resilient Cities: Preliminary Version*. Retrieved from https://bebka.org.tr/wp-content/uploads/2021/07/Resilient-Cities-OECD.pdf on January 14, 2024.

Özaslan, A. & Gül, H. (2023). İklim Dirençli Kentler, Sürdürülebilirlik ve Kentsel Dönüşüm. In: H. Gül, H. Küçük Bayraktar & V. E. Çetintürk (Ed.), *İklim Dostu Kentler Türkiye'den ve Dünyadan İklim Dostu Kent Örnekleri* (pp. 38–73). Detay Yayınevi, Ankara.

Poli, I., Ravagnan, C. & Ricci, L. (2022). A Planning Framework for Urban Resilience toward Climate Adaptation and Mitigation: Potentials and Limits of "Eco-Districts." *Urban Science, 6*(49), 1–28.

Prasad, N., Ranghieri, F., Shah, F., Trohanis, Z., Kessler, E. & Sinha, R. (2009). *Climate Resilient Cities A Primer on Reducing Vulnerabilities to Disasters*. The International Bank for Reconstruction and Development/ The World Bank, Washington.

Sancino, A., Stafford, M., Braga, A. & Budd, L. (2022). What Can City Leaders do for Climate Change? Insights from the C40 Cities Climate Leadership Group Network. *Regional Studies, 56*(7), 1224–1233.

Sezgin, S. (2023). İklim Dostu Kentlerde Akıllı İnovasyon Uygulamaları: Sydney Örneği. In: H. Gül, H. Küçük Bayraktar & V. E. Çetintürk (Ed.), *İklim Dostu Kentler Türkiye'den ve Dünyadan İklim Dostu Kent Örnekleri* (pp. 233–249). Detay Yayınevi, Ankara.

Shalaby, H. & Aboelnaga, S. (2017). Climate Change Impacts On Urban Planning in The Cities. *The 1st International Conference: Towards A Better Quality of Life*, November 24–26, 2017, Technische Universität Berlin Campus El Gouna, Egypt.

Sharifi, A. & Yamagata, Y. (2016). Urban Resilience Assessment: Multiple Dimensions, Criteria, and Indicators. In: Y. Yamagata and A. Sharifi (Ed.), *Urban Resilience: A Transformative Approach* (pp. 259–276). Springer, Cham.

Shirgir, E., Kheyroddin, R. & Behzadfar, M. (2019). Developing Strategic Principles of Intervention in Urban Green Infrastructure to Create and Enhance Climate Resilience in Cities—Case Study: Yousef Abad in Tehran. *Journal of Climate Change, 5*(1), 61–73.

Sınmaz, S. (2013). Yeni Gelişen Planlama Yaklaşımları Çerçevesinde Akıllı Yerleşme Kavramı ve Temel İlkeleri. *Megaron, 8*(2), 76–86.

Sulak, B. (2018). The New Planning Approaches and Smart Cities. *SETSCI Conference Indexing System, 3*, Samsun, 808–813.

Tollin, N. (2015). *The Role of Cities and Local Authorities Following COP21 and the Paris Agreement*. Retrieved from https://upcommons.upc.edu/handle/2117/82004, on February 29, 2024.

Taylor, P. J. (2017). Cities in Climate Change. *International Journal of Urban Sciences, 21*(1), 1–14.

Tekin, Ö. F. (2023). Global Climate Change and Climate-Smart Urban Development: The Case of Hyllie. *Yönetim ve Ekonomi Araştırmaları Dergisi*, *21*(3), 473–502.

Tuğaç, Ç. (2018). Türkiye İçin İklim Değişikliğine Dayanıklı Kentsel Planlama Modeli Önerisi: Eko-Kompakt Kentler. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *32*(4), 1047–1068.

Tuğaç, Ç. (2021). Kentsel Sürdürülebilirlik, Dirençlilik ve İklim Değişikliğiyle Mücadele Bağlamında Yerel Yönetimler Üzerine Bir Değerlendirme. *Çağdaş Yerel Yönetimler Dergisi*, *30*(2), 21–69.

Tuğaç, Ç. (2022). İklim Dirençli Kalkınma Bağlamında Kentleşme Politikaları. *İdealkent Dergisi*, *13*(37), 1640–1666.

UN (1992). *United Nations Framework Convention on Climate Change*. FCCC/INFORMAL/84. Retrieved from https://unfccc.int/resource/docs/convkp/conveng.pdf, on February 5, 2024.

UN (2013). *Towards Sustainable Cities*. Retrieved from https://www.un.org/en/development/desa/policy/wess/wess_current/wess2013/Chapter3.pdf, on February 7, 2024.

UN (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. A/RES/70/1. Retrieved from https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf, on February 5, 2024.

UN (2018). *The World's Cities in 2018 (ST/ESA/SER.A/417)*. Retrieved from www.un.org/en /development/desa/population/publications/pdf/urbanization/the_worlds_cities_in_2018_data_booklet.pdf, on September 10, 2024.

Uncu, B. A. (2019). *İklim İçin Kentler Yerel Yönetimlerde İklim Eylem Planı*. +350, İstanbul.

UNDP (2024). *Cities Have A Key Role To Play In Tackling Climate Change—Here's Why*. Retrieved from https://climatepromise.undp.org/news-and-stories/cities-have-key-role-play-tackling-climate-change-heres-why, on November 14, 2024.

UNEP (2021). *The Heat is on: A World of Climate Promises Not Yet Delivered—Emissions Gap Report 2021*. UNEP, Nairobi. Retrieved from file:///C:/Users/huseyingul/Downloads/EGR21.pdf, on February 29, 2024.

UNFCCC (United Nations Framework Convention on Climate Change) (2015). *Building Climate Resilience in Urban Areas*. Retrieved from https://unfccc.int/files/adaptation/application/pdf/calendar_final.pdf on January 02, 2024.

UNFCCC (United Nations Framework Convention on Climate Change) (2002). *A Guide to the Climate Change Convention and Its Kyoto Protocol*. Climate Change Secretariat Bonn. Retrieved from https://unfccc.int/sites/default/files/guideconvkp-p.pdf, on February 2, 2024.

World Bank (2024). *What is Climate Change*? Retrieved from https://climateknowledgeportal.worldbank.org/overview#:~:text=Climate%20change%20is%20the%20significant,change%20from%20natural%20weather%20variability, on February 29, 2024.

Xiao, L., Xinhu Li, X. & Wang, R. (2011). Integrating climate change adaptation and mitigation into sustainable development planning for Lijiang City. *International Journal of Sustainable Development & World Ecology, 18*(6), 515–522.

Xu, H., Liu, L. & Ding, P. (2021). Building Climate Resilient City through Multiple Scale Cooperative Planning: Experiences from Copenhagen. *IOP Conf. Series: Materials Science and Engineering, 1203*(032063), 1–10.

Cooling Cities Through Street Tree Plantation as a Nature-Based Solution: Case Study of Antalya

Derya Arabacı,[24] Çağdaş Kuşçu Şimşek[25] and Büşra Öztürk[26]

8.1 Introduction

One of the major environmental challenges arising from urbanization is the increase in urban temperatures, primarily driven by human activities (Yang et al., 2019; Bai et al., 2018; Gaur, 2018; Garuma, 2018; Ng and Ren, 2018; Xu et al., 2017; Bassett et al., 2016). The urban climate is influenced by various factors, making it both complex and difficult to assess. A review of the literature reveals that elements such as land use and land cover (LULC), impervious surface areas, vegetation density, urban structure, bare soil, proximity to natural cooling elements (such as forests and water bodies), population density, emissivity, albedo, elevation, seasonal variations, and energy consumption (Buyantuyev et al., 2010; Jalan and Sharma, 2014; Kuşçu Şimşek and Ödül, 2019) play a significant role in urban warming. Among these, the two most influential factors are the growing proportion of impervious surfaces and the decreasing density of green space.

Increasing the city's natural cooling capacity is the most effective, environmentally friendly, economical, and feasible strategy for mitigating urban temperature rise (Qiu and Jia, 2020; Aram et al., 2019; Carvalho et al., 2017; Byrne and Jinjun, 2009). Forested areas, green spaces, street afforestation, water surfaces, coastlines, and undeveloped valleys are critical in enhancing urban cooling (Güldü and Kuşçu Şimşek, 2022; Kuşçu Şimşek, 2020;

24 Ph.D., Atça Vocational School, Department of Architecture and Urban Planning, Land Registry and Cadastre Program, Aydın Adnan Menderes University, Aydın, Türkiye, derya.isik@adu.edu.tr, 0000-0003-0795-9970.

25 Assoc Prof. Dr., Akdeniz University, Faculty of Science, Department of Space Science and Technology - Remote Sensing and GIS, Antalyaö Türkiye, cksimsek@akdeniz.edu.tr, 0000-0002-3161-6508.

26 M.Sc. Student, Akdeniz University, Faculty of Science, Department of Space Science and Technology, Antalya, Türkiye, busraolgun1998@gmail.com, 0000-0001-6176-7764

Fabijańczyk and Zawadzki, 2022; Wang et al., 2018; Du et al., 2017; Feyisa et al., 2014; Honjo and Takakura, 1990).

As posited by Astor (2019), streets represent the most expansive public domains within urban settlements. They serve a pivotal function in influencing the urban climate's comfort level through their design and landscaping. The climate of urban environments is influenced by factors such as street layouts, building height-to-street width ratios, architectural configurations, facade materials, green zones, street tree planting, and tree species characteristics (Ren et al., 2021; Qaid et al., 2018; Lee and Mayer, 2018; Chatzidimitriou and Yannas, 2017). Thus, the impact of landscape and urban design on climate must be considered during the planning process. However, many cities often overlook the importance of aligning designs with the local climate. Particularly after the urban morphology and construction phases are completed, regulating climatic comfort becomes challenging. In this context, landscape design solutions, such as considering more affordable alternatives to green roofs with more affordable options like facade material adjustments and green wall installations, offer the most effective approach (Razzaghmanesh et al., 2016; Mohajerani et al., 2017).

Landscape design techniques offer valuable advantages in enhancing urban-climate comfort, particularly in densely populated areas. Creating cool islands to maximize natural cooling potential is among the most effective strategies (Gebert et al., 2019; Revelli and Porporato, 2018). Street afforestation is a key method within this approach, providing both evaporation and shading to reduce air temperatures and improve urban-climate comfort (Wang and Akbari, 2016; Armson et al., 2012). Study findings comparing surface temperatures of streets exposed to direct sunlight versus those shaded by trees clearly underscore the significance of street afforestation (Gillner et al., 2015).

Due to global climate change and rapid urbanization, more people are likely to experience extreme weather events, such as heatwaves (Ward et al., 2016). Human comfort standards generally define ideal environments as those with air temperatures ranging from 17°C to 24.9°C and humidity levels below 65 percent (Çetin, 2020). These parameters serve as foundational benchmarks in establishing optimal conditions for human habitation and activities. Within this temperature range, individuals often experience a sense of comfort and well-being, conducive to various daily endeavors. However, in a place like Antalya, the average temperature in the summer months is as high as 35°C and humidity levels exceed 64 percent. Consequently, urban residents face increased climatic risks due to a rise in extremely hot days. Ensuring bioclimatic comfort in Antalya is thus of paramount importance.

The significance of street afforestation in improving the bioclimatic comfort of Antalya is underscored in this study. Utilizing synthetic images of afforested streets generated through the deformation of satellite imagery, Artificial Neural Network (ANN) simulations were performed. The impact of street afforestation on the region was assessed through a comparison of thermal variations between simulated surface temperatures and observed surface temperatures. The objective of the analysis was to determine the extent to which street afforestation affects temperature regulation in the area. The employment of an Artificial Neural Network (ANN) methodology has been proven to be of significant value in conducting modeling and simulation endeavors, particularly in the context of addressing complex problems with multifaceted variables and ambiguous interrelationships. Its capacity to process intricate data structures and identify patterns within large datasets makes ANN a powerful tool for assessing the thermal impacts of street afforestation, providing insights that are valuable for environmental planning and mitigation strategies.

8.2 Materials and Methods

8.2.1 Study Area

The urban residential areas of Muratpaşa, the central district of Antalya, were selected for the purposes of this study (Figure 8.1). The average temperature in Antalya ranges from 9°C to 15°C in winter and from 30°C to 34°C in summer. According to the Köppen-Geiger Climate Classification system (Köppen, 1972), Antalya is categorized as having a Mediterranean climate, characterized by hot summers, and it is therefore classified as falling within the Csa climate category, which denotes a temperate climate with dry, hot summers (warm temperate, dry summer, hot summer). The region includes both coastal and inland areas, featuring extensive green spaces and a diverse urban landscape.

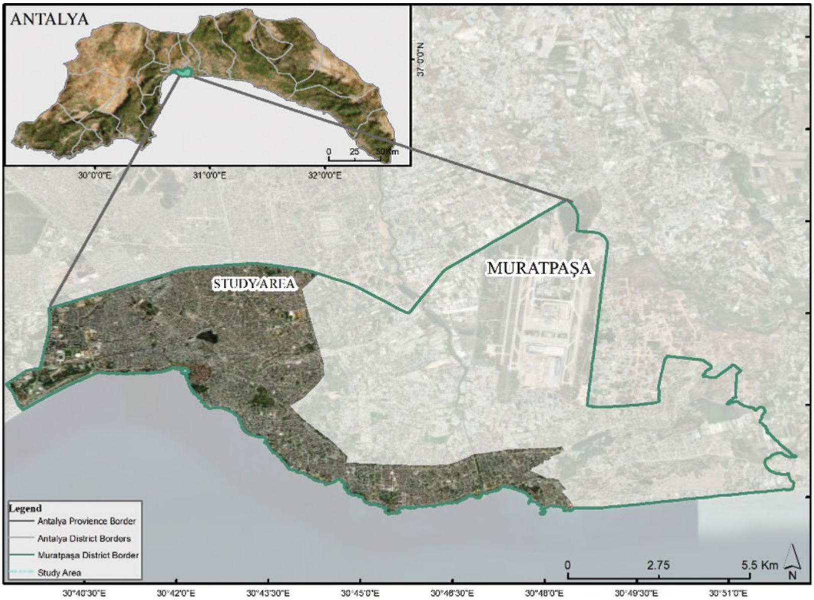


Figure 8.1: Study Area.
Source: Created by the authors.

8.2.2 Data Sets

In this research, the database NDVI (Normalized Difference Vegetation Index), ε (emissivity), LST (land surface temperature), DEM (digital elevation model) and distances to factors such as road, coastline and forest were used. NDVI, emissivity, and land surface temperature were derived from Landsat 8 OLI imagery. The selected dates for satellite imagery are July 14, 2018, August 15, 2018, and July 1, 2019. Daily climate data corresponding to these satellite image dates are provided in Table 8.1.

Table 8.1: Daily Climate Data for Satellite Image Dates

Image Acquisition Dates	Daily Min. Temperature (°C)	Daily Max. Temperature (°C)
14.07.2018	28	38
15.08.2018	24	36
01.07.2019	24	34

Source: Created by the authors.

Furthermore, the elevation values were obtained from DEM data; the road data was downloaded from Open Street Map (OSM), the shoreline data was obtained by digitizing the DEM data, and the Corine-2018 data was used to calculate the distances to forest areas.

8.2.3 Methodology

This study explored the influence of enhanced street afforestation on climate change using the Artificial Neural Network simulation method.

In practical terms, synthetic images are generated by modifying the NDVI images extracted from available satellite imagery, simulating afforestation activities on the streets. These synthetic images are then employed to analyze climate changes in the region based on predicted surface temperatures.

8.2.3.1 Image Preprocessing

Before utilizing data derived from satellite imagery, a preprocessing phase is essential, during which raw satellite images undergo necessary adjustments and corrections. These corrections include the application of atmospheric and radiometric correction algorithms, as outlined in the USGS (2018) guidelines specifically for Landsat 8 imagery. Subsequently, an analysis was conducted to compute the NDVI (Normalized Difference Vegetation Index) and ε (emissivity) values, which provide insights into the reflective properties of surface elements. Emissivity, crucial for influencing emitted thermal radiation, plays a fundamental role in calculating surface temperatures. Emissivity calculations employed a variety of methodologies, such as the Temperature and Emissivity Separation (TES) method, the Temperature Independent Spectral Indices (TISI) algorithm, and the NDVI Threshold Method (NDVITHM) (Neinavaz et al., 2020). Notably, among these techniques, the NDVITHM emerged as a widely adopted approach. This approach assigns distinct emissivity values to each pixel based on its NDVI value (Sobrino et al., 2008; Jeevalakshmi et al., 2017). In formula (1), Pv denotes the pure pixel values of NDVI, representing the ratio of vegetation to bare soil.

$$Pv = \left(\frac{NDVI - NDVI_S}{NDVI_V - NDVI_S} \right)^2 \tag{1}$$

Emissivity (ε) was determined using formula (2). This equation includes emissivity values attributed to vegetation (εv), water (εw), bare soil (εs), and a mixture of vegetation and bare soil (εvs), obtained from studies by Jeevalakshmi et al. (2017) and Mallick et al. (2008). Additionally, a constant value denoted as C, set at 0.005, has been applied within the formula.

$$\varepsilon_\lambda = \begin{cases} \varepsilon_{w\lambda} & NDVI < 0 \\ \varepsilon_{s\lambda} & NDVI < NDVI_s \\ \varepsilon_{v\lambda} P_V + \varepsilon_{s\lambda}(1 - P_V) + C & NDVI_s \leq NDVI < NDVI_v \\ \varepsilon_{v\lambda} + C & NDVI > NDVI_v \end{cases} \tag{2}$$

Following this, thermal data from Landsat 8 were rectified using formula (3), leveraging calibration parameters outlined in the metadata. Employing the radiative transfer formula (4) utilized by Jiménez-Muñoz et al. (2009), radiation brightness values were then calculated, followed by the determination of surface temperatures for each thermal image using formulas (5) and (6).

$$L\lambda = \text{Grescale} * \text{DN} + \text{Brescale} \tag{3}$$

$$L\lambda(Ts) = \left(\frac{L\lambda - L\lambda atm \uparrow}{\tau . \varepsilon\lambda} \right) - \left(\frac{1 - \varepsilon\lambda}{\varepsilon\lambda} . L\lambda atm \downarrow \right) \tag{4}$$

Lλ=spectral radiance at the sensor's aperture [W/(m^2. sr. μm)]; Lminλ, Lmaxλ = radiance that is scaled to Qcalmin, Qcalmax [W/(m^2. sr. μm)]; Qcal = quantized calibrated pixel value [DN]; Brescale = Band-specific rescaling bias factor [(W/(m^2. sr. μm))/DN]; Grescale = Band-specific rescaling gain factor [(m^2. sr. μm))/DN];

$$Ts_{(K)} = K2 / \ln [(K1/L\lambda) + 1] \tag{5}$$

$$T_{(°C)} = Ts_{(K)} - 273.15 \tag{6}$$

Finally, surface temperatures for each thermal image were computed individually. However, it's important to note a significant discrepancy: on date t+1, the recorded air temperature was 30°C, whereas on date t, it reached 35°C. This discrepancy does not imply a climatic variation solely due to anthropogenic factors in the area. Consequently, a direct comparison between surface temperatures derived from satellite images couldn't ascertain areas experiencing cooling or warming. Advanced processing was conducted to identify climate changes, requiring the standardization of images to eliminate the effects of daily meteorological conditions. Kuşçu Şimşek and Ödül (2019) suggest using Ts_{Ratio} (formula 7) values obtained by scaling images to their mean values to ensure this standardization. By applying this method, Ts_{Ratio} values were computed for each pixel, indicating the ratio of individual surface temperatures to the average surface temperature of the entire image. This normalization technique streamlined the process of conducting precise comparative analyses across a range of images. As a result, proportional values derived from thermal images, standardized and consistent irrespective of daily meteorological conditions, were integrated as inputs for surface temperature data.

Moreover, by normalizing the surface temperature data in this manner, it helped mitigate the confounding effects of daily meteorological fluctuations, enabling a more robust assessment of temperature trends and changes across the studied area. This approach ensured that variations in surface temperature observed in the thermal images could be more confidently attributed to underlying environmental factors rather than transient atmospheric conditions.

$$Ts_{\text{Ratio}} = Ts_{\text{(pixel value)}} / T_{\text{S Mean (image)}} \tag{7}$$

8.2.3.2 ANN Simulation

The research was conducted in three main stages: test simulation, main simulation, and spatial analysis, employing Artificial Neural Networks (ANNs) for the simulations. ANNs, characterized by interconnected layers of neurons and weighted edges, serve as powerful tools for modeling intricate relations and patterns.

The objective of the study's test simulation phase was to establish parameters for use in the main simulation. During this phase, the network's weights were initialized randomly, with iterative adjustments made to minimize disparities between predicted outcomes and observed data. Following the guidelines provided by Panchal and Panchal (2014) for determining the number of neurons in the model, numerous trials were conducted. Subsequently, the simulation parameters demonstrating the highest predictive accuracy, including neuron and layer numbers, were documented as designated ANN parameters for subsequent stages. In the ANN model, input data such as NDVI, emissivity, DEM, distance to roads, distance to the coast, and distance to the forest were utilized, with surface temperature serving as the output variable (Figure 8.2).

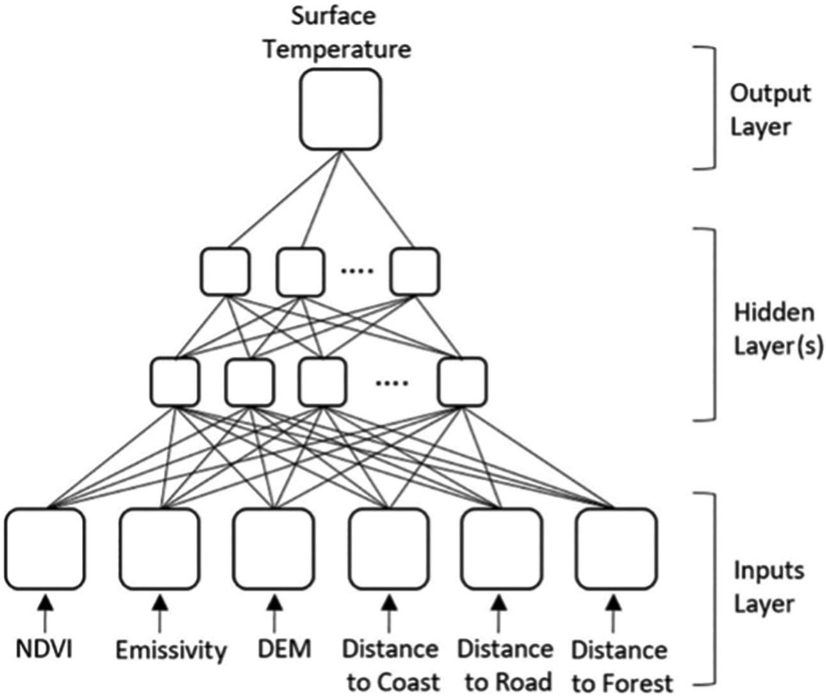


Figure 8.2: ANN Model.
Source: Işık (2019).

During the second stage, adjustments were made to the pixel values representing streets in NDVI images based on the NDVI pixel values found in densely forested streets. Throughout this process, pixels indicating areas covered by trees with NDVI values exceeding 0.45 were retained, while pixels with lower NDVI values were replaced with new values randomly selected from the range of 0.25 to 0.55. These replacement values were confined within the minimum and maximum NDVI pixel values observed within the street areas, which ranged from 0.014 to 0.45. Subsequently, a synthetic NDVI image was generated by modifying the NDVI pixel values (Figure 8.3), and a synthetic emission image was derived from this modified image. Finally, leveraging these synthetic images alongside other input parameters, a new set of surface temperatures was obtained through ANN simulation.

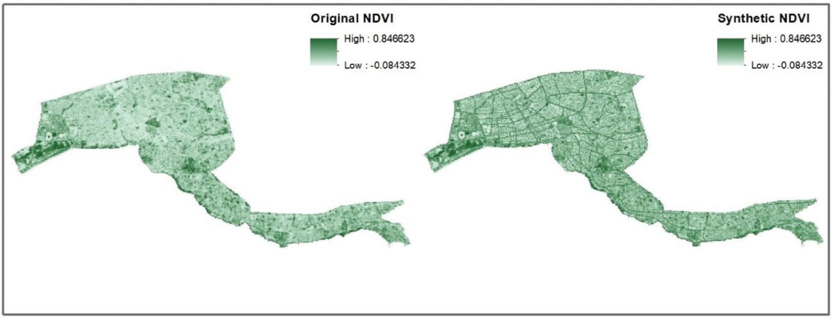


Figure 8.3: Synthetic NDVI Image.
Source: Created by the authors.

8.2.3.3 Spatial Analysis

In the final phase of the research, the impact of street afforestation on urban cooling was investigated through an analysis of surface temperatures using a GIS-based thermal change detection method introduced by Kuşçu Şimşek and Ödül (2019). The differences between observed surface temperatures and those derived from simulation results were examined and assessed. This method is employed to distinguish surface temperatures below or above the average to highlight the cooling effect. To ensure data comparability, each pixel's surface temperature values were normalized by calculating their ratio to the average surface temperature of the image.

To identify significant deviations in the results, the Mahalanobis distance method was employed. This method measures the distance of each observation from the center point of a multidimensional point cloud, as demonstrated by Kuşçu Şimşek and Arabacı (2021). Through this analysis, the degree of variation in the cooling direction for each point is revealed, allowing for an assessment of the cooling distance along the network of tree-lined roads. Furthermore, through an analysis of the distances between cooled pixels and the tree-lined streets, this study established both the maximum cooling distance and the weighted cooling distance associated with street tree planting.

In addition to assessing the cooling effect of street afforestation, the research also examined its broader implications for urban environmental quality and human well-being.

8.3 Results

A comparative analysis of the thermal change between existing surface temperatures and expected surface temperatures with street afforestation indicates that street afforestation significantly affects the cooling of the city (Figure 8.4). It is important to note, however, that the method used to display changes in temperature relative to the mean temperature does not illustrate overall cooling. In other words, the analysis of thermal changes exclusively identifies areas where there is a transition from above the average to below the average or vice versa. As a result, the map does not illustrate the changes that occur within the same interval, such as an increase or decrease that occurs above or below the average. It is therefore crucial to consider that the map does not illustrate uniform cooling across the entire area, but rather significant shifts.

The findings suggest that street afforestation is an effective tool in combating urban heat islands. Specifically, in areas where extreme changes (from above to below the average) were detected, the most substantial cooling occurred in the historic city center, where heat islands are densely concentrated. Additionally, the results indicate that cooling was most prominent in coastal areas, suggesting that the cooling effect along coastal regions is enhanced by the addition of street afforestation.

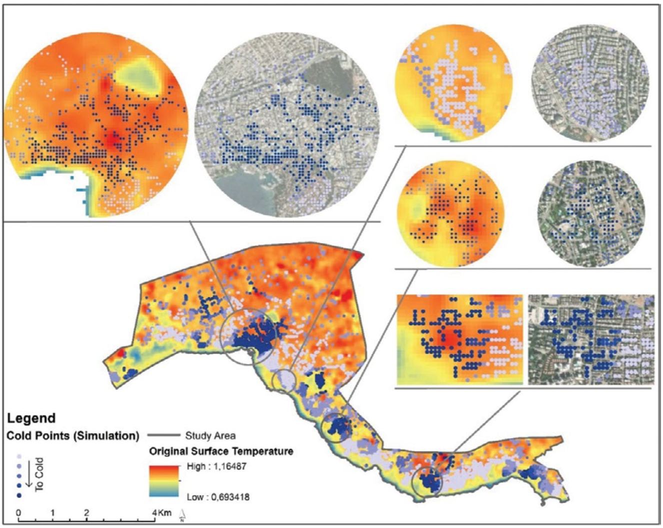


Figure 8.4: Thermal Change Detection Analysis.
Source: Created by the authors.

To investigate the cooling effect ranges of street afforestation, the distances from cooling points along tree-lined streets were analyzed using the near-distance analysis (Figure 8.5). The results indicate that street afforestation typically provides a cooling effect extending up to 100 meters around it, though in some areas, this effect can reach up to 200 meters.

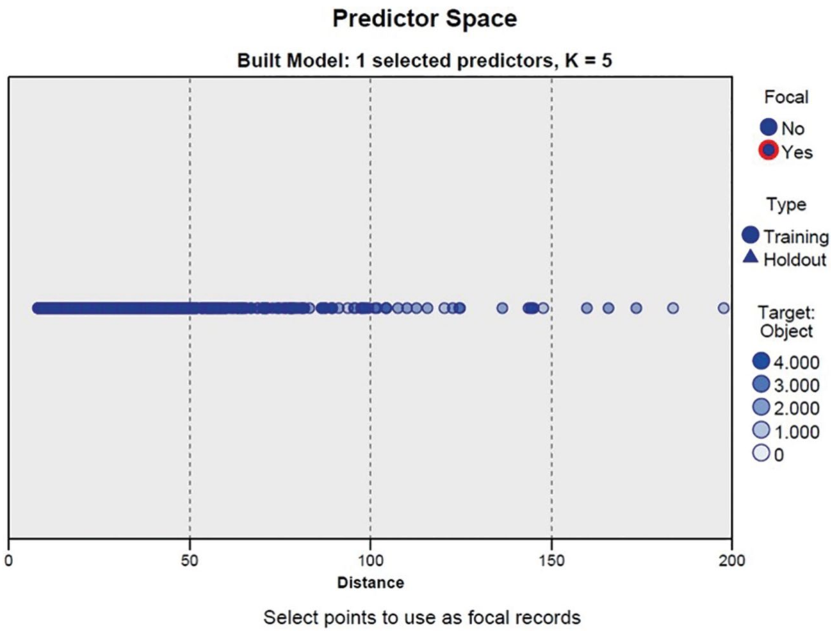


Figure 8.5: Cooling Distances of Afforested Streets.
Source: Created by the authors.

In this study, which examines the usability of street afforestation as a tool for cooling urban areas, the ANN method was used based on surface temperature data obtained from satellite images, rather than air temperature measurements as in traditional simulation methods. The study's findings revealed that ANN can serve as an alternative simulation method. Remote sensing techniques play a crucial role in accurately identifying target areas that require more detailed analysis, especially in urban-climate research, as they enable the analysis of wide areas at a lower cost. Furthermore, remote sensing's ability to pinpoint specific areas in need of detailed examination enhances its effectiveness in urban planning and climate mitigation efforts.

8.3.1 Discussion

Streets are the primary public spaces within urban areas, characterized by high levels of human activity. These spaces not only facilitate social interactions but also influence human movements and preferences, significantly impacting overall climatic comfort (Peng et al., 2021; White et al., 2017; Mullaney et al., 2015). It is widely recognized that tree-covered spaces exhibit stronger cooling effects compared to areas with grass and flowers; furthermore, the height of the tree canopy has been demonstrated to further enhance this cooling efficacy (Jiang et al., 2020). In this context, street afforestation emerges as a crucial strategy aimed at enhancing thermal comfort for people and mitigating the urban heat island effect (Gebert et al., 2019; Dos Santos et al., 2017). Moreover, incorporating green infrastructure within street design not only enhances aesthetic appeal but also contributes to biodiversity conservation and improves air quality, thereby fostering healthier and more sustainable urban environments.

Ge et al. (2023) found that the cooling effect of street afforestation varies according to the morphological characteristics of the urban area. The study found that planting trees around densely built and low-rise buildings is more effective than around densely built and high-rise buildings. Similarly, in their study, Kuşçu Şimşek et al. (2024) obtained different results in cities with distinct morphological structures. The findings revealed that street tree planting is more effective in Antalya, where low-density, low-rise buildings predominate, compared to Istanbul. Scientific studies indicate that street tree planting is an effective strategy in combating heat islands (Honjo and Takakura, 1990; Feyisa et al., 2014). Consistent with similar studies in the literature, the findings suggest that increasing the density of street tree plantings alters the climatic balance of the region and has a cooling effect on the surroundings of the road network.

