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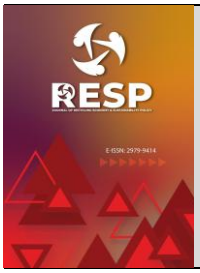

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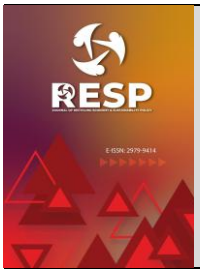

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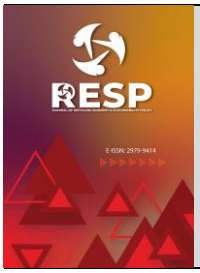

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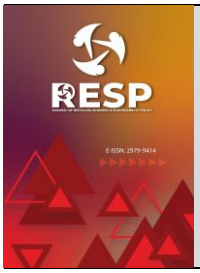

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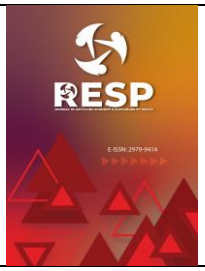

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Araştırma Makalesi ● Research Article

Sustainable and Inclusive Economic Development: A Global Imperative

Sürdürülebilir ve Kapsayıcı Ekonomik Kalkınma: Küresel Bir Zorunluluk

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A N A H T A R K E L İ M E L E R

Sürdürülebilirlik
Kapsayıcılık
Yeşil Teknoloji
Yeşil Enerji
Yeşil Ticaret

ÖZ

Sürdürülebilir ve kapsayıcı ekonomik kalkınma, iklim değişikliği, kaynak tükenmesi ve kalıcı sosyal eşitsizlikler gibi artan zorluklar karşısında acil bir küresel gereklilik olarak ortaya çıkmıştır. Bu makale, ekonomik büyüme, çevresel yönetim ve sosyal adalet arasındaki karmaşık bağlantıları inceleyerek bu boyutları sorunsuz bir şekilde bütünleştiren dönüştürücü stratejilere duyulan ihtiyacı vurgulamaktadır. Çok taraflı girişimlerin, özellikle Sürdürülebilir Kalkınma Amaçlarının, uluslararası iş birliğini teşvik etmede ve ekonomik refahı ekolojik ve sosyal gerekliliklerle dengeli bir şekilde birleştiren politikalar savunmada oynadığı kritik rol açıklanmaktadır. Yenilenebilir enerji teknolojileri, döngüsel ekonomi modelleri ve sosyal girişimcilik gibi yenilikçi çözümler, bu çok yönlü sorunların ele alınmasında uygulanabilir yollar olarak incelenmektedir. Çalışma, bütüncül, kapsayıcı ve iş birliğine dayalı bir yaklaşımın önemini vurgulayarak, dayanıklı, adil ve sürdürülebilir bir geleceği güvence altına almak için küresel çabaların uyumlaştırılmasının aciliyetine dikkat çekmektedir. Sistemik zorluklarla kararlılıkla yüzleşerek ve yenilik ile ortaklık fırsatlarından yararlanarak, ülkeler daha uyumlu ve sürdürülebilir bir küresel yol haritası oluşturabilir.

K E Y W O R D S

Sustainability
Inclusiveness
Green Technology
Green Energy
Green Trade

A B S T R A C T

Sustainable and inclusive economic development has emerged as an urgent global imperative amidst escalating challenges such as climate change, resource depletion, and persistent social inequities. This paper delves into the intricate interconnections between economic growth, environmental stewardship, and social equity, underscoring the necessity for transformative strategies that seamlessly integrate these dimensions. It elucidates the critical role of multilateral initiatives, notably the Sustainable Development Goals, in fostering international cooperation and advocating for policies that equitably balance economic prosperity with ecological and social imperatives. Innovative solutions, including renewable energy technologies, circular economic models, and social entrepreneurship, are explored as viable pathways to address these multifaceted challenges. Emphasizing the importance of a holistic, inclusive, and collaborative approach, the study highlights the urgency of aligning global efforts to secure a resilient, equitable, and sustainable future. By confronting systemic challenges with determination and leveraging opportunities for innovation and partnership, nations can pave the way toward a more harmonious and sustainable global trajectory.

1. Introduction

Sustainable and inclusive economic development has ascended as a critical global imperative, particularly in the face of intensifying challenges such as climate change, resource depletion, and entrenched social inequalities. These interconnected issues demand transformative strategies that not only reconcile economic growth with environmental stewardship but also ensure social equity and resilience. This paper investigates these intricate interrelations, arguing that a holistic, integrated approach is essential to align economic objectives with ecological and social imperatives in the pursuit of a sustainable future.

Multilateral frameworks, notably the Sustainable

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Development Goals (SDGs), provide a guiding architecture for global cooperation, emphasizing equity, sustainability, and innovation. However, despite the availability of sophisticated technologies, significant financial resources, and well-intentioned efforts, many development initiatives—whether state-led or corporate-driven—struggle to navigate the complexities of community life. Paradoxically, such initiatives often exacerbate the very hardships they aim to alleviate, particularly in the Global South. This underscores the need to reconceptualise development as an endogenous process—one that emerges organically from within communities rather than being imposed by external actors.

The legacies of colonialism and the pressures of globalization, including the relentless demand for natural resources, further complicate development paradigms. Questions of self-determination, social equity, communal cohesion, and ecological sustainability loom large. How can these issues be addressed practically, particularly in a way that respects traditional knowledge systems and fosters grassroots resilience? Why do some communities exhibit extraordinary adaptability in the face of adversity, while others falter or even fragment under similar pressures?

The term "development" itself is fraught with complexities and conflicting interpretations. In corporate contexts, it is often synonymous with infrastructure creation, workforce training, and profit maximization. In state-led paradigms, development encompasses nation-building efforts, such as civil administration and legislative frameworks for economic growth. Yet, within civil society and community-oriented frameworks, development may be conceived as the equitable distribution of resources, the cultivation of social capital, and the enhancement of sustainability and adaptability at the local level.

This analysis highlights the systemic challenges posed by the prevailing debt-based capitalist model, underscored by an unprecedented US$315 trillion global debt burden spanning households, businesses, and governments. The proliferation of "Buy Now, Pay Later" platforms illustrates the financial precarity faced by many households, compounding risks of defaults and potential economic crises. Furthermore, the chronic underinvestment in infrastructure and technological innovation in developing regions, particularly across Africa and Asia, accentuates the disparities hindering global progress toward sustainable development.

Amid these challenges, opportunities for sustainable economic growth persist. Renewable energy technologies, digital innovation, and social entrepreneurship provide critical avenues to decouple economic growth from environmental degradation while fostering inclusivity and resilience. Multilateral initiatives like the SDGs offer a robust framework for collective action, enabling nations to collaborate on shared goals of equity, sustainability, and prosperity.

This study argues that by addressing systemic challenges with determination and leveraging opportunities for innovation and partnership, nations can overcome the inherent contradictions of contemporary development paradigms. Through an inclusive, context-sensitive approach, it is possible to chart a course toward a resilient, equitable, and sustainable global future.

2. Significance of the Study

This study, Sustainable and Inclusive Economic Development: A Global Imperative, holds profound significance in addressing one of the most pressing challenges of our era: the intricate balance between economic growth, environmental sustainability, and social equity. Its relevance spans multiple domains, offering critical contributions to academic inquiry, policy development, and practical implementation.

2.1. Advancing Academic Understanding

The study enriches the academic discourse on sustainable development by bridging the divide between theoretical constructs and real-world applications. It illuminates the complex interdependencies among economic, environmental, and social dimensions, offering a comprehensive perspective that advances fields such as economics, environmental science, and development studies. By integrating contemporary challenges, including climate change, resource depletion, and systemic social inequities, the research deepens the understanding of global dynamics and their implications for sustainable growth strategies.

2.2. Informing Policy Formulation

Global policymakers face the daunting task of promoting economic development while safeguarding the environment and ensuring equitable resource distribution. This study underscores the necessity of inclusive policies that integrate sustainability and equity into the core of national and international agendas. Highlighting the pivotal role of multilateral frameworks like the Sustainable Development Goals (SDGs), the research provides a roadmap for aligning policy initiatives with global sustainability objectives, and fostering cooperative and equitable solutions to shared challenges.

2.3. Guiding Practical Implementation

At the implementation level, the study identifies practical, innovative solutions such as renewable energy technologies, circular economic models, and social entrepreneurship. These approaches offer actionable strategies for stakeholders across governments, businesses, and civil society to address systemic challenges effectively. By emphasizing community-driven and context-sensitive approaches, the research advocates for development paradigms that are not only sustainable but also attuned to the cultural and social realities of local populations.

2.4. Addressing Global Disparities

Particularly relevant to the Global South, this study highlights the challenges posed by historical legacies and structural inequities. It calls for the adoption of endogenous development models that prioritize self-determination, respect traditional knowledge systems, and foster grassroots resilience. By shedding light on the disparities in resource access and underinvestment in critical infrastructure, the research advocates for equitable partnerships and targeted investments to support sustainable development in underrepresented regions.

2.5. Promoting Resilience and Innovation

In a world increasingly defined by rapid technological and environmental change, the study emphasizes resilience and innovation as critical pillars for sustainable development. It presents a compelling vision for decoupling economic growth from environmental harm, advocating for forward-thinking strategies that foster adaptability and innovation while maintaining ecological balance.

2.6. Highlighting Broader Implications

The research further underscores: Environmental Preservation: It advocates for sustainable resource management to mitigate climate change, deforestation, and pollution.

Long-Term Prosperity: It emphasizes resilience in economic systems through the integration of environmental and social considerations.

Social Equity: It calls for equitable economic paradigms that uplift marginalized populations.

Responsible Governance: It stresses the importance of transparent, accountable governance for sustainable outcomes.

Global Collaboration: It recognizes the interconnectedness of nations in addressing global challenges like climate change.

Risk Mitigation: It proposes proactive strategies to manage risks associated with unsustainable practices.

By addressing these critical dimensions, this study underscores the urgency of a global transition toward sustainable and inclusive economic models. It provides a framework for reimagining development as a process that respects planetary boundaries, promotes human well-being, and ensures a resilient and equitable future for generations to come.

3. Aims and Scope

3.1. Aims

1. Promote Equitable Growth: To ensure that economic development is inclusive, benefiting all strata of society by addressing disparities in income, wealth distribution, and access to essential resources.
2. Foster Sustainability: To advocate for economic systems that prioritize environmental stewardship, optimize resource efficiency, and significantly reduce greenhouse gas emissions to mitigate climate change.
3. Enhance Social Inclusion: To develop frameworks that empower marginalized and vulnerable populations, guaranteeing equitable opportunities for participation in economic activities.
4. Ensure Global Collaboration: To fortify international partnerships that address cross-border challenges such as poverty, inequality, and environmental degradation through coordinated efforts.
5. Build Resilient Economies: To devise strategies that enhance economies' capacities to endure global disruptions—such as pandemics and financial crises—while adhering to sustainability principles.

3.2. Objectives

1. Reduce Poverty: To implement targeted interventions that lift individuals and communities out of extreme poverty by ensuring access to fundamental needs such as food, clean water, education, and healthcare.
2. Achieve Decent Work for All: To foster policies that guarantee fair remuneration, safe working environments, and equal opportunities, particularly for women, youth, and marginalized communities.
3. Support Green Innovation: To incentivize investment in renewable energy, sustainable agricultural practices, and environmentally friendly technologies, balancing economic growth with ecological preservation.
4. Strengthen Education and Skill Development: To equip populations with advanced knowledge and skills, enabling them to thrive in and contribute to an evolving global economy.
5. Encourage Fair Trade and Investment: To promote trade practices and investments that uphold labour rights, protect local economies, and ensure environmental sustainability.
6. Mitigate Climate Risks: To integrate climate adaptation and mitigation strategies into national and international development agendas, ensuring the long-term viability of economic systems.
7. Bridge Infrastructure Gaps: To prioritize investments in sustainable infrastructure—

spanning transportation, energy, and digital networks—to ensure equitable access to economic opportunities.

8. Promote Gender Equality: To dismantle systemic barriers that hinder women's economic participation and leadership, thereby fostering truly inclusive growth.
9. Enhance Public-Private Partnerships: To leverage the strengths of public and private sectors in creating innovative solutions that balance profitability with social and environmental objectives.
10. Monitor Progress and Accountability: To establish comprehensive frameworks for evaluating development outcomes, ensuring transparency, accountability, and sustained progress toward inclusive economic goals.

3.3. Scope and Depth of Analysis

The aims and scope of sustainable economic development research are inherently multifaceted, embracing a rich tapestry of challenges and opportunities.

1. Comprehensive Understanding: This entails delving into the theoretical foundations, historical evolution, and contemporary dynamics of sustainable economic development, examining its principles, practices, and inherent complexities.
2. Identification of Challenges: Critical challenges such as environmental degradation, resource depletion, social inequality, economic instability, and institutional inertia are identified and analyzed to devise actionable strategies.
3. Exploration of Opportunities: Emerging opportunities, including technological advancements, market-driven incentives, progressive policy reforms, and transformative social initiatives, are explored to maximize sustainable development's benefits.
4. Policy Implications: By assessing the efficacy of existing policies, this research seeks to inform innovative policy solutions that promote sustainability and address developmental challenges comprehensively.
5. Cross-disciplinary Insights: Emphasizing interdisciplinary collaboration, the research integrates perspectives from economics, environmental sciences, sociology, political science, and engineering to propose holistic solutions.
6. Capacity Building: Empowering individuals, institutions, and societies through education, training, and resource mobilization to foster a culture of sustainability and catalyze transformative change.
7. Global Perspective: Situating sustainable economic development within a global framework, the study emphasizes collective action and international cooperation, reflecting the interconnectedness of regional and global economies.

By advancing understanding, informing policy, fostering innovation, and building capacity, this agenda envisions a more sustainable, inclusive, and prosperous future for all, harmonizing human progress with planetary stewardship.

4. Methodology

Crafting a robust methodology for investigating Sustainable Economic Development: Challenges and Opportunities requires meticulous attention to a wide array of factors, given the complexity of the subject, its interdisciplinary nature, and the necessity for both qualitative and quantitative approaches.

- Literature Review: The research endeavour should commence with a comprehensive review of existing literature on sustainable economic development. This process entails identifying foundational theoretical frameworks, empirical studies, policy doctrines, and relevant case studies that provide critical insights into the field. The literature review will serve as the cornerstone for knowledge acquisition, highlighting gaps in the current understanding and identifying areas where further investigation is needed.
- Conceptual Framework: A conceptual framework must be established to delineate the key concepts, variables, and interrelationships central to sustainable economic development. This framework should draw upon theories and perspectives from economics, environmental science, sociology, political science, and related disciplines. It should account for the intricate interdependence between economic, social, and environmental factors, providing a structured approach to analyzing their convergence and divergence.
- Case Studies: In-depth case studies of specific locales, sectors, or policy interventions are vital for understanding the practical challenges and opportunities inherent in sustainable economic development. These case studies provide rich, context-specific insights, enabling a nuanced understanding of how theoretical frameworks manifest in real-world scenarios. They can reveal both the successes and the shortcomings of existing approaches, offering valuable lessons for future policy and practice.
- Qualitative Analysis
- Stakeholder Engagement: Active and continuous engagement with a diverse array of

stakeholders—spanning governmental agencies, civil society organizations, academic institutions, and the corporate sector—is essential throughout the research process. Stakeholder engagement ensures that the research remains relevant, credible, and actionable. Furthermore, it fosters collaboration, consensus-building, and knowledge co-creation, ensuring that the findings are not only academically rigorous but also practically applicable and supported by those most directly involved in sustainable economic development.

- Policy Analysis: A critical element of the research methodology is a thorough analysis of existing policies and institutional frameworks that govern sustainable economic development. This analysis should evaluate the effectiveness of current policies, identify gaps or inefficiencies, and provide evidence-based recommendations for improvement. Policy analysis could involve comparative assessments of policies across different jurisdictions, cost-benefit analyses of policy interventions, and scenario modelling to explore potential future policy directions.

- Interdisciplinary Integration: To achieve a comprehensive understanding of sustainable economic development, insights from various academic disciplines must be integrated. This requires synthesizing findings from economics, ecology, sociology, political science, engineering, and related fields, fostering a holistic view that transcends the limitations of any single disciplinary perspective. The integration of interdisciplinary knowledge is crucial for developing innovative solutions that address the multifaceted nature of sustainable development.

- Validation and Peer Review: Research findings should undergo rigorous validation through peer review, expert consultations, and stakeholder feedback. Peer review ensures that the methodology and conclusions are robust, credible, and scientifically sound, while expert consultation provides further refinement and depth to the analysis. Validation by stakeholders, particularly those involved in policy-making or implementation, helps ensure that the research outcomes are practical and applicable to real-world challenges.

By adopting a methodological framework that combines theoretical rigour, empirical scrutiny, interdisciplinary collaboration, and stakeholder involvement, researchers can effectively probe the inherent challenges and opportunities of sustainable economic development. Such an approach will not only advance academic knowledge but also catalyze practical solutions that can drive meaningful progress in both policy and practice.