Conversely, the study's outcomes reveal that the majority of alterations occurred within the downtown area, characterized by densely constructed structures. This finding suggests that implementing street tree planting is particularly effective within densely populated urban cores, where efforts to mitigate urban heat are constrained. Additionally, it was observed that a significant extent of cooling occurred along the coastal regions, indicating that the cooling efficacy of street tree planting amplifies when complemented by coastal cooling mechanisms. However, it is imperative to underscore the significance of seasonal effects as a pivotal variable in the realm of local climate research (Xiang et al., 2023; Ma et al., 2021). To control for this effect, the study was conducted in the summer, and the findings should be interpreted within the context of that season.

Furthermore, as known from the scientific literature, urban morphology and geometry influence urban climate and thermal comfort (Cárdenas-Jirón et al., 2023; Bedra et al., 2023). At this point, using terrestrial measurements, especially in meso-scale climate simulations, may result in a loss of precision depending on the number of stations. The substantial amount of data provided by satellite imagery, contingent upon image resolution, plays a critical role in precisely uncovering the influences of urban morphology and geometry. In this research, we examined the influence of street tree planting on the local climate utilizing Artificial Neural Network simulations based on remote sensing data. The high amount of data provided by image processing techniques demonstrates that ANN-based simulations have sufficient sensitivity to track climate changes in urban areas (Kuşçu Şimşek and Arabacı, 2021). Indeed, the results obtained from this study are consistent with the literature, supporting the safe use of ANN-based modeling in climate simulations of urban areas.

8.4 Conclusion

This research explored how the introduction of street trees affects the nearby climate by employing Artificial Neural Network (ANN) simulations based on remote sensing data. Unlike approaches that utilize direct air temperature measurements, this study utilized surface temperature data obtained from satellite imagery for ANN modeling. The findings demonstrated that employing ANN simulations grounded in image processing methodologies exhibits significant sensitivity in monitoring urban-climate variations. Furthermore, consistent with similar studies in the literature, the findings suggest that increasing the density of street tree plantings alters the regional climate balance and has a cooling effect on the surrounding road network. In the specific case of the Muratpaşa district, most changes were observed in the densely built city center. This finding shows that street tree planting, an effective method, is particularly applicable in urban centers, which often face urban heat problems due to dense development. In addition, it was noted that cooling occurs largely in coastal areas, indicating that the cooling capacity of street afforestation increases when combined with coastal cooling. Moreover, this study highlights the advantages of remote sensing-based simulation methods. The research demonstrates the effective use of remote sensing techniques in monitoring urban climate, allowing for a low-cost assessment of regional climate characteristics and identification of problem areas. The results contribute to devising pertinent strategies for improving urban-climate comfort by pinpointing areas in need of further analysis and follow-up. Consequently, urban-climate research should begin with an examination of the region's climate structure using remote sensing techniques, followed by sub-scale measurements, analyses, and simulations, culminating in planning strategies developed to address identified needs.

Bibliography

Aram, F., García, E. H., Solgi, E., & Mansournia, S. (2019). Urban green space cooling effect in cities. Heliyon, 5(4), e01339. https://doi.org/10.1016/j.heliyon.2019.e01339.

Armson, D., Stringer, P., & Ennos, A. R. (2012). The effect of tree shade and grass on surface and globe temperatures in an urban area. Urban Forestry and Urban Greening, 11(3), 245–255. http://dx.doi.org/10.1016/j.ufug.201.

Astor, A. (2019). Street performance, public space, and the boundaries of urban desirability: the case of living statues in Barcelona. International Journal of Urban and Regional Research, 43(6), 1064–1084.

Bai, X., Dawson, R. J., Ürge-Vorsatz, D., Delgado, G. C., Barau, A. S., Dhakal, S., Dodman, D., Leonardsen, D., Masson-Delmotte, D., Roberts, D., Schultz, S. (2018). Six research priorities for cities and climate change, Nature, 555(7694), 23–25.

Bassett, R., Cai, X., Chapman, L., Heaviside, C., Thornes, J. E., Muller, C. L., … Warren, E. L. (2016). Observations of urban heat island advection from a high-density monitoring network. Quarterly Journal of the Royal Meteorological Society, 142(699), 2434–2441, https://doi.org/10.1002/qj.2836.

Bedra, K. B., Zheng, B., Li, J. & Luo, X. (2023). A Parametric-Simulation Method to Study the Interconnections between Urban-Street-Morphology Indicators and Their Effects on Pedestrian Thermal Comfort in Tropical Summer. Sustainability, 15, 8902. https://doi.org/10.3390/su15118902.

Buyantuyev, A., Wu, J. Urban heat islands and landscape heterogeneity: linking spatiotemporal variations in surface temperatures to land-cover and socioeconomic patterns. Landscape Ecol 25, 17–33 (2010). https://doi.org/10.1007/s10980-009-9402-4.

Byrne, J., & Jinjun, Y. (2009). Can urban greenspace combat climate change? Towards a subtropical cities research agenda. Australian Planner, 46(4), 36–43. https://doi.org/10.1080/07293682.2009.10753420.

Cárdenas-Jirón, L. A., Graw, K., Gangwisch, M. & Matzarakis, A. (2023). Influence of street configuration on human thermal comfort and benefits for climate-sensitive urban planning in Santiago de Chile. Urban Climate, 47, 101361 https://doi.org/10.1016/j.uclim.2022.101361.

Carvalho, D., Martins, H., Marta-Almeida, M., Rocha, A., & Borrego, C. J. U. C. (2017). Urban resilience to future urban heat waves under a climate change scenario: A case study for Porto urban area (Portugal). Urban Climate, 19, 1–27. https://doi.org/10.1016/j.uclim.2016.11.005.

Chatzidimitriou, A., & Yannas, S. (2017). Street canyon design and improvement potential for urban open spaces; the influence of canyon aspect ratio and orientation on microclimate and outdoor comfort. Sustainable cities and society, 33, 85–101.

Çetin, M. (2020). Climate comfort depending on different altitudes and land use in the urban areas in Kahramanmaras City. Air Quality, Atmosphere & Health, 13(8), 991–999.

Dos Santos, A. R., de Oliveira, F. S., da Silva, A. G., Gleriani, J. M., Gonçalves, W., Moreira, G. L., … & Mota, P. H. S. (2017). Spatial and temporal distribution of urban heat islands. Science of the Total Environment, 605, 946–956.

Du, H., Cai, W., Xu, Y., Wang, Z., Wang, Y., & Cai, Y. (2017). Quantifying the cool island effects of urban green spaces using remote sensing Data.

Urban Forestry & Urban Greening, 27, 24–31. https://doi.org/10.1016/j.ufug.2017.06.008.

Fabijańczyk, P., & Zawadzki, J. (2022). Spatial correlations of NDVI and MSAVI2 indices of green and forested areas of urban agglomeration, case study Warsaw, Poland. Remote Sensing Applications: Society and Environment, 26, 100721.

Feyisa, G. L., Dons, K., & Meilby, H. (2014). Efficiency of parks in mitigating urban heat island effect: An example from Addis Ababa. Landscape and Urban Planning, 123, 87–95. doi:10.1016/j.landurbplan.2013.12.008.

Garuma, G. F. (2018). Review of urban surface parameterizations for numerical climate models. Urban climate, 24, 830–851.

Gaur, A., Eichenbaum, M. K., & Simonovic, S. P. (2018). Analysis and modelling of surface Urban Heat Island in 20 Canadian cities under climate and land-cover change. Journal of Environmental Management, 206, 145–157.

Ge, J., Wang, Y., Akbari, H., Zhou, D., Gu, Z. & Meng, X. (2023). Cooling energy saving by vegetation planting in high-density districts: Evaluation using the coupled simulation, Building and Environment, 232, 110054. https://doi.org/10.1016/j.buildenv.2023.110054.

Gebert, L. L., Coutts, A. M., & Tapper, N. J. (2019). The influence of urban canyon microclimate and contrasting photoperiod on the physiological response of street trees and the potential benefits of water sensitive urban design. Urban Forestry & Urban Greening, 40, 152–164.

Gillner, S., Vogt, J., Tharang, A., Dettmann, S., & Roloff, A. (2015). Role of street trees in mitigating effects of heat and drought at highly sealed urban sites. Landscape and Urban Planning, 143, 33–42. https://doi.org/10.1016/j.landurbplan.2015.06.005.

Güldü, E. and Kuşçu Şimşek, A. (2022). İklime Uyumlu Kentsel Planlamada, Kent Morfolojisi ve Soğuk Ada İlişkilerinin İncelenmesi, "Kriz" Bildiriler Kitabı, İklime Uyumlu Kentsel Planlamada, Kent Morfolojisi ve Soğuk Ada İlişkilerinin İncelenmesi, Şehir Plancıları Odası Yayını, ISBN: 978-605-01-1492-8.

Honjo, T., & Takakura, T. (1990). Simulation of thermal effects of urban green areas on their surrounding areas. Energy and Buildings, 15(3–4), 443–446. https://doi.org/10.1016/0378-7788(90)90019-F.

Işık, D. (2019). Kentsel iklim değişiminin yapay sinir ağları ile simülasyonu. Sivas Cumhuriyet Üniversitesi Fen Bilimleri Enstitüsü Geomatik Mühendisliği Ana Bilim Dalı (Yüksek Lisans Tezi), 67 s, Sivas.

Jalan, S., & Sharma, K. (2014). Spatio-temporal assessment of land use/ land cover dynamics and urban heat island of Jaipur city using satellite data. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 40, 767–772.

Jeevalakshmi, D., Reddy, S. N. & Manikiam, B. (2017). Land surface temperature retrieval from LANDSAT data using emissivity estimation. International Journal of Applied Engineering Research, 12(20), 9679–9687.

Jiang, Y., Jiang, S. & Shi, T. (2020). Comparative Study on the Cooling Effects of Green Space patterns in Waterfront Build-Up Blocks: An Experience from Shanghai, International Journal of Environmental Research and Public Health, 17, 8684, https://doi.org/10.3390/ijerph17228684.

Jiménez-Muñoz, J. C., Cristóbal, J., Sobrino, J. A., Sòria, G., Ninyerola, M. & Pons, X. (2009) Revision of the single-channel algorithm for land surface temperature retrieval from landsat thermal-infrared data. IEEE Transactions on Geoscience and Remote Sensing, 47(1):339–349.

Köppen, W. (1972). Das Geographische System der Klimate [The geographical system of climates]. Handbuch Der Klimatologie [Handbook of Climatology], 1(Part C).

Kuşçu Şimşek, Ç., Arabacı, D., Yücel, C., & Öztürk, B. (2024). Monitoring the climatic effects of street tree plantation in different urban patterns by synthetic image based BPNN simulations. Building and Environment, 250, 111173, https://doi.org/10.1016/j.buildenv.2024.111173.

Kuşçu Şimşek, Ç., & Arabacı, D. (2021). Simulation of the climatic changes around the coastal land reclamation areas using artificial neural networks. Urban Climate, 38, 100914.

Kuşçu Şimşek, Ç. (2020). İstanbul'un Mezo ve Mikro İklimsel Değişiminin Kuzey Ormanları ve Kent İçi Yeşil Alanlarla İlişkisi. Şu eserde: Ünal Akkemik (Ed.). Ekosistem, İklim ve Kentsel Büyüme Perspektifinden İstanbul ve Kuzey Ormanları. Türkiye Ormancılar Derneği Yayın

No:50, Marmara Şubesi Yayın No: 4, İstanbul. ISBN: 978-975-93478-7-1. s: 96–109.

Kuşçu Şimşek, Ç., & Ödül, H. (2019). A method proposal for monitoring the microclimatic change in an urban area. Sustainable Cities and Society, 46, 101407, https://doi.org/10.1016/j.scs.2018.12.035.

Lee, H., & Mayer, H. (2018). Thermal comfort of pedestrians in an urban street canyon is affected by increasing albedo of building walls. International journal of biometeorology, 62(7), 1199–1209.

Ma, L., Wang, Y., Liang, Z., Ding, J., Shen, J., Wei, F., & Li, S. (2021). Changing effect of urban form on the seasonal and diurnal variations of surface urban heat island intensities (SUHIIs) in more than 3000 cities in China. Sustainability, 13(5), 2877.

Mallick J, Kant Y, Bharath BD (2008) Estimation of land surface temperature over Delhi using Landsat-7 ETM+. J. Ind. Geophys. Union 12(3):131–140.

Mohajerani, A., Bakaric, J., & Jeffrey-Bailey, T. (2017). The urban heat island effect, its causes, and mitigation, with reference to the thermal properties of asphalt concrete. Journal of environmental management, 197, 522–538.

Mullaney, J., Lucke, T., & Trueman, S. J. (2015). A review of benefits and challenges in growing street trees in paved urban environments. Landscape and Urban Planning, 134, 157–166. https://doi.org/10.1016/j.landurbplan.2014.10.013.

Neinavaz E., Skidmore AK, Darvishzadeh R (2020). Effects of prediction accuracy of the proportion of vegetation cover on land surface emissivity and temperature using the NDVI threshold method. International Journal of Applied Earth Observation and Geoinformation, 85, 101984. doi:10.1016/j.jag.2019.101984.

Ng, E., & Ren, C. (2018). China's adaptation to climate & urban climatic changes: A critical review. Urban Climate, 23, 352–372.

Panchal FS, Panchal M (2014) Review on methods of selecting number of hidden nodes in artificial neural network. International Journal of Computer Science and Mobile Computing 3(11):455–464.

Peng, F., Xiong, Y. & Zou, B. (2021). Identifying the optimal travel path based on shading effect at pedestrian level in cool and hot climates, Urban Climate, 40, 100988, https://doi.org/10.1016/j.uclim.2021.100988.

Qaid, A., Lamit, H. B., Ossen, D. R., & Rasidi, M. H. (2018). Effect of the position of the visible sky in determining the sky view factor on micro-meteorological and human thermal comfort conditions in urban street canyons. Theoretical and applied climatology, 131(3), 1083–1100.

Qiu, K., & Jia, B. (2020). The roles of landscape both inside the park and the surroundings in park cooling effect. Sustainable Cities and Society, 52, 101864. https://doi.org/10.1016/j.scs.2019.101864.

Razzaghmanesh, M., Beecham, S., & Salemi, T. (2016). The role of green roofs in mitigating Urban Heat Island effects in the metropolitan area of Adelaide, South Australia. Urban Forestry & Urban Greening, 15, 89–102.

Ren, Z., Zhao, H., Fu, Y., Xiao, L., & Dong, Y. (2021). Effects of urban street trees on human thermal comfort and physiological indices: a case study in Changchun city, China. Journal of Forestry Research, 1–12.

Revelli, R., & Porporato, A. (2018). Ecohydrological model for the quantification of ecosystem services provided by urban street trees. Urban Ecosystems, 21(3), 489–504.

Sobrino JA, Jiménez-Muñoz JC, Sòria G, Romaguera M, Guanter L Moreno J (2008) Land surface emissivity retrieval from different VNIR and TIR sensors. IEEE Transactions on Geoscience and Remote Sensing 46(2): 316–327.

United States Geological Survey (USGS). (2018). Landsat 8 (LT8) Data Users Handbook, https://www.usgs.gov/media/files/landsat-8-data-users-handbook [March 15, 2021].

Valor, E., & Caselles, V. (1996). Mapping land surface emissivity from NDVI: Application to European, African, and South American areas. Remote sensing of Environment, 57(3), 167–184.

Wang, X., Cheng, H., Xi, J., Yang, G., & Zhao, Y. (2018). Relationship between park composition, vegetation characteristics and cool island effect. Sustainability, 10(3), 587.

Wang, Y., & Akbari, H. (2016). The effects of street tree planting on Urban Heat Island mitigation in Montreal. Sustainable Cities and Society, 27, 122–128. https://doi.org/10.1016/j.scs.2016.04.013.

Ward, K., Lauf, S., Kleinschmit, B., & Endlicher, W. (2016). Heat waves and urban heat islands in Europe: A review of relevant drivers. Science of the Total Environment, 569, 527–539.

White, M., Kimm, G., & Langenheim, N. (2017). Pedestrian Access Modelling with Tree Shade—Won't Someone Think of the Children. Procedia Engineering, 198, 139–151. https://doi.org/10.1016/j.proeng.2017.07.078.

Xiang, Y., Zheng, B., Bedra, K. B., Ouyang, Q., Liu, J., & Zheng, J. (2023). Spatial and seasonal differences between near surface air temperature and land surface temperature for Urban Heat Island effect assessment. Urban Climate, 52, 101745.

Xu, Y., Ren, C., Ma, P., Ho, J., Wang, W., Lau, K. K.-L., … Ng, E. (2017). Urban morphology detection and computation for urban climate research. Landscape and Urban Planning, 167, 212–224. https://doi.org/10.1016/j.landurbplan.2017.06.018.

Yang, J., Jin, S., Xiao, X., Jin, C., Xia, J. C., Li, X., & Wang, S. (2019). Local climate zone ventilation and urban land surface temperatures: Towards a performance-based and wind-sensitive planning proposal in megacities. Sustainable Cities and Society, 47, 101487.

The Reflection of Urban Climate Justice on Urban Agricultural Lands: Evidence from Antalya Kırcami Case

Gülşah Tırış,[27] *Hilal Erkuş*[28] *and Yavuz Selim Alkan*[29]

9.1 Introduction

As stated in the fourth assessment report by the Intergovernmental Panel on Climate Change (IPCC, 2007), the Mediterranean Basin, which includes Türkiye's city of Antalya, is identified as the riskiest region in the Europe, Middle East, and North Africa in terms of climate change, with a high level of vulnerability, especially in coastal areas. Antalya, known for its hot, dry summers and mild winters, is particularly susceptible to the increasing risks of extreme heat waves, rising sea levels, and water scarcity due to climate change. Although the climate vulnerability of the Antalya Basin is high, the risk and vulnerability in agricultural areas are even higher due to the increasing density of urban construction in the city of Antalya (Işınkaralar, 2023) (see Tırış and Erkuş, 2024: 2340).

To elaborate further on this, the risk to coastal areas is indeed a primary concern, particularly due to the projected rise in sea levels as indicated by climate models for 2050. However, agricultural areas are at higher risk in the Antalya Basin because of a different factor: the increasing urbanization, which exacerbates the vulnerability of agricultural lands. The dense construction in urban areas raises the overall pressure on the environment, increasing the risk of salinization in agricultural soils, and further amplifying the challenges posed by climate change. This creates a compound vulnerability that affects

[27] Ph.D. Cand., Akdeniz University, Faculty of Architecture, Department of Urban and Regional Planning, gulsahtiris7@gmail.com. ORCID ID: https://orcid.org/0000-0001-7725-7179

[28] Prof. Dr. Akdeniz University, Faculty of Architecture, Department of Urban and Regional Planning, herkus@akdeniz.edu.tr ORCID ID: https://orcid.org/0000-0003-2466-6862

[29] Assoc. Prof. Dr. Akdeniz University, Faculty of Economics and Administrative Sciences, Department of Political Science and Public Administration, yavuzselimalkan@akdeniz.edu.tr ORCID ID: https://orcid.org/0000-0002-5211-5809

both the urban and agricultural areas. Furthermore, when referring to "vulnerability" and "risk," it is essential to note that these terms can be seen as closely linked but distinct. Vulnerability refers to the inherent susceptibility of an area to the impacts of climate change, while risk relates to the probability of adverse outcomes occurring due to those impacts. In the case of the Antalya Basin, the vulnerability is heightened due to the environmental changes, while the risk of negative outcomes is compounded by the urban expansion, particularly in agricultural zones.

Furthermore, floods represent the most prevalent form of climate-related disaster in Türkiye. In 2021, the flood disaster that occurred in the Western Black Sea Basin was documented as one of the most significant natural disasters in the history of the republic (Gözüm and Zengin Çelik, 2022; see Tırış and Erkuş, 2024: 2340). In Antalya, where rainfall levels are high, the total precipitation measured was 173 kg per square meter over 24 hours in January 2023. This measurement was the highest recorded for the year under investigation (precipitation rates were recorded in kilograms per square meter, a method that is equivalent to millimeters). The 2024 measurement showed a precipitation rate of 233.9 kg per square meter. The average annual rainfall, according to the official statistics of the General Directorate of Meteorology, was determined to be 1177.7 mm. Numerous greenhouse areas, agricultural lands, citrus groves, and houses were significantly damaged due to the high rainfall (BirGün, 2023). According to research (Özen Bayraktar and Çiçek, 2022), there also were 520 tornadoes recorded in Türkiye between 2000 and 2020, 178 of which occurred in Antalya. The climate change risks and negative consequences presented earlier have also led to the emergence of various issues related to climate justice in the region.

Given these issues, the Kırcami Region of Antalya, Türkiye, has been selected as a case study for this research for several important reasons. Firstly, it serves as a representative example of an urban agricultural area, which is located in the center of the city with an ongoing agricultural production, involved in a prolonged, over 40-year-long political and legal conflict regarding potential changes in urban land use. Secondly, the region has gained significance as a case in the context of increasing natural disasters worldwide and in Türkiye, particularly following the February 6, 2023 Kahramanmaraş earthquake, as well as the ongoing climate crisis and environmental justice issues. In other words, negative effects of climate change are felt in different ways in the region, and this makes the Kırcami a unique case to examine from the issues of climate change impacts and urban-climate justice on an agrihood (for more comprehensive reasons as to why Kırcami is a case worth examining in terms of urban planning, see Erkuş et al. 2024: 3–4).

Considering these reasons, this chapter aims to examine the impacts of climate change and climate justice on the residents of the region (living and working in the area), as they are among the first to be affected by these issues. Their livelihoods are directly influenced by environmental changes, making them critical stakeholders in understanding the broader implications of climate change at the local level. Thus, the objective of this study is to reveal the views of residents in the Kırcami Region on the impacts of climate change on their life. It will also reveal their expectations from the urban planning process in the region to address the impacts of climate change and identify problems related to (urban) climate justice, spatial justice, and implementation of current policies. Besides residents, two urban planning experts from local authorities were also interviewed to assess the current land use plan in terms of its sensitivity to climate change and disasters. Methodologically, in-depth interviews were conducted with the participants and the findings were analyzed through their discursive expressions as a qualitative research design approach.[30]

This study is therefore structured into three sections, each addressing a specific aspect of the topic. The first part explores the relationship between urban areas and climate justice; the second part examines how the climate crisis impacts urban agriculture; and the methodology section details the case study area, the methods used, and presents the results of the study.

[30] This chapter is part of a broader research initiative, which has not been funded or financed by any institution. The data utilized in this study were collected from participants with diverse characteristics, focusing on their expectations regarding the Kırcami development plan, its potential for disaster resilience, its legitimacy based on deliberative democracy practices, and their perspectives on environmental justice and climate change. While some of the data overlap with other studies produced as part of this research, each of the studies is grounded in distinct theoretical frameworks, and explores different topics, leading to unique findings, discussions, analyses, and conclusions. Consequently, although there is overlap in the referenced literature, certain findings, and the methodology, the results and contributions of each study remain independent and offer distinct insights. For further details, particularly on the shared methodological data, see Erkuş et al. (2024); Tırış and Erkuş (2024).

9.2 The City and Climate Justice

According to the Global Carbon Project Report, global carbon emissions increased by 1.1 percent in 2023 compared to 2022, atmospheric CO_2 concentrations reached approximately 420 ppm (Friedlingstein et al., 2023). This increase is having a detrimental effect on climate system. It is the densely populated, compact urban areas of cities that are most vulnerable to the resulting impacts. Urban areas are highly vulnerable to climate-induced risks due to their interconnected infrastructure (water networks, sewerage systems, transport networks, metro systems, road networks, energy networks, telecommunications networks, and green infrastructure) (Elmqvist et al., 2019). The fundamental cause of these vulnerabilities is the unjust and unequal processes that occur in producing urban space. The concepts of environmental justice, climate justice, and spatial justice are employed in theoretical discussions of these processes.

The concept of environmental justice focuses on the distribution of environmental burdens and benefits in society. The concept of climate justice, on the other hand, is comprehensive, encompassing not only distributive justice but also inequalities in policies and practices, considering equal access to resources, existing social and economic inequality, intergenerational justice, and diversity (Amorim-Maia et al., 2012). The concept of climate justice also refers to the imbalance between those who contribute the most to climate change and those who are most affected by it (Schlosberg and Collins, 2014). Currently, with the increase in different publics, the concept of climate justice intersects with other concepts of justice. The primary intersection where these different publics express and negotiate their demands for justice is "space" (Dikeç, 2001).

Soja (2009) argues that the spatial dimensions of urban policies are an indicator of social justice issues, while Dikeç (2001) argues that spatial injustices are reproduced every day through existing structures. Land use policies, infrastructure, access to food, access to clean water, equitable distribution of urban services, and housing policies in urban space are all areas where processes related to urban-climate justice and spatial justice are evident (Swyngedouw, 2006). Urban spaces exposed to spatial inequalities become more vulnerable to the negative impacts of climate change, and the issue of climate inequalities is linked to the issue of socio-spatial inequalities. To correct these forms of injustice, a great number of cities are now developing local climate action plans.

The most internationally recognized basis for these solutions is the Sustainable Development Goals (SDGs, 2016; see Tırış and Erkuş, 2024: 2322), established by the United Nations in 2015. Goal 11 is defined as "Building Sustainable Cities and Communities." Under this goal, several urban targets have been set for the major future risks, such as the climate crisis, food security, and safe housing (UNSTATS, 2020; see Tırış and Erkuş, 2024: 2323). The indicators under this goal include affordable housing, access to basic services, upgrading of slums, transport, public transport systems, democratic and participatory urban planning processes, improvement of infrastructure, waste management, the implementation of urban policies considering diversity axes such as gender, age and disability, and preparedness for disaster risks.

However, factors like the weakness of the SDG monitoring and oversight mechanisms, the lack of mandatory powers, and the lack of clear strategies between developed and developing nations mean that these goals thus far are merely aspirational (Scholtz and Barnard, 2018). In order to achieve these goals, it is essential to implement a multi-actor global governance process with fair and equitable rules, as well as to develop global institutional arrangements (Bierman et al., 2017).

While the implementation of global environmental governance has yet to be realized, urban population projections estimate that the urban population will approach 7 billion by 2050 (IPCC, 2022). With this increase, it is expected that urbanization will accelerate, and natural areas and agricultural land will be opened for development, necessitating urban plans that consider the physical and biological components of cities, as highlighted in the scholarly literature (Tong, 2021; see Tırış and Erkuş, 2024: 2324). There are numerous planning approaches and practices that have been developed to mitigate the effects of climate change in cities. These include eco-city approaches, green transport approaches, equitable infrastructure distribution policies, resilient urban policies, and sustainable urban policies. Another important example is that of urban agricultural practices. There are many different types of urban agriculture, which offer significant benefits such as "food security and access to food," as well as a solution to the increase in the "urban heat island effect" due to increased urban development. Urban agriculture is seen as an alternative production model to industrial agriculture in terms of sustainable urbanization. Urban agriculture is a system that is practiced within the city and in peri-urban areas, integrated with the economic, ecological, and social systems of the city (Zezza and Tasciotti, 2010; see Erkuş et al., 2024: 2). This brings us to the crucial link between the climate crisis and urban agriculture.

9.3 The Link Between Climate Crisis and Urban Agriculture

Currently, agricultural production is predominantly characterized by industrial agriculture, which involves intensive energy use and the use of various technological and engineering systems. The development of technology to reduce human labor, coupled with the increase in input costs, has presented significant challenges for small-scale producers in the agricultural field (Aysu, 2019). In the context of the dissemination of this production model, there has been a concomitant increase in the difficulty of accessing hybrid seeds, local food, and clean food (Woodhouse, 2010). This situation gives rise to concerns regarding reduced food quality, high energy use (refrigeration and fuel) associated with transporting food over long distances, soil degredation, or health risks and and biodiversity risks associated with plant protection products. The idea of support for local food production systems is at the forefront of international solutions to minimize these risks (Heinberg and Bomford, 2016; Rasouli, 2012; FAO, 2016).

According to the IPCC's Sixth Assessment Report (2023), 3.6 billion people live in climate-vulnerable and sensitive areas, more than half of them estimated to live in rural areas. The World Meteorological Organization (WMO, 2007) stresses the importance of continuing agricultural production in urban areas to make cities more resilient to climate change. UN-HABITAT (2017) highlights that urban agriculture is an important practice for creating an integrated food system and adapting to climate change, and that urban agriculture strategies should be included in urban planning. Urban agriculture has the potential to increase access to food for the urban poor, reduce dependence on food imports, and facilitate access to food in agricultural areas within the city rather than sourcing food from rural areas in times of disaster. Urban agriculture can also cool urban areas where the urban heat island effect is intense, increase urban biodiversity, and create resilient and sustainable urbanization practices (Dubbeling and de Zeeuw, 2011).

Urban agriculture activities can be categorized into three groups: commercial practices, non-commercial practices, and hybrid practices. Non-commercial activities include hobby gardening, community gardens, edible landscaping, and urban orchards, whereas commercial activities include all market-based agricultural production. Hybrid practices include educational activities regarding the processes of food production, distribution, and marketing (Rasouli, 2012). In each of these categories, it is expected that the deepening distinction between urban and rural areas will be eliminated with urban agriculture practices, and cities will gain more sustainable qualities (Kanbak, 2018). As previously stated, typologies of urban agriculture encompass a variety of practices and are praticed for purposes such as individual or collective consumption, education, and sale. In addition, distinctions are also made according to "the location, the scale, the production technology, and the type of production" (Rasouli, 2012; Napawan, 2016).

Building upon the discussions of climate justice and its connection to urban agriculture, the following section will explore the case area and the methodology employed to analyze these dynamics.

9.4 Case Study Area and Method

9.4.1 General Characteristics of the Kırcami Region

The Kırcami Region (Figure 9.1) covers approximately 1477 hectares between the city center and the Düden Stream. The Kırcami Region includes the Doğuyaka, Topçular, Mehmetçik, Güzeloluk, Zümrütova, Yeşilova, Kırcami, and Alan neighborhoods, as well as parts of the Fener and Çağlayan neighborhoods. It is estimated that 7 percent of Antalya's greenhouse area is located in this region (Demirbaş Topçu, 2016: vii; see Erkuş et al., 2024: 8; Tırış and Erkuş, 2024: 2340). The urban planning area under consideration, as part of a comprehensive urban development project, has a population of 20,000 inhabitants. The Kırcami Region, which has a rural settlement character, is part of the Muratpaşa Municipality. This municipality has the second-highest population of all municipalities in Antalya, after Kepez, and there has been an increase in construction and urban development in the neighborhoods adjacent to the region (see Erkuş et al., 2024: 7–11; Tırış and Erkuş 2024:2318–2321).

Figure 9.1: Neighborhoods Included in the Kırcami Region Development Process. *Source*: Created by the authors using Google Earth 2023 data (see Erkuş et al., 2024: 8; Tırış and Erkuş 2024: 2319).

The economy of the region is based on the greenhouse-based agriculture and green vegetables in general. The Düden Stream is the main source of irrigation for agriculture in the region. The Kırcami Region is surrounded by urban areas on all sides and, being an undeveloped area for various reasons, can be classified within the typology of urban agricultural areas due to its location and scale (see Erkuş et al., 2024:8; Tırış and Erkuş 2024: 2319–2320). According to the urban agriculture typology, if production continues in areas like this and the produce is consumed within either an urban or national market, such areas should be considered urban agricultural areas (Koç, 2003).