5. Survey of Literature

Sustainable and inclusive economic development has crystallized as a central pillar of global development discourse, encapsulating the dual imperatives of fostering economic growth while mitigating social inequities and addressing environmental imperatives. This review integrates the prevailing theoretical underpinnings, empirical evidence, and strategic policy directions, offering a nuanced synthesis of this multifaceted field.

5.1. Theoretical Foundations

Sustainable development, as articulated in the Brundtland Report (1987), underscores the necessity of satisfying present needs without jeopardizing future generations' ability to fulfil their own. In parallel, inclusive economic development emphasizes diminishing inequalities and ensuring equitable distribution of growth benefits across all societal strata (UNDP, 2016). These principles converge in Amartya Sen's capabilities approach, which advocates for the prioritization of human freedoms and capabilities as authentic markers of development (Sen, 1999).

5.2. Global Trends and Drivers

The literature delineates several pivotal drivers and enduring challenges underpinning sustainable and inclusive growth. Technological innovation, globalization, and progressive policy reforms have facilitated significant advancements in some regions. Nonetheless, persistent issues such as escalating income inequality, environmental degradation (Sachs, 2015), and entrenched gender disparities remain formidable barriers (Piketty, Capital in the Twenty-First Century , 2014). However, contemporary analyses question its applicability amid the pervasive impacts of globalization and technological disruption (Milanovic, 2016).

5.3. Regional Perspectives

The global panorama of sustainable and inclusive economic development reveals divergent regional trajectories:

- Asia: Countries like China and India exemplify rapid economic ascension, lifting millions out of poverty. Yet, these gains are tempered by environmental degradation and stark urban-rural divides (Bank., 2020).

- Africa: Rich in resources but beset by systemic challenges, many African nations grapple with weak governance, infrastructural inadequacies, and unsustainable debt burdens, impeding inclusive growth (Collier, 2007).

- Europe: The European Union’s “Green Deal” exemplifies integrative strategies linking sustainability with economic advancement, although disparities within and among member states persist (Commission, 2020).

- Latin America: High levels of inequality and reliance on extractive industries have constrained progress, yet emergent initiatives in renewable energy and social welfare systems offer pathways to balanced growth (ECLAC, 2021).

5.4. Policy Instruments and Best Practices

The literature identifies a suite of policy measures integral to fostering sustainable and inclusive economic development:

1. Green Growth Strategies: Investments in renewable energy, sustainable infrastructure, and circular economies are pivotal for reducing ecological footprints while generating employment opportunities (OECD, 2011).
2. Social Protection Systems: Expanding access to essential services, including healthcare and education, alongside robust social safety nets, is vital for addressing inequality (ILO, 2017).
3. Inclusive Financial Systems: Enhancing financial inclusion through mechanisms such as microfinance, digital banking, and mobile money platforms empowers marginalized groups, spurring entrepreneurial activity (Demirgüç-Kunt, 2018).
4. International Cooperation: The Sustainable Development Goals (SDGs) offer a global framework for harmonizing national policies with sustainability and equity objectives (UN, 2015).

5.5. Challenges and Critiques

Critics of prevailing economic paradigms contend that the singular emphasis on GDP growth often undermines ecological integrity and social equity (Raworth, 2017). Moreover, the implementation of inclusive development policies is frequently hampered by political resistance, fiscal constraints, and institutional inefficiencies (Acemoglu, 2012).

The scholarly discourse underscores the imperative of embedding sustainability and inclusion within economic development strategies. While notable progress has been realized, the path to truly equitable and sustainable development necessitates confronting systemic inequities, fostering transnational collaboration, and prioritizing ecological stewardship. Future research must prioritize scalable success models, interdisciplinary methodologies, and adaptive policy frameworks tailored to evolving global contexts.

The pursuit of sustainable economic development has become a critical goal for nations worldwide. It encompasses a broad spectrum of objectives, including economic growth, social inclusion, and environmental protection. This review of literature explores the theoretical foundations, challenges, and opportunities related to sustainable economic development, drawing on recent scholarly work and reports from international organizations.

Theoretical Foundations: The concept of sustainable economic development emerged from the intersection of economic, environmental, and social dimensions. The Brundtland Commission's report, "Our Common Future" (1987), laid the groundwork by defining sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Development, 1987). Subsequent studies have elaborated on this definition, emphasizing the importance of integrating economic, social, and environmental goals (Kates, 2005).

5.6. Sustainable Economic Development: Issues & Challenges

Environmental Degradation and Resource Depletion: One of the most significant challenges to sustainable economic development is environmental degradation. The overexploitation of natural resources leads to biodiversity loss, soil erosion, and climate change (Rockström, 2009). The unsustainable consumption patterns of developed nations exacerbate these problems, placing additional strain on the planet's ecosystems (Steffen, 2015).

Social Inequality: Social inequality poses another substantial barrier to sustainable development. Disparities in income, education, and healthcare access hinder the equitable distribution of economic benefits. Piketty (2014) highlighted the growing income inequality within and between countries, emphasizing its detrimental impact on social cohesion and economic stability (Piketty, 2014). Addressing these inequalities is crucial for achieving inclusive and sustainable growth.

Economic Instability: Economic instability, often characterized by financial crises, trade imbalances, and volatile markets, impedes sustainable development efforts. The 2008 global financial crisis underscored the interconnectedness of economies and the vulnerability of financial systems (Stiglitz, 2010). Effective regulatory frameworks and international cooperation are necessary to mitigate these risks and promote economic resilience.

Institutional Barriers: Institutional barriers, including weak governance, corruption, and inadequate legal frameworks, undermine sustainable development initiatives. North (1990) argued that robust institutions are essential for economic development, as they provide the necessary legal and regulatory environment for businesses to thrive (North, 1990). Strengthening institutions and enhancing transparency are critical for fostering sustainable economic practices.

5.7. Sustainable Economic Development: Future Opportunities

Technological Innovations: Technological innovations present significant opportunities for advancing sustainable economic development. Renewable energy technologies,

such as solar and wind power, offer viable alternatives to fossil fuels, reducing greenhouse gas emissions and promoting energy security ((IRENA), 2019). Additionally, digital technologies and the Internet of Things (IoT) can enhance resource efficiency and optimize supply chains, contributing to sustainability goals (Forum, 2018).

Market Incentives: Market incentives, including carbon pricing, green bonds, and sustainable investment funds, can drive the transition towards sustainable economic development. By internalizing the environmental costs of production and consumption, these mechanisms encourage businesses to adopt sustainable practices (Stern, 2007). Moreover, consumer demand for sustainable products and services is rising, creating new market opportunities for companies that prioritize sustainability (Nielsen, 2015).

Policy Reforms: Policy reforms at the national and international levels are crucial for promoting sustainable economic development. The Paris Agreement (2015) and the 2030 Agenda for Sustainable Development underscore the need for coordinated global efforts to address climate change and achieve sustainable development goals (UN, 2015). Effective policies should focus on reducing carbon emissions, enhancing social protection, and fostering inclusive growth.

Social Initiatives: Social initiatives, including education, healthcare, and community development programs, are vital for achieving sustainable economic development. Investing in human capital enhances productivity, reduces poverty, and promotes social equity ((UNDP), 2019). Furthermore, empowering marginalized groups, such as women and Indigenous communities, can lead to more inclusive and resilient economies (Bank, 2018).

The literature on global sustainable economic development highlights both the challenges and opportunities inherent in this ambitious endeavour. While environmental degradation, social inequality, economic instability, and institutional barriers pose significant obstacles, technological innovations, market incentives, policy reforms, and social initiatives offer promising pathways to sustainability. Achieving sustainable economic development requires integrated and holistic approaches, underscored by international cooperation and robust institutional frameworks. As nations strive to balance economic growth with social inclusion and environmental stewardship, the insights from scholarly research and international reports provide valuable guidance for policymakers and stakeholders alike.

6. Global Landscape: An Overview

In 2024, the global landscape of sustainable economic development is marked by a dynamic interplay of challenges and opportunities. Governments, businesses, and individuals are increasingly recognizing the urgent need to harmonize economic growth with environmental protection and social equity, recognizing that the path forward requires careful navigation of a complex set of global imperatives.

6.1. Climate Crisis

The climate crisis remains one of the paramount challenges to sustainable economic development. Extreme weather events, rising sea levels, and disruptions to agricultural systems are jeopardizing livelihoods and economic stability worldwide. Governments and corporations face mounting pressure to transition expeditiously toward renewable energy sources, implement robust carbon pricing mechanisms, and adapt to the exigencies of a rapidly changing climate. The economic costs of inaction are profound, making it imperative to prioritize climate resilience alongside growth.