Since the 1980s, there have been efforts to open the area to urban construction. As a result, numerous definitions have been made regarding the area to make a development plan and determine the general character of the region:

Table 9.1: Descriptions of the Character of the Region in the Development Plans of the Kırcami Region

Years	Description of the general character of the Kırcami Region
1980	Settlement Area for the Preservation of The Agricultural Character
2003	Settlement of Low-Density with Agricultural Character
2005	Residential Area with Agricultural Character
2006	Prestige Project Area and Agricultural Planning Area
2007	Urban Agricultural Planning Area
2008	Prestige Project Area and Urban Development Area
2013	Special Planning Area

Source: Created by the authors (based on Antalya Metropolitan Municipality, 2019; see also Erkuş et al., 2024: 8–9); Tırış and Erkuş (2024: 2327).

The current urban development plan for the region includes the definition of the "settlement area." The master development plan, at a scale of 1:5000, outlines the density of commercial and residential areas, and there is no mention of agricultural production in this plan (Antalya Metropolitan Municipality, 2019; see also Erkuş et al., 2024: 8–9; Tırış and Erkuş 2024: 2327). However, the plan faced opposition from numerous experts in the field, which led to the initiation of legal proceedings. In 2023, the development process of Kırcami was halted with the cancellation of the Law on the Amendment of the 1/100000 Scale Environmental Plan by the Council of State (Çağdaş Haber, 2023). A total of 24 lawsuits were filed concerning the parcellation plans in Kırcami. The Regional Administrative Court overturned previous decisions that aimed to invalidate the general parceling plan, ruling that the cases should be evaluated on a parcel-by-parcel basis, with plaintiffs considered individually. The court further concluded that a general cancellation was not in accordance with the law. Additionally, the court confirmed that the Kırcami Development Plan aligns with the public interest. Currently, two case files are still in process, and the licensing procedures have commenced (Muratpaşa Municipality, 2025 a; Muratpaşa Municipality, 2025b; for a succinct examination of the aforementioned latest status of this long legal process, see Erkuş et al., 2024: 9–10; Tırış and Erkuş, 2024: 2327–2328).

Finally, the Kırcami Region possesses plant and landscape diversity is also home to the Düden Stream (Döşemeci, 2020). However, it should be noted that during the winter months a significant number of greenhouses and farmlands in the region are destroyed by tornadoes, and that agricultural products are spoiled by excessive heat in the summer months (Milliyet, 2018; Sabah, 2022; HaberTürk, 2023; see Tırış and Erkuş, 2024: 2329). Occasional fires occur in the reed and scrub areas, as well as in the citrus groves of the region. The primary causes of these fires are rising temperatures and the disposal of refuse in these areas (Akdeniz Gerçek, 2015). In addition to these, on February 6, 2023, in the great earthquake disaster centered on Kahramanmaraş, the inhabitants of the Kırcami Region felt the tremors due to the alluvial soil structure and the old and neglected masonry buildings throughout the region. After the earthquake, discussions about the structure of cities increased both in the Kırcami Region and throughout Türkiye, and there have been changes in the expectations of actors involved in urban planning, living, and investing in areas with a high risk of being affected by disasters (Tırış and Erkuş, 2024: 2317, 2319).

Having outlined the general characteristics of the Kırcami region, the urban planning processes, and the legal proceedings involved, the following section will discuss the methodology employed in this study, including the presentation of the findings.

9.4.2 Method

Within the aforementioned context, the changes in the perceptions of different actors in Kırcami regarding disasters, especially after the various natural disasters in the country and the Kahramanmaraş earthquake, and the increasing sensitivity and demands for planning the region in a more resilient and sustainable way in the future motivated this study to investigate another dimension of the aforementioned topic, namely climate change and climate justice. Therefore, as part of the study, qualitative research techniques were utilized to conduct in-depth interviews, which took place in May 2023, with the region with the region's inhabitants (who were selected according to their land size, location, and socioeconomic status) and two experts (urban planners) involved in the local government (one from the Muratpaşa

Municipality and the other from the Antalya Metropolitan Municipality). Questions on spatial justice (infrastructure, urban services, transportation, water and sanitation, and building quality) and climate justice (flood risk, disaster risk, temperature, precipitation) were posed to the residents of the region. In addition, the region's inhabitants were asked about their views on urban agriculture and about their climate-related expectations of the development plan to be drawn up. In the interviews with two experts from the local government, they were invited to evaluate the current land use plan with regard to its sensitivity to climate change and disasters. Finally, another question asked of both group of participants was whether participatory democratic processes in the current land use plan were sufficient for both parties involved. Views of all participants were analyzed through their discursive expressions.[31]

9.4.3 Findings

An analysis of the findings in terms of gender, age, level of education, profession, additional income, and the neighborhood in which the interviewees live reveals that eight residents derived their sole income from agriculture, nine only worked agricultural jobs for additional income, and one was a tradesman in this region (Table 9.2).

---

[31] In the broader research initiative of which this book chapter is a part, when examining the processes of deliberative planning methods specific to the Kırcami Region, we conducted in-depth interviews with 20 participants living and working in the Kırcami Region, 10 investor landowners who do not live in the region, and two experts (urban planners) from local authorities (a total of 32 participants). In this particular study, the analysis focuses solely on the perspectives and experiences of 20 participants who have directly encountered the impacts of climate change and environmental justice issues, specifically individuals who both produce and reside in the region. Additionally, the evaluations of two officials from local authorities regarding the impacts of climate change and environmental justice were included in the analysis of this study. The semi-structured interview form used in the study includes all the questions related to deliberative democratic decision-making and disaster-resistant urban planning in the context of Kırcami, as well as other questions concerning planning processes within the broader project. For details on how we designed the research and methodology (including the definition of the unit of analysis and the sample; demographic information about the participants, details about the neighborhoods where participants and residents live, and the types of questions included in the in-depth interviews), see Erkuş et al. (2024: 7–12); Tırış and Erkuş (2024: 2318–2321).

Table 9.2: Findings on Gender, Age, Education, Profession, Additional Income, and Neighborhood of the Residents

Participants	Gender	Age	Education	Profession	Additional Income	Neighborhood
P1	Male	59	High School	Farmer	A Middleman Dealing in Agricultural Trade	Kırcami
P2	Female	53	Primary School	Farmer	None	Kırcami
P3	Male	42	High School	Realty	Agriculture	Güzeloluk
P4	Male	32	Foundation degree	Artisan	None	Zümrütova
P5	Male	25	High School	Farmer	None	Mehmetçik
P6	Female	65	No formal education	Farmer	None	Tarım
P7	Female	72	Primary School	Retired	Field Rental	Tarım
P8	Male	54	Primary School	Public Officer	Agriculture	Güzeloluk
P9	Female	52	Primary School	Farmer	None	Topçular
P10	Female	46	High School	Executive Assistant	Agriculture	Doğuyaka
P11	Female	45	High School	Farmer	None	Yeşilova
P12	Female	63	Primary School	Retired	Agriculture	Topçular
P13	Male	68	Primary School	Retired	Agriculture	Fener
P14	Male	41	High School	Worker	Agriculture	Yeşilova
P15	Female	52	Primary School	Farmer	None	Çağlayan
P16	Male	80	Primary School	Retired	Agriculture	Güzeloluk
P17	Male	52	Primary School	Retired	Agriculture	Güzeloluk
P18	Male	34	Undergraduate	Nurse	Agriculture, Health	Güzeloluk
P19	Female	64	Primary School	Farmer	Leasing Agricultural Land for Farming Activities	Güzeloluk
P20	Male	48	Primary School	Farmer	None	Yeşilova

Source: Created by the authors (see Erkuş et al., 2024: 12; Tırış and Erkuş, 2024: 2330–2331).

Half of the resident participants expressed interest in exploring the agricultural sector as a source of additional income. Participants noted a lack of interest among young people in pursuing careers in the agricultural sector. Notably, half of the participants who are fully engaged in agriculture indicated that all family members work in this field (Table 9.2). It has been observed that the younger population is not inclined to live in the region due to factors such as marriage, and for this reason, older family members, women, and even children take part in agricultural production. The data in the table clearly demonstrates that older people continue to take part in production (the average age is 53.5.). It is therefore possible to conclude that the region, when considering the age groups and genders of the participants, is vulnerable to climate change, particularly because climate change affects women, children, and the elderly the most, and these groups are more vulnerable (Uysal Oğuz and Ilık Bilben, 2020).

Participants, as mentioned before, were invited to provide their views on a range of key issues, including questions about climate change, infrastructure, urban services, transport, water, sanitation, pollution, green spaces, building quality, and spatial equity. They were then asked to rate them as sufficient or not. The results obtained indicate that there is a perception that the infrastructure is inadequate, that the quality of buildings is poor, that the water is not sanitized, and that the water is polluted (Table 9.3). In alignment with these observations, the tremors of the February 6 earthquake could be felt in this region due to the age and inadequate quality of the buildings. In the aftermath of an earthquake, there is a prevalent expectation among the populace that future building will be characterized by enhanced resilience and reduced density (TMMOB Chamber of Architects, 2005).

In this context, the concept of spatial justice becomes particularly relevant among the residents of Kırcami, as it focuses on the socioeconomic organization of space and the distribution of resources, and securing the opportunity to use these resources (Weck, et al., 2021). Building on this, the basic conditions for ensuring spatial justice in cities are the equitable distribution of land use, the repair and resilience of transport infrastructure, critical infrastructure such as sewerage, water sanitation services, urban pollution, and drainage systems (Moroni et al., 2019). The inequitable distribution of these elements in the urban space is causing vulnerability to a great variety of crises, including the climate crisis, which will have the most devastating consequences. Spatial injustice in a city results in urban-climate injustice in cities experiencing a climate crisis.

Accordingly, the responses provided in Table 9.3 concerning the Kırcami Region, which is located in the center of the city and surrounded by dense settlements, indicate a significant degree of spatial injustice. According to experts, the prolongation of the development process without provision of the necessary infrastructure (transport, sewerage, water, sanitation, etc.) poses risks to the people living in the region (Hürriyet, 2023; see Tırış and Erkuş, 2024: 2328).

Table 9.3: Findings Related to Spatial Justice

	Sufficient (%)	Insufficient (%)
Infrastructure	0	100
Urban services	35	65
Sanitation	0	100
Transportation	55	45
Building quality	10	90
Greenspace	100	0
Flood risk	100	0

Source: Created by the authors.

Although all participants stated that there was no flood risk in the region, the Düden Stream flooded in 2002 and 2010 (DSİ, 2021; see Tırış and Erkuş, 2024: 2328), affecting some greenhouse areas, agricultural land, and residential areas near the Stream. The flood risk map, prepared by the State Hydraulic Works (DSİ), shows that in the event of a flood, there would be significant destruction (Figure 9.2).

Another question posed to the residents concerned with the advantages and disadvantages of agricultural production in the city center. "Proximity to the city centre and wholesale market, the presence of the Düden stream (proximity to the water), and proximity to the market" were mentioned by them as advantages (see Erkuş et al., 2024: 14).

Figure 9.2: Flood Risk Map of the Düden River.
Source: DSİ (2021); see also Tırış and Erkuş (2024: 2329).

In the responses concerning the disadvantages of urban farming, issues related to agricultural production are highlighted. The most common answers are the high input costs in agricultural production and the low profit in return. Conventional agricultural production methods are employed in Kırcami to increase productivity, and participants emphasize that productivity in the region is lower than in the village areas. Another aspect concerns the distribution dimension of agricultural production; the fact that less profit is being made due to the agricultural intermediaries involved in the distribution process is also considered a disadvantage (see Erkuş et al., 2024: 14). The opinion of one participant (P7) on this situation is as follows:

> The costs are expensive. That is the difficulty. They also say not to use agricultural pesticides. But we must. Because the seed we buy comes with pesticides. If we use some pesticides, we are punished by the government. And I cannot go to the market at this age. I must give it to the brokers. They make a profit. What is left for us is chickenfeeds. (P7)

When participants were asked whether they wanted to continue farming in the future, more than half of the participants said they did not (12 people), while fewer said they did want to continue farming (8 people). Uncertainty in the development process, loss of soil fertility, and high input costs in agricultural production were the main reasons given when asked why they did not want to continue farming. The fact that 12 participants do not want to continue production due to "agricultural input costs and inefficiency" suggests that new policies and planning processes need to be implemented, given that projections for 2030 emphasize that the world's population will increase to 8 billion and that agricultural production will have to increase by 60 percent to feed this population (Zaimoğlu, 2019). The views of two of the participants, (P9) (see also Erkuş et al., 2024: 14) and (P13), were as follows in this regard:

> The cost is too high. And the middlemen take most of the money. Our share is very small. We cannot go to the market because we cannot find labourers. Wages are high. I sometimes go to work for daily wages to make a living myself. It is very difficult to do agriculture here now. (P9)

> They say that the soil is not fertile, the seeds they give us to plant are imported, and they also give us pesticides. Then they punish us for using them. Will the soil remain fertile with the foreign seeds and the pesticides given to it? Do you know that it is forbidden to use local seeds in this country? Why should I continue with agricultural production? (P13)

The participants were asked whether climate change was having an impact on the region and what they expected from the plan in this regard. It was found that they most often referred to "temperature increase and rainfall" to express what they thought about climate change. They explained that as temperatures have risen, different species have appeared which they describe as "harmful" to their crops. To combat them, they use agricultural pesticides (see Tırış and Erkuş, 2024: 2332–2333; 2335–2336). This aligns with broader trends observed across Türkiye, where the impact of climate change on agricultural production in Türkiye is characterized by "decreased yields, increased irrigation, and costs, changed planting and harvesting times, changed soil structure, and increased plant diseases and harmful species in the soil" (Kadıoğlu et al., 2017). One participant (P12) also shared their perspective on this issue is as follows:

> The heat has increased. It affects everything. The crops have been ruined. Different insects and pests have emerged. We have to use new pesticides every time. This is not only harmful to our health but also spoils the soil. We cannot work in the heat. We have to work with lights at night, which is also difficult. They should not build concrete, there should be greenery around. (P12)

When analyzing the statements of the participants regarding excessive rainfall, floods, inundations, and storms, it was assumed that disasters such as floods and inundations do not occur due to the high amount of permeable soil surfaces in the region. However, greenhouses and agricultural land are destroyed due to the tornadoes that occur during storm periods and there is not enough support during these times. In the context of Türkiye, following the Uruguay Round organized by the World Trade Organisation in 1994 and the decisions taken in course of the Agenda 2000, there has been a reduction in agricultural subsidies due to a decrease in state support and the provision of this support through market instruments. Concurrently, there has been a decline in small and medium-scale agricultural production. This situation was reflected in a significant increase in the prices of agricultural inputs, causing small producers to struggle in the market and to migrate to the cities (Yeni and Teoman, 2023). Furthermore, it should be noted that various small producers in Türkiye do not have sufficient information about the current agricultural support and insurance procedures (Temürcü, 2021). The statement of one of the participants (P1) (see also Tırış and Erkuş, 2024: 2332) on this situation is as follows:

> There has been a change in the climate and so have the weeds and insects in our fields. Most people in this neighbourhood would not say that this is the reason. But when the heat comes, different insects and pests appear. The rain does not affect us because the soil absorbs it. But it is the tornadoes/cyclones in winter that force us. When you go to the district agriculture department, they say "Sorry about that," they send an expert, but there is no result for us. We have no time to deal with it. They have to patch it up the day after the cyclone so that the crop is not exposed. None of them think about the farmer. (P1)

As part of this study, interviews were also conducted with two urban planning experts involved in the planning process and working in two different municipalities. The interview questions addressed whether the plan was prepared in a climate-sensitive manner. The results show that while one expert stated that the plan was climate-sensitive, the other expert emphasized that it was inadequate in terms of climate and disaster issues. The contradictory views of the experts on this issue are as follows:

> A plan with more open space, integration with the city centre by increasing the number of bicycle paths, and support for sustainable energy sources with plan notes. (E1)

> The plan has no advantages. The plan was already very bad. There is neither climate sensitivity nor disaster sensitivity. The parcellation is over now; if the parcellation was not over, maybe these sensitivities could have been included in the plan. But now the plan will go as it is ...The purpose is not to open this area for development, nor is it to make a good plan. This is what the public expects. Citizens are not interested in how correct the plan is for the city. (E2) (see also, Erkuş et al., 2024: 21; Tırış and Erkuş, 2024: 2335)

Finally, when analyzing the involvement of the participants in the democratic decision-making mechanisms of the development planning process, it was found that most of the participants (15) were not involved in the process at all. Only 25 percent of the participants (5) attended the meetings with their wishes and follow-ups, but they did not consider these meetings to be sufficient. Upon further analysis of the reasons behind their involvement in the process, they provided answers such as "we did not trust the development plan and we were not given enough information" (see also Erkuş et al., 2024: 13).

Consequently, following 40 years of discussions on development process, little to no infrastructure and urban services have been brought to the region, and the participants' definition of their region as a "disadvantaged area" is a clear indicator of the existing spatial and climatic injustice.

9.5 Conclusion

Cities can be key drivers in both creating and solving the climate crisis. Measures implemented through a participatory urban planning process can ensure climate and spatial justice, and holistic local policies to combat the climate crisis can be developed as part of this process. It is imperative that climate-sensitive plans should be prioritized in unbuilt regions and that built regions should be transformed with equal sensitivity.

In this sense, we aimed in this study to explore land-use change in the Kırcami Agrihood through the perspectives of local stakeholders, focusing on the role of climate change and environmental justice. Specifically, we assessed whether the Kırcami development plan (i) adresses climate change and environmental justice concerns, and (ii) utilizes appropriate tools to ensure fairness and inclusivity. In-depth interviews with the residents of the region (living and working in the area), and two urban planning experts from local government were conducted to understand their views on urban agriculture, climate change, and the planning process.

The findings of this study indicate that issues leading to spatial and climatic injustice, including infrastructure, urban services, and water sanitation, ought to be addressed with utmost urgency, irrespective of the Kırcami Region's urban planning process. It was observed that the inhabitants of the region had lost their confidence in local politics due to the uncertainty surrounding the planning process, and that they were no longer able to meet their basic needs. Regarding climate change, the participants emphasized that tornadoes have a particularly significant impact on the region due to the presence of greenhouses (since they are made of plastic nylons covered on thin iron frames), and that it is also profoundly affected by the change in the ecosystem due to temperature changes. It is their stated position that the development plan must be formulated in such a manner as to incorporate the principles of climate justice and spatial justice. Considering the floods in Antalya due to the excessive rainfall that affected the houses and workplaces, participants stated that the risk of flooding in the Düden Stream may increase if the drains in the region are closed after the construction, which is an essential element related to spatial and climate justice that should be considered in the development planning phase.

While 60 percent of the resident participants would like to live in the Kırcami Region after the development planning process, 40 percent of them said that they would move to a place where they could engage in agricultural production, though not necessarily in direct contact with the countryside, after the process. The planning pressure for urban construction purposes in the Kırcami Region, where agricultural production continues, should be revisited with regards to a climate-sensitive planning approach, and, furthermore, solutions for urban agriculture should also be considered in areas that can be productive. The aforementioned measures alone could play an essential part in creating resilient regions.

The case of Kırcami also shows that this is a multi-actor region, involving residents, investors, and planners at the local and national level. Therefore, the Kırcami planning process should be carried out in a more democratic, collective, and inclusive manner, where power imbalances between local society, planning authorities, and investors are addressed, and the preferences of all actors are reconciled. In addition, policymakers should also develop institutional mechanisms for participatory urban planning, especially in countries like Türkiye, where deliberative democracy tools are not legally integrated into the political system (Erkuş et al., 2024). The Kırcami example clearly shows the necessity of incorporating climate-sensitive strategies and practices into the development planning process, to ensure food security. The development of such deliberative democratic processes and tools for the design and implementation of the urban plan is imperative.

This study has the potential to inform future research by underscoring the importance of incorporating residents' perspectives in climate change adaptation and urban planning processes. It can provide valuable insights into the integration of climate justice and spatial justice into local policymaking, offering a foundation for more inclusive and sustainable urban development in the face of climate change.

Bibliography

Ackerman, K., Conard, M., Culligan, P., Plunz, R., Sutto, M., Whittinghill, L. (2014). "Sustainable Food Systems for Future Cities: The Potential of Urban Agriculture." *The Economic and Social Review*, 45(2): 189–206.

Akdeniz Gerçek (2015). "Kırcami'de can pazarı [A Life-and-Death Struggle in Kırcami!]." Akdeniz Gerçek Gazetesi. Retrieved February 8, 2024 from https://www.akdenizgercek.com.tr/kircamide-can-pazari

Amorim-Maia, A. T., Anguelovski, I., Chu, E., Connolly, J. (2022). Intersectional Climate Justice: A conceptual pathways for bridging adaptation planning, transformative action, and social equity. *Urban Climate*. Vol. 41, DOI: https://doi.org/10.1016/j.uclim.2021.101053.

ABB (Antalya Büyükşehir Belediyesi) (2019). *Antalya İli Muratpaşa İlçesi, Kırcami Bölgesi 1/5.000 Ölçekli Nazım İmar Planı Revizyonu Plan Açıklama Raporu* [*Antalya Province Muratpaşa District, Kırcami Area 1/5,000 Scale Master Development Plan Revision Plan Explanation Report*]. Retrieved February 8, 2024 from https://www.antalya.

bel.tr/Content/UserFiles/Files/KentselBolgesel%2FKIRCAM%C4%B0_5000N%C4%B0P_REV_PlanRapor.pdf

Aysu, A. (2019). *Kooperatifler* [*Cooperatives*]. Yeni İnsan Yayınevi, Ankara.

Bernstein, H. (2014). *Tarımsal Değişimin Sınıfsal Dinamikleri* [*Class Dynamics of Agrarian Change (2010)*]. (Çev. O. Köymen). Yordam Yayınları, İstanbul.

Biermann, F., Kanie, N., Kim, R. E. (2017). Global governance by goal-setting: the novel approach of the UN Sustainable Development Goals. *Current Opinion in Environmental Sustainability*. Vol. 26–27. pp: 26–31. DOI: https://doi.org/10.1016/j.cosust.2017.01.010.

BirGün (2023). "Antalya'da sağanak: En yüksek yağış miktarı kaydedildi [Heavy rain in Antalya: The highest amount of rainfall recorded]." BirGün Gazetesi. Retrieved February 9, 2024 from https://www.birgun.net/haber/antalya-da-saganak-en-yuksek-yagis-miktari-kaydedildi-417315

Çağdaş Haber (2023). Antalya'da ‚büyük' iptal! [The 'big' cancellation in Antalya]. Çağdaş Haber Gündem. Retrieved February 8, 2024 from https://www.cagdashaber.com/antalyada-buyuk-iptal/

Deilami, K., Kamruzzaman, M., Liu, Y. (2018). Urban heat island effect: A Systematic review of spatio-temporal factors, data, methods, and mitigation measures. *International Journal of Applied Earth Observation and Geoinformation*. Vol. 67. pp: 30–42. DOI: https://doi.org/10.1016/j.jag.2017.12.009.

Demirbaş Topçu, E. (2015). The Growing Problem Between Urban Expansion and Sustainability of Agricultural Lands, Kırcami Example in Antalya. [This is a doctoral thesis that has not been published.]. Ortadoğu Teknik Üniversitesi, Ankara.

Dikeç, M. (2001). Justice and the spatial imagination. *Environment and Planning*. Vol. 33(10): 1785–1805. DOI: 10.1068/a3467.

Döşemeci, E. (2020). *How to expand the city into agricultural landscape? Integrating tangible and intangible assets in the framework model in Kırcami, Türkiye*. School of Architecture Urban Planning Construction Engineering Master of Science in Sustainable Architecture and Landscape Design. [Unpublished Master's thesis], University of Politecnico di Milano, Italy.

DSİ (Devlet Su İşleri (State Water Works)). (2021). İl Afet Risk Azaltma Planı [Provincial Disaster Risk Reduction Plan]. Retrieved From https://antalya.afad.gov.tr/kurumlar/antalya.afad/Tasarim/IRAP/Antalya-IRAP_2022.pdf, on 04/02/2024.

Elmqvist, T., Andersson, E., Frantzeskaki, N., Mcphearson, T., Olsson, P., Gaffney, O., Takeuchi, K., Folke, C. (2019). Sustainability and resilience for transformation in the urban century. Nature Sustainability, 2(2019): 267–273. DOI: https://doi.org/10.1038/s41893-019-0250-1.

Erkuş, H. and Terhorst, P. (2013). "Devlet-Girişimci İlişkilerinin (Yeniden) Ölçeklenmesi: Turizm Kapitalizmi ve Mekânsal Etkileri Üzerine Eleştirel Bir Değerlendirme [The (Re)Scaling of State-Entrepreneur Relations: A Critical Evaluation of Tourism Capitalism and Its Spatial Effects]." *4. Kentsel ve Bölgesel Araştırmalar Sempozyumu, Neo-liberalizm Sonrası Mekânsal Müdahale Biçimleri ve Yansımaları:* 459–473. Mersin.

Erkuş, H., Alkan, Y. S., and Tırış, G. (2024). Deliberative democracy and making sustainable and legitimate development plans: The case of the Antalya Kırcami Agrihood. Land, 13(4): 1–28. DOI: https://doi.org/10.3390/land13040447.

FAO (2016). *Urban Agriculture Twelve Organizations Promoting Urban Agriculture around the World*. Retrieved From http://www.fao.org/family-farming/detail/en/c/461898/, on 20/12/2023.

Friedlingstein, P.; O'Sullivan, M.; Jones, M. W.; Andrew, R. M.; Bakker, D. C. E.; Hauck, J.; Landschützer, P.; Le Quéré, C.; Luijkx, I. T.; Peters, G. P.; et al. (2023). Global Carbon Budget 2023. *Earth System Science Data*. Vol. 15(12): 5301–5369. DOI: https://doi.org/10.5194/essd-15-5301-2023.

Gözüm, İ. G. and Zengin Çelik, H. (2022). Kentleşme ve İklim Değişikliği İlişkisinde Sel ve Su Baskınlarının Türkiye ve Güney Kore Bağlamında İncelenmesi [Examination of Floods and Water Inundations in the Relationship Between Urbanization and Climate Change in the Context of Turkey and South Korea]. *Van Yüzüncü Yıl Üniversitesi Uluslararası Avrasya İklim Değişikliği Kongresi*, EURACLI'2022. 29/09/2022-01/10/2022.

Haber Türk (2023). "Antalya'da hortum dehşeti. Mağazanın camları patladı! AFAD'dan alarm! [Tornado horror in Antalya. The store's windows shattered! AFAD issues an alert!]." Retrieved February 8, 2024 From https://www.haberturk.com/son-dakika-antalya-da-hortum-dehseti-magazanin-camlari-patladi-afad-dan-alarm-one-cikan-haberler-3555558

Heinberg, R. ve Bomford, M. (2016). *Tarım ve Gıdanın Dönüşümü* [*The Food and Farming Transition*]. (Çev. H. Doğrul). Yeni İnsan Yayınları, İstanbul.

Hürriyet Gazetesi (2023). "Zeminimiz sağlammış" [They told the ground is stable!]. Retrieved October 20, 2024, from https://www.hurriyet.com.tr/yerel-haberler/antalya/zeminimiz-saglammis-42229608,

IPCC (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK.

IPCC (2022). Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. [H. -O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

IPCC (2023). "Summary for Policymakers," in Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the IPCC. ed. H. Lee and J. Romero. pp. 1–34. DOI: 10.59327/IPCC/AR6-9789291691647.001.

Işınkaralar, Ö. (2023). Kent Planlama Perspektifinden İklimin Geleceğine İlişkin Mekânsal Öngörüler: Antalya Havzası Örneği [Spatial Estimates on The Future of Climate From an Urban Planning Perspective: The Case Of Antalya Basin]. *Çevre, Şehir ve İklim Dergisi*, 2(4): 128–145.

Kadıoğlu, M., Ünal, Y., İlhan, A. ve Yürük, C. (2017). Türkiye'de İklim Değişikliği ve Tarımda Sürdürülebilirlik [Climate Change and Sustainability in Agriculture in Türkiye]. *Türkiye Gıda ve İçecek Sanayii Dernekleri Federasyonu*. Retrieved February 9, 2024 from http://www.tgdf.org.tr/wpcontent/uploads/2017/10/iklim-degisikligi-raporelma.compressed.pdf

Kanbak, A. (2018). Endüstriyel Tarımın Ekolojik Krizine Karşı Kentsel Tarım Bir Çözüm Olabilir mi? [Can Urban Agriculture Be A Solution to

The Crisis of Industrial Agriculture?]. *Anadolu Üniversitesi Sosyal Bilimler Dergisi*, 18(3): 193–204. DOI: https://doi.org/10.18037/ausbd.552556

Koç, H. (2003). Daha yaşanabilir yerleşmeler arayışında kentsel tarım [The search for liveable settlements in urban agriculture]. *Planlama*, 1: 34–40. Retrieved April 1, 2025, from https://www.spo.org.tr/resimler/ekler/da04049a062f5ad_ek.pdf

Lucertini, G. and Di Giustino, G. (2021). Urban and Peri-Urban Agriculture as a Tool for Food Security and Climate Change Mitigation and Adaptation: The Case of Mestre. *Sustainability*, 13(11): 5999. DOI: https://doi.org/10.3390/su13115999.

Milliyet Gazetesi (2018). "Antalya'da hortum, serada ve tarım alanlarında hasara yol açtı [Tornado in Antalya caused damage to greenhouses and agricultural fields]." Retrieved February 8, 2024 from https://www.milliyet.com.tr/gundem/antalyada-hortum-serada-ve-tarim-alanlarinda-hasara-yol-acti-2637102

Moroni, S. (2019). The Just city. Three background issues: Institutional justice and spatial justice, social justice and distributive justice, concept of justice and conceptions of justice. *Planning Theory*. Vol. 19(3):251–267, DOI: https://doi.org/10.1177/147309521987767.

Muratpaşa Municipality (2025 a). Kırcami müjdesinin eli kulağında [The good news for Kırcami is just around the corner]. Retrieved April 1, 2025 from https://muratpasa-bld.gov.tr/haber/10457/kircami-mujdesinin-eli-kulaginda?utm_source

Muratpaşa Municipality (2025b). Kırcami'de değişim başlıyor [Change is starting in Kırcami]. Retrieved April 1, 2025 from https://muratpasa-bld.gov.tr/haber/8657/kircami-de-degisim-basliyor?utm_source

Napawan, N. C. (2016) Complexity in urban agriculture: the role of landscape typologies in promoting urban agriculture's growth. *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, Vol. 9(1): 19–38, DOI: 10.1080/17549175.2014.950317.

Özen Bayraktar, S. and Çiçek, İ. (2022). Türkiye'de hortum olayları [Tornado events in Türkiye]. *Journal of Social and Humanities Sciences Research*. Vol. 9(86): 1604–1616. DOI: http://dx.doi.org/10.26450/jshsr.3202.

Paprocki, K. (2020). The climate change of your desires: Climate migration and imaginaries of urban and rural climate futures. *Environment* *and Planning D: Society and Space*. Vol. 38(2): 248–266. DOI: https://doi.org/10.1177/026377581989260.

Rasouli, S. (2012). Kent Topraklarının tarımsal amaçlı kullanımı: Kentsel tarım [The utilisation of urban land for agricultural activities: Urban agriculture]. Retrieved, December 3, 2023 from https://www.skb.gov.tr/kent-topraklarinin-tarimsal-amacli-kullanimi-kentsel-tarim-s1238k/

Sabah Gazetesi (Şubat, 2022). Hortumun vurduğu seralarda çiftçinin hasar tamiri mesaisi başladı [Farmers have started their damage repair work in the greenhouses hit by the tornado]. Retrieved, October 20, 2023 from https://www.sabah.com.tr/antalya/2022/02/04/hortumun-vurdugu-seralarda-citcinin-hasar-tamiri-mesaisi-basladi

Schlosberg, D. ve Collins, L. B. (2014). From environmental to climate justice: climate change and the discourse of environmental justice. *WIREs Climate Change*. Vol. 5(3): 359–374. DOI: https://doi.org/10.1002/wcc.275.