6.2. Resource Scarcity

The depletion of critical natural resources—such as water, arable land, and minerals—further complicates the quest for sustainable economic development. This scarcity drives up costs, strains business operations, and heightens geopolitical tensions. In response, sustainable resource management practices, including circular economy principles and responsible sourcing, are gaining prominence as crucial strategies for ensuring long-term economic viability. Without such measures, resource shortages will continue to threaten both environmental and economic stability.

6.3. Inequality and Social Justice

For economic development to be genuinely sustainable, inclusivity and social justice must be at the core of the agenda. The widening chasm of income inequality, exacerbated by the COVID-19 pandemic, threatens not only social cohesion but also broader economic stability. Governments face increasing demands to implement progressive taxation policies, invest in essential services such as education and healthcare, and ensure equitable access to economic opportunities for marginalized communities. Addressing these inequities is essential for fostering a resilient and fair global economy.

6.4. Technological Disruption

The rapid pace of technological innovation—including artificial intelligence, automation, and blockchain—continues to reshape industries and labour markets. While these advancements present substantial opportunities to drive economic growth and productivity, they also raise concerns regarding job displacement, digital divides, and data privacy. Sustainable economic development strategies must harness technology to facilitate inclusive growth, mitigate adverse effects such as unemployment, and ensure that technological advancements are leveraged for broad societal benefit.

6.5. Global Health Challenges

The COVID-19 pandemic underscored the inextricable link between global health and economic systems. Health crises can have far-reaching economic consequences, disrupting supply chains, diminishing consumer demand, and placing immense strain on healthcare systems. Building resilient economies requires investing in pandemic preparedness, strengthening healthcare infrastructure, and fostering international cooperation. Global health security is inextricably tied to sustainable economic development, and investment in this area is essential for long-term stability.

6.6. Green Transition Opportunities

The transition to a low-carbon economy presents significant opportunities for sustainable economic development. Renewable energy industries, green infrastructure projects, and eco-friendly technologies are not only driving innovation but also generating employment opportunities. Governments and businesses that prioritize investments in clean energy, sustainable infrastructure, and green technologies stand to benefit from long-term cost savings, improved competitiveness, and a more resilient economy. The green transition is not merely a necessity—it is an opportunity to reimagine economic growth in ways that are both environmentally and economically sustainable.

6.7. Policy and Governance

Effective governance frameworks and sound policy interventions are indispensable for advancing sustainable economic development goals. International agreements, such as the Paris Agreement and the United Nations Sustainable Development Goals (SDGs), provide a blueprint for collective action. However, translating these lofty commitments into tangible outcomes demands robust political will, regulatory enforcement, and cross-sectoral collaboration. The role of policy-makers in driving these transformations cannot be overstated, and their ability to navigate the complexities of sustainability will determine the future trajectory of global development.

6.8. Rising Inflation and Unemployment

The contemporary global landscape is further complicated by rising inflation, increasing unemployment, and growing income and wealth disparities. These challenges, compounded by geopolitical tensions, external debt burdens, and climate-induced disruptions, exacerbate global economic instability. The urgency of transitioning from the prevailing 'structural adjustment' models to a more transformative approach is evident. A shift toward structural transformation—one that fosters resilience, sustainability, and equitable growth—has become a critical imperative for sustaining long-term economic development.

Since the 2008 financial crisis, global GDP growth has generally been sluggish, hindered by imbalanced production and consumption patterns. Projections suggest that by 2030, global economic growth may reach a nadir, exacerbated by declining investment rates, diminishing productivity, and stagnation in international trade. Developing nations, particularly 107 countries, are particularly vulnerable, grappling with sovereign debt crises, food shortages, and energy deficits, with 69 countries facing economic crises akin to Sri Lanka’s.

Sri Lanka's economic catastrophe, precipitated by fiscal imbalances since 2020, serves as a stark reminder of the vulnerabilities inherent in unsustainable economic policies. Current account deficits, a collapse in exports, and a depletion of foreign reserves have plunged the nation into a dire economic situation, characterized by soaring inflation, food and fuel shortages, and a critical public debt default.

6.9. Systemic Overhaul

Global institutions such as the World Trade Organization (WTO), International Monetary Fund (IMF), and World Bank appear increasingly ill-suited to address the complexities of modern economic challenges. The failure to adapt regulatory frameworks to the realities of a globalized, rapidly evolving economy undermines their effectiveness. Despite this, the global economy surpassed a $104 trillion GDP by 2022, a testament to the resilience of the system, even amid disruptions like the COVID-19 pandemic and subsequent economic recession.

6.10. Food Insecurity

Rising food prices have pushed over 1.25 billion people into economic hardship, with approximately 349 million individuals facing acute food insecurity due to disrupted supply chains and geopolitical tensions. In response, many nations have adopted contractionary policies that, while intended to mitigate inflation, have exacerbated unemployment rates and further destabilized economies. The convergence of climate change, pandemic fallout, and geopolitical instability has made addressing global food insecurity more urgent than ever.

6.11. Sustainable Growth Potential

The World Bank has suggested that sustainable policies could boost global GDP growth by as much as 0.7%, potentially reaching an annual growth rate of 2.9%. Key areas for investment, such as transportation infrastructure, renewable energy, agriculture, manufacturing, healthcare, education, and trade, represent critical pathways to achieving sustainable economic growth globally. By aligning policy and investment strategies with sustainability principles, nations can not only address immediate economic challenges but also lay the foundation for long-term prosperity and environmental stewardship.

In sum, achieving sustainable economic development in 2024 and beyond requires a nuanced, multifaceted approach. This approach must tackle the environmental, social, and economic dimensions of development in an integrated manner, embracing innovation, inclusivity, and environmental stewardship. Only through such a holistic and collaborative framework can nations and organizations capitalize on the opportunities of a low-carbon, sustainable

future while overcoming the myriad challenges that lie ahead (Izuaka, 2023).

The United States, home to the world's largest economy, has experienced a subdued growth pattern, with a modest increase of merely 1.6% in 2022. However, the nation is now contending with the dual challenges of persistently high inflation and an unprecedented spike in unemployment, both of which have been exacerbated by an anomalous surge in demand for goods and services. This unfolding economic scenario bears a striking resemblance to the stagflationary conditions that prevailed during the late 1970s and early 1980s.

In contrast, the Asia-Pacific region, led by the economic titans of China and India, is poised for a robust growth trajectory, with projections indicating a rise from 4.2% in 2022 to 4.8% in both 2023 and 2024. The strong economic performance of these key nations takes on particular importance within the global context, especially as the current financial landscape grapples with escalating business risks, heightened interest rates, inflationary pressures, and volatile exchange rates. A modicum of relief may be observed on the inflationary front within the Asian region, with forecasts from the Asian Development Bank's Asian Development Outlook (April 2023) predicting a gradual deceleration of inflation from 4.4% in 2022 to 4.2% in 2023, and further easing to 3.3% in 2024. Such a trajectory brings the region closer to pre-pandemic inflationary norms, fostering optimism for economic stability and resilience amidst ongoing global uncertainties.

6.12. Global Sovereign Debt Burden

A dramatic escalation in sovereign debt has emerged as a defining characteristic of the contemporary economic landscape, with a particularly pronounced surge observed among developing and impoverished nations. These countries, facing unprecedented economic challenges, have turned to substantial loans from international institutions such as the World Bank and the IMF, viewing these financial lifelines as essential for spurring economic recovery. This necessity arises from the severe downturns triggered by the widespread industrial lockdowns implemented in response to the COVID-19 pandemic. The infusion of these special economic packages was critical not only to facilitate economic recovery but also to instill a sense of confidence among business and economic stakeholders, who were grappling with precipitous declines in private investment.

In the era of financial liberalization and global financial dominance, many nations have refrained from disclosing comprehensive data regarding capital flight, particularly in relation to inflows and outflows of financial capital. Remittances to major recipient countries, such as China and India, have seen a notable decline. For instance, India, which typically receives an average of US$70 billion annually, has experienced a reduction despite approximately 30 million Indian workers being employed abroad.

Global Investment, Trade, and Geopolitical Dynamics: A substantial portion, approximately two-thirds, of developing countries, including India, remain heavily dependent on commodities and face challenges related to economic diversification and volatility. Nonetheless, these nations are home to critical resources essential for the global energy transition, in addition to possessing untapped renewable energy potential. By implementing strategies that promote local value addition and investing in technological advancements, these nations can leverage their natural resources to diversify their economies, ascend the value chain, and reap broader economic benefits through targeted industrial and innovation policies. In 2023, global services exports registered a notable 8.9% annual increase, surpassing the US$7.9 trillion mark (UNCTAD, 2023).

FDI-based Development: A recently published UNCTAD report highlights significant shifts in global foreign direct investment (FDI), shaped by trends in global value chains, technological advancements, geopolitical dynamics, and growing environmental concerns. FDI has faced increasing difficulty in keeping pace with production (GDP), trade, and employment generation. Investment decisions are increasingly influenced by factors that extend beyond mere economic considerations, complicating traditional approaches to investment promotion (UNCTAD, Foreign Direct Trends in Sectoral-Wise, 2024).

Table 1. Foreign Direct Investment Trends (Sectoral-Wise in %)

Years	Manufacturing Sector (in %)	Service Sector (in %)	Other Non-Services Sectors
2004-2007	26	66	8
2008-2011	21	72	8
2012-2015	18	78	5
2016-2019	17	76	7
2020-2023	13	81	6

Source: UNCTAD's Report 2024

Concomitantly, global investment ratios have experienced a downturn, constricting the channels of international trade, thereby exacerbating the global sovereign public debt crisis, particularly within the ambit of developing nations. According to the latest report issued by the IMF on April 11, 2023, a dire picture emerges, with approximately 15% of low-income nations teetering on the brink of "debt distress." Furthermore, an additional 45% of developing

countries find themselves ensnared in the perilous domain of "debt distress," while among emerging economies, nearly 25% confront elevated risks, grappling with "default-like" borrowing spreads. In the year 2024, a greater number of low-income nations find themselves grappling with the spectre of debt distress or teetering on its precipice more profoundly than ever documented. According to the most recent debt sustainability analysis conducted by the International Monetary Fund (IMF) for low-income countries, a staggering count of 10 nations stands ensnared in the clutches of debt distress, while an additional 52 jurisdictions hover perilously at the thresholds of moderate to severe debt distress. Within this cohort of 62 nations, a substantial contingent of 40 hails from the continent of Africa.

The African continent, in particular, bears the brunt of global vicissitudes, chief among them being the reverberations of the COVID-19 pandemic, the ongoing conflict in Ukraine, and the consequential ripples stemming from heightened interest rates prevalent in numerous advanced economies. These external factors have jointly conspired to elevate the burdens of indebtedness across the breadth of the continent. Notably, the debt burdens are most acutely felt within the expanse of Africa's larger lower-middle-income economies. In delineating this issue, it becomes evident that nations such as Egypt, where indebtedness stands at a staggering 92 per cent of Gross Domestic Product (GDP), Angola at 84.9 per cent, and Kenya at 70.2 per cent, typify the profound challenges posed by burgeoning debt levels.

Table 2. Debt to GDP Ratio 2021 (%)

Country	Debt in % to GDP Ratio
USA	133
Canada	116
China	70
Japan	257
Germany	70
India	87
UK	107
France	115
Italy	157
Singapore	130
Greece	210
Sudan	212
Brazil	98
Russia	18
South Africa	81
Australia	72
South Korea	53
Belgium	116
Sri Lanka	105

Source: IMF, 2022

Japan leads the world with the highest debt-to-GDP ratio, standing at an astronomical 257 per cent. The onset of the COVID-19 pandemic precipitated a marked escalation in government indebtedness globally. Consequently, three nations—Japan, Sudan, and Greece—now surpass the ominous threshold of 200 per cent debt to GDP, while an additional 32 countries find themselves burdened with debt levels exceeding 100 per cent.

Nations endowed with abundant reserves of petroleum oil and gas exhibit markedly diminished debt obligations relative to their GDP, exemplified by Kuwait (14%), Russia (18%), and Saudi Arabia (31%). In stark contrast, Hong Kong boasts a negligible debt-to-GDP ratio of a mere 1 per cent.

Despite this, the specter of burgeoning public debt looms ominously across the global landscape, with particular vulnerability evident on the African continent. Notably, eight African nations currently confront the throes of debt distress, while an additional 13 teeter precariously on the brink of such fiscal peril, as per the Debt Sustainability Analysis jointly conducted by the International Monetary Fund and the World Bank.

Moreover, during the High-level Working Group on Global Financial Architecture, convened on the sidelines of the Economic Commission for Africa's 55th Conference of African Ministers of Finance, Planning, and Economic Development in Addis Ababa, Ethiopia, on the 6th of April, 2023, estimations underscored the imperative for Africa to secure a minimum annual influx of US $500 billion to advance toward the attainment of sustainable development and climate objectives encapsulated within the ambit of the Sustainable Development Goals (SDGs).

7. The Role of the Group 20

The Group of Twenty (G20), comprising the world's most influential economies and accounting for a staggering 95% of global GDP, emerged abruptly in the aftermath of the 2007-08 Financial Crisis. Its inception aimed at collectively addressing the profound financial and economic tribulations besieging the Western world through a concerted amalgamation of financial, technological, and trade-oriented initiatives geared towards fostering enduring global economic sustainability. However, despite the formidable collective might of these 20 powerful nations, they have regrettably faltered in addressing the critical issue of cross-border data transmissions, a pivotal necessity for fostering trade openness, investment, and technology diffusion, particularly vital for the industrialization pursuits of developing and impoverished nations.

8. The Collapse of the Bretton Woods System

Since the 1940s, the global monetary landscape has experienced three profound transformations:

- The Bretton Woods-I era, inaugurated in 1944, established a monetary order in which the US dollar was pegged to the gold standard.
- The Bretton Woods-II paradigm shift occurred in 1971, marked by President Nixon's decision to

sever the dollar's ties to gold, instead of semi-tethering it to oil.

- The ongoing transition to Bretton Woods-III, concurrent with the advent of the "new world order 2022," witnesses the yuan assuming a semi-tethered status to the "Petro-Yuan." This signifies a fundamental reconfiguration of the prevailing international order spanning Latin America (Argentina, Brazil, Mexico), Africa, and Asia (Russia, China, India, Saudi Arabia, and Iran). China's introduction of the digital yuan, backed by the Chinese Central Bank and underpinned by tangible goods and commodities, epitomizes this transformative shift.

9. A New Geo-Political Landscape

Consequently, a new epoch of geo-political manoeuvring has begun to unfold across the spheres of political, economic, and military domains, marked by the emergence of opposed power blocs spearheaded by China and the USA, and by Russia and the USA, respectively. India, a pivotal actor in this global arena, historically maintains cordial ties with Russia, yet grapples with the challenge of navigating a delicate equilibrium between China and the USA. The recent collaboration pact between China and Russia, underscored by their commitment to counter the USA-led QUAD group (deemed imperialistic), comprising India, Japan, and Australia, further accentuates the burgeoning geopolitical tensions.

Iran and Saudi Arabia, wielding considerable economic clout in the Arabian/Gulf/Middle Eastern/West Asian domain, stand poised as potential economic superpowers. Iran's anticipated ascension to economic prominence by 2025 hinges significantly on the unfreezing of billions of dollars in Iranian assets abroad, estimated between US$50 billion to US$150 billion. This financial windfall could enable Iran to augment global oil supplies by an additional 1.5 million barrels per day, leveraging these 'Petro-dollars' to fuel its developmental aspirations and solidify its alliances with Russia, China, and North Korea.

The burgeoning strategic trilateral partnerships between Russia, China, and Iran, extending their influence into the Middle East/West Asia/Arabian/Persian Gulf territories, have garnered further momentum, encompassing erstwhile allies such as Saudi Arabia, the United Arab Emirates, Iraq, Egypt, and Syria. This concerted geo-political realignment portends the potential emergence of formidable power blocs in the realms of energy, trade, and military, heralding a palpable escalation in strategic rivalries between the USA and the combined forces of China and Russia.

10. Emergence of the Global South

The prevailing consensus among global pundits asserts a paradigmatic shift in the balance of power, discernibly tilting away from the traditional bastions of Western dominance, which have held sway for the past three to four centuries, towards the burgeoning influence of the East in the twenty-first century. Indeed, indicators such as GDP ratios and trade performance evince a threefold augmentation within the global south, indicative of a pronounced ascendancy on the world stage. Moreover, select emerging nations, including but not limited to China, Russia, India, Brazil, South Africa, Iran, North Korea, Cuba, Vietnam, and Venezuela, have successfully attained formidable technological and financial prowess, surpassing the benchmarks set forth by the Group of Seven (G7), encompassing Western Europe, the United States, Japan, and Canada.