Scholtz, W. and Barnard, M. (2018). The environment and the Sustainable Development Goals: "We are on a road to nowhere." in *Sustainable Development Goals* (eds. D. French and L. J. Kotze). Monograph Book, pp: 222–249. DOI: https://doi.org/10.4337/9781786438768.

Soja, E. (2009). The city and spatial justice. in Justices et Injustices Spatiales, ed. B. Bret, P. Gervais-Lambony, C. Hancock, F. Landy. Presses Univeritaires de Paris Ouest, Paris. pp: 55–74.

SDGs (2016). The Sustainable Development Goals Report 2016. *UNSTATS*. Retrieved, October 18, 2023 from https://unstats.un.org/sdgs/report/2016

Swyngedouw, E. (2006). Metabolic urbanization: the making of cyborg cities. In the nature of Cities: Urban Political Ecology and the Politics of Urban Metabolism. Heynen, N., Kaika, M., & Swyngedouw, E. (Eds.), (1st ed.). Routledge. DOI: https://doi.org/10.4324/9780203027523.

Temürcü, C. (2021). Türkiye'de tarım ve gıda: Mevcut durum ve öneriler [Agriculture and food in Turkey: Current situation and recommendations]. Dört Mevsim Ekolojik Yaşam Derneği. Retrieved February 11, 2024 from https://www.dortmevsimekoloji.org/wp-content/uploads/2021/09/T%C3%BCrkiye%E2%80%99de-tar%C4%B1m-ve-g%C4%B1da-mevcut-durum-ve-%C3%B6neriler.pdf, on 11/02/2024.

Tırış, G. and Erkuş, H. (2024). Afet dirençli kent planlamada politika beklentileri: Antalya Kırcami bölgesi örneği [Policy expectations for a disaster resilient urban planning: Case of Antalya Kırcami Agrihood]. *İDEALKENT*, 16(46): 2315–2347. DOI: https://doi.org/10.31198/idealkent.1431048.

TMMOB Chambers of Architects (2005). Deprem ve Mimarlık [Earthquake and Architecture]. TMMOB Mimarlar Odası İstanbul Büyükkent Şubesi, Yuvarlak Masa Toplantısı. Mimarlık Vakfı İktisadi İşletmesi, İstanbul.

Tong, P. (2021). Characteristics, dimensions and methods of current assessment for urban resilience to climate-related disasters: A systematic review of the literature. *International Journal of Disaster Risk Reduction*. 60. DOI: https://doi.org/10.1016/j.ijdrr.2021.102276.

Uncu, B. A. (2021). İklim için Kentler, İzleme & Değerlendirme [Cities for Climate, Monitoring and Evaluation]. (ed. E. Baysal). 350Turkiye. Retrieved, February 8, 2024 from www.iklimicinkentler.org.

UN-Habitat III (2017). *New Urban Agenda*. United Nations Press. Retrieved February 1, 2024 from http://habitat3.org/wp-content/uploads/NUA-English.pdf.

UNSTATS (2020). *The Sustainable Development Goals Report 2020*. Retrieved, January 7, 2024 from https://unstats.un.org/sdgs/report/2020/

Uysal Oğuz, C. and Ilık Bilben, M. S. (2020). İklim Adaleti Tartışmalarına Güncel Bir Bakış [A Current Perspective on Climate Justice Debates]. in Ekolojik Kriz ve Küresel Çevre Politikları. (ed. H. Sağır). Beta Yayınları, İstanbul.

Weck, S., Madanipour, A., Schmitt, P. (2021). Place-based development and spatial justice. *European Planning Studies*. Vol.30(5): 791–806. DOI: https://doi.org/10.1080/09654313.2021.1928038.

WMO (2007). United Nations Agency calls for urban agriculture: WMO press release, December 7, 2007. Retrieved February 2, 2024 from https://news.un.org/en/story/2007/12/244302

Woodhouse, P. (2010). Beyond Industrial Agriculture? Some questions about Farm Size, productivity and sustainability. *Journal of Agrarian Change*. 10(3): 437–453.

Yeni, O. and Teoman, Ö. (2023). Agroekolojik Bakış Açısından Türkiye'de Tarımsal Sürdürülebilirlik [Agricultural Sustainability in Türkiye from an Agroecological Perspective]. Fiscaoeconomia, 7, 120–151. Doi: 10.25295/fsecon.1355937.

Zaimoğlu, Z. (2019). İklim Değişikliği ve Türkiye Tarımı Etkileşimi [Climate Change and Its Interaction with Turkish Agriculture]. İklim Değişikliği Eğitim Modülleri Serisi 7. İklimİn, Ankara.

Zezza, A. and Tasciotti, L. (2010). "Urban agriculture, poverty, and food security: Empirical evidence from a sample of developing countries." *Food Policy*, 35(4): 265–273. DOI: 10.1016/j.foodpol.2010.04.007.

Investigation of the Effect of Green Roof Systems on Building Heating Load and Cost Relationship

Ender Yetim[32] *and Aynur Kazaz*[33]

10.1 Introduction

Today, approximately 50 percent of the world's population lives in cities. It is predicted that this rate will increase to 75 percent by 2050 (European Commission, 2022). This rapid increase in the rate of urbanization leads to an increase in the demand for energy. To meet the increasing demand, natural resources are consumed rapidly and unconsciously. Greenhouse gas emissions resulting from the consumption of natural resources cause environmental disasters in the world in a continuous and increasing manner.

Cities are responsible for 70 percent of natural resources and energy consumption and 70 percent of greenhouse gas production (European Investment Bank, 2021). As part of the 2030 strategy, the European Union (EU) aims to achieve a 40 percent reduction in greenhouse gas emissions relative to 1990 levels, increase the proportion of renewable energy in total energy consumption to a minimum of 32 percent, and ensure energy savings of 32.5 percent (European Commission, 2014). In order to minimize the energy consumed in the world, efforts to increase energy efficiency in many areas, especially in building, transport, industry and agriculture, have gained momentum. In this context, it has become obligatory to create planning and design approaches under concepts such as sustainable cities, ecological cities, or low-carbon cities (Van Kamp et al., 2003). The building sector represents a significant share of global energy demand and environmental impact. This sector is responsible for approximately 39 percent of total energy consumption worldwide, exceeding the shares of both the industrial (33%) and transportation (28%)

[32] Ph.D. student, Akdeniz University, Faculty of Engineering, Civil Engineering Department, ender-ytm@hotmail.com, ORCID Code: 0000-0002-1676-6778.

[33] Prof. Dr. Akdeniz University, Faculty of Engineering, Civil Engineering Department, akazaz@akdeniz.edu.tr, ORCID Code: 0000-0001-7926-7178.

sectors. Within this scope, residential buildings alone account for nearly 54 percent of the total energy use in the building sector, while the remainder is attributed to commercial structures. Additionally, the building sector is considered a major contributor to global greenhouse gas emissions, accounting for nearly one-third of the total (Kumar et al., 2022). To mitigate energy consumption in buildings, sustainable and energy-efficient strategies are being developed and implemented. In Türkiye, 81 percent of the energy consumed in residential buildings is allocated to heating. The country's energy-saving potential in buildings is estimated to reach up to 50 percent (Pamir, 2017). In the Final Declaration on Combating Climate Change published by the Republic of Türkiye Ministry of Environment and Urbanisation, it is stated that energy-efficient, climate-sensitive new settlements will be established by expanding smart city applications in Türkiye (T. C. Ministry of Environment and Urbanization, 2021).

Decisions made during a building's design phase significantly influence the energy consumption during its operational life. To minimize energy demand for heating, cooling, ventilation, and lighting, it is essential to implement energy-efficient building criteria. Among these criteria, the building envelope design offers the greatest opportunity for designer intervention. Numerous studies focus on optimizing the energy efficiency of opaque components, such as wall elements and insulation materials, as well as transparent components, including glazing and framing systems (Alsayed and Tayeh, 2019; Kazaz and Yetim, 2023; Mousavi Motlagh et al., 2021; Sayadi et al., 2021). In recent years, given the global impacts of climate change and the increasing frequency of extreme climatic events in urban areas, green roofs have emerged as one of the key building-scale strategies for climate resilience and adaptation. Green roofs are referred to as eco-roofs, living roofs or vegetated roofs and are defined as systems that enable the growth of various plant species on the roofs of buildings (Manso et al., 2021). Green roofs are artificial ecosystems developed to integrate urban infrastructure with natural elements. Designed under limited soil volume and water potential, these systems support the ecological balance of the urban environment by replacing traditional roofs (Polo-Labarrios et al., 2020). Roofs, which occupy an important place in urban areas, harbor a largely unused potential. Considering that they constitute 20–30 percent of these areas (Langemeyer et al., 2020), it is possible to strengthen the urban green fabric and increase the sustainable urban life quality with alternative solutions such as green roofs.

Green roofs differ significantly from conventional roofs in terms of functionality, environmental impacts and structural characteristics. Traditional roofs are usually covered with materials such as gravel or asphalt, aiming to provide protection against external factors such as rain and sun, and don't contribute significantly to energy efficiency or environmental sustainability. On the other hand, green roofs reduce the need for cooling by preventing overheating of buildings in summer and reduce heating costs by providing insulation in winter (Berardi, 2016; Jamei et al., 2021; Kaboré et al., 2020). This leads to a substantial decrease in the energy consumption of buildings. Furthermore, green roofs play a critical role in stormwater management; the vegetation and soil layer absorbs and gently retains rainwater, preventing flash flooding and reducing flood risk by lowering the load on urban infrastructure (Johannessen et al., 2018; Stovin et al., 2012). Green roofs contribute significantly to improving air quality, as plants absorb harmful gases and release oxygen, thereby reducing air pollution (Bellini et al., 2024; Kuittinen et al., 2023; O'Hara et al., 2022). Furthermore, green roofs provide an effective solution to the urban heat island effect by lowering temperatures in urban centers, creating a more livable environment (Takebayashi and Moriyama, 2007; Wang et al., 2022). These roofs increase biodiversity in cities by providing habitats for birds, insects and other small creatures through diverse vegetation (Coulibaly et al., 2023; Mayrand and Clergeau, 2018; L. Wang et al., 2022). In addition, green roofs reduce urban noise, creating quieter and more peaceful living spaces (Tadeu et al., 2024; Yang et al., 2012). Structurally, green roofs impose additional load on buildings due to the weight of the growing medium and vegetation and therefore require careful engineering consideration during the design phase. Although their initial investment costs are high, green roofs stand out as an integrated solution in sustainable urban design, considering the energy saving and environmental sustainability advantages they provide in the long term (Jim and Peng, 2012; Kon and Caner, 2023; Polo-Labarrios et al., 2020). The effects of green roofs on the urban ecosystem are presented in Figure 10.1, while a typical cross-section of a standard green roof system is presented in Figure 10.2.

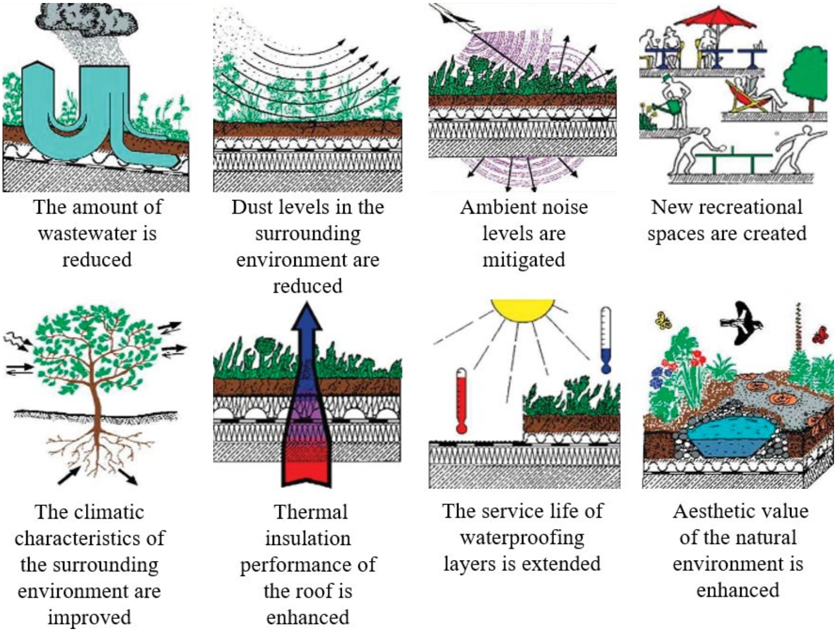


Figure 10.1: Impacts of Green Roofs on the Urban Ecosystem.
Source: Özyavuz et al. (2015).

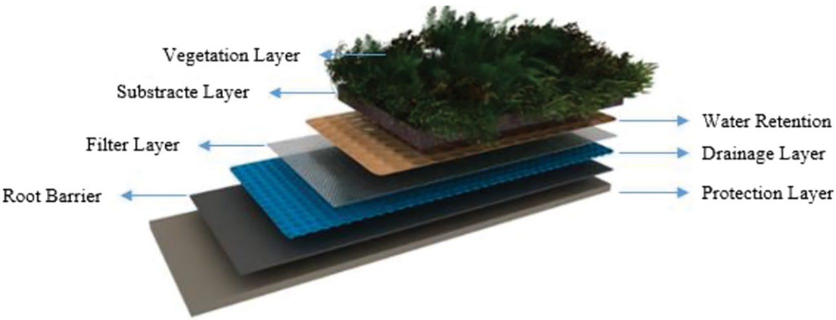


Figure 10.2: Typical Structural Section of a Green Roof.
Source: Shahmohammad et al. (2022).

In terms of utilization and functionality, green roof systems are analyzed in two main groups as extensive and intensive green roofs in terms of their characteristics such as the type of plants used and the depth of the growing environment shaped depending on the needs of the plant species, the planted surface area and the amount of load on the carrier system (Zamanı, 2022). The characteristics of extensive and intensive green roofs are presented comparatively in Table 10.1.

Table 10.1: A Comparison of Extensive and Intensive Green Roofs

Characteristic	Extensive roof	Intensive roof
Purpose	Functional benefits: stormwater management, thermal insulation, fire resistance	Functional and aesthetic benefit: expanded living space
Structural requirements	Typically within standard roof load-bearing limits; adds 70 to 170 kg/m²	Requires planning during the design phase or structural enhancements; adds 290 to 970 kg/m²
Substrate type	Lightweight: high porosity and low organic content	Lightweight to heavy: high porosity, low organic content
Average substrate depth	2 to 20 cm	20 cm or more
Plant communities	Low-growing plant communities: stress-tolerant species (e.g., *Sedum* spp., *Sempervivum* spp.)	No restrictions beyond substrate depth, climate, building height, exposure, and irrigation availability
Irrigation	Most require minimal or no irrigation	Often require irrigation
Maintenance	Minimal maintenance required; occasional weeding or mowing as needed	Maintenance requirements are similar to those of a comparable garden at ground level
Cost	\$100 to \$300 per m²	\$200 or more per m²
Accessibility	Generally functional rather than accessible; basic accessibility required for maintenance	Typically accessible; subject to bylaw considerations

Source: Özyavuz et al. (2015).

Today, it has been observed that studies on green roof systems—which provide many benefits such as water management and reduction of urban heat islands, improvement of air quality, reduction of noise and electromagnetic radiation, as well as providing energy efficiency in buildings—have gained momentum. These studies are generally pilot-scale studies (Ksiazek-Mikenas et al., 2018; Mickovski et al., 2013; Vijayaraghavan and Raja, 2015) and empirical studies

(Jahangir and Motlagh, 2023; Kotsiris et al., 2019; Porcaro et al., 2019) on waterproof membrane layers, root retaining layers, drainage layers, filter layers, growing mediums and plant areas in order to improve green roof components and obtain optimal components.

There are many studies in the literature investigating the effect of green roofs on the energy performance of buildings. Veronica et al. (2022) showed that by converting the roof of an office building in Romania to a green roof, approximately 14 percent energy savings in heating and 67 percent energy savings in cooling were achieved. In their experimental study, Azkorra-Larrinaga et al. (2023) calculated the energy consumption values by converting the roof of an educational building in Spain to a green roof. According to the study, the cooling energy demand was reduced by approximately 54 percent under dry green roof conditions and by 84 percent when the roof was saturated with water, highlighting the substantial role of moisture in enhancing thermal performance. In an experimental study by Peñalvo-López et al. (2020) a part of a public building in Spain was converted from a conventional roof to a green roof and measurements were taken throughout the year. The research found a 6 percent increase in energy consumption during the winter months, along with a 19 percent overall decrease in energy consumption throughout the year.

The existing literature includes numerous studies on green roofs within the scope of energy-efficient building design. These studies typically focus on individual floors or specific locations, conducting analyses for a particular climate zone. What sets this study apart is its calculation of energy efficiency at the block scale for four distinct degree-day regions in Türkiye. Additionally, the study uniquely examines the additional structural loads introduced by green roof applications using a static analysis program, quantifying the resulting increase in steel requirements for the load-bearing system. By evaluating both the material costs of green roofs and their impact on the structural system's cost, this research aims to address a critical gap in the literature.

10.2 Materials and Methods

Türkiye is divided into four different degree-day regions according to the TS 825—Thermal Insulation Requirements for Buildings. The thermal insulation requirements for buildings in Türkiye are defined by the national standard TS 825 issued by Turkish Standards Institution. TS 825 contains values to be used in the calculation of the heating energy requirement of buildings and rules for determining the maximum permissible heating energy (TSE, 2009). In the selected provinces representing these regions (Antalya, İstanbul, Ankara, Erzurum), Design Buildings were obtained by applying nine green roof scenarios, created by increasing the thickness of the growing medium by 5 cm each between 10 cm and 50 cm, to a Base Building with a traditional gravel coating roof. The heating energy cost, emission and savings rates between the Base Buildings and Design Buildings were obtained by performing monthly analyses using the TGÜB-TS825 Thermal Insulation Calculation Program, which uses software developed by the Turkish Autoclaved Aerated Concrete Association (TGÜB) in accordance with the calculation methods in TS 825.

With the implementation of the green roof system, the additional loads on the load-bearing system of the building were statically and dynamically analyzed using the ideCAD Static Program, a structural-carrier system analysis program, according to TS500 (Standard for Design and Construction of Reinforced Concrete Structures), TBDY-2018 (Türkiye Building Earthquake Regulations) and various international design rules, and the amounts of concrete and steel were calculated (ideCAD, 2024).

10.2.1 Analysis of the Study

Türkiye is located in the northern hemisphere, between 36° and 42° north latitude and 26° and 45° east longitude. It lies at the border of the temperate and subtropical zones, experiencing the influence of polar air masses in winter and tropical air masses in summer. Figure 10.3 shows Türkiye's location in the world, degree-day regions and the provinces selected to represent the degree-day regions within the scope of the study. Table 10.2 presents the climatic data of the provinces selected within the scope of the study between 1991 and 2020.

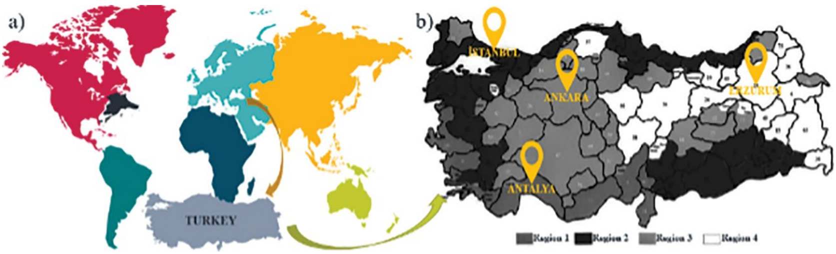


Figure 10.3: (a) Türkiye's Position in the World (b) Degree-Day Regions of Türkiye.
Source: TSE (2009).

Table 10.2: Climatic Characteristics of Antalya, İstanbul, Ankara and Erzurum

Parameters	Antalya	İstanbul	Ankara	Erzurum
Climatic region	**Warm humid**	**Moderately humid**	**Moderately dry**	**Cold**
Degree-day regions number	1	2	3	4
Record high temperature (°C)	45.0	40.6	41.0	36.5
Record low temperature (°C)	−4.6	−9.0	−24.9	−37.2
Average temperature (°C)	18.8	15.2	12.0	5.8
Average highest temperature (°C)	24.2	19.3	17.9	12.0
Average lowest temperature (°C)	13.8	11.9	6.3	−0.5
Average sunshine duration (hours)	8.2	1,0	6.7	7.0
Average number of rainy days	73.6	116.4	103.3	121.6
Average monthly total precipitation (mm)	1054.9	660.9	391.1	429.3

Source: Service (2023).

10.2.2 Structural Analysis of the Base Building

The study compares the energy consumption, material costs, and emission rates of the Base Building with those of the Design Buildings incorporating the green roof system. The Base Building is a 10-storey residential project comprising 76 independent units. It encompasses a gross volume of 14824 m^3 and a net usage area of 4743.68 m^2. The Base Building has an east-west orientation (Figure 10.4). The total area of brick walls with external air contact is 1485 m^2 and the area of reinforced concrete walls with external air contact is 904 m^2. The 540 m^2 total area of roof slab (roof-open) has been designed as an unnavigable roof with gravel coating. The opaque components of the building envelope are shown in Figure 10.5 and the thermophysical design parameters of the building envelope opaque components are shown in Table 10.3. The model image of the transparent components of the Base Building envelope is presented in Figure 10.6, while the thermophysical design parameters of the opaque components are provided in Table 10.4.

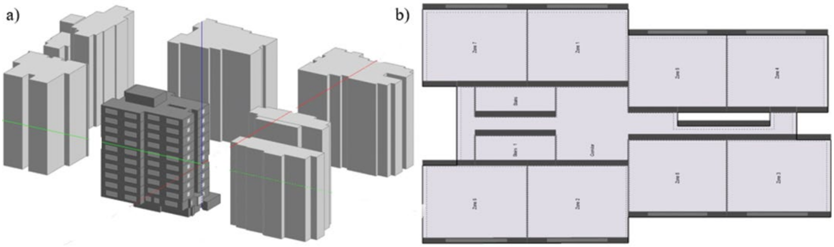


Figure 10.4: Base Building Model: (a) Site Plan, (b) Floor Plan.
Source: Created by the authors.

Table 10.3: Design Parameters of the Base Building

Material	Element thickness of the structure d (m)	Thermal conductivity calculation value λh (w/mK)	k resistance of thermal conductor R (m^2K/W)
Hollow brick wall			
Surface thermal conductivity coefficient (interior)			13.00
Gypsum mortar, gypsum mortar with lime (interior)	0.03	0.7	0.04
Hollow brick	0.25	0.22	1.14
Extruded polystyrene (XPS)	0.03	0,035	0.86
Lime-cement mortar (exterior)	0.03	1.00	0.03
Surface thermal conductivity coefficient (exterior)			4.00
Total =			19.07
Concrete wall			
Surface thermal conductivity coefficient (interior)			13.00
Gypsum mortar, gypsum mortar with lime (interior)	0.03	0.70	0.04

(Continued)

Tabla 10.3: (Continued)

Material	Element thickness of the structure d (m)	Thermal conductivity calculation value λh (w/mK)	k resistance of thermal conductor R (m^2K/W)
Reinforced concrete	0.25	2.50	0.10
Extruded polystyrene (XPS)	0.03	0,035	0.86
Lime-cement mortar (exterior)	0.03	1.00	0.03
Surface thermal conductivity coefficient (exterior)			4.00
Total=			18.03
Roof flooring			
Surface thermal conductivity coefficient (exterior)			4.00
Cement-based mortar	0.05	1.40	0.04
Tyre asphalt coating ≥7 mm	0,008	0.70	0.01
Extruded polystyrene (XPS)	0.03	0,035	0.86
Reinforced concrete	0.15	2.50	0.06
Lime-cement mortar	0.03	0.07	0.04
Surface thermal conductivity coefficient (interior)			13.00
Total =			18.01
Earth-contact flooring			
Surface thermal conductivity coefficient (interior)			17.00
Lime-cement mortar	0.03	1.00	0.03
Metamorphic stones with crystal structure	0.02	3.50	0.01
Cement-based mortar	0.05	1.40	0.04
Reinforced concrete	0.15	2.50	0.06
Surface thermal conductivity coefficient (exterior)			13.00
Total=			30.14

Source: Created by the authors.

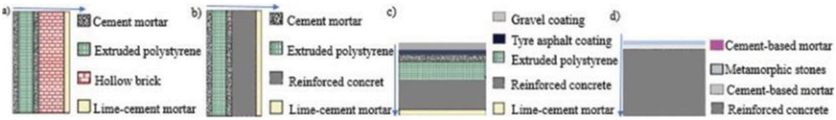


Figure 10.5: Building Envelope Layers: (a) Hollow Brick Wall, (b) Concrete Wall, (c) Roof Flooring, (d) Earth-Contact Flooring.
Source: Geliş and Yeşildal (2020).

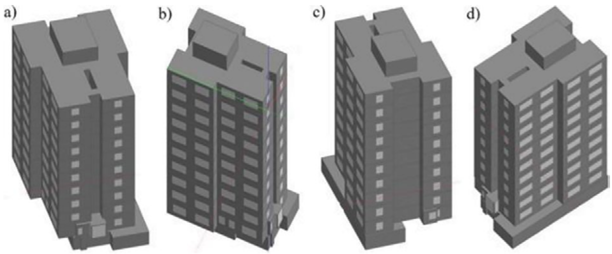


Figure 10.6: Base Building Model View: (a) South Facade, (b) West Facade, (c) North Facade, (d) East Facade.
Source: Created by the authors.

Table 10.4: Optical Design Parameters of the Base Building

Parameters		Windows	Doors
Area (m²)	Southern front	60.6	19.0
	Northern front	51.7	22.0
	Eastern front	388.3	0.0
	Western front	394.1	0.0
	Total	894.7	41.0
U-value (W/m²k)		2.8	3.5
Sunlight penetration (g)		0.75	
Shading factor		0.80	
Window to wall ratio (WWR)		0.30	

Source: Created by the authors.

10.2.3 Structural Analysis of Design Buildings

This study aimed to analyze the heating energy consumption values by designing a green roof system instead of a traditional gravel roof. The main difference between the Base Building and the Design Building was the roof envelope configuration, as all other envelope parameters (hollow brick wall, concrete wall, earth-contact flooring, and windows-doors) were kept constant. The variations in the green roof system were examined only within the Design Building models. The study also aimed to investigate the effect of different growing medium thickness on building heating loads. In this context, Design Building Models were obtained by applying 9 different green roof scenarios, increasing each by 5 cm from 10 cm to 50 cm, the Base Building with traditional gravel-covered terrace roofs. The applied scenarios are shown in Figure 10.7.

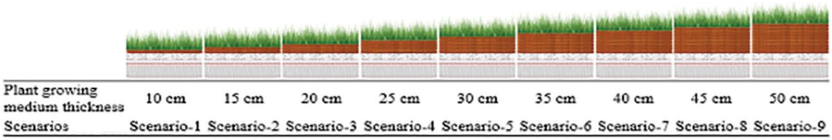


Figure 10.7: Green Roof Scenarios Applied to the Base Building.
Source: Created by the authors.

The only variable in the green roof system was the thickness of the growing medium, while all other parameters remained constant. The thermophysical design parameters of the green roof system used in the study are shown in Table 10.5, whereas the cross-sectional views of the roof shell of the Base Building and Design Building are shown in Figure 10.8 (a) and Figure 10.8 (b), respectively.

Table 10.5: Building Components of a Green Roof System

Material	Element thickness of the structure d (m)	Thermal conductivity calculation value λh (w/mK)	k resistance of thermal conductor R (m^2K/W)
Green roof flooring			
Surface thermal conductivity coefficient (exterior)			4.00
Plant	0.1	0.3	0.33
Plant-growing medium	0.1–0.5	0.25	0.40–2.00
Geotextile felt	0,005	0.06	0.08

Material	Element thickness of the structure d (m)	Thermal conductivity calculation value λh (w/mK)	k resistance of thermal conductor R (m^2K/W)
Drainage (gravel) layer	0.1	2.0	0.05
Cement-based mortar	0.05	1.4	0.04
Bituminous waterproofing	0.01	0.19	0.05
Geotextile filter element	0,005	0.06	0.08
Extruded polystyrene (XPS)	0.03	0,035	0.86
Reinforced concrete	0.15	2.50	0.06
Lime-cement mortar	0.03	0.07	0.04
Surface thermal conductivity coefficient (interior)			13.00

Source: Gülten and Turan (2020); Okan and Caner (2023); Saydam et al. (2021).

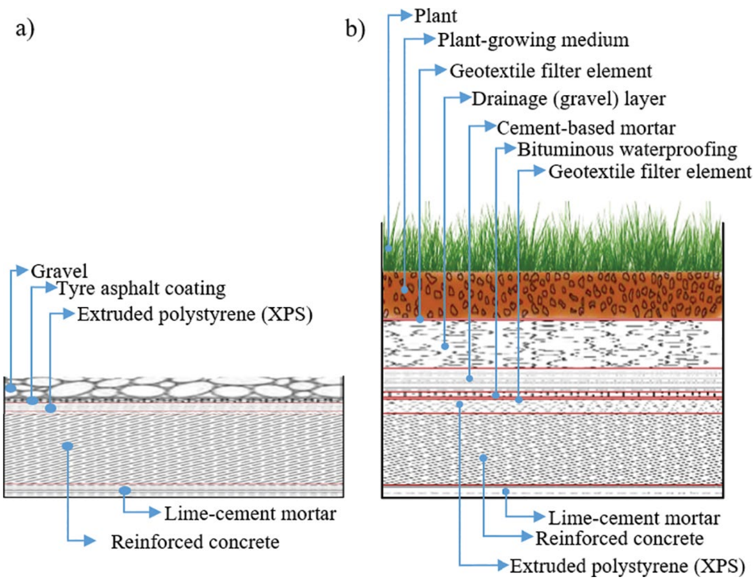


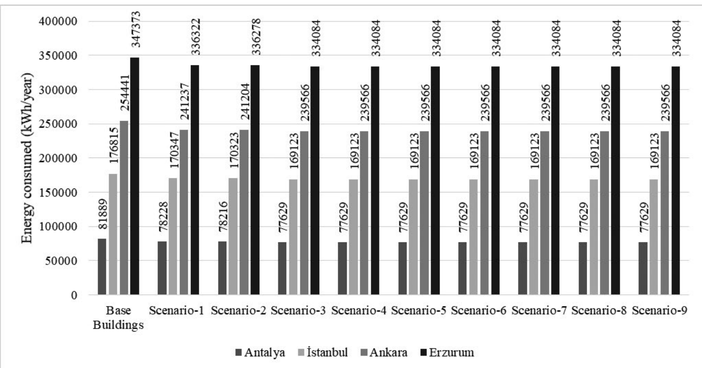
Figure 10.8: Details of the Roof Types: (a) Gravel-coated Roof, (b) Green Roof.
Source: Canım (2022).