The Global South, collectively, poses a formidable challenge to the prevailing unipolar world order, where the United States has wielded hegemonic influence. This challenge manifests in multifarious dimensions, ranging from the military sphere, epitomized by the NATO military bloc comprising 31 member countries, including recent entrants like Finland, to the pervasive hegemony exerted by the US dollar, facilitated through international financial institutions such as the World Bank and the International Monetary Fund. Additionally, the Global South contests the existing trade hegemony orchestrated via institutions like the World Trade Organization, signalling a resolute intent to assert its autonomy and reshape the contours of the global geopolitical landscape (Prabhakar A. C., 2020).

The Global South, propelled by the formidable presence of influential regional blocs such as BRICS (comprising Brazil, Russia, India, China, and South Africa), assumes an increasingly prominent role on the world stage. This ascendancy is underscored by a concerted endeavour to bolster technological, financial, trade, and military capabilities, thereby fostering a robust internal infrastructure geared towards resource exploitation for infrastructural development. Central to this endeavour is a concerted effort to ameliorate the disjunction between demand and supply by enhancing production capacity and fortifying distribution networks, all underpinned by the guiding ethos of collective self-reliance at the South-South nexus (Prabhakar A. C., 2015).

The Global South, propelled by the emergence of influential regional alliances such as BRICS (comprising Brazil, Russia, India, and China, with South Africa joining later, covering a substantial 30% of global GDP), the Shanghai Cooperation Organization (SCO), East Asian Cooperation (EAC), the Regional Comprehensive Economic Partnership (RCEP), and the Africa Free Trade Association (AfCFTA), stands poised to redefine the contours of international trade and cooperation. These regional coalitions, spanning the continents of Asia, Africa, and Latin America, collectively represent the world's largest free trading blocs. Through meticulously crafted agreements, they endeavour to catalyze industrialization via infrastructural development, investment facilitation, trade liberalization, and technology transfer within the

Global South, effectively challenging the hegemony of the US dollar while championing the cause of multilateralism.

Consequently, a palpable conflict arises between the United States and China, particularly within high-stakes industries such as semiconductor manufacturing and frontier technologies like quantum computing. The Global South, in turn, reaps substantial benefits from China's ambitious 'One Belt One Road' initiative, realized through collaborative efforts spearheaded by BRICS, SCO, EAC, and RCEP. Indeed, BRICS assumes a pivotal role as a nexus for economic and financial discourse, not merely aiming at global governance but also demonstrating unwavering commitment to fostering infrastructural and sustainable development projects. Noteworthy initiatives include the allocation of a $32 billion package for green energy initiatives, urban mobility enhancements, and digital infrastructure development, alongside investments in One Belt One Road projects, highway construction, railways, and seaport networks facilitated by the New Development Bank (NDB). Functioning as a viable alternative to the Western-dominated World Bank and IMF, the NDB epitomizes the Global South's quest for financial autonomy.

The growing allure of BRICS is evidenced by the enthusiastic overtures of potential partners such as Iran, Indonesia, and Argentina, poised to join its ranks. Moreover, the BRICS summit has extended permanent invitations to Nigeria, Saudi Arabia, the United Arab Emirates (UAE), Kazakhstan, and Thailand since 2013, highlighting the coalition's expanding influence. With BRICS, alongside SCO and EAC, attaining formidable financial and technological capabilities, it not only fulfils the developmental needs of emerging economies but also adeptly navigates geopolitical tensions, heralding a new era of Global South solidarity and empowerment.

11. De-Dollarization Trading Campaign Initiative

Trade imbalances, predominantly afflicting developing and impoverished nations, perpetually engender 'balance of payments' quandaries, largely attributable to the pervasive hegemony of the US dollar. In response, a concerted 'de-dollarization' movement has gained traction within the Global South encompassing Asia, Africa, and Latin America, as well as among European nations. The European Union, spearheaded by France, has emerged as a vocal protagonist in challenging the supremacy of the dollar within the international financial and monetary framework. Notably, the EU has undertaken initiatives aimed at establishing its autonomous financial infrastructure, exemplified by the European Payment Initiative (EPI), aimed at diminishing the dollar's stranglehold on global transactions.

Furthermore, European nations find themselves increasingly reliant on China for trade, with a staggering 98% dependency documented. In recognition of this reality, agreements facilitating trade payments in Yuan have been brokered. Similarly, Russia and China have taken significant strides towards reducing reliance on foreign currencies, with a remarkable 90% of their trade and investment transactions conducted in domestic currencies. India, mirroring this trend, has inked agreements with 18 nations, endorsing the utilization of local currencies for trade settlements, thus further diluting the dominance of the US dollar in international commerce.

11.1. Charting a New Course: The Rise of the Asian Monetary Fund as an Alternative to the US Dollar

The BRICS nations are spearheading a concerted effort towards de-dollarization, aiming to disengage the global economy from the entrenched hegemony of the US dollar and euro, which have wielded dominance since the culmination of the Second World War. A coalition of resource-rich nations, including Saudi Arabia, Iran, Iraq, Algeria, Nigeria, Egypt, Indonesia, Thailand, Vietnam, Cambodia, Syria, the United Arab Emirates, Kazakhstan, South Africa, Tanzania, Uganda, Senegal, alongside other African and Latin American nations, has joined forces with China to facilitate trade transactions denominated in Yuan. Notably, Malaysia has recently proposed the establishment of an 'Asian Monetary Fund,' an initiative endorsed by China, underscoring the quest for an alternative Asian currency aimed at reducing reliance on the International Monetary Fund (IMF). This move gains added significance in light of the diminishing global reserve status of the US dollar, which has dwindled from 72% in 1999 to a mere 59% in 2022.

BRICS is actively fortifying its financial infrastructure, exemplified by the creation of a joint payments network. Countries such as Egypt, Turkey, Iran, and Saudi Arabia have expressed keen interest in securing permanent membership within BRICS. Furthermore, agreements have been reached among Saudi Arabia, France, Brazil, Russia, Iran, and India to utilize Yuan for transactions related to Chinese imports. Over 18 nations have signed agreements with India, consenting to the acceptance of domestic currencies, notably the Indian Rupee (INR), for trade settlements. Additionally, a significant number of countries, numbering 41, have opted to transact in their respective domestic currencies, while concurrently embracing the Chinese Yuan, including its 'Petro-Yuan' variant. Bilateral trade between China and Brazil has soared to US$150.5 billion, while India-Russia bilateral trade has experienced a remarkable 36% increase in the year 2023. Furthermore, the trade volume between Russia and China surged by 38% during the same period, with Russian banks reallocating a substantial 60% of their assets into Yuan.

Meanwhile, in 2022, American consumers purchased goods and commodities worth US$3.3 trillion from other nations, while non-US consumers procured a comparatively lower amount of US$2.1 trillion from the USA. This discrepancy underscores the enduring allure of the US dollar as a safe haven asset among non-US entities,

with some opting to hold USD in cash, thereby increasing liabilities for the US Federal Reserve Bank to print and issue additional currency.

The geographic expanse of the Indo-Pacific extends from the eastern shores of Africa to the western fringes of the Americas. Although precise delineations of its borders are less critical, given its primarily geostrategic significance, it constitutes a pivotal arena for international geopolitics and burgeoning global power dynamics. Encircled by major population centres, the Indo-Pacific houses eight of the top 20 global economies, cementing its status as a vital geo-economic hub with immense geopolitical importance (Mukherji, 2022).

12. Emerging Trends of Geo-economics and Geo-politics

The unipolar world, historically buttressed by the hegemony of the United States, is presently undergoing a transformative shift in the year 2022, gravitating towards a configuration characterized by bipolar or multipolar dynamics. The initiation of a trade conflict between China and the United States in 2017, coupled with the protracted military hostilities between Russia and Ukraine since the 24th of February 2022, orchestrated with the support of the United States and NATO, alongside the escalating tensions between China and Taiwan, exacerbated by the backing of the United States, underscores the profound recalibration of global power structures. Concurrently, the intensification of conflicts involving Iran and Israel, as well as Iran and the United States, the adversarial engagements between Turkey and Greece, and the military confrontations between Azerbaijan and Armenia, have starkly illuminated the prevailing global order, colloquially termed "globalization".