Heating load calculations for both the Base Buildings and Design Buildings were performed using climate data recommended by TS 825. The design parameters of the Base Building were defined within the TGÜB Calculation Program. The TGÜB-TS825 Thermal Insulation Calculation Program, developed by the Turkish Autoclaved Aerated Concrete Association, is a software tool designed to calculate the thermal insulation and energy performance of buildings in accordance with Türkiye's TS 825 "Thermal Insulation Rules in Buildings" standard. This program estimates the annual heating energy requirement by considering heat losses and gains. These factors are then used to determine the building's energy consumption. The calculations account for the thermophysical properties of the building's structural elements, indoor conditions, ventilation, and the type of fuel used. TGÜB-TS825 also evaluates the energy performance of buildings against the limit values set by TS 825, incorporating regional climate data. The TGÜB-TS825 Thermal Insulation Calculation Program V5.1 is compatible with the TS 825 standard and has been validated through verification studies for various climatic regions of Türkiye (TGÜB, 2024). In this context, the input parameters required for the heating load calculations of the Base Building were defined based on the design specifications and TS 825 guidelines. These parameters included gross volume (Vb) of 14,824 m^3, usage area (An) of 4,743.68 m^2, a ceiling height greater than 2.6 m, and a total of 10 floors. The Building type was residential, with glazing on less than 60 percent of vertical exterior surfaces. Natural ventilation was assumed (ventilation volume: 11,859.2 m^3; air exchange coefficient: 0.8 h^{-1}; ventilation losses: 3130.83 W/K), and natural gas was selected as the fuel type. The internal design conditions were set to 19°C and 65 percent relative humidity. The monthly heating energy requirement was obtained by calculating the heat losses and heat gains for each Base Building and Design Building. The compliance of the Base Buildings and Design Buildings with the TS 825 Standard was analyzed by comparing the calculated heat demand with the maximum allowable values defined for each climate region in TS 825 Energy consumption values, cost, emission and saving ratios between the Base Buildings and Design Buildings were analyzed. Energy cost was calculated by Enerya Energy Inc. based on the September 2023 natural gas consumer unit price (0.23 $/$m^3$). The additional steel costs in the Design Buildings were calculated based on the unit price list published by the Ministry of Environment, Urbanisation and Climate Change of the Republic of Türkiye for the year 2023, whereas the green roof cost was determined through market research.

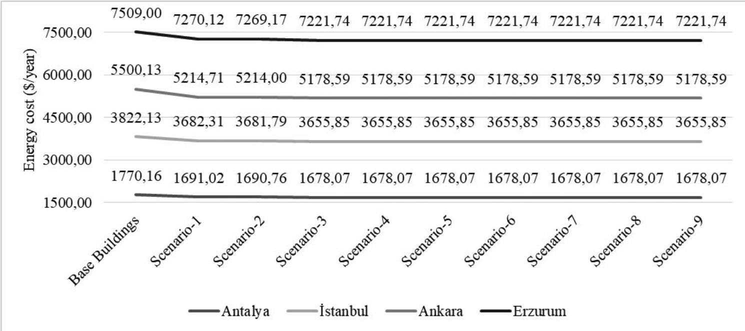
10.3 Results and Discussion

In this study, nine different green roof scenarios were applied to Base Buildings with traditional gravel-covered terrace roofs in selected cities representing four distinct degree-day zones of Türkiye (Antalya, Istanbul, Ankara, Erzurum). The green roof thicknesses were increased by 5 cm increments, ranging from 10 cm to 50 cm. Heating energy costs, emissions, and savings were determined through monthly analyses using the TGÜB-TS825 Thermal Insulation Calculation Program, in accordance with the calculation methods outlined in TS 825. Furthermore, the additional loads placed on the building structural-carrier system by the green roof system were analyzed using ideCAD Static Program and the quantities of concrete and reinforcement were calculated.

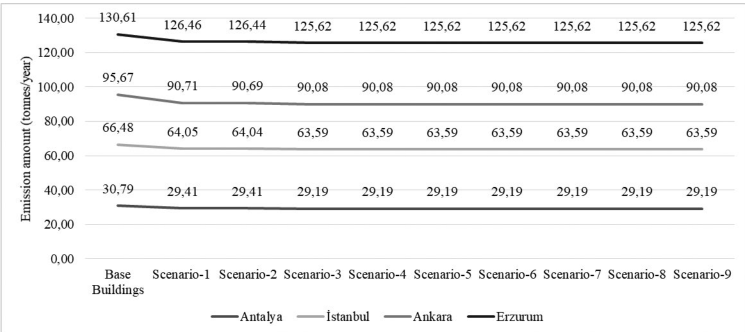
The optimum green roof system was identified by comparing the heating energy consumption between the Base Buildings and the Design Buildings, which were created based on the green roof scenarios, using the TGÜB-TS825 Thermal Insulation Calculation Program. The annual energy consumption for both the Base Buildings and Design Buildings is presented in Graph 10.1, energy consumption costs are shown in Graph 10.2, emission amounts are illustrated in Graph 10.3, savings rates are displayed in Graph 10.4, and the savings in energy costs are presented in Graph 10.5. In Table 10.6, in addition to the cost of the green roof, the amount of weight increase, the amount of steel increase caused by the weight increase and the cost of the green roof are shown. Table 10.7 presents a comparison of the energy savings and total cost relationship of the green roof systems by region.



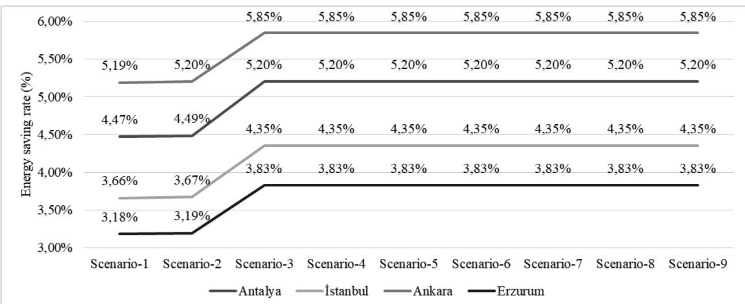
Graph 10.1: Comparison of Energy Consumption Between Base Buildings and Design Buildings.
Source: Created by the authors.



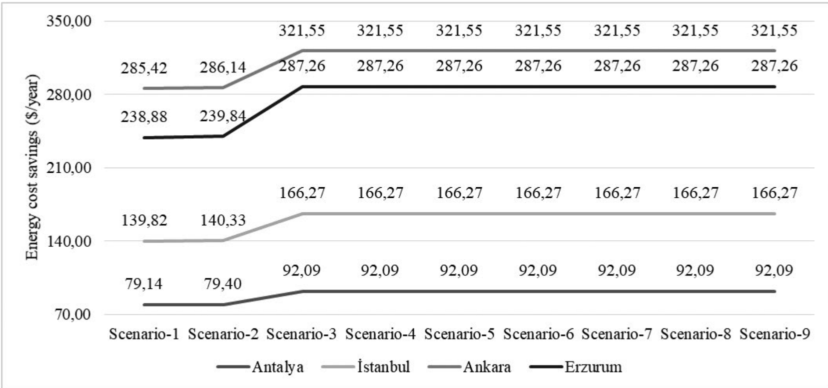
Graph 10.2: Comparison of Energy Consumption Costs Between Base Buildings and Design Buildings.
Source: Created by the authors.



Graph 10.3: Comparison of CO_2 Emission Levels Between Base Buildings and Design Buildings.
Source: Created by the authors.



Graph 10.4: Comparison of Energy-Saving Rates of Design Buildings.
Source: Created by the authors.



Graph 10.5: Comparison of Energy Cost Savings in Design Buildings.
Source: Created by the authors.

Table 10.6: Cost Analysis of Roof Systems

Base Building-gravel-coated roof cost analysis									
Gravel-coated roof cost ($/m²-roof)					31.4				
Total cost ($)					16956.00				
Design Buildings-green roof cost analysis									
Thickness of growing medium (cm)	10	15	20	25	30	35	40	45	50
Green roof application cost ($/m²-roof)	78.00	106.00	134.00	162.00	190.00	218.00	246.00	274.00	302.00
Structural-carrier system cost analysis									
The amount of weight on the roof slab (kg/m²)	82.9	124.4	165.8	207.3	248.7	290.2	331.6	373.1	414.5
Amount of steel increase in the structure (kg)	0.00	81.30	128.12	223.14	354.32	575.95	702.45	801.72	919.65
Cost of steel increase ($/m²-roof)	0.00	0.17	0.28	0.48	0.75	1.22	1.48	1.68	1.92

(Continued)

Tabla 10.6: (Continued)

Base Building-gravel-coated roof cost analysis									
Total cost ($/ m²-roof)	78.00	106.17	134.28	162.48	190.75	219.22	247.48	275.68	303.92
Total cost ($)	4212	57332	72511	87739	103005	118379	133639	148867	164117

Source: Created by the authors.

Table 10.7: Comparison of Energy Saving and Cost Relationships of Green Roof Systems

Cities	Account parameters	Thickness of growing medium (cm)								
		10	15	20	25	30	35	40	45	50
Antalya	Energy cost savings ($/year)	79.14	79.40	92.09	92.09	92.09	92.09	92.09	92.09	92.09
	Energy-saving rates (%)	4.47	4.49	5.20	5.20	5.20	5.20	5.20	5.20	5.20
İstanbul	Energy cost savings ($/year)	139.82	140.33	166.27	166.27	166.27	166.27	166.27	166.27	166.27
	Energy-saving rates (%)	3.66	3.67	4.3	4.35	4.35	4.35	4.35	4.35	4.35
Ankara	Energy cost savings ($/year)	285.42	286.14	321.55	321.55	321.55	321.55	321.55	321.55	321.55
	Energy-saving rates (%)	5.19%	5.20	5.85	5.85	5.85	5.85	5.85	5.85	5.85
Erzurum	Energy cost savings ($/year)	238.88	239.84	287.26	287.26	287.26	287.26	287.26	287.26	287.26
	Energy-saving rates (%)	3.18	3.19	3.83	3.83	3.83	3.83	3.83	3.83	3.83
Cost increase ($/m²)		46.60	74.77	102.88	131.08	159.35	187.82	216.08	244.28	272.52
Cost increase rate (%)		59.74	70.42	76.62	80.67	83.54	85.68	87.31	88.61	89.67

Source: Created by the authors.

Analysis of the graphs and tables reveals that the implementation of green roof systems resulted in a reduction in heating energy consumption across all regions. The minimum annual energy saving was 3.69% in Erzurum, located in the 4th degree-day zone, while the maximum energy saving was 5.70% in Ankara, within the 3rd degree-day zone. As the growing medium thickness of the green roof increases, energy savings are found to increase non-linearly. It can be seen that the rate of increase of energy savings in the 15–20 cm range of green roof growing medium thickness is higher than the rate of energy savings in the 10–15 cm range, while the rate of energy savings in the 20–50 cm growing medium thickness range remains constant. Regarding the green roof system taken as a basis in this study, a growing medium thickness of 20 cm was found to be the energy saturation point. With the implementation of the green roof system, energy savings between $ 79.14 and $ 321.55 per year were achieved, as well as CO_2-eq. emission savings between 1.38 t and 5.59 t. Due to the additional loads placed on the building by the green roof system, it was observed that there was an increase in steel in the building ranging from 81.30 kg to 919.65 kg, while there was no change in the amount of concrete used. It was calculated that the cost increase of green roof applications compared to traditional gravel-coated terrace roofs ranged between 46.60 $\$/m^2$ and 272.52 $\$/m^2$, and that the cost increase rate ranged between 59.74% and 89.67%.

10.4 Conclusions

This study investigated the impact of replacing traditional gravel-coated roofs with green roofs on the heating energy performance of buildings in selected cities representing four different degree-day regions of Türkiye. It was calculated that the application of green roofs in different climatic regions of Türkiye provides energy savings in heating at different rates. Consequently, it was observed that a maximum of 5.85 percent annual heating energy savings could be achieved in return for a 76.62 percent increase in cost due to the implementation of the green roof system. Following a thorough analysis of the energy-saving rates, it has been determined that the cost of green roof material and the costs arising from the additional load placed on the structural-carrier system of the building are not significant impediments to the adoption of green roof design over traditional terrace roof design in buildings.

In the extant literature, there are numerous studies on green roofs within the scope of energy-efficient building design. However, most green roof design studies focus on a single room or floor within a building and typically conduct analyses for only one climate zone or degree-day region. The most distinctive feature that distinguishes this study from others in the field is that energy-efficiency calculations are made on the basis of a block for four different degree-day regions of Türkiye. Furthermore, a key element of this study is the analysis of the aforementioned additional loads on the building resulting from the implementation of a green roof. This analysis is conducted using a static program, enabling the determination of the necessary increases in steel within the structural-carrier system. Thus, in addition to the material cost of the green roof application, the structural-carrier system cost increase of the building was calculated.

As a result of the analyses, it was found that the optimum growing medium thickness in green roof system design for all degree-day regions of Türkiye is 20 cm. It is anticipated that the results of this study will provide valuable guidance for academia, the construction sector, municipalities and climate change policies, since it places its focus on sustainable energy and examining green roofs and green roof application cost relationships together.

Bibliography

Alsayed, M. F., & Tayeh, R. A. (2019). Life cycle cost analysis for determining optimal insulation thickness in Palestinian buildings. Journal of Building Engineering, 22, 101–112. https://doi.org/10.1016/j.jobe.2018.11.018

Azkorra-Larrinaga, Z., Romero-Antón, N., Martin-Escudero, K., & Lopez-Ruiz, G. (2023). Environmentally sustainable green roof design for energy. buildings, 13(7), 1846. https://doi.org/10.3390/buildings13071846

Bellini, A., Bartoli, F., & Caneva, G. (2024). Extensive Green Roofs (EGRs) and the five ws: a quantitative analysis on the origin and evolution, aims, approaches, and botanical views. Sustainability, 16(3), 1033. https://doi.org/10.3390/su16031033

Berardi, U. (2016). The outdoor microclimate benefits and energy saving resulting from green roofs retrofits. Energy and Buildings, 121, 217–229. https://doi.org/10.1016/j.enbuild.2016.03.021

Canım, D. S. (2022). Yeşil çatılarda bitki taşıyıcı tabaka derinliği ve yaprak alan indeksinin enerji performans değerlendirmesi. Tesisat Mühendisliği, 2022(189), 29–37. https://www.mmo.org.tr/sites/default/files/yayin_dosyalar/Tesisat-189-18042022.pdf

Castleton, H. F., Stovin, V., Beck, S. B., & Davison, J. B. (2010). Green roofs; building energy savings and the potential for retrofit. Energy and Buildings, 42(10), 1582–1591. https://doi.org/10.1016/j.enbuild.2010.05.004

Coulibaly, S. F., Aubry, C., Provent, F., Rousset-Rouvière, S., & Joimel, S. (2023). The role of green roofs as urban habitats for biodiversity modulated by their design: a review. Environmental Research Letters, 18(7), 073003. https://doi.org/10.1088/1748-9326/acd801

European Commission (2014). 2030 climate and energy framework. Retrieved from https://climate.ec.europa.eu/eu-action/climate-strategies-targets/2030-climate-energy-framework_en, on November 20, 2023.

European Commission (2022). The EU in the world: 2020 edition. Eurostat. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/22f8164d-b689-11ea-bb7a-01aa75ed71a1/language-en, on October 21, 2023.

European Investment Bank (December 20, 2021). The 15 circular steps for cities. Retrieved from https://www.eib.org/attachments/thematic/circular_economy_15_steps_for_cities_second_edition_en.pdf, on October 11, 2024.

Geliş K., & Yeşildal F. (2020). Determination of minimum insulation thickness with the change of heat conduction coefficient in the use of classic and modern building elements, Gümüşhane University Journal of Science and Technology, 10(4), 869–877. https://doi.org/10.17714/gumusfenbil.725909

Gültekin, A., & Turan, B. K. (2020). Analysis of the effect of green roofs on the heating and cooling load of buildings for different building forms and degree day regions. Fırat Üniversitesi Mühendislik Bilimleri Dergisi, 32(1), 105–118. https://doi.org/10.35234/fumbd.592559

ideCAD (2024). ideCAD Structural Engineering Software. Retrieved from https://idecad.com.tr/architecture-engineering-construction/building design/structural/overview/ on 17.9.2023

Jahangir, M. H., & Motlagh, S. G. (2023). Building energy and exergy analysis of the light-weight roofs compared with the traditional ones in different climates. Energy Reports, 10, 1069–1090. https://doi.org/10.1016/j.egyr.2023.07.043

Jamei, E., Chau, H. W., Seyedmahmoudian, M., & Stojcevski, A. (2021). Review on the cooling potential of green roofs in different climates. Science of The Total Environment, 791, 148407. https://doi.org/10.1016/j.scitotenv.2021.148407

Johannessen, B. G., Muthanna, T. M., & Braskerud, B. C. (2018). Detention and retention behavior of four extensive green roofs in three nordic climate zones. Water, 10(6), 671. https://doi.org/10.3390/w10060671

Kaboré, M., Bozonnet, E., & Salagnac, P. (2020). Building and urban cooling performance indexes of wetted and green roofs—a case study under current and future climates. Energies, 13(23), 6192. https://doi.org/10.3390/en13236192

Kazaz, A., & Yetim, E. (2023). Investigation of social cost of carbon in the context of environmental sustainability in the housing sector. Journal of Construction Engineering, Management & Innovation, 2023 6(4):297–317. https://doi.org/10.31462/jcemi.2023.04297317

Kon, O., & Caner, İ. (2023). Calculation of insulation thickness depending on the coolest & hottest climate conditions for different flat roof types of buildings. Black Sea Journal of Engineering and Science, 6(1), 1–9. https://doi.org/10.34248/bsengineering.1125983

Kotsiris, G., Androutsopoulos, A., Polychroni, E., Souliotis, M., & Kavga, A. (2019). Carbon footprint of green roof installation on school buildings in Greek Mediterranean climatic region. International Journal of Sustainable Energy, 38(9), 866–883. https://doi.org/10.1080/14786451.2019.1605992

Ksiazek-Mikenas, K., Herrmann, J., Menke, S. B., & Köhler, M. (2018). If you build it, will they come? Plant and arthropod diversity on urban green roofs over time. Urban Naturalist, 1, 52–72. Retrieved from https://www.eaglehill.us/urna-pdfs-special/pdfs-URNA-sp1/14%20U127b%20Ksiazek-Mikenas%2021.pdf on 17.10.2024

Kuittinen, M., Zernicke, C., Slabik, S., & Hafner, A. (2023). How can carbon be stored in the built environment? A review of potential options.

Architectural science review, 66(2), 91–107. https://doi.org/10.1080/00038628.2021.1896471

Kumar, D., Alam, M., Memon, R. A., & Bhayo, B. A. (2022). A critical review for formulation and conceptualization of an ideal building envelope and novel sustainability framework for building applications. Cleaner engineering and technology, 11, 100555. https://doi.org/10.1016/j.clet.2022.100555

Langemeyer, J., Wedgwood, D., McPhearson, T., Baró, F., Madsen, A. L., & Barton, D. N. (2020). Creating urban green infrastructure where it is needed—A spatial ecosystem service-based decision analysis of green roofs in Barcelona. Science of the total environment, 707, 135487. https://doi.org/10.1016/j.scitotenv.2019.135487

Manso, M., Teotónio, I., Silva, C. M., & Cruz, C. O. (2021). Green roof and green wall benefits and costs: A review of the quantitative evidence. Renewable and Sustainable Energy Reviews, 135, 110111. https://doi.org/10.1016/j.rser.2020.110111

Mayrand, F., & Clergeau, P. (2018). Green roofs & green walls for biodiversity conservation: a contribution to urban connectivity? Sustainability, 10(4), 985. https://doi.org/10.3390/su10040985

Mickovski, S. B., Buss, K., McKenzie, B. M., & Sökmener, B. (2013). Laboratory study on the potential use of recycled inert construction waste material in the substrate mix for extensive green roofs. Ecological engineering, 61, 706–714. https://doi.org/10.1016/j.ecoleng.2013.02.015

Mousavi Motlagh, S. F., Sohani, A., Djavad Saghafi, M., Sayyaadi, H., & Nastasi, B. (2021). Acquiring the foremost window allocation strategy to achieve the best trade-off among energy, environmental, and comfort criteria in a building. Energies, 14(13), 3962. https://doi.org/10.3390/en14133962

O’Hara, A. C., Miller, A. C., Spinks, H., Seifert, A., Mills, T., & Tuininga, A. R. (2022). The sustainable prescription: benefits of green roof implementation for urban hospitals. Frontiers in Sustainable Cities, 4, 798012. https://doi.org/10.3389/frsc.2022.798012

Özyavuz, M., Karakaya, B., & Ertin, D. G. (2015). The effects of green roofs on urban ecosystems. GreenAge Symposium, April 15–17, 2015, Istanbul, Türkiye https://www.researchgate.net/profile/Murat Oezyavuz/publication/315792406_The_Effects_of_Green_Roofs_on_Urban_

Ecosyst ms/links/58e54b49a6fdcc6800b144f1/The-Effects-of-Green-Roofs-on-Urban Ecosystems.pdf

Pamir, N. (2017). Enerjinin İktidarı. (2nd Edition). Hayykitap.

Peñalvo-López, E., Cárcel-Carrasco, J., Alfonso-Solar, D., Valencia-Salazar, I., & Hurtado-Pérez, E. (2020). Study of the improvement on energy efficiency for a building in the Mediterranean area by the installation of a green roof system. Energies, 13(5), 1246. https://doi.org/10.3390/en13051246

Polo-Labarrios, M. A., Quezada-García, S., Sánchez-Mora, H., Escobedo-Izquierdo, M. A., & Espinosa-Paredes, G. (2020). Comparison of thermal performance between green roofs & conventional roofs. Case Studies in Thermal Engineering, 21, 100697. https://doi.org/10.1016/j.csite.2020.100697

Porcaro, M., de Adana, M. R., Comino, F., Peña, A., Martín-Consuegra, E., & Vanwalleghem, T. (2019). Long term experimental analysis of thermal performance of extensive green roofs with different substrates in Mediterranean climate. Energy and Buildings, 197, 18–33. https://doi.org/10.1016/j.enbuild.2019.05.041

Pusat, S., & Ekmekci, I. (2016). A study on degree-day regions of Turkey. Energy Efficiency, 9(2), 525–532. https://doi.org/10.1007/s12053-015-9378-7

Sayadi, S., Hayati, A., & Salmanzadeh, M. (2021). Optimization of window-to-wall ratio for buildings located in different climates: An IDA-indoor climate and energy simulation study. Energies, 14(7), 1974. https://doi.org/10.3390/en14071974

TGÜB (2024). Turkish Autoclaved Aerated Concrete Association. Retrieved from http://tgub.org.tr/ on 11.11.2024

Turkish State Meteorological Service (2023). Official Statistics. Retrieved from https://www.mgm.gov.tr/eng/forecast-cities.aspx on 09.10.2024.

Shahmohammad, M., Hosseinzadeh, M., Dvorak, B., Bordbar, F., Shahmohammadmirab, H., & Aghamohammadi, N. (2022). Sustainable green roofs: a comprehensive review of influential factors.

Environmental Science and Pollution Research, 29(52), 78228–78254. https://doi.org/10.1007/s11356-022-23405-x

Stovin, V., Vesuviano, G., & Kasmin, H. (2012). The hydrological performance of a green roof test bed under UK climatic conditions. Journal of Hydrology, 414, 148–161. https://doi.org/10.1016/j.jhydrol.2011.10.022

Tadeu, A., Carrilho, J., Cortês, A., Ferreira, F., & Almeida, J. (2024). Acoustic absorption, scattering, and diffusion provided by green roof systems. Building and Environment, 262, 111778. https://doi.org/10.1016/j.buildenv.2024.111778

Takebayashi, H., & Moriyama, M. (2007). Surface heat budget on green roof & high reflection roof for mitigation of urban heat island. Building and Environment, 42(8), 2971–2979. https://doi.org/10.1016/j.buildenv.2006.06.017

Turkish Standards Institution (2009). TS 825-Thermal insulation requirements for buildings (Revised edition). Turkish Standards Institution. Retrieved from https://intweb.tse.org.tr/standard/standard/Standard.aspx?081118051115108051104119110104055047105102120088111043113104073099117105079120119074111082078114 11.11.2024T.C. Ministry of Environment and Urbanization (2021). İklim değişikliğiyle mücadele sonuç bildirgesi. Retrieved from https://csb.gov.tr/bakan-kurum-iklim-degisikligiyle-mucadele-zirvesi-sonuc-bildirgesini-acikladi-bakanlik-faaliyetleri-30880, on October 13, 2024.

Van Kamp, I., Leidelmeijer, K., Marsman, G., & De Holl&er, A. (2003). Urban environmental quality and human well-being: Towards a conceptual framework and demarcation of concepts; a literature study. Landscape and urban planning, 65(1–2), 5–18. https://doi.org/10.1016/S0169-2046(02)00232-3

Veronica, I., Calbureanu, M., Ionescu, A., Calbureanu, D., & Malcıu, R. (2022). Contributions about the energy efficiency using green roofs for a specific office buildings in Oltenia. Acta Technıca Napocensıs-series: Applied Mathematics, Mechanıcs, and Engineering, 65(2 s). Retrieved from https://atna-mam.utcluj.ro/index.php/Acta/article/view/1912/1511 on 14.11.2024.

Vijayaraghavan, K., & Raja, F. D. (2015). Pilot-scale evaluation of green roofs with Sargassum biomass as an additive to improve runoff quality. Ecological engineering, 75, 70–78. https://doi.org/10.1016/j.ecoleng.2014.11.029

Wang, L., Wang, H., Wang, Y., Che, Y., Ge, Z., & Mao, L. (2022). The relationship between green roofs and urban biodiversity: A systematic review. Biodiversity and Conservation, 31(7), 1771–1796. https://doi.org/10.1007/s10531-022-02436-3

Wang, X., Li, H., & Sodoudi, S. (2022). The effectiveness of cool and green roofs in mitigating urban heat island and improving human thermal comfort. Building and Environment, 217, 109082. https://doi.org/10.1016/j.buildenv.2022.109082

Yang, H. S., Kang, J., & Choi, M. S. (2012). Acoustic effects of green roof systems on a low-profiled structure at street level. Building and Environment, 50, 44–55. https://doi.org/10.1016/j.buildenv.2011.10.004

Zamanı, P. M. (2022). Comparison of dense (dense) and extensive (sparse) green roof systems. TAS Journal, 2(2), 08–18. Retrieved from https://www.tasjournal.com/index.php/tas/article/view/46, on October 7, 2024.

Local Government Policies to Combat Climate Change: The Examples of Kyoto and Stockholm

Hülya Küçük Bayraktar[34]

11.1 Introduction

Local governments play a crucial role in the fight against climate change by developing and enforcing policies aimed at both mitigating and adapting to its impacts. Additionally, due to their intimate understanding of citizens' daily needs and their ability to integrate climate change adaptation into broader policy objectives, local governments often spearhead adaptation and planning efforts (Termini and Kalafatis, 2021). However, the implementation of climate change policies at the local level presents challenges for regional and local governments, including issues of cooperation and coordination (McGuirk et al., 2014). This underscores the necessity for clearer incentives and active intervention from higher-level government entities to support local climate change initiatives (Krause, 2011; Schwartz, 2019). It is imperative that other stakeholders take part in the fight against climate change together with local governments. Among the stakeholders, the central government stands out. It should display a holistic and effective approach in combating climate change. In this context, cooperation between the central government and local governments is essential (Parlak and Partigöç, 2022).

In the overall policy formulation of local governments, there's a recognized importance in enhancing local adaptive capacity through the enhancement of climate information services and the establishment of a robust institutional framework to bolster resilience against climate change. In order for local governments to adapt to climate change and manage it effectively, it is important for them to engage in multi-stakeholder cooperation and joint studies.

Within this context, it is evident that local governments play a pivotal role in combating climate change. Effective policies and measures by local

[34] Asst. Prof. Dr., Ph.D., Department of Social Vacation School, Kafkas University, Türkiye, hulya.kucuk@kafkas.edu.tr, ORCID: 0000-0003-2885-8386.

governments are essential for climate change governance. However, they face challenges in terms of coordination, cooperation, and the need for more explicit encouragement and support from higher levels of government. Strengthening local adaptation capacities and fostering multilateral cooperation are vital to enhance the efficacy of local climate change policies.

It is important to examine the cities that are successful in the studies carried out by local governments on climate change in order to create sustainable and long-term strategies focused on this issue. According to the report of the Carbon Disclosure Project (CDP), which evaluates the efforts of cities to combat climate change, Stockholm and Kyoto are among the successful examples. Stockholm entered the A List, which is evaluated within the scope of the CDP, in 2016, Kyoto in 2020. In order for cities to be included in this list, they must have received a high evaluation score in the fight against climate change. There is no ranking among the cities included in the CDP A List, and all cities included are considered equivalent. To enter this list, cities must meet criteria such as reducing carbon emissions, developing strategies to reduce climate risks and transparent reporting (CDP, 2024).

Stockholm and Kyoto stand out for their goal of becoming carbon-neutral cities, large investments in renewable energy sources, energy-efficiency projects, environmentally friendly policies in transport and circular economy practices in waste management. Stockholm is developing various strategies as part of its goal to become carbon neutral by 2040. As of 2019, the city has reduced its carbon emissions by 50 percent compared to 1990 levels. In addition to this, Stockholm is turning to renewable energy sources in electricity generation, providing about 80 percent of its energy from renewable sources and operating approximately 50 percent of the buses in public transport using biofuels or electricity. The city, which also carries out effective studies on waste management, has increased its recycling rate to 70 percent. Stockholm has also been a member of Cities Climate Leadership Group (C40) since 2005 (IRENA, 2020).

Kyoto has become symbolic for its international and local efforts to combat climate change and for signing the Kyoto Protocol in 1997. In 2020, the city reduced its carbon emissions by 20 percent compared to 1990. In 2015–2020, it reduced energy consumption in homes and commercial buildings by 18 percent (Shimotsuma, 2020). Kyoto has also focused on reducing the amount of waste through a comprehensive recycling program and promoting circular economy models. In this context, Stockholm and Kyoto, with their innovative policies, are among the exemplary cities in the fight against climate change. Within this framework, the present study scrutinizes the climate change combating policies of local governments, focusing on those of Kyoto and Stockholm. The notable achievements of these two cities' local governments in both mitigating and adapting to climate change position them as exemplary models for other urban areas to emulate (OECD, 2025).

11.2 Literature Review

Local governments are increasingly recognized as pivotal players in formulating local policies to combat climate change. To effectively address this global challenge, local governments encounter the task of adopting various forms of governance. In addition, the importance of governance in the adaptation of local governments to climate change and the need for institutional structures are emphasized (Parlak and Partigöç, 2022).

While local institutions play a crucial role in supporting adaptation, the escalation of future climate impacts may heighten vulnerability, thereby underscoring the importance of enhancing adaptive capacities (Agrawal, 2008). Local governments are delineated as effective facilitators in pursuing objectives related to climate change (Nalbant and Sevinçli, 2023).

Barriers to taking action on climate change at the local level include financial and resource constraints that impede local government initiatives. Despite these challenges, it is imperative to focus on climate policies and programs across different tiers of government to effectively implement national climate change strategies (Uysal, 2022). In addition to national climate change policies, it has been emphasized that locally crafted policies by local governments are crucial and necessary. This highlights the importance of cities, where local policies are implemented.

In the study titled "Zero Emission and Climate Change Resilient Green City: Tokyo," authored by Ekici (2023), it is noted that the local government of Tokyo, a city anticipated to be severely affected by storms, extreme precipitation, and sea-level rise, has developed the Tokyo Metropolitan Adaptation Plan, serving as a significant guiding document for the city. According to this plan, Tokyo has outlined several fundamental policies, including the establishment of a smart energy city, the promotion of the "3Rs" (recycle, reduce, reuse), and the sustainable utilization of resources. The study reveals that Tokyo, as a major metropolis with a continuously growing population, has undertaken initiatives that could serve as a model for other municipalities in Japan. Leveraging its financial prowess and scientific knowledge, Tokyo is enhancing its resilience against climate change.

In Memiş's study titled "Policies towards Climate Change and Climate Friendly Waste Management Practices in South Korea: The Case of Seoul" (2023), the effective management of waste, which plays a crucial role in combating climate change, is analyzed within the context of Seoul, the capital of South Korea. An integral aspect of Seoul's climate change policies is the efficient handling of waste, with the long-term objective of transforming Seoul into a zero-waste capital. The study highlights the prominence of "recycling and recovery" oriented waste management, spearheaded by the state, in South Korea.