These conflicts and contradictions have precipitated a schism between the entrenched forces of Western imperialism, spearheaded by the United States, Britain, France, Germany, and various other European nations, and the ascendant powers, such as China, Russia, India, Iran, Brazil, and South Africa. From Turkey, traversing through Syria, Saudi Arabia, Iran, Iraq, and the United Arab Emirates, encompassing the Gulf and Arabian countries, to the African continent, and from Pakistan, Afghanistan, Tajikistan, Uzbekistan, Kazakhstan, and Kyrgyzstan, constituting nearly all Central Asian nations affiliated with the Shanghai Cooperation Organisation (SCO), to Thailand, Cambodia, Laos, Vietnam in Southeast Asia, and North Korea in East Asia, and further extending to Bangladesh, Nepal, Sri Lanka, Myanmar, Bhutan forming the BIMSTEK coalition, as well as encompassing Fiji, Papua New Guinea, the Solomon Islands in the South Pacific region, and South Africa, Ethiopia, Madagascar, Uganda, Zimbabwe, in addition to Venezuela, Cuba, Nicaragua, Mexico, and Argentina in Latin America, these emergent major trade blocs are fervently endeavouring to circumvent Western influence entirely, consolidating their partnerships with China, Russia, and India, to harness and leverage their considerable capabilities.

Meanwhile, the United States and the European Union remain primarily fixated on the Indo-Pacific region, which constitutes the second-largest market for both entities. A significant portion, approximately 75%, of European and American trade traverses the maritime thoroughfares within the South China Sea, en route to the top trading partners of the EU, including Taiwan, the Philippines, Malaysia, South Korea, Japan, and other member states of the Association of Southeast Asian Nations (ASEAN). The Indo-Pacific theatre is delineated by a precarious nexus of fault lines and historical strategic distrust, emerging as the focal point of China's endeavour to assert its preeminence as the predominant, if not sole, superpower, manifesting in concerted efforts to exert control over maritime trade routes through the strategic realignments of geopolitical spheres of influence.

13. Self-reliance Goal Achievement Is Far Away

The process of industrialization remains an ongoing endeavour in the developing and impoverished nations of Asia and Africa, despite the passage of six to seven decades since their attainment of political autonomy. A United Nations Report unveiled on the 15th of November, 2022, unequivocally underscores the global population's surge to 8 billion, prognosticating India's ascension over China by the year 2023. Projections outlined in this report delineate a trajectory wherein the global populace may burgeon to approximately 8.5 billion by 2030, escalating to 9.7 billion by 2050, culminating in an apex of roughly 10.4 billion within the temporal span of 2080 to 2100. Noteworthy is the observation that more than half of this anticipated population surge will be concentrated within eight nations, specifically: India, Pakistan, the Philippines, Ethiopia, Congo, Egypt, Nigeria, and Tanzania. Sub-Saharan African nations are forecasted to emerge as epicentres of population expansion by the year 2050.

The phenomenon of rapid population growth, while ostensibly auspicious, bears nuanced implications. It possesses the potential to furnish a reservoir of inexpensive labour indispensable for catalyzing the pursuit of industrialization and the realization of self-sufficiency objectives. However, the veritable dividends of this demographic trend hinge precariously upon our capacity to alleviate poverty, redress hunger and malnutrition, and foster the genesis of novel employment opportunities. Failure to address these imperatives risks transmuting the very bulwark of the burgeoning populace into a formidable yoke, engendering socio-economic stagnation rather than catalyzing progress.

14. Pollution and Environmental Degradation

Rough estimations suggest that the most affluent 1% of the global population is responsible for emitting over twice the quantity of CO2 emissions compared to the bottom 50% of

the world's populace. The developed nations, including the United States, collectively contribute a staggering 95% share to the global pool of greenhouse gas emissions. India and China, leveraging coal and natural oil and gas for their energy requisites, substantially compound the global air pollution quandary. China, in particular, accounts for approximately 20% of the world's air pollution burden.

In the pursuit of capital formation and accumulation, predominantly developing nations have espoused a market-oriented growth paradigm, predominantly under the auspices of urban business elites. This trajectory has been marked by conspicuous neglect of the vast rural hinterlands, where substantial populations have resided over the past five to six decades. Embracing an urban-centric developmental schema, these nations have incentivized the migration of surplus agricultural labour from rural to urban spheres, thereby replenishing the labour reservoirs essential for sustaining urban-centric private corporate enterprises (Prabhakar A. C., 2015). Mitigating the spectres of global warming, environmental degradation, and the capricious vicissitudes of the global economy necessitates a strategic pivot towards the adoption of alternative energy reservoirs, chief among them being green renewable energy, exemplified by solar energy, alongside the integration of cutting-edge nano-technological innovations. Such a paradigm shift promises to inaugurate sustainable trajectories for economic and commercial endeavours, redolent of resilience and longevity.

15. Digitalization and Automation Process: A Pre-mature De-industrialization

The relentless march of digitalization and automation permeates economies worldwide, heralding both auspicious and adverse ramifications for the global economic landscape. A technology-centric economy augments the productive apparatus, conspicuously evidenced by the strides made in scientific and technological acumen, proficiency, and dominion over natural phenomena witnessed in nations such as the USA, Japan, and China. Concurrently, this epochal transformation diminishes the exigencies of socially mandated labour time, alleviates burdensome tasks, enhances living conditions, and elevates the quality of life for denizens. Technology catalyzes trade and economic expansion, engenders prosperity, and fosters sustainability and inclusivity through the realization of comparative advantages, epitomized by cost reduction in production processes.

However, the digital revolution engenders a profound schism between a select cohort endowed with expertise and affluence and the remainder of society, accentuating socio-economic disparities (Prabhakar A. C., 2015). Approximately 51% of American workers find themselves imperilled by the spectre of job displacement stemming from a deficiency in reskilling attributable to the relentless march of digitalization and automation. Illustratively, India's Unified Payments Interface (UPI) has facilitated an impressive eight billion transactions, democratically enfranchising 400 million denizens residing in rural hinterlands, who wield legacy push-button phones. India has unequivocally repudiated the designation of private cryptocurrencies as legal tender, yet evinces a receptiveness to deliberating their classification as an asset class, concurrently extolling the virtues of blockchain technology underpinning cryptocurrencies. Notably, India's UPI and Singapore's PayNow platforms have jointly announced the seamless facilitation of instantaneous cross-border monetary transfers, heralding a paradigm shift in the realm of international financial transactions (Jha, 2023).

Thus, the pivotal question remains unresolved: how shall policymakers navigate the expansive potential of digital advancement to engender a future world characterized by equity, inclusivity, and sustainability? Furthermore, how ought economic stakeholders contemplate the dividends accrued from digital tax administration, envisaging both revenue enhancement and compliance bolstering? Additionally, the prospect of greater transparency facilitated by online procurement mechanisms presents a potent tool in the arsenal against corruption. Lastly, the imperative of imbuing digital public financial management systems with accountability stands poised to fortify the social contract, instilling trust and confidence in governance structures.

16. Economic and Business Roads to Sustainability

The trajectory of economic and commercial pathways towards sustainability necessitates an intrinsic linkage with the imperatives of poverty eradication, the amelioration of income and wealth disparities, and the eradication of gender, caste, racial, and ethnic-based inequalities. Furthermore, it mandates the provision of equitable access to health and educational services and facilities, the assurance of social security and justice, and the fulfilment of basic human needs encompassing food security, housing, water, and electricity provision for all. Central to this paradigm is the facilitation of freedom and choice in occupational pursuits for all individuals, alongside the preservation of a pristine and salubrious environment. This holistic approach aligns seamlessly with the United Nations' 2030 targeted agendas encapsulated in the 17 sustainable development goals, emblematic of a concerted global effort towards fostering enduring prosperity and well-being (Overton. John., 1999).

The ethos of sustainable and inclusive development encapsulates a multifaceted endeavour to construct intricate layers of economic, societal, and environmental stability concomitant with the pursuit of advancement and progress. Central to this paradigm is the augmentation of community sustainability, bolstering resilience, fortifying security, and fostering adaptability in the face of evolving challenges and contingencies (James, 2012).

17. The Role of MSMEs Sectors

The MSME sector plays a pivotal role in both employment generation and its substantial contribution to gross domestic product (GDP). As per the World Bank's 2022 report, Small and Medium Enterprises (SMEs) account for a staggering 90% of international business and contribute 50% to the global Gross Domestic Product. SMEs possess the capacity to engender approximately 600 million jobs, crucial for absorbing the burgeoning global workforce by 2030. In tandem with the burgeoning array of business prospects, MSMEs are poised to assume a crucial mantle in realizing the aspirations of sustainable business, projected to inject over US $12 trillion into the global GDP while facilitating the creation of 380 million jobs in developing nations.

Hence, there exists an imperative to effectuate the transfer of "Nano-technology" from the United Kingdom and other European nations to developing countries on a complimentary basis, particularly within the domains of agriculture, manufacturing, and transportation. China, hitherto an agrarian-dominated economy until 1978, masterfully pivoted towards an industrial economy by fostering an expansive network of rural-based household businesses, notably within the SME sector encompassing both private and social entrepreneurship. This transformation catapulted China into a preeminent global manufacturing hub and workshop, emblematic of the transformative potential inherent in leveraging MSMEs as agents of economic dynamism and progress.