Sezgin's study titled "Smart Innovation Practices in Climate Friendly Cities: The Case of Sydney" (2023) evaluates smart innovation practices in combating climate change, using the city of Sydney as an example. Sydney, Australia, renowned for its successful implementation of smart city initiatives, is also distinguished for its endeavors to address climate change. The findings of the study underscore the effectiveness of smart innovation applications in combating climate change. They emphasize the notion that traditional methods alone are insufficient for cities to tackle environmental challenges, such as climate change, which encompass various factors. Smart city applications in Sydney are shown to facilitate the city's efforts to combat climate change.

Keskin and Chaychi Semsari (2023) analyze China's substantial shift from fossil fuels to renewable energy sources in their study titled "Green Energy and Climate Friendly Urban Policies in China: The Case of Wuhan." The research highlights Wuhan's urban strategies aimed at promoting green energy utilization and mitigating pollution to address environmental concerns and mitigate soaring energy expenses. Furthermore, the study underscores Wuhan's emphasis on collaboration to secure a more sustainable future amidst the challenges it encounters.

In addition to the aforementioned aspects, local governments are emerging as key actors in the fight against climate change by implementing policies focused on both mitigation and adaptation strategies (Hamza-Çelikyay and Küçük-Bayraktar, 2023; Nalbant and Sevinçli, 2023). Local governments have a significant potential to contribute to the implementation of the targets set out in national and international climate policy documents aimed at combating climate change. Local governments can play an effective role in reducing greenhouse gas emissions in the city and adapting to climate change through the powers available to them in waste management, energy supply, zoning planning and social services (Talu, 2019).

It can be argued that the powers and autonomy of local governments are effective in cities when it comes to combating climate change, but that they are not sufficient on their own. In instances where local governments are unable to adequately address climate change, the central government must also provide support through the allocation of resources and authorization. This underscores the importance of cooperation and collaboration between different government levels for effective climate governance (Leck and Simon, 2012; Parlak and Partigöç, 2022).

At the same time, local governments can place greater emphasis on activities to be undertaken in response to climate change by incorporating citizens' views on the issue. In this way, it can be said that local governments play an effective role in tackling climate change by engaging in strategic planning with the capacity to integrate the findings into policy objectives (Termini and Kalafatis, 2021).

However, national governments and international regimes may display limited interest in climate change activities, while local governments might engage in a broader range of initiatives to formulate climate change strategies. Additionally, it is noted that local governments are encouraged to develop plans and strategies for climate change, with financial assistance provided by national authorities (Bulkeley, 2010).

Local governments' involvement is indispensable in fostering collaboration with citizens and community-driven initiatives aimed at adapting to climate change (Mees et al., 2019). The active engagement of local governments in climate change policymaking is paramount, considering that the majority of repercussions resulting from these policies are experienced at the regional and local levels (Galarraga et al., 2011).

In addition to the aforementioned roles, local governments are also capable of taking rapid action in emergency situations in the context of climate change and can implement local strategies to increase climate resilience (Chou, 2020). The importance of local governments in making adaptation plans in the cities most affected by climate change and in leading the implementation of these plans is emphasized (Eissa and Khalil, 2021).

Consequently, local governments possess the capacity to address climate change through the formulation of comprehensive climate change strategies, active engagement in citizen initiatives, the formulation of progressive climate policies, and spearheading local adaptation planning and implementation efforts (Bayraktar Küçük and Çetintürk, 2022). Acknowledging the importance of local action, it is important that all stakeholders support the struggle of local governments against climate change and work in cooperation.

Local governments serve as linchpins in climate change adaptation and mitigation endeavors. The establishment of collaborative governance structures, bolstered by capacity-building initiatives and accountability mechanisms, is imperative for facilitating effective climate action at the local level. By recognizing the challenges and opportunities inherent in climate change, local governments can lead the implementation of sustainable climate policies and programs.

The role of local governments in the fight against climate change holds significant importance, as evidenced by studies in the field. Furthermore, analyses of city case studies within the literature underscore the pivotal role played by local governments in combating climate change and crafting effective policies. In this context, it becomes pertinent to examine the research findings and policy initiatives undertaken by local governments in Kyoto and Stockholm, which have demonstrated success in their endeavors to combat climate change. Local governments, exemplified by those in Kyoto and Stockholm, are increasingly recognized for their crucial involvement in shaping and executing policies aimed at addressing climate change. The significance attributed to the Kyoto local government primarily arises from the increasing endeavor of local administrations to actively engage in formulating policies addressing climate change (Sharp et al., 2010). It is emphasized that these policies are necessary for the realization of national and local objectives, mitigation, and adaptation to perceived threats and climate change (Termini and Kalafatis, 2021). At this point, the Kyoto Protocol, which is an important international agreement in the fight against climate change, has assumed an important role in influencing the actions of local governments around the world (Kim, 2021). In terms of compliance with the Kyoto Protocol, local governments' policies to combat climate change should be supported (Hoppe et al., 2014).

The local government of Stockholm is implementing national targets and setting local targets, reducing threats to the climate and creating new opportunities by orientating local institutions (Termini and Kalafatis, 2021; Holm et al., 2011). However, urban local governments have a significant impact on climate change governance both nationally and internationally (Schwartz, 2019).

Stockholm's local government also stands out in terms of sustainability, urban regeneration and local autonomy (Borgström, 2019). Local governments in Sweden, including Stockholm, manage climate adaptation at the local level, but also face challenges related to climate risk management, planning and science-policy (Storbjörk, 2007).

Therefore, local governments are at the forefront of planning and implementation strategies to mitigate the impacts of climate change and adapt to it, and they direct these practices.

Hence, the local governments of Kyoto and Stockholm, like many other local governments around the world, play an active role in combating climate change through their role in policy formulation, implementation, and citizen participation, as well as in the provision of needs-based services. The initiatives undertaken by the Stockholm local government, encompassing policy development, sustainability projects, and community involvement, serve as major drivers of climate change efforts at the local level, thereby significantly bolstering the overarching global climate change agenda.

11.3 Methodology

In this study, climate change mitigation policies of the local governments in Kyoto and Stockholm were evaluated using qualitative research methods. In this framework, a literature review was conducted and articles, plans, activity reports and websites of the local governments of Kyoto and Stockholm that examine climate change, local governments, and policies on combating climate change at the local level were investigated. As a result of the evaluation of these sources, conclusions were drawn regarding the Kyoto and Stockholm local government policies on climate change and recommendations were presented for Türkiye.

In this study, the cities of Stockholm and Kyoto have been selected due to their successful policies in combating climate change and their high scores within the scope of the CDP. These two cities stand out in climate change efforts as they meet criteria such as reducing carbon emissions, developing strategies to mitigate climate risks, and ensuring transparent reporting (CDP, 2024).

(https://www.cdp.ne).CDP report on climate change, the successful studies of the Kyoto and Stockholm local governments are examined, and suggestions are made for other cities to follow suit. The absence of a comparative study analyzing these two cities with their successful policies in combating climate change constitutes the unique value of this study.

11.4 Kyoto's Policies on Climate Change

The City of Kyoto is formulating and implementing a variety of policies to address climate change that are in line with the global efforts set out in the Kyoto Protocol (Boussalis et al., 2019). Adopted in 1997 and enforced in 2005, the Kyoto Protocol serves as a pivotal institutional framework for climate change mitigation (Kim, 2021). The city's approach includes international climate policy mitigation and adaptation strategies. At this point, where greenhouse gas emission reduction policies are on the agenda of the Kyoto local government, there is also an increasing awareness of the necessity for the undertaking of studies on climate change adaptation (Boussalis et al., 2019). In this vein, Kyoto has set forth ambitious targets, including a 25 percent reduction in greenhouse gas emissions compared to 1990 levels by 2020, an 80 percent reduction in emissions compared to 1990 levels in the long term, and a 40 percent reduction by 2030. Concurrently, Kyoto aspires to become the inaugural local government in Japan to devise a comprehensive strategy dubbed the "Road to Zero Project" (A-Plat, 2024).

In this context, it can be seen that the climate change targets of Kyoto City are aligned with the objectives of the Kyoto Protocol, an international agreement that aims to reduce greenhouse gas emissions in order to combat climate change. Following the termination of the Nevertheless, cities have played an important role in advancing efforts to mitigate and adapt to climate change.

In the context of what has been stated, the climate change objectives of Kyoto city are closely related to the impact left by the Kyoto Protocol, with the latter being regarded as a significant advance in global climate change governance. Cities like Kyoto continue to play a vital role in promoting climate action and harmonizing their initiatives with international frameworks such as the Kyoto Protocol.

Consequently, as an instrument of international environmental policy, the Kyoto Protocol has exerted a profound influence on the climate change strategies of Kyoto city. It has furnished a framework for addressing greenhouse gas emissions and fostering sustainable development (Ge and Lin, 2021). Concurrently, the Protocol has stimulated technological innovation within the city, as meeting the targets outlined in the Kyoto Protocol necessitates the development of future-oriented sustainable energy systems (Lund, 2006). Moreover, the economic ramifications of the Kyoto Protocol and climate policy have garnered considerable attention. While extensive ex ante assessments have been conducted, empirical analyses of the economic implications of the Kyoto Protocol and climate policy remain limited. Understanding the economic repercussions is paramount for gauging the efficacy and efficiency of future climate policies, including those implemented within Kyoto city (Kuosmanen et al., 2020; Buchner et al., 2002). A framework delineating Kyoto City's legal regulations concerning climate change is presented in Table 11.1.

Table 11.1: Kyoto City's Legal Arrangements for Climate Change

Years	Kyoto City
1997	Kyoto City Regional Propulsion Program of Global Warming Countermeasure COP3 / establishment of Kyoto Protocol; formulation of the Kyoto City Global Warming Action Plan
2003	Kyoto City Regional Propulsion Program of Global Warming Countermeasure (revised edition)
2004	Kyoto City Code of Global Warming Countermeasure (enacted)
2006	Kyoto City Program of Global Warming Countermeasure Action plan to reduce CO_2 emissions from Kyoto City Hall
2009	Action Plan of Kyoto Eco-Model City

(Continued)

Tabla 11.1: (Continued)

Years	Kyoto City
2010	Kyoto City Code of Global Warming Countermeasure (fully amended)
2011	Kyoto Protocol Program of Global Warming Countermeasure
2012	Kyoto City Office’s Implementation Plan for Active Reduction of CO_2 Emissions
2013	Strategy for the Promotion of Kyoto City’s Energy Policy
2015	SDGs, Paris Agreement “From low carbon to decarbonization”
2017	20th anniversary of the Kyoto Protocol “Kyoto Declaration for Cultivating a Culture of Sustainable Cities”; Revised Global Warming Action Plan “The Road to Project ‘0’”
2019	Declaration of “Net-Zero by 2050” ahead of all municipalities in Japan
2020	Amendments of ordinance (mentioned the goal of Net-Zero by 2050)
2021	Formulated the new Kyoto City Plan for 2021–2030
2022	Selected as “Decarbonization Leading Area by the government”

Source: City of Kyoto (2024).

As depicted in Table 11.1, Kyoto city has undertaken significant efforts regarding studies and arrangements pertaining to its legal framework in the fight against climate change. These legislative measures align with both international and national requirements. The Kyoto local government implements a variety of policies aimed at mitigating climate change. However, the formulation and execution of these policies are influenced by several factors, including environmental regulations, competition among local governments, and the impact of central government policies. The intensity of environmental regulations imposed by local governments is shaped by competitive dynamics among them, which can sometimes result in instances of “government-business collusion” and the relaxation of environmental standards to attract investments.

Conversely, the management of economic growth targets is regarded as a pivotal mechanism for constraining and incentivizing local governments and authorities, thereby impacting their approach toward environmental regulations and their stringency.

The competitive incentives among local governments also affect the intensity of environmental regulations. It is evident that the competitive behavior of local governments significantly shapes environmental policies and can directly impact governmental decisions regarding environmental regulation, consequently influencing the trajectory of green development. Effective coordination between local government environmental regulation initiatives and public participation mechanisms is imperative to achieve desired environmental outcomes.

The City of Kyoto has set reduction targets compared to 1990 levels in the fight against climate change. In 1997, the city's energy consumption was 104,201 TJ, whereas in 2016 it was 75,833 TJ—representing a 2.2% reduction. The targets are (City of Kyoto, 2024):

1. Reduction of at least 80%
2. 25% below those levels by 2020
3. 40% below those levels by 2030

All stakeholders in the city have been involved in the process of combating climate change within the framework of governance, and climate change has been focused on as an important issue. To address this issue, attention is being directed to energy saving by asking the question "Are you doing something good for the environment?" using the slogan "Do you Kyoto?" (UN Climate Change, 2024). The local government of Kyoto is actively engaged in combating climate change through a multifaceted approach, including the establishment of climate change and renewable energy targets, the implementation of energy-efficiency incentive programs, and the promotion of educational initiatives. In March 2012, following the adoption of the "Resolution on Reducing Dependence on Nuclear Energy and Transition to Renewable Energy Policies" by the Kyoto City Council, the city embarked on a comprehensive energy conservation initiative, significantly increasing the promotion of renewable energy and encouraging environmental projects. In addition, it introduced the obligation to install a renewable energy system for buildings of 300 m^2 or more in energy use, subsidies to encourage the installation of solar PV attachments, the joint purchase of solar panels, renewable energy demand, local production, local consumption and local circulation of renewable energy for residential buildings were encouraged.

However, as of 2022, the obligations of renewable energy facilities have been increased in the long term, with a quantitative uniform requirement of 30,000 MJ and a metered range of 60,000–450,000 MJ. Additionally, a new obligation has been introduced for the medium term, also with a quantitative uniform of 30,000 MJ. In the short term, regulations have been introduced for the housing sector, aiming to promote projects that encourage the use of local and regional renewable energy sources, particularly solar energy, within residential areas (City of Kyoto, 2024).

The emission reduction target for large enterprises in the city was doubled as of 2023 and an energy consumption reporting system was established for medium-sized enterprises. For the new generation of high emission vehicles, the existing obligation has been strengthened from 2023, and for sales, a reporting obligation on sales performance has been introduced from 2022 (Climate Action Progress Report, 2023).

In order to reduce greenhouse gas emissions from the housing sector by identifying environmentally friendly regions in Kyoto, environmentally friendly lifestyles are encouraged in school districts that play a central role in social activities. Within this framework, 222 school districts have become Eco-School Districts and various activities are carried out in these districts to address climate change. The "Children Eco-Life Challenge Workbook" is used to raise awareness on climate change while children are still young. With this book, environmental education is provided to children in upper primary school grades across the Kyoto Municipality. The book encourages children to consider ways in which they can change their lifestyles and teaches them to take measures against global warming from a child's perspective. This project is being modeled both throughout Japan and in other countries. It is being implemented in all primary schools in the Iskandar Development Region of Malaysia with the cooperation and support of the Kyoto Municipality (UN Climate Change, 2024). Furthermore, the city has placed emphasis on adopting green local government procurement standards, instituting public transport policies, fostering public–private partnership agreements with local businesses, and undertaking tree planting initiatives (Bulkeley, 2010). These endeavors align with the notion that local governments are uniquely positioned to drive sustainability by devising programs that educate and involve local communities (Atisa et al., 2020). However, it is essential to underscore the role of cities as key agents in global climate change mitigation and sustainable development within the framework of multilevel governance.

Another important project in Kyoto is the "Citizen Shared Power Plant System." In this system, photovoltaic electricity generation facilities are established by renting the roof of the municipality's facilities with funds received from residents and businesses. Thus, the inhabitants of the city directly contribute to the use and dissemination of renewable energy. In addition, the city is also working on the production of biodiesel fuel. Since the Kyoto Protocol came into effect in 1997, waste and used cooking oil generated from communal meals have been converted into biodiesel fuel, which has subsequently been utilized to power refuse collection vehicles and municipal buses. Approximately one million liters of biodiesel fuel is produced each year. This fuel is used to power 136 garbage trucks and 104 city buses (UN Climate Change, 2024).

A further project is the "Cellulose Nanofibre (CNF) Project." The Kyoto Municipal Institute of Industrial Technology and Culture and the Kyoto University are promoting joint ventures on cellulose nanofiber (CNF), a new plant-derived material, and production using CNF at low costs.

The project "Support for Entry of Local Kyoto Businesses into the Green Innovation Market" provides support to companies in Kyoto that want to develop and enter the market as leading industries to respond to the needs of society today. An "All-Kyoto" system for the development and commercialization of business models that can contribute to eco-energy-related industries involving industrial systems related to Kyoto City and the Kyoto Prefecture has been established.

The Kyoto Green Chemical Network has established green technologies, focusing on research and development in the field of chemical technology, one of the city's strengths, in collaboration with industries, academia, the government and civil society to support environment and energy-related industries in Kyoto. At the same time, the city supports the establishment of new companies focused on green technology.

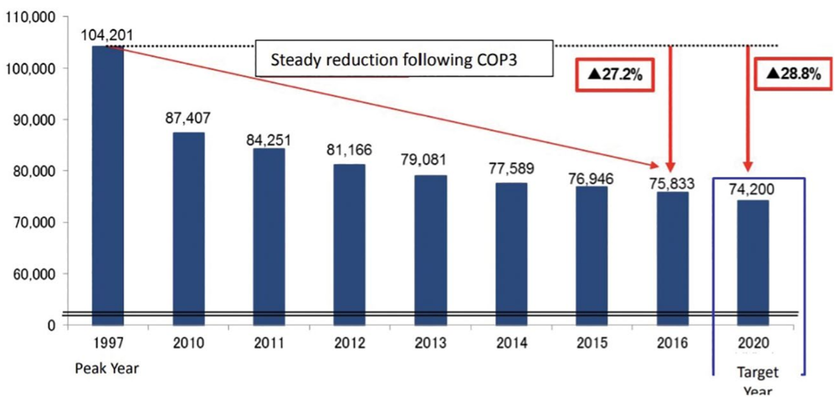
One of the prominent initiatives of Kyoto City in combating climate change is waste management. With waste management in the city, the number of waste incineration plants has been reduced from five to three and greenhouse gas emissions have decreased by 45 percent. Kyoto has also been analyzing waste composition since 1980 and this analysis is among the leading initiatives on climate change. Kyoto City utilizes the advantages of a university and student city, analyzing waste composition in cooperation with the Kyoto University. By conducting surveys on the subject, proposals for waste minimization measures are planned and developed, and the awareness of residents and businesses is raised.

Another important initiative is the “New Kyoto City Plan for Reducing Waste by Half.” Efforts are being made to reduce the amount of waste, and under this plan, waste was reduced from 820,000 tonnes in 2000 to 390,000 tonnes in 2020. However, Kyoto is the first municipality to set numerical targets for reducing food loss while also advancing initiatives (City of Kyoto, 2024).

The “Gion Festival Zero-Waste Project” has been promoting reusable plates on stalls at the Gion Festival, which has been recognized as an Intangible Cultural Heritage by the UNESCO since 2014. Thanks to the collection of these plates and the separation of waste, a 25% waste reduction was achieved in Kyoto city compared to before the Project (City of Kyoto, 2024).

With the introduction of the “Incorporation of Biomass Polyethylene into Garbage Bags” initiative, Kyoto has become the first city in Japan to adopt biomass polyethylene—derived from the inedible parts of sugar cane—for all household waste bags that require purchase. This measure aims to reduce greenhouse gas emissions and promote environmental awareness among residents.

With the Shijo Street project, the number of lanes on the main streets of Kyoto was reduced from four to two and the width of the pavements was increased. Thus, the number of pedestrians per day increased by approximately 10 percent and the traffic volume of the city decreased by 40 percent. Greenhouse gas emissions in the city decreased by 15% in 2010 compared to the level in 1990 (City of Kyoto, 2024). The graph shows the energy consumption of the Kyoto municipality by years.



Graph 11.1: Municipality Energy Consumption.
Source: UN Climate Change (2024).

As shown in Graph 11.1, the energy consumption of the Kyoto municipality has decreased every year. Compared to 1997, a 28.8% decrease in energy consumption was observed in 2020. These are important steps in the fight against climate change. “Developing the Culture of Sustainable Cities,” a conference organized by the city in 2017, is another notable initiative. With the organization of this conference, held 20 years after the signing of the Kyoto Protocol, new commitments have been introduced. Within this framework, it was announced that cities—recognized for their significant contribution to the rise in greenhouse gas emissions—will undertake concrete decarbonization measures in the coming years, specifically aligned with Kyoto’s objectives. In this context, the focus is on maximizing the use of solar and other renewable energy technologies, along with energy storage systems, particularly in cultural heritage sites. The initiative also aims to identify suitable locations for such installations, promote the energy-efficient renovation of equipment, and support decarbonization through the increased use of renewable energy sources. It is also intended to develop mega solar power plants on municipal land and encourage private sector initiatives to contribute to the local community (City of Kyoto, 2024).).

Other Kyoto commitments include redesigning daily lifestyles, reducing environmental impact, developing urban transport systems and creating a sustainable society.

The anticipated vulnerability of Kyoto local government to climate change is shown in Table 11.2.

Table 11.2: The Anticipated Vulnerability of Kyoto Local Government to Climate Change

No	Hazard	Probability	Time Scale
01	Cyclone (hurricane/typhoon)	High	Long-term
02	Extreme hot temperature	High	Long-term
03	Extreme precipitation	High	Long-term

Source: UN Climate Change (2024).

Buildings are one of the main contributors to greenhouse gas emissions in the city. Figure 11.1 shows the factors that cause greenhouse gas emissions in Kyoto.

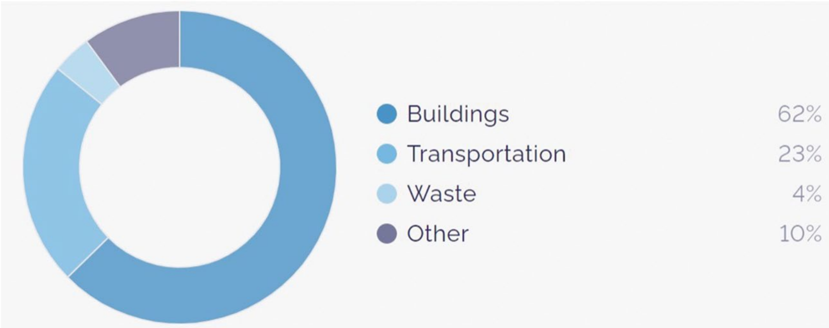


Figure 11.1: Greenhouse Gas Emissions of Kyoto.
Source: UN Climate Change (2024).

As shown in Figure 11.1, buildings cause 62% of the emissions, transport 23%, waste 4% and other factors 10%.

Figure 11.2: Badges of Kyoto.
Source: https://unfccc.int/

As illustrated in Figure 11.2, Kyoto City has earned 8 out of 9 badges across three key domains: climate change mitigation, adaptation, and energy access and poverty. These badges are awarded based on a comprehensive framework assessing local governments' climate actions. Criteria typically include:

- For **mitigation:** the existence of quantified emission reduction targets, implementation of energy-efficiency measures, renewable energy integration, and monitoring systems;

- For **adaptation:** vulnerability assessments, climate risk mapping, early warning systems, and resilience-building strategies in critical infrastructure and communities;
- For **energy access and poverty:** ensuring affordable, clean energy access for all, especially vulnerable groups, alongside policies to reduce energy poverty.

Kyoto's strong performance in these areas stems from a number of pioneering initiatives. The city has established ambitious carbon neutrality targets and implemented low-carbon urban design principles, including transit-oriented development and green building standards. Kyoto was also one of the first Japanese cities to adopt a municipal climate adaptation plan, incorporating flood risk management, urban heat island mitigation, and biodiversity conservation. In the field of energy access, the city has supported solar panel installation subsidies, community-owned renewable energy projects, and energy-efficiency upgrades in low-income households (OECD, 2025).

This high level of achievement reflects Kyoto's effective coordination between its proactive municipal government, cutting-edge universities, and innovative private sector. The successful implementation of national policies promoting research and technological innovation has allowed the city to respond adaptively and decisively to climate challenges, outperforming similarly sized cities in western Japan (Edgington, 2008). Altogether, Kyoto's example underscores the necessity of integrating climate strategies across all levels of government—national, regional, metropolitan, and local—to ensure coherent and effective delivery of climate policy. It also demonstrates how local action, when properly supported, can lead to tangible progress in addressing the climate crisis (Schreurs, 2008). Furthermore, the "Cities for Climate Protection (CCP)" program, serving as a state and non-state network with simultaneous global and local dimensions, can be conceptualized as an integral component of global environmental governance, highlighting the significance of multilevel governance in addressing climate change (Betsill and Bulkeley, 2006). Additionally, local governments have been actively engaged in promoting sustainability through the adoption of various e-government systems aimed at enhancing efficiency and transparency (Nurdin et al., 2022). Furthermore, they have embraced a diverse array of initiatives aimed at addressing all facets of sustainability through public procurement (Preuss, 2009). These endeavors exemplify that local governments possess the capacity to implement policies that contribute to sustainability, even if not explicitly labeled as such (Saha and Paterson, 2008).

As can be seen, the Kyoto local government has been actively engaged in addressing climate change through a multitude of initiatives and policies. The ratification of the Kyoto Protocol served as a catalyst for the implementation of cross-border initiatives aimed at mitigating climate change impacts (Nolasco, 2004). Local governments, including that of Kyoto, are taking concrete steps to transition toward more sustainable practices, adopting an increasingly proactive stance in addressing environmental concerns (Smedby, 2019). However, the Kyoto Protocol has highlighted the significance of collaboration by uniting nations in the endeavor to combat climate change, a matter that is of global importance.

The significance of local governments in climate policy cannot be overstated, as they possess the potential to assume leadership roles in climate governance and make substantial contributions to global climate policy.

The measures taken by Kyoto against climate change are as follows (City of Kyoto, 2024):

The beginning of measures against global warming: Kyoto City prepared the Regional Stimulation Program in 1997. Initiation of the target to reduce carbon dioxide emissions by 10% compared to 1990 levels by 2010. In 2003, the Kyoto City Regional Propulsion Program was renewed.

Enactment of laws, amendments to regulations, and establishment of plans: To encourage further efforts, the first specialized Kyoto City Anti-Global Warming Law was enacted in Japan in December 2004. In 2006, the Kyoto City Global Warming Precautions Program was developed It aims to further fulfill and improve the efforts and policies of citizens, businesses and governments.

Eco-model city selection*:* In 2009, the City of Kyoto announced its goal of becoming a low-carbon city. As a matter of fact, Kyoto was chosen as an Eco-Model City because it significantly reduces greenhouse gases and carries out pioneering work. The city is not only working to reduce greenhouse gas emissions, but also underlines its long-term commitment to becoming a "Carbon-Free City" by adopting the principle of "zero emissions." This has been established as a "medium-term objective."

In 2010, a renewed commitment was made to reducing greenhouse gas emissions and transitioning toward a low-carbon society. As part of this effort, comprehensive regulatory reforms were implemented, contributing to an 80% reduction in emissions. This strategy constitutes a concrete action plan aimed at achieving the predetermined reduction targets. Development of the strategy for the promotion of Kyoto city energy policy: In 2013, the Strategy for the Development of Kyoto City Energy Policy was developed. The overarching objectives of this initiative were as follows: to establish the direction of energy policy and develop it as a basic policy; to create a sustainable energy society that does not rely on nuclear energy; to protect and improve the quality of life of citizens; to build a smart city Kyoto.

Within this framework, Kyoto City's policies aimed at combating climate change are profoundly influenced by the principles and objectives outlined in the Kyoto Protocol. The local government of Kyoto has demonstrated active participation in addressing climate change through various initiatives, including the ratification of the Kyoto Protocol, engagement in multilevel environmental governance, and contributions to global climate policy. These efforts demonstrate the commitment of local governments to combat climate change and promote sustainability. Kyoto City's approach encompasses both mitigation and adaptation measures, with a focus on leveraging technological innovations and considering the economic impacts of climate policies.

Table 11.3: The Role of Each Level

Level	Role
Citizens	– Promote greater awareness and comprehension of the challenges posed by global warming while simultaneously engaging in activities that conserve resources and energy, adopt renewable energy sources, and incorporate eco-friendly products and services into our daily routines.
Businesses	– Incorporate resource and energy-saving practices, employ renewable energy sources, and integrate eco-friendly products and services at every stage of the business cycle, encompassing production, distribution, usage, recycling, and disposal. Additionally, offer environmental education to employees and forge partnerships with citizens and government entities to collectively address global warming challenges.

(Continued)

Tabla 11.3: (Continued)

Level	Role
Kyoto City	– Utilize community-oriented facilities like ward offices and branch offices to bolster citizen and business-led initiatives against global warming. This involves implementing regulatory frameworks and incentives, while actively participating in resource and energy-saving measures, integrating renewable energy, and adopting eco-friendly products and services within Kyoto City's administrative operations, both as a governing entity and a consumer.
Environmental conservation groups	– Engage in tangible environmental conservation efforts by flexibly addressing areas where governmental initiatives may fall short in meeting the diverse needs of society. This includes catering to tourists and other visitors.
Tourists and other visitors	– Collaborate with citizens, businesses, governmental bodies, and environmental conservation organizations in implementing measures to combat global warming.

Source: City of Kyoto (2024).

As depicted in Table 11.3, the Kyoto local government has allocated responsibilities to citizens and various units across all levels for the implementation of policies and environmental regulations aimed at combating climate change. It is evident that the responsibility for combating climate change is shared among the Kyoto local government, citizens, businesses, environmental protection groups, as well as tourists and other visitors. The dynamics of competition between local governments are influenced by a complex interplay of factors, including central government policies and mechanisms for public participation. These policies play a pivotal role in fostering green development and mitigating environmental degradation, necessitating effective coordination and regulation to achieve desired environmental outcomes. The Kyoto local government has enacted a range of policies and initiatives targeting climate change mitigation, with a focus on renewable energy, sustainability, and multi-level governance. These endeavors underscore the indispensable role of local governments in combating climate change and promoting sustainability.

In 1997, the city's total energy consumption amounted to 104,201 terajoules (TJ), whereas by 2016, it had declined to 75,833 TJ. This notable reduction in energy usage highlights the city's response to climate change. Kyoto has set a target to reduce emissions by 40% by 2030. Furthermore, by implementing measures such as reducing traffic congestion and expanding pedestrian zones, the city achieved a 15% reduction in greenhouse gas emissions in 2010 compared to 1990 levels. Kyoto is also actively addressing waste management—an area with significant implications for climate change—having decreased its annual waste volume from 820,000 tonnes in 2000 to 390,000 tonnes in 2020 (City of Kyoto, 2024).

However, despite these successful efforts to address climate change, there are also areas where Kyoto has encountered significant difficulties and has not fully achieved its targets. In particular, there have been difficulties in reaching the targets for the reduction of carbon emissions. Despite its great symbolic importance as the host of the Kyoto Protocol, the goals of reducing energy consumption in the city and increasing the use of renewable energy have been limited by Japan's overall energy policies and the country's commitment to nuclear energy. Following the 2011 Fukushima nuclear disaster, fossil fuel use increased across Japan, which negatively affected Kyoto's efforts to reduce its carbon footprint (Vivoda, 2012). Furthermore, due to rapid urbanization and increasing population density, it has not made the expected progress in reducing carbon emissions in the transport and housing sectors. Therefore, Kyoto City still needs to make significant improvements in order to achieve its goals of transitioning to sustainable energy and promoting low-carbon lifestyles (OECD, 2025).

11.5 Stockholm's Policies on Climate Change

The Stockholm local government is implementing a range of policies aimed at addressing climate change, with a particular emphasis on improving air quality, mitigating greenhouse gas emissions, and promoting sustainable development. The Stockholm local government is widely recognized as a frontrunner in climate action, particularly for its innovative integration of climate change mitigation strategies into urban planning processes (Wretling and Balfors, 2021). Stockholm's better understanding of future urban growth and greenhouse gas emissions has made it a pioneer in climate planning and a model for other cities (Pan et al., 2019).

The origins of the legislative framework concerning climate change in Stockholm can be traced back to the 1972 Stockholm Conference on the Human Environment. This landmark conference marked a pivotal moment in the evolution of international environmental law and resulted in the adoption of the Stockholm Declaration, which underscored the significance of safeguarding and enhancing the environment for both present and future generations (Yamamoto and Esteban, 2014).

In addition, the Stockholm Conference played an active role in establishing environmental management laws and governance mechanisms globally. The Conference paved the way for the establishment of legal frameworks to address environmental issues (Jumbe and Nandini, 2007). The culmination of these efforts was evident in the signing of the Stockholm Convention on Persistent Organic Pollutants in 2001, which represented a significant step forward in addressing environmental challenges. The convention aimed to curtail the emissions of persistent organic pollutants, with the overarching goals of safeguarding the environment and protecting human health (Zhao et al., 2019).

Stockholm, a prominent city grappling with the challenges posed by climate change, has been recognized as one of the 100 climate cities selected in the EU in 2023. Moreover, the city achieved the prestigious accolade of being crowned the greenest capital of Europe following a competition among 35 cities across the continent. Despite its northern geographical location and expanding population, Stockholm has managed to maintain remarkably low-emission levels (Carbon Center, 2024). The city has set an ambitious target to become fossil fuel-free by 2050. However, projections suggest that by 2100, Stockholm may experience a notable increase in average annual temperature, ranging between 2.5° and 4.5° Celsius, alongside heightened precipitation and rising water levels in seas and lakes (Stockholms Stad, 2024; Carbon Center, 2024).

To tackle these challenges, the municipality has implemented two action programs aimed at curbing greenhouse gas emissions. The primary objective of the initial program, which ran from 1995 to 2000, was to reduce greenhouse gas emissions from electricity, heating, and transportation to levels equivalent to those recorded in 1990, amounting to 5.4 tonnes of carbon dioxide equivalent (CO2) per year for Stockholm. Remarkably, not only did Stockholm achieve this target, but it also surpassed it, with greenhouse gas emissions dropping to 4.5 tonnes of CO2 by the onset of the new millennium (Stockholms Stad, 2024; European Environment Agency, 2024).

Stockholm has laid out a comprehensive plan to transition to a zero-carbon city by 2050, accompanied by environmental initiatives aimed at supporting this ambitious goal. Despite these endeavors, however, the Stockholm region has yet to achieve any of the 16 “National Environmental Quality Goals,” signaling the need for further action (Stockholms Stad, 2024). Localized adaptation strategies, designed to enhance the resilience of local governments in the face of a changing climate, are gaining traction in numerous localities across Sweden underscoring the significance of such approaches in addressing climate change (Chou, 2020). Moreover, the implementation of the EU 2050 climate policy, which aims to reduce carbon emissions, and the Baltic Sea Action Plan, which also aims to do so, have been rolled out in the Stockholm-Mälar region, highlighting the importance of local-level implementation of climate policies (Gren, 2015).

Apart from municipal initiatives, regional administrations in Stockholm are actively engaged in combating climate change. Particularly noteworthy are the contributions of the Stockholm County Administrative Board and the Stockholm County Council, aligning with national regulations and policies, including those related to regional development plans (Borgström, 2019). Furthermore, governmental bodies have taken proactive steps to assess the implications of climate change on air quality and population exposure within urban planning frameworks. They employ a nested system comprising global and regional climate models to evaluate the effects of shifting air pollutant emissions on air quality levels in Stockholm (Gidhagen et al., 2012). Effectiveness of emission reduction policies has been evidenced in the improvement of air quality, with significant reductions in pollutants such as ozone (Markakis et al., 2016).

The Anticipated Vulnerability of Stockholm local government to climate change is shown in Table 11.4.

Table 11.4: The Anticipated Vulnerability of Stockholm Local Government to Climate Change

No	Hazard	Probability	Time Scale
01	Extreme hot temperature	High	Medium
02	Extreme precipitation	High	Medium
03	Flood and sea-level rise	Medium	Long-term

Source: EU Climate Change (2024).

Buildings are the main factor causing greenhouse gas emissions in Stockholm. Figure 11.3 illustrates the factors that contribute to greenhouse gas emissions in the city.

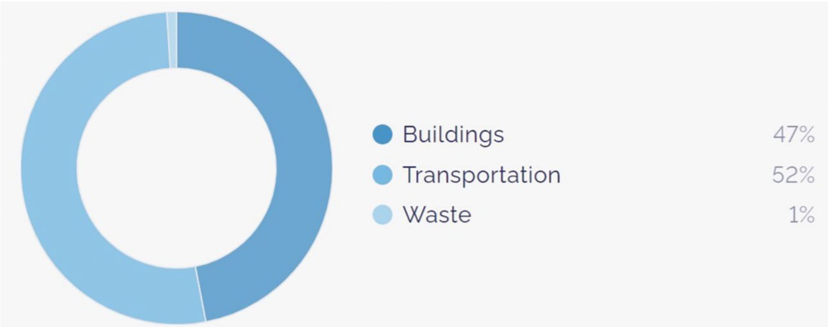


Figure 11.3: Greenhouse Gas Emissions of Stockholm.
Source: EU Climate Change (2024).

As shown in Figure 11.3, buildings cause 47%, transport 52% and waste 1% of the emissions in Stockholm.

Figure 11.4: Badges of Stockholm.
Source: EU Climate Change (2024).

As illustrated in Figure 11.4, Stockholm has achieved 6 out of 9 badges related to reduction, adaptation, and energy access & poverty. These "badges" are typically awards or indicators associated with sustainability and environmentally friendly practices. Each badge represents a specific achievement or performance metric, and in this context, it demonstrates the extent to which Stockholm has met various environmental and climate-related objectives.

These badges symbolize the city's contributions to global environmental goals and its success in sustainable development efforts.

The policies of Stockholm's local government align with the global agenda for addressing climate change and ensuring environmental sustainability. The city's efforts to improve air quality, regulate persistent organic pollutants, and promote sustainable development are in harmony with international initiatives, underscoring its commitment to mitigating the impacts of climate change. Stockholm stands out as an active participant in efforts aimed at both mitigating and adapting to climate change. The emphasis on reducing greenhouse gas emissions and enhancing air quality through emission reduction policies is central to the city's approach (Markakis et al., 2016). Furthermore, the city's incorporation of various climate scenarios to evaluate the impact of climate change on the energy efficiency of its building stock highlights its proactive stance on climate adaptation (Yang et al., 2020).

Furthermore, Stockholm is actively engaged in integrating climate change adaptation and mitigation strategies, aiming to reconcile these dual objectives and effectively harmonize climate change policies (Huang-Lachmann and Guenther, 2020). From a governance perspective, Stockholm is tackling challenges related to the management of urban ecosystem services and green spaces, emphasizing the necessity for governance frameworks to address spatial structure and habitat suitability within urban areas (Ernstson et al., 2010). Moreover, the city actively participates in local climate networks to implement climate, energy, and transportation policies, adopting a collaborative approach to addressing climate change (Krause, 2012). In this context, Stockholm's strategies to combat climate change encompass a diverse array of initiatives, including sustainable urban development, biodiversity conservation, air quality enhancement, and other efforts in climate change mitigation and adaptation. These policies underscore the city's steadfast commitment to confronting the challenges posed by climate change and fostering sustainable and resilient urban environments.

Stockholm's goals include a fossil-free and climate-positive city by 2040, a fossil-free 2030, a climate-smart Stockholm, a city that uses resources wisely, rich in biodiversity and with well-functioning and harmonious ecosystems, clean air and a healthy environment. It is the vision of a toxin-free Stockholm.

The European Green Capital Award is based on 12 criteria (AWARDS, 2024):

Local Contribution to Climate Change, Local Transport, Presence of Public Green Spaces: Nature and Biodiversity, Air Quality, Noise Pollution, Waste Production and Management, Water Consumption, Wastewater Treatment, Municipal Environmental Management, Sustainable Land Use, Other Measurements, Sharing Experience and Practices.

Table 11.5: Criteria for Stockholm's European Green Capital Award

2010	Why Did It Receive an Award?
Sweden-Stockholm 800,000 Population	– An effective plan against noise pollution – Significant Initiatives for clean air – Innovative waste recycling systems – More than green areas – Use of environmentally friendly technologies in transportation

Source: AWARDS (2024).

As stated in Table 11.5, Stockholm, which has met a significant part of the European Green Capital targets, has been awarded the title of "European Green Capital" by the European Commission since 2010. Making eco-improvements in buildings to combat climate change, creating new eco-neighborhoods, benefiting from renewable energy, designing water, rainwater and waste management plans, developing environmentally friendly public transportation, protecting biodiversity and greenery, and sharing all these experiences are among the important aspects. Stockholm aims to become the world's first city with a positive carbon footprint by 2040 (C40 Cities, 2024). Stockholm therefore aims to become independent from fossil fuels by 2050. Since 2005, the city has carried out an annual inventory of CO2 levels and has seen a significant reduction in CO2 emissions (Stockholms Stad Miljöbarometern, 2024).

In the city, pedestrian, bus, bicycle, and rail systems play a significant role in facilitating urban mobility. Public transportation stops are conveniently located within 300 meters of most residents. Moreover, traffic reduction initiatives are enforced in the city center, with 25% of the urban area designated as pedestrian zones. While Stockholm boasts an extensive bus network interconnected with the metro system, the city also prioritizes alternative fuel vehicles. As part of this initiative, Stockholm operates biogas and ethanol hybrid buses to promote sustainable transportation solutions (Stockholms Stad, 2024).

Stockholm is leading efforts to establish the world's first carbon-negative district heating system, and to achieve this goal, Stockholm Exergi plans to transform the city's regional heating infrastructure. Stockholm Exergi is actively working to transition Stockholm's district heating system to carbon-negative operations in energy production. A notable project in this endeavor is the Carbon Capture and Storage with Bioenergy (BECCS) facility, which aims to capture the biogenic CO_2 emissions from biomass combustion and store them underground, effectively removing CO_2 from the atmosphere (European Commission, 2024). In addition to BECCS, Stockholm Exergi is investigating the production of biochar, a stable form of carbon that can be used as a soil enhancer, through the pyrolysis of biomass. This method also contributes to negative emissions by sequestering carbon that would otherwise be released into the atmosphere (Stockholm Exergi, 2024). Additionally, research is underway to explore the feasibility of implementing biofuel-powered regional heating systems. Stockholm's climate initiatives underscore the importance of public policy in incentivizing companies to adopt climate-friendly practices (Smart City Sweden, 2024). In line with this, Fortum, a Finnish state-owned enterprise (SOE), has announced the closure of the last coal-fired boiler used for energy and heat production at the Värtaverket combined cycle plant in Stockholm. The company is now evaluating the potential integration of a carbon capture system (CCS) at Värtaverket. Fortum asserts that CCS represents a cost-effective solution for reducing carbon dioxide emissions, citing data obtained from an ongoing pilot project (FORTUM, 2024).

As evidenced by the information provided, Stockholm is deeply engaged in combating climate change through a variety of policies and initiatives. The city places emphasis on sustainable urban development, biodiversity preservation, and the enhancement of air quality. Initiatives like the "Walkable City" program have been implemented to foster sustainable growth and expand urban boundaries (Xiu et al., 2018). Stockholm is rigorously assessing the impact of climate change on air quality and population (Gidhagen et al., 2012). In addition, the city endeavors to examine changes in urban green infrastructure and to ensure sustainable urban development (Furberg et al., 2020). These efforts appear to be in line with the city's aim to fulfill its environmental quality objectives and combat climate change. Stockholm's local government has taken significant strides in mitigating and adapting to climate change, positioning the city as a frontrunner in climate planning. Nonetheless, challenges persist, necessitating continued efforts to meet environmental quality targets and ensure effective climate governance at the local level.

In addition to central governments, local governments should also carry out activities to tackle an issue such as climate change, which has both global and local implications. It can be seen that the local governments of Kyoto and Stockholm, which are analyzed in the study, are implementing effective policies and carrying out studies in the fight against climate change. As climate change has a profound impact on cities, local governments, which bear responsibility for urban management, face significant duties and responsibilities. Since local governments are the closest administrative units to the public and each local area may have different problems, the services to be provided by local governments and the struggle policies to be implemented have an important place. In tackling an issue as important as climate change, local governments should not only have the necessary authority, but also the financial resources to implement measures. Therefore, the administrative and financial autonomy of local governments is imperative for the effective formulation of climate change policies. However, in instances where local governments are unable to adequately address climate change, the intervention of the central government may be necessary. Nevertheless, this should not affect the quality of work carried out by local governments on the city, as they are the units closest to the people at the local level.

11.6 Conclusion

In this study, the efforts of local governments in combating climate change were examined through the case studies of the cities of Kyoto and Stockholm. It was observed that these cities have undertaken significant initiatives in this regard.

The Stockholm local government has made considerable endeavors to combat climate change, focusing on initiatives such as establishing an 80 percent renewable district heating production system, optimizing energy resource utilization in heating networks, and implementing waste-to-energy conversion systems. These endeavors are conducted in collaboration with state and local government officials, reflecting effective governance within the city. Key outcomes of these efforts include the promotion of energy-efficient buildings, the implementation of district heating and cooling systems, the enhancement of climate change adaptation measures, and the provision of support for research on environmental factors such as air and water quality, noise pollution, waste management, and chemical safety. Furthermore, the local government encourages and promotes the use of public transportation, invests in renewable vehicles, implements traffic congestion taxes, and fosters the development of smart city infrastructure. These actions collectively demonstrate Stockholm's commitment to mitigating climate change and fostering sustainability.

In this context, Table 11.6 presents the climate targets of Kyoto and Stockholm on climate change.

Table 11.6: Kyoto's and Stockholm's Climate Goals

Climate Goals	Kyoto	Stockholm
Smart, Fossil-Free and Climate-Positive	– In line with this goal, Kyoto is carrying out various projects to increase the energy efficiency of buildings, to use renewable resources such as solar and wind energy more widely, and to develop electric transport infrastructure. – Especially in the transport sector, Kyoto has reduced fossil fuel dependency by modernizing public transport systems with electric and hybrid vehicles. – Kyoto's fossil-free economy goal is also integrated with circular economy principles, incorporating waste management into energy production and minimizing its carbon footprint.	– Stockholm is striving to become climate-smart by eliminating the use of fossil fuels to minimize its climate impact. – District heating and electricity consumption in Stockholm rely on renewable and waste to energy sources, while climate-conscious transportation options such as public transit, cycling, or eco-friendly vehicles are encouraged throughout the city. – Through its climate action plan, the City of Stockholm aims to align with the global climate agreement, ensuring that it meets the standards outlined for all countries worldwide, thus making Stockholm 'Paris compatible.'

(Continued)

Tabla 11.6: (Continued)

Climate Goals	Kyoto	Stockholm
Sustainable Energy Consumption	– The aim is to establish renewable and sustainable energy systems. – 100% renewable electricity scheme. – The Citizen Common Power Plant System and Eco-energy system are implemented. – Utilization of renewable energy sources in cultural heritage sites.	– Stockholm's energy supply is progressively shifting toward renewable sources. – Around 80% of the city's heating demand is met through regional heating, with an additional 15% provided by electricity. To mitigate the greenhouse effect, there's a pressing need for enhanced energy efficiency and the wider adoption of renewable energy. – The Energy Center within the Department of Environment assists municipal units and businesses in their endeavors to curtail energy consumption. – The Environment Department offers an energy and climate consulting service catered to individuals, organizations, and businesses, providing guidance and recommendations on reducing energy usage and the environmental footprint.
Waste	– The waste and fat from meals eaten in communities is converted into biodiesel fuel, which is used by refuse collection trucks and city buses. Approximately one million liters of biodiesel fuel are produced each year and 136 refuse trucks and 104 city buses operate using this fuel.	– On average, each Swede generates around half a ton of waste annually. It's crucial to minimize this volume and ensure proper disposal of the resulting waste. One objective outlined in the city's environmental program is to raise Stockholm's food waste collection rate to 70%.

Climate Goals	Kyoto	Stockholm
Chemicals	– Kyoto imposes strict regulations on the management of chemicals in accordance with national and international standards aimed at reducing the release of harmful chemicals into the environment. – Kyoto also supports the development of environmentally friendly chemical processes and products by promoting the principles of green chemistry. – Kyoto Green Chemical Network, green technology oriented areas are being established and the New Kyoto City Plan for Reducing Waste by Half is being implemented.	– Stockholm has established a chemicals plan outlining its commitment to achieving a toxic-free environment. – The city's organizational structure incorporates the Chemicals Center within the Department of Environment and Health, comprising specialists in chemistry and ecotoxicology. – The Chemicals Center supports various city departments and businesses in reducing chemical usage and adhering to the city's chemicals plan.
Sustainable Transportation Operations	– The aim is to reduce environmental impacts by creating a sustainable society. – With the Shijo Street Project, greenhouse gas emissions were reduced by reducing the number of lanes on the main streets of Kyoto. – Children Eco-Life Challenge Workbook. – Climate awareness in children is raised by creating an eco-school zone.	– Every day, two million individuals commute within Stockholm. – Road traffic poses several adverse effects including traffic congestion, air pollution, and its contribution to climate change. – Stockholm's environmental program outlines five intermediate objectives aimed at promoting eco-friendly transportation. – The city's accessibility strategy details ways for residents to boost walking, cycling, and public transportation usage, thereby alleviating traffic congestion and reducing climate and environmental impacts.

(Continued)

Tabla 11.6: (Continued)

Climate Goals	Kyoto	Stockholm
Weather	– Kyoto aims to minimize air pollution by focusing on renewable energy sources. – The city is focused on improving air quality within the city through efforts to protect and increase its green areas.	– Stockholm's weather has significantly improved over the past 50 years, with better management of air pollution, including sulfur dioxide, lead, carbon monoxide, benzene, and other pollutants. – A crucial measure in this improvement is the expansion of the district heating network. Eight out of ten buildings in the city are now connected to this network, with 80% of heating sourced from non-fossil fuel sources. – The city actively participates in the Eastern Sweden Air Quality Management Association, which oversees, analyses, and reports on air quality in the region.
Noise	– The introduction of electric vehicles in public transport and the use of hybrid buses play an important role in reducing noise from motor vehicles. – Noise pollution levels have been reduced by 10% thanks to practices that optimize traffic flow within the City of Kyoto. – Kyoto's extensive green spaces and parks contribute to reducing the impact of noise by creating natural sound barriers in urban areas.	– Noise pollution ranks among the top environmental concerns in Stockholm, prompting longstanding efforts by the city to mitigate ambient noise. Key initiatives include protective measures like insulating building facades in high-risk areas and erecting sound barriers.

Climate Goals	Kyoto	Stockholm
Water	– In line with its sustainability goals, Kyoto has developed a comprehensive infrastructure that protects the city's water resources using advanced technologies and innovative approaches. – By utilizing innovative methods in wastewater treatment plants, Kyoto has increased the water recycling rate and conserved clean water resources. – In addition, rainwater harvesting systems have been expanded and the use of water to reduce the urban heat island effect has been promoted. – Kyoto's water management policies that are sensitive to local ecosystems set an important example in combating climate change by increasing water conservation and urban resilience.	– Stockholm has devised an action plan to guarantee that its lakes, coastal waters, and waterways adhere to the environmental quality standards set by the EU. The city intends to develop local action programs for all lakes, streams, and coastal waters within its jurisdiction.
Renewable Energy	– Decision to decrease dependence on nuclear energy and transition to renewable energy policies and putting it into practice. – In this context, 100% renewable energy use is targeted.	– In Stockholm, significant investments are being made in renewable energy systems such as solar, wind, and biogas. Additionally, a city-wide central heating-cooling system has been implemented, utilizing energy derived from waste.
Measures Taken in Buildings	– For buildings of 300 m^2 or larger, the obligation to install a renewable energy system was introduced, subsidies to encourage the installation of solar PV attachments, co-purchase of solar panels, renewable energy demand, local production, local consumption and local circulation of renewable energy for residential buildings were encouraged.	– The city prioritizes energy efficiency in new construction projects and implements energy-saving measures in existing buildings.

Source: Stockholms Stad (2024); City of Kyoto (2024). (The table has been compiled by the authors using these sources.)

As shown in Table 11.6, the Kyoto and Stockholm climate change targets include minimizing the use of chemicals, using renewable energy sources, energy saving in buildings, waste, water, air and noise management, sustainability of transportation operations, and sustainable energy consumption. Kyoto is a city of symbolic and practical importance at the global level in the fight against climate change. The city has been a pioneer in the global climate struggle with the Kyoto Protocol adopted in 1997 and has set an example with its sustainable policies at the local level. To reduce carbon emissions, Kyoto has expanded the use of renewable energy, developed projects to improve energy efficiency and modernized public transport with electric and hybrid vehicles. It has also made progress in waste management with a circular economy approach and increased recycling rates. The city's water and noise management policies support environmental sustainability, while the protection and expansion of green spaces have contributed to improving air quality. Kyoto's climate change policies have been an inspiring model both locally and globally, demonstrating an innovative, comprehensive and sustainable approach.

Like Stockholm, Kyoto has implemented significant and effective measures to address climate change. Key initiatives include enacting plans for climate change mitigation within the city, being designated as an eco-model city, updating regulations and developing plans to support these changes, and formulating strategies to promote Kyoto's energy policy. Much like Stockholm, Kyoto's efforts involve collaboration between the central government, the local government, citizens, businesses, and various institutions and organizations. Kyoto's climate change policies encompass the following components: fostering cross-sectoral cooperation among institutions, transport policy, the children's eco-life challenge, waste policy, an fossil free, eco-energy economy policy, the convening of the Global Warming Prevention Headquarters to address climate change, the establishment of committees, the promotion of collaboration among citizens, businesses, and private organizations through effective governance, and the fostering of international cooperation with other cities. These efforts underscore Kyoto's commitment to combating climate change through comprehensive and collaborative strategies. The Kyoto local government is tackling climate change by setting climate change and renewable energy targets, implementing energy-efficiency incentive programs, and promoting educational efforts. The city has also focused on green local government procurement standards, public transport policies, public–private partnership agreements with local businesses, and tree planting. The city is taking a comprehensive approach to climate change mitigation and adaptation, leveraging technological innovations while considering the economic impacts of climate policies.

The laws, regulations, and action plans implemented in both Kyoto and Stockholm regarding climate change play a crucial role in their efforts to combat this global challenge. Enacting legislation is often considered the first step in this endeavor, and the initiatives undertaken by both cities demonstrate their success in addressing climate change. Key practices that have proven effective in both Kyoto and Stockholm include the establishment of eco-neighborhoods, the implementation of smart city initiatives, the development of district heating systems, and the establishment of climate change combat units by the central government. These policies serve as valuable examples for other cities seeking to address climate change effectively. Within the scope of the issues outlined, it is observed that the City of Kyoto has particularly focused on technological solutions and energy efficiency, whereas Stockholm has adopted a more holistic approach, aiming for the complete abandonment of fossil fuels. Although Kyoto holds symbolic global significance due to the Kyoto Protocol signed in 1997, its local environmental policies remain relatively limited when compared to those of Stockholm. Stockholm, on the other hand, follows a comprehensive sustainability strategy, ranging from emission reductions in transportation and the use of renewable energy to urban planning and participatory governance processes. In this context, Stockholm has reinforced its leadership in the field by setting the goal of becoming entirely fossil fuel-free by the year 2040. Therefore, it can be stated that Stockholm implements more comprehensive and effective policies in combating climate change, while Kyoto's significance is primarily highlighted in a historical and diplomatic context.

The experiences of Kyoto and Stockholm also offer valuable lessons for cities in Türkiye, particularly considering Türkiye's geographical location in the Mediterranean Basin and its susceptibility to the impacts of climate change. In this context, it is imperative for local governments to assume responsibilities and conduct comprehensive studies on climate change. However, local governments need to work in cooperation with other actors in the city besides the central government. This is due to the fact that addressing a global problem such as climate change is a multifaceted and challenging endeavor. Being located within the Mediterranean Basin and thus subject to the impacts of climate change, it is imperative that Türkiye's cities undergo an ecological transformation. It is important to initiate this transformation from the neighborhood level, implementing Stockholm's eco-neighborhood model in practice. It is evident that policies that are implemented at a local level and involve the public and local actors are more functional and solution-oriented than uniform decisions made centrally. Consequently, the actions of local governments concerning climate change are proving to be remarkably effective and are assuming a central role. Local governments in Türkiye should also conduct studies on waste management, air, water, noise and renewable energy utilization, and implement the findings. While Türkiye has initiated studies on climate change in its cities and enacted relevant legal regulations, there is a necessity to address shortcomings in implementation. The climate change laws, eco-city models, eco-neighborhood initiatives, energy management strategies, district heating systems, and programs targeting air, water, noise, and waste management implemented by Kyoto and Stockholm serve as exemplary case studies for Turkish cities. However, in both Kyoto and Stockholm, it can be seen that all stakeholders in the city are collaborating on the governance axis in the fight against climate change. It is imperative for local governments to collaborate with other actors in this context to implement effective practices. By adapting and implementing these practices while considering the unique dynamics of Turkish cities, effective policies for combating climate change can be developed and put into action.

Bibliography

Agrawal, A. (2008). The Role of Local Institutions in Adaptation to Climate Change. https://doi.org/10.1596/28274

Atisa, G., Zemrani, A., Weiss, M. (2020). Decentralized Governments: Local Empowerment and Sustainable Development Challenges in Africa. Environment Development and Sustainability, 23(3), 3349–3367. https://doi.org/10.1007/s10668-020-00722-0

AWARDS (2024). European Green Capital Awards: Role Models for a Sustainable Europe, Retrieved from https://www.nparks.gov.sg/-/media/cuge/ebook/citygreen/cg6/cg6_02.pdf, on April 5, 2025.

Bayraktar Küçük, H., Çetintürk, V. E. (2022). İklim değişikliğinin kentlere etkisi üzerine bir değerlendirme: Dünyada ve Türkiye'de iklim dostu kentler. İ. Akbal ve F. Nalbant (Ed.), Güncel araştırmalar çerçevesinde iklim değişikliği (nedenler, sonuçlar ve mücadele politikaları) içinde (s. 69–94). Ankara: Nobel Yayıncılık.

Betsill, M., Bulkeley, H. (2006). Cities and the Multilevel Governance of Global Climate Change. Global Governance a Review of Multilateralism and International Organizations, 12(2), 141–160. https://doi.org/10.1163/19426720-01202004

Boussalis, C., Coan, T., Holman, M. (2019). Communicating Climate Mitigation and Adaptation Efforts in American Cities. Climate, 7(3), 45. https://doi.org/10.3390/cli7030045

Borgström, S. (2019). Balancing diversity and connectivity in multi-level governance settings for urban transformative capacity. Ambio, 48(5), 463–477. https://doi.org/10.1007/s13280-018-01142-1

Buchner, B., Carraro, C., Cersosimo, I. (2002). Economic Consequences of The Us Withdrawal from The Kyoto/Bonn Protocol. Climate Policy, 2(4), 273–292. https://doi.org/10.3763/cpol.2002.0234

Bulkeley, H., Kern, K. (2006). Local Government and the Governing of Climate Change In Germany And The UK. Urban Studies, 43(12), 2237–2259. https://doi.org/10.1080/00420980600936491

CDP Disclosure Insight Action (2024). Retrieved from https://www.cdp.net/en/articles/media/43-cities-score-an-a-grade-in-new-cities-climate-change-ranking 10.09.2024.

Chou, M. (2020). Australian Local Governments and Climate Emergency Declarations: Reviewing Local Government Practice. Australian Journal of Public Administration, 80(3), 613–623. https://doi.org/10.1111/1467-8500.12451

C40 Cities (2024). Cities100: Stockholm-Becoming Fossil Fuel-free by 2040, Retrieved from https://www.c40.org/case-studies/cities100-stockholm-becoming-fossil-fuel-free-by-2040/, on April 5, 2025.

Edgington, D. (2008). The Kyoto Research Park and Innovation in Japanese Cities. Urban Geography, 29(5), 411–450. https://doi.org/10.2747/0272-3638.29.5.411

Eissa, Y., Khalil, H. (2021). Urban Climate Change Governance Within Centralised Governments: A Case Study of Giza, Egypt. Urban Forum, 33(2), 197–221. https://doi.org/10.1007/s12132-021-09441-9

Ernstson, H., Barthel, S., Andersson, E., Borgström, S. (2010). Scale-Crossing Brokers and Network Governance of Urban Ecosystem Services: The Case of Stockholm. Ecology and Society, 15(4). https://doi.org/10.5751/es-03692-150428

Ekici, M. (2023). "Sıfır Salımlı ve İklim Değişikliğine Dirençli Yeşil Kent: Tokyo" İklim Dostu Kentler: Türkiye ve Dünyadan Örnekler, (Ed.) Hüseyin Gül, Hülya Küçük Bayraktar, Veli Ercan Çetintürk, Detay Yayıncılık, Ankara.

European Green Capital Awards: Role Models for a Sustainable Europe (t.y.). Retrieved from https://www.nparks.gov.sg/-/media/cuge/ebook/citygreen/cg6/cg6_02.ashx#:~:text=Entrants%20are%20required%20to%20demonstrate,air%2C%20quality%20of%20the%20acoustic on November 10, 2023.

European Commission (2023). Climate Action Progress Report 2023, Retrieved from https://climate.ec.europa.eu/system/files/2023-11/com_2023_653_glossy_en_0.pdf, on April 5, 2025.

European Commission European Climate, Infrastructure and Environment Executive Agency (2024). Beccs Stockholm: delivering net carbon removals with clean energy, Retrieved from https://cinea.ec.europa.eu/featured-projects/beccs-stockholm-delivering-net-carbon-removals-clean-energy_en?utm_source=chatgpt.com, on April 5, 2025.

European Environment Agency (2024). Climate change mitigation: reducing emissions, Retrieved from https://www.eea.europa.eu/en/topics/in-depth/climate-change-mitigation-reducing-emissions, on April 5, 2025.

Furberg, D., Ban, Y., Mörtberg, U. (2020). Monitoring Urban Green Infrastructure Changes and Impact on Habitat Connectivity Using High-Resolution Satellite Data. Remote Sensing, 12(18), 3072. https://doi.org/10.3390/rs12183072

FORTUM (2024). Retrieved from https://www.fortum.com/media/2020/01/fortum-joint-venture-will-close-its-last-coal-boiler-stockholm-spring-2020-explores-possibility-making-district-heating-carbon-negative on January 14, 2024.

Galarraga, I., González-Eguino, M., Markandya, A. (2011). The Role of Regional Governments in Climate Change Policy. Environmental Policy and Governance, 21(3), 164–182. https://doi.org/10.1002/eet.572

Ge, J., Lin, B. (2021). Does the Kyoto Protocol as an International Environmental Policy Promote Forest Carbon Sinks? Journal of Global Information Management, 30(6), 1–22. https://doi.org/10.4018/jgim.289651

Gidhagen, L., Engardt, M., Lövenheim, B., Johansson, C. (2012). Modeling Effects of Climate Change on Air Quality and Population Exposure in Urban Planning Scenarios. Advances in Meteorology, 2012, 1–12. https://doi.org/10.1155/2012/240894

Gren, I. (2015). Estimating Values of Carbon Sequestration and Nutrient Recycling in Forests: An Application to The Stockholm-Mälar Region in Sweden. Forests, 6(12), 3594–3613. https://doi.org/10.3390/f6103594

Hamza-Çelikyay, H., Küçük-Bayraktar, H. (2023). İklim politika belgelerinde iklim dostu kentler ve dirençlilik stratejileri. Humanitas, 11(INCSOS VIII Özel Sayısı), 87–107.

Hoppe, T., Berg, M., Coenen, F. (2014). Reflections on the Uptake of Climate Change Policies by Local Governments: Facing the Challenges of Mitigation and Adaptation. Energy Sustainability and Society, 4(1). https://doi.org/10.1186/2192-0567-4-8

Huang-Lachmann, J., Guenther, E. (2020). From Dichotomy to An Integrated Approach: Cities' Benefits of Integrating Climate Change Adaptation and Mitigation. Sustainability, 12(18), 7591. https://doi.org/10.3390/su12187591

International Renewable Energy Agency (IRENA) (2020). Rise of Renewables in Cities-Energy Solutions for the Urban Future, Retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Oct/IRENA_Renewables_in_cities_2020.pdf, on April 5, 2025.

Jumbe, A., Nandini, N. (2007). Legal Aspects of Water Pollution in India: A Review on Statutory Frameworks. Mapana Journal of Sciences, 6(1), 118–131. https://doi.org/10.12723/mjs.10.9

Keskin, O., Chaychi Semsari, M. (2023). "Çin'de Yeşil Enerji ve İklim Dostu Kent Politikaları: Wuhan Örneği" İklim Dostu Kentler: Türkiye ve Dünyadan Örnekler, (Ed.) Hüseyin Gül, Hülya Küçük Bayraktar, Veli Ercan Çetintürk, Detay Yayıncılık, Ankara.

Kim, Y. (2021). Technological Innovation, The Kyoto Protocol, and Open Innovation. Journal of Open Innovation Technology Market and Complexity, 7(3), 198. https://doi.org/10.3390/joitmc7030198

Krause, R. (2012). An Assessment of the Impact That Participation in Local Climate Networks Has on Cities' Implementation of Climate, Energy, And Transportation Policies. Review of Policy Research, 29(5), 585–604. https://doi.org/10.1111/j.1541-1338.2012.00582.x

Krause, R. (2011). Policy Innovation, Intergovernmental Relations, And the Adoption of Climate Protection Initiative by U.S. Cities. Journal of Urban Affairs, 33(1), 45–60. https://doi.org/10.1111/j.1467-9906.2010.00510.x

Kuosmanen, T., Zhou, X., Dai, S. (2020). How Much Climate Policy Has Cost for OECD Countries? World Development, 125, 104681. https://doi.org/10.1016/j.worlddev.2019.104681

Kyoto City Official Website (2024). Retrieved from https://www.city.kyoto.lg.jp/ on January 5, 2024.

A-Plat Climate Change Adaptation Information Platform (2024). Retrieved from https://adaptation-platform.nies.go.jp/en/articles/lccac/vol26_kyoto.html on 05.01.2024.

Kyoto City (2023). Retrieved from https://unfccc.int/sites/default/files/resource/352_%E3%80%90City%20of%20KYOTO%E3%80%91.pdf, on June 4, 2024.

Leck, H., Simon, D. (2012). Fostering Multiscalar Collaboration and Co-Operation for Effective Governance of Climate Change Adaptation. Urban Studies, 50(6), 1221–1238. https://doi.org/10.1177/0042098012461675

Lund, H. (2006). The Kyoto Mechanisms and Technological Innovation. Energy, 31(13), 2325–2332. https://doi.org/10.1016/j.energy.2006.01.010

Markakis, K., Valari, M., Engardt, M., Lacressonnière, G., Vautard, R., Andersson, C. (2016). Mid-21st Century Air Quality at the Urban Scale Under the Influence of Changed Climate and Emissions—Case Studies for Paris and Stockholm. Atmospheric Chemistry and Physics, 16(4), 1877–1894. https://doi.org/10.5194/acp-16-1877-2016

McGuirk, P., Dowling, R., Bulkeley, H. (2014). Repositioning Urban Governments? Energy Efficiency and Australia's Changing Climate and Energy Governance Regimes. Urban Studies, 51(13), 2717–2734. https://doi.org/10.1177/0042098014533732

Mees, H., Uittenbroek, C., Hegger, D., Driessen, P. (2019). From Citizen Participation to Government Participation: An Exploration of The Roles of Local Governments in Community Initiatives for Climate Change Adaptation in the Netherlands. Environmental Policy and Governance, 29(3), 198–208. https://doi.org/10.1002/eet.1847

Memiş, L. (2023). "Güney Kore'de İklim Değişikliğine Yönelik Politikalar ve İklim Dostu Atık Yönetimi Uygulamaları: Seul Örneği" İklim Dostu Kentler: Türkiye ve Dünyadan Örnekler, (Ed.) Hüseyin Gül, Hülya Küçük Bayraktar, Veli Ercan Çetintürk, Detay Yayıncılık, Ankara.

Nalbant, F., Sevinçli, Ç. (2023). "Büyükşehir Belediyelerinin İklim Değişikliğiyle İlgili Mevzuat ve Kurumsal Raporlarının Kent Ekonomisi Kapsamında İncelenmesi" Kent Ekonomisi ve Kentsel Gelişme, (Ed.) Bulut Yakup, Kayan Ahmet, Sayda Yayıncılık, Bursa.

Nolasco, D. (2004). Climate Change: What Opportunities Lie Outside Kyoto Protocol for Green House Gas Emission Reductions in the Water Environment Arena? Proceedings of the Water Environment Federation, 2004(15), 506–514. https://doi.org/10.2175/193864704784148303

Nurdin, N., Scheepers, H., Stockdale, R. (2022). A Social System for Sustainable Local E-Government. Journal of Systems and Information Technology, 24(1), 1–31. https://doi.org/10.1108/jsit-10-2019-0214

OECD (2025). OECD Environmental Performance Reviews: Japan 2025, OECD Publishing, Paris, https://doi.org/10.1787/583cab4c-en.

Pan, H., Page, J., Le, Z., Cong, C., Ferreira, C., Jonsson, E., Nasström, H., Destouni, G., Deal B., Kalantari, Z. (2019). Understanding Interactions Between Urban Development Policies and Ghg Emissions: A Case Study in Stockholm Region. Ambio, 49(7), 1313–1327. https://doi.org/10.1007/s13280-019-01290-y

Parlak, C., Partigöç, N. S. (2022). İklim Değişikliği ile Mücadelede Yerel Yönetimlerin Rolü: Yetki ve Sorumluluklar Üzerinden Bir İnceleme, Resilience Journal, 6(2), 321–334.

Preuss, L. (2009). Addressing Sustainable Development Through Public Procurement: The Case of Local Government. Supply Chain Management an International Journal, 14(3), 213–223. https://doi.org/10.1108/13598540910954557 Saha, D., Paterson, R. (2008). Local Government Efforts to Promote The "Three Es" of Sustainable

Development. Journal of Planning Education and Research, 28(1), 21–37. https://doi.org/10.1177/0739456x08321803

Schreurs, M. (2008). From the bottom up. The Journal of Environment & Development, 17(4), 343–355. https://doi.org/10.1177/1070496508326432

Schwartz, E. (2019). Autonomous Local Climate Change Policy: An Analysis of The Effect of Intergovernmental Relations Among Subnational Governments. Review of Policy Research, 36(1), 50–74. https://doi.org/10.1111/ropr.12320

Sezgin, S. (2023). "İklim Dostu Kentlerde Akıllı İnovasyon Uygulamaları: Sydney Örneği," İklim Dostu Kentler: Türkiye ve Dünyadan Örnekler, (Ed.) Hüseyin Gül, Hülya Küçük Bayraktar, Veli Ercan Çetintürk, Detay Yayıncılık, Ankara.

Sharp, E., Daley, D., Lynch, M. (2010). Understanding Local Adoption and Implementation of Climate Change Mitigation Policy. Urban Affairs Review, 47(3), 433–457. https://doi.org/10.1177/1078087410392348

Shimotsuma, T. (2020). Kyoto City's Challenge to Jointly Achieve 1.5 ^{0}C, City of Kyoto, Retrieved form https://www.city.kyoto.lg.jp/kankyo/cms-files/contents/0000312/312157/be(en).pdf on 05.04.2025.

Smart City Sweden (2024). Retrieved from https://smartcitysweden.com/best-practice/401/stockholm-innovates-district-heating-with-new-solutions-and-renewable-sources/, on January 14, 2024.

Smedby, N. (2019). Limits To Polycentricity? Institutional Layering and Policy Feedbacks Of Building Energy Performance Requirements in Sweden. Environmental Policy and Governance, 30(2), 71–83. https://doi.org/10.1002/eet.1874

Stockholms Stad (2024). Retrieved from https://start.stockholm/en/about-the-city-of-stockholm/how-the-city-is-governed/climate-and-environment/, on February 10, 2024.

Stockholms Stad City (2024). Retrieved from https://start.stockholm/en/about-the-city-of-stockholm/how-the-city-is-governed/climate-and-environment/, on November 10, 2023.

Stockholms Stad Miljöbarometern (2024). Retrieved from https://miljobarometern.stockholm.se/, on February 18, 2024.

Stockholm City Plan (t.y.). Retrieved from https://vaxer.stockholm/siteassets/stockholm-vaxer/tema/oversiktsplan-for-stockholm/english_stockholm_city_plan.pdf, on November 12, 2023.

Stockholm European Green Capital 2010 (2010). Retrieved from https://miljobarometern.stockholm.se/content/docs/tema/Stockholm-European-Green-Capital-2010.pdf on 10.10.2023.

Stockholm Exergi (2024). Negative emissions, Retrieved from https://www.stockholmexergi.se/en/environment-and-sustainability/negative-emissions/?utm_source=chatgpt.com, on March 28, 2025.

Storbjörk, S. (2007). Governing Climate Adaptation in The Local Arena: Challenges of Risk Management and Planning in Sweden. Local Environment, 12(5), 457–469. https://doi.org/10.1080/13549830701656960

Termini, O., Kalafatis, S. (2021). The Paradox of Public Trust Shaping Local Climate Change Adaptation. Atmosphere, 12(2), 241. https://doi.org/10.3390/atmos12020241

Talu, N. (2019). Yerel İklim Eylem Planlaması ve Türkiye Pratikleri, İklim Değişikliği Eğitim Modülleri Serisi 10, İklim Değişikliği Alanında Ortak Çabaların Desteklenmesi Projesi (iklimİN) Ankara, https://www.iklimin.org/moduller/kent-yiep.pdf.

United Nations Climate Change (2024). Working together for climate action, Retrieved from https://unfccc.int/, on April 5, 2025.

Urban Mobility Strategy (2012). Retrieved from https://start.stockholm/globalassets/start/om-stockholms-stad/politik-och-demokrati/styrdokument/urban-mobility-strategy.pdf, on February 12, 2024.

Uysal, Y. (2022). İklim Değişikliği ve Küresel Isınma ile Mücadelede Yerel Yönetimlerin Rolü: Tespitler Ve Öneriler, Kesit Akademi Dergisi, 8(30), 324–354.

Vivoda, Vlado (2012). Japan's energy security predicament post-Fukushima, Energy Policy, 46, 135–143.

Wretling, V., Balfors, B. (2021). Are Local Authorities Building Their Capacity to Plan for Reduced Climate Impact? A Longitudinal Analysis of Swedish Comprehensive Plans. Land, 10(6), 652. https://doi.org/10.3390/land10060652 https://carbonn.org/uploads/tx_carbonndata/Stockholm_Climate_Initiatives.pdf

Xiu, N., Ignatieva, M., Bosch, C. (2018). Historical Perspectives on Green Structure Development: The Examples of Stockholm, Sweden and Xi'an, China. Landscape Research, 44(8), 1050–1063. https://doi.org/10.1080/01426397.2018.1551522

Yamamoto, L., Esteban, M. (2014). Atoll Island States and International Law. https://doi.org/10.1007/978-3-642-38186-7

Yang, Y., Javanroodi, K., Nik, V. (2020). Impact Assessment of Climate Change on The Energy Performance of The Building Stocks in Four European Cities. E3s Web of Conferences, 172, 02008. https://doi.org/10.1051/e3sconf/202017202008

Zhao, W., Chen, H., Jun, W., Zhang, M., Chen, K., Guo, Y., Ke, H., Huang, W., Liu, L., Yang, S., Cai, M. (2019). Current Status, Challenges, And Policy Recommendations of China's Marine Monitoring Systems for Coastal Persistent Organic Pollution Based on Experts' Questionnaire Analysis. International Journal of Environmental Research and Public Health, 16(17), 3083. https://doi.org/10.3390/ijerph16173083

Conclusion

Erol Esen, Veli Ercan Çetintürk and Cem Şentürk

Climate change has profound effects on the living conditions on our planet. Rising temperatures and the accompanying phenomena such as droughts, rising sea levels, and increasingly frequent and intense meteorological disasters primarily lead to short-term demographic movements. However, the link between climate change and large-scale, long-distance migration becomes particularly evident through the threat to food security. While climate-induced long-term migration can be directly observed in regions such as East Asia and the Pacific, these movements remain marginal in comparison to the dominant global migration flows. The two primary drivers of migration on a global scale are economic hardships and armed conflicts, which are often interconnected.

This reality is illustrated in two graphs from the 2022 World Migration Report (IOM, 2021) by the International Organization for Migration (IOM). The first graph highlights that climate-related disasters occur in nearly all inhabited regions of the Earth. The second graph depicts displacement caused by conflicts, which often result in more permanent and long-distance migration movements. The geographic overlap of these two graphs is not coincidental: in many affected regions, food security is not guaranteed due to climatic factors. Particularly in the Sahel zone and other regions with high migration pressure, it is therefore crucial to eliminate threats to food security and establish fairer distribution mechanisms. This is not only a measure to reduce migration pressure on existing systems but also a fundamental humanitarian obligation of the international community. Achieving this requires the coherent integration of international, national, and local decision-making processes, as well as the implementation and strengthening of efficient and sustainable political mechanisms.

Graphic: Displacement Due to Disasters.
Source: IOM World Migration Report (2021).

Graphic: Displacement Due to Conflicts.
Source: IOM World Migration Report (2021).

Consistent definitions and conceptual clarity are indispensable in this context. The unpredictability of climatic disasters demonstrates that even under optimal conditions—where food security is assured and distribution mechanisms operate fairly—climate-induced demographic shifts remain inevitable. The debate surrounding terms such as "climate migration" or "climate refugees," along with an international consensus on these definitions, is essential for ensuring a fair distribution of burdens during crises. Forced migrations due to violence or natural disasters primarily occur in neighboring countries, exacerbating existing resource shortages and leading to destabilizing effects.

The primary responsibility for addressing the challenges of climate change lies with the major industrial emitters of greenhouse gases. In addition to reducing emissions, it is essential to structure supply chains in a sustainable and socially responsible manner. At the national level, targeted incentive mechanisms should be developed to support sustainable economic structures. A key challenge remains balancing the development needs of growing industries in emerging economies with the requirements of international competition within the framework of climate-friendly policies. In this context, the temporary withdrawal of the United States from the Paris Climate Agreement under the Trump administration demonstrated how such exits can severely undermine the credibility of international climate protection mechanisms.

Beyond international and national measures, locally developed strategies and innovative models are also of great significance. In addition to food security, municipalities must focus on adaptation strategies to changing climatic conditions, such as measures to lower urban temperatures and the efficient management of limited resources.

With this publication, we aim to provide interested readers with new perspectives. Beyond the answers offered by these contributions, two fundamental questions remain crucial for shaping our shared existence on this planet: How can we establish food security and fair distribution systems in an inevitably changing world? And how can we improve the quality of life in cities worldwide?

Bibliography

International Organization for Migration (IOM) (2021), World Migration Report 2022. IOM.

Notes on Contributors

Ishmael Adjei completed his Ph.D. at Dokuz Eylul University, Izmir-Türkiye (Department of Political Science and International Relations), with a dissertation on climate migration governance, a case study of Ghana. He obtained his M.Sc. degree in International Relations from Eskisehir Osmangazi University (Turkiye). He also holds a dual Bachelor of Arts (Honors) in Political Science and Linguistics from the University of Ghana. He served as a Teaching and Research Assistant at the University of Ghana. Currently, he is a research affiliate at the Center for Migration, Citizenship and Development (COMCAD), Faculty of Sociology (Bielefeld University). He is a member of the Networking Project "Paradigm Shift in the Migration Society" (NUPS) at Berlin Technical University and a member of the Population and Environment Working Group at the University of Wisconsin (Madison). His research interests include climate migration, migration governance and policy, refugees and displaced persons, international institutions, food security, and human security.
E-mail: adishcare15@gmail.com

Sevilay Zehra Aksoy is Associate Professor in the Department of Political Science and International Relations at Dokuz Eylül University. She received her bachelor's degree in international relations from the Middle East Technical University (ODTÜ). She completed her M.A. in Middle East Politics and subsequently earned her Ph.D. in Politics at the University of Exeter, United Kingdom, with a dissertation on the socialization of international human rights norms in Türkiye. She was the recipient of an award granted under the British Academy Visiting Fellowship scheme for her research on the normative aspects of Turkish foreign policy during the 2003 Iraq War. Her research focuses on the normative aspects of world politics and IR theory, with particular interest in international regimes, the logics of state behavior, responsibility to protect, human security, and recently, the impact of climate change on peacebuilding.

Yavuz Selim Alkan holds a Ph.D. in Law from the University of Leicester, United Kingdom. He received his M.A. in International Relations from Middle East Technical University (ODTÜ) and his B.A. in Political Science and Public Administration from Hacettepe University, both in Ankara, Türkiye. He is currently Associate Professor in the Department of Political Science and Public Administration at Akdeniz University in Antalya, Türkiye. His academic work explores themes in political science, international relations, and constitutional law with particular attention to democracy and human rights.
E-mail: yavuzselimalkan@akdeniz.edu.tr

Derya Arabacı completed her Ph.D. in Remote Sensing and Geographic Information Systems at Akdeniz University, following her M.Sc. in Geomatics Engineering at Cumhuriyet University and B.Sc. in Geomatics Engineering at Erciyes University. She is Lecturer at Aydın Adnan Menderes University, Atça Vocational School, Department of Land Registry and Cadastre. Her research focuses on urban-climate modeling, air pollution, land use, and the integration of remote sensing and machine learning methods in environmental studies.
E-mail: derya.isik@adu.edu.tr

Yaşar Aydın is Researcher at the Centre for Applied Turkey Studies (CATS) at the German Institute for International and Security Affairs (SWP). He holds a graduate degree in Social Economy from the University of Hamburg, a Master's in Sociology from the University of Lancaster, and a doctorate from the University of Hamburg. His research focuses on international affairs, geopolitics, diaspora, and the relationships between the EU, Germany, and Türkiye. Previously, Aydın worked as a researcher at the HWWI, the BpB, and as a guest lecturer at the Turkish German University in Istanbul. Besides numerous articles in scientific journals, Dr. Aydın is also the author of two

edited volumes and three books: Topoi des Fremden: Zur Kritik und Analyse einer sozialen Konstruktion (2009), Pop Kultur Diskurs: Zum Verhältnis von Gesellschaft, Kulturindustrie und Wissenschaft (2010), Transnational statt nicht integriert (2013), Türkei (2017), and Graue Wölfe—Türkischer Ultranationalismus in Deutschland (2022).
E-mail: Yasar.Aydin@swp-berlin.org

Önder Bakırcıoğlu is Associate Professor of Law at the University of Leicester, where he has been teaching since 2014. Before that, he worked as Lecturer in Law at Queen's University Belfast (QUB) between 2008 and 2014. His research focuses on public international law and human rights law, with a particular emphasis on the use of force and the just war tradition. His interdisciplinary approach draws from law, history, international relations, politics, and philosophy. His work addresses both theoretical and policy-relevant issues such as conflict resolution, the balance between individual freedoms and societal interests, multiculturalism, radicalism, and terrorism.
E-mail: ob51@leicester.ac.uk

Esin Basım completed her Ph.D. research in Plant Pathology at the University of Florida and holds a Ph.D. from Akdeniz University. She has been a faculty member at Süleyman University from 1999 to 2004 and at Akdeniz University in the Department of Plant Protection since 2004. Since 2018, she has been working in the Department of Organic Agriculture at Akdeniz University as Full Professor. She teaches many undergraduate and graduate courses in her area of expertise. Her research interests include plant diseases, modern biotechnology, biocontrol, and alternative strategies for managing plant diseases.
E-mail: esinbasim@akdeniz.edu.tr

Hüseyin Basım earned his Ph.D. in Plant Pathology from the University of Florida. He has been a faculty member at Akdeniz University in the Department of Plant Protection since 1990. Since 2005, he has served as the head of the Phytopathology Department as Full Professor, teaching a variety of undergraduate and graduate courses. His research interests focus on plant diseases, molecular plant pathology, modern biotechnology, biocontrol methods, plant disease resistance, and alternative strategies for managing plant diseases.
E-mail: hbasim@akdeniz.edu.tr

Veli Ercan Çetintürk studied Public Administration at Süleyman Demirel University, graduating with a B.A. in 2007, and completed his master's degree in 2011 with a thesis on Total Quality Management in municipalities. In 2021, he earned his Ph.D. from Akdeniz University for a dissertation comparing decentralization in Türkiye with France and Poland within the context of European integration. His research focuses on local governance, urbanization, migration, EU integration, and climate-friendly cities. He is currently a lecturer and project developer at Alanya Alaaddin Keykubat University.

Pelin Demircan Yıldırım completed her master's degree at Süleyman Demirel University, Institute of Social Sciences, Department of Labour Economics and Industrial Relations in 2016 and her Ph.D. at Kocaeli University, Department of Social Policy in 2022. She continues her studies as an independent researcher and works in the fields of social policy, labor economics, disadvantaged groups, cooperatives, sustainable development and solidarity economics. She has taken part in various research and implementation projects and conducts interdisciplinary scientific studies with field-based knowledge production and social benefit-oriented studies.
E-mail: pelindemircan33@gmail.com

Bettina Emir studied social anthropology and sociology at Martin Luther University Halle-Wittenberg and at Bogazici University in Istanbul. She works as a project coordinator for the Centre for Applied Turkey Studies (CATS) at the German Institute for International and Security Affairs (SWP) in Berlin.
E-mail: bettina.emir@swp-berlin.org

Hilal Erkuş is Full Professor in the Department of Urban and Regional Planning at Akdeniz University, Türkiye. She studied urban and regional economic development at Middle East Technical University (METU), where she also completed her Ph.D. on local tourism development. She later worked as a postdoctoral researcher at the University of Amsterdam, collaborating on comparative studies of urban tourism governance. Her research focuses on urban and regional development, with particular interest in tourism economies, economic resilience in crisis-affected cities, and future imaginaries of urban transformation.
E-mail: hilalerkus@akdeniz.edu.tr

Erol Esen is Professor of Political Science and Public Administration. He studied at the University of Bonn and earned his doctorate focusing on Türkiye–EU relations. He teaches at Akdeniz University in Antalya, where he serves as Head of the Department of Political Science and Public Administration and has been the Director of the Center for Application and Research of Social Policies and Migration Studies (ASPAG). His main areas of expertise include European integration, migration and integration, and local governance.
E-mail: esen@akdeniz.edu.tr

Hüseyin Gül received his undergraduate degree from the Faculty of Political Sciences at Ankara University in 1991. He earned his M.P.A. and M.A. in urban affairs from the University of Texas at Arlington. He also holds a Ph.D. in urban and public administration from the University of Texas at Arlington. He serves as Full Professor in the Department of Political Science and Public Administration at Süleyman Demirel University. His research interests include urban and public policy, urban governance, urban poverty, reform in public administration and welfare state, etc.
E-mail: huseyingul@sdu.edu.tr

Aynur Kazaz completed her postgraduate studies in Construction Management at the Institute of Natural Sciences, Fırat University in Elazığ. She is currently Professor in the Department of Civil Engineering, Faculty of Engineering, Akdeniz University in Antalya, where she also leads the Division of Construction Management. In addition, she heads the Division of Occupational Health and Safety at the Institute of Natural Sciences at Akdeniz University. Her research focuses on construction management and occupational safety, particularly on quality management and labor productivity in construction projects.
E-mail: akazaz@akdeniz.edu.tr

Hülya Küçük Bayraktar completed her undergraduate studies in Political Science and Public Administration at Sakarya University in 2013. In 2016, she graduated from Istanbul University with a master's degree in Political Science and Public Administration, specializing in Local Governments, Urban and Environmental Studies. The following year, in 2017, she obtained a second master's degree in Public Administration from Sakarya University. In 2023,

she earned her doctorate in Political Science and Public Administration from Istanbul University. Since 2018, she has been serving as Assistant Professor at Kafkas University, Vocational School of Social Sciences. Her research interests primarily include local government, climate change, water management, and migration policies at the local level.
E-mail: hulya.kucuk@kafkas.edu.tr

Çağdaş Kuşçu Şimşek received her Ph.D. in Urban Planning from Yildiz Technical University, after completing her earlier studies in Geomatics Engineering and Remote Sensing and GIS. She is currently Associate Professor at the Department of Remote Sensing and Geographic Information Systems within the Faculty of Science at Akdeniz University. Her research focuses on urban-climate modeling, remote sensing applications, spatial analysis, and the use of simulation techniques in environmental studies. She teaches courses on spatial analysis techniques, GIS, image processing, and smart cities. She has participated in national and international research projects and has supervised numerous graduate theses in related fields.
E-mail: cksimsek@akdeniz.edu.tr

Ahmet Özaslan completed his undergraduate education at Gaziantep University, Department of Economics and his master's degree at Süleyman Demirel University in the same department. In 2017, he started his doctoral education in the Department of Political Science and Public Administration YÖK 100/2000 Urban Transformation Studies program and received his doctorate degree in 2021. His research areas are urban transformation, urban economy, urban growth, climate-resilient cities, urban and environmental policies, local governments.
E-mail: ahmetozaslan07@hotmail.com

Büşra Öztürk completed her undergraduate studies in the Department of Space Sciences and Technologies at the Faculty of Science, Akdeniz University. Her main research interests include remote sensing and image processing, the climatic impacts of urban afforestation, environmental simulations using artificial neural networks, and the analysis of changes in water bodies.
E-mail: busraolgun1998@gmail.com

Benjamin Schraven studied Political Science at the University of Bonn. Currently, he works as a freelance consultant. Furthermore, he is Associate Senior Research Fellow of the German Institute of Development and Sustainability (IDOS), where he has worked as a Senior Researcher for more than ten years. Benjamin Schraven, who holds a Ph.D. in Development Studies from the Center for Development Research (ZEF) at the University of Bonn, has done consultancy work on various migration-related issues for the International Organization for Migration (IOM), the World Bank, various UN organizations as well as German institutions such as German Federal Ministry for Economic Cooperation and Development (BMZ) or the Expert Council on Integration and Migration (SVR). In the past, he has worked several times as a guest researcher/ guest lecturer, for example, for the University of Ghana. The thematic complex "climate mobility" is Benjamin Schraven's major focus of work.
E-mail: benj.schraven@gmail.com

Cem Şentürk studied Political Science and International Relations at Istanbul University and Yildiz Technical University in Istanbul. He is currently program manager of the "Participation in the Economy and Communities" program at the Centre for Studies on Turkey and Integration Research (ZfTI), affiliated with the University of Duisburg-Essen. He also lectures at HSPV NRW and the University of Witten/Herdecke. His work focuses on the labor market participation of migrants, with a particular emphasis on self-employment and vocational education. Further areas of expertise include inter-municipal cooperation in the German Turkish context, social cohesion, migration management and municipal integration strategies in Germany and Türkiye.
E-mail: sentuerk@zfti.de

Gülşah Tırış is a Ph.D. candidate in Urban and Regional Planning at Akdeniz University in Antalya, Türkiye. She holds a bachelor's degree from Muğla Sıtkı Koçman University and a master's degree in Public Administration from Akdeniz University. Her research focuses on urban-climate justice, sustainable urban development, and the socio-spatial dynamics of urban agriculture. Her work addresses the intersections of environmental sustainability and urban governance, with a particular interest in the challenges faced by rapidly urbanizing regions.
E-mail: gulsahtiris7@gmail.com

Ender Yetim completed his undergraduate studies in Civil Engineering at Karadeniz Technical University in Trabzon. He earned his master's degree in Construction Management from the Institute of Natural Sciences at Akdeniz University in Antalya, where he is currently pursuing his doctoral studies. He previously worked in the Static Project Control Unit of the Directorate of Zoning and Urban Planning at Antalya Kepez Municipality and now serves as a civil engineer at the Directorate of Social Housing within the same municipality. His academic research focuses on sustainable cities, with a particular emphasis on energy-efficient building design.
E-mail: ender-ytm@hotmail.com

Core Institutional Partners of ANISF

ASPAG-Center for Application and Research of Social Policies and Migration Studies at Akdeniz University

Founded in 2017, ASPAG adopts an interdisciplinary approach to address pressing social issues such as poverty, migration, gender inequality, health, environmental challenges, education, and housing. The Centre generates social impact through a wide range of activities, including academic research, educational programs, scientific events, publications, and consultancy services.

In recent years, ASPAG has placed a strong emphasis on climate change, promoting environmental awareness through initiatives such as ANISF 23 under the theme "Climate Change, Environmental Crisis, and Migration," as well as the Carbon Footprint and Trading Training and the Corporate Sustainability Certificate Programme. In November 2024, ANISF 24 was held under the motto "Climate Change and Migration from Local to Global."

The Centre is also active in the areas of migration and social policy, hosting events like the seminar series "They Are Our Compatriots: Migration Awareness Training" and the "Migration Experiences in the Mediterranean" conversation series. Through congresses, seminars, and consultancy work, ASPAG contributes to the integration of migrants, fosters intercultural dialogue, and facilitates academic knowledge exchange.

Working in cooperation with the European Union and other international partners, ASPAG also develops joint projects and offers undergraduate and graduate educational programs in collaboration with the academic departments of Akdeniz University. All of its activities aim to foster social awareness and support sustainable development.

For more information: https://goc.akdeniz.edu.tr/tr/merkez_hakkinda-6047

Antalya Metropolitan Municipality—Department of Climate Change and Zero Waste

The Department of Climate Change and Zero Waste was established on May 18, 2022, following the earlier creation of the Climate Change Branch Directorate on January 10, 2020. That same year, the Sustainable Energy Action Plan (SEAP) was introduced, and in 2022, the Sustainable Energy and Climate Action Plan (SECAP) was finalized and aligned with international targets.

The Department leads efforts in climate change mitigation, adaptation, and zero waste management. It develops projects and reports to enhance the environmental sustainability of Antalya and supports scientific studies and public initiatives grounded in social responsibility. Through national and international collaborations, the Department strengthens the city's climate resilience in alignment with its forward-looking vision.

Under the leadership of Antalya Metropolitan Mayor Muhittin Böcek, and with the active involvement of all relevant municipal departments, the Department has taken on a leading role in coordinating the Antalya International Science Forum in both 2023 and 2024.

For more information: www.antalya.bel.tr

Centre for Studies on Turkey and Integration Research (ZfTI)

The Centre for Studies on Turkey and Integration Research (ZfTI), founded in 1985, aims to foster German–Turkish relations. Over the years, it has evolved into a leading academic center on migration, integration, and contemporary developments in Türkiye. Its scope has expanded beyond German–Turkish migration to encompass European and transnational contexts.

The ZfTI conducts research on migration and integration in Germany, Türkiye, and Europe, promotes academic exchange between researchers in both countries, and encourages scientific networking. It is a foundation of the state of North Rhine-Westphalia, affiliated with the University of Duisburg-Essen, and a member of the Johannes Rau Research Association. Institutes within this association receive institutional funding from the state of North Rhine-Westphalia.

Since its inception, the Center has focused on the transnational dimension of migration—an aspect that has gained increasing importance in the era of globalization and digital communication. By combining integration research with analyses of countries of origin, the ZfTI offers a nuanced and contemporary understanding of migration realities.

For more information: www.zfti.de