18. Conclusion

Achieving sustainable and inclusive economic development necessitates a paradigm shift, prioritizing human well-being alongside environmental sustainability. This multifaceted endeavour demands integrated and holistic policy approaches that balance economic dynamism with social equity and ecological preservation. Global efforts, such as the Sustainable Development Goals (SDGs), have catalyzed progress; however, significant gaps remain in implementation, particularly in developing regions. These challenges are exacerbated by widening financing gaps, climate crises, and geopolitical tensions.

Realizing this ambitious vision will require unprecedented global cooperation, innovative financing mechanisms, and robust institutional reforms. Initiatives like the SDG Stimulus for developing countries and debt relief programs exemplify the urgent need for tailored solutions that address the specific challenges faced by the Global South, middle-income nations, and least-developed countries. At the same time, developed nations must fulfil their commitments, including Official Development Assistance (ODA) and climate finance pledges, while leveraging private capital and technological advancements to support sustainable growth.

Strengthening the global financial architecture is central to fostering equity and resilience. Efforts to reform tax systems, mitigate illicit financial flows, and provide affordable, long-term financing are critical to bridging development gaps. Furthermore, empowering micro, small, and medium enterprises and promoting youth entrepreneurship are vital strategies for driving inclusive growth and creating sustainable employment opportunities.

The path to a sustainable and inclusive future is replete with challenges, yet it also holds immense potential. According to the Global Council for the Promotion of International Trade (GCPIT), sustainable business models could generate over USD 12 trillion in economic value and 380 million jobs annually by 2030. Harnessing this potential will require unwavering commitment, innovative solutions, and cooperative global action to ensure that economic development serves as a catalyst for prosperity, equity, and environmental stewardship in the 21st century.

Amid the pressing imperatives of safeguarding our planet and realizing the Sustainable Development Goals (SDGs), the necessity for policy frameworks imbued with holistic integration has never been more critical. This approach demands not merely the cessation of protectionist measures favoring domestic industries but, more crucially, the strategic provision of green subsidies to accelerate the adoption of emerging green technologies within domestic sectors. Such initiatives are instrumental in catalyzing the transition to a green economy, transcending the traditional paradigm of conferring a "competitive advantage" within a global system historically shaped by imperialist dominance.

In a global milieu increasingly defined by trade tensions, geopolitical conflicts, and wars, alongside the unsustainable exploitation of energy resources driven by nationalistic fervor, the call for a paradigm shift toward sustainability is both urgent and indispensable. The prioritization of sustainability within this context becomes not only a moral imperative but also a pragmatic strategy for fostering global stability and resilience.

Equally vital is the adoption of a multilateral approach, necessitating robust mechanisms to mitigate geopolitical tensions. This requires reevaluating and, where feasible, removing economic and financial sanctions imposed on nations such as Russia, Iran, North Korea, Venezuela, and others, as these measures often exacerbate divisions and hinder collective progress. Simultaneously, global coordination and cooperation must be galvanized to ensure the effective implementation of climate policies, thereby advancing the shared pursuit of achieving the SDGs by 2030.

This dual focus—on fostering domestic green transitions and enhancing international collaboration—provides a pathway for transcending entrenched conflicts and aligning global efforts with the overarching goals of sustainability, equity, and collective prosperity.

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RESP

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Araştırma Makalesi ● Research Article

The Influence of Financial Innovation and Market Capitalization on Economic Growth: A Comparative Review of Global and Emerging Markets

Finansal İnovasyon ve Piyasa Kapitalizasyonunun Ekonomik Büyüme Üzerindeki Etkisi: Küresel ve Gelişmekte Olan Piyasaların Karşılaştırmalı Bir İncelemesi

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A N A H T A R K E L İ M E L E R

Piyasa Kapitalizasyonu
Finansal Yenilik
Ekonomik Büyüme

Ö Z

Finansal piyasa, ekonomik büyümede hayati bir rol oynar ve dalgalanmalar ile şoklar, ekonominin gelişiminde önemli bir etkiye sahiptir. Gelişmekte olan ekonomilerde borsa piyasalarının büyümesi, borsa büyümesinin nedenleri üzerine kapsamlı araştırmalara yol açmıştır. Finansal kapsayıcılıktaki olumlu şoklar ve özellikle borsalar gibi iyi gelişmiş finansal piyasalar, yabancı portföy yatırımlarını teşvik eder ve finansal sistemin yapısını iyileştirir. Finansal yenilik, finansal kurumların yeni biçimleri ve yapıları, teknolojik ilerlemelerle daha iyi finansal hizmetler ve gelişmiş finansal ürünler aracılığıyla ekonomide finansal aktiviteyi teşvik ederek ekonomik büyümeye katkı sağlar. Özellikle hisse senedi finansmanı, hem ABD'de hem de Avrupa'da ekonomik büyüme için faydalıdır, ancak bu etkinin Avrupa'da daha belirgin olduğu görülmektedir. Bu çalışma, piyasa kapitalizasyonu ile makroekonomik büyüme unsurları arasındaki teorik ve literatür tabanlı bağlantıyı araştırmayı amaçlamaktadır.

K E Y W O R D S

Market Capitalization
Financial Innovation
Economic Growth

A B S T R A C T

The financial market plays a crucial role in economic growth, with volatility and shocks playing a significant role in the development of the economy. The growth of stock markets in emerging economies has led to significant research on the causes of stock market growth. Positive shocks in financial inclusion and well-developed financial markets, particularly stock markets, encourage foreign portfolio investment and improve the structure of the financial system. Financial innovation promotes financial activity in the economy through new forms and structures of financial institutions, better financial services via technology advances, and enhanced financial goods, leading to economic growth. Equity financing is particularly beneficial for economic growth in both the US and Europe, with the effect being more significant in Europe. This study aims to explore the theoretical and literature-based connection between Market Capitalization and macroeconomic growth drivers.

1. Introduction

The link between financial development and economic growth has garnered significant attention from economists and policymakers (Awdeh & Hamadi, 2018). The growing role of stock markets in emerging economies has shifted researchers' focus towards understanding the factors driving their growth (Chiad & Hadj Sahraoui, 2021). Numerous studies have explored the relationship between stock market development and economic growth, highlighting the influence of financial inclusion and well-developed financial markets on foreign capital flows. Positive shocks in financial inclusion and efficient financial markets, particularly stock markets, attract foreign investment. Financial inclusion also encourages foreign investors to participate in infrastructure and manufacturing projects, improving the financial system's structure. Moreover, financial instruments adopted by local

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markets enhance connections between domestic and foreign financial systems (Qamruzzaman et al., 2019).

Financial innovation supports economic activity by introducing new financial institutions, services, and products, promoting effective resource allocation and economic growth. The government should focus on fostering financial innovation to benefit households and contribute to development. Capital market performance plays a key role in pooling surplus funds for medium- and long-term investments.

Orlowski (2020) found that equity financing positively impacts economic growth in the US and Europe, with a stronger effect in the euro area. Increasing equity financing is recommended to enhance GDP growth, particularly in Europe. Conversely, while debt accumulation may foster growth in Europe, it has a negative impact on the US economy, and expanding total credit is unlikely to benefit either region.

Economic fundamentals such as money supply, exchange rate, and inflation are linked to share return volatility. Both money supply and exchange rates impact stock market volatility, with evidence showing bidirectional causality and interdependence. The financial market is divided into two parts: the money market, dealing with highly liquid, short-term debt securities (Abbas et al., 2018), and the capital market, which trades longer-term financial instruments and is broader in scope (Moosavi et al., 2019).

Financial market volatility influences real production, particularly during financial crises. Increased uncertainty can lead to reduced consumption, investment, and output, as observed during the Great Recession, where financial volatility contributed to economic downturns. Financial instability negatively impacts production by reducing aggregate demand, and this effect is significant (Yıldırım-Karaman, 2018).

Recessions are often accompanied by increased microeconomic uncertainty. Uncertainty shocks can cause GDP declines of around 2.5%. Matching consumption throughout the economic cycle requires combining first-moment shocks with uncertainty shocks. Bloom et al. (2018) found that the best model for recessions involves negative first-moment shocks and positive second-moment shocks.

The relationship between financial market growth and economic development has been a subject of extensive research. Several studies have examined the link between stock market development and economic growth. This study aims to explore the theoretical and literature-based relationship between market capitalization and the macroeconomic drivers of growth.

2. Theoretical Framework

The following paragraphs present several significant theories that form a solid foundation for this research study.

2.1. Harrod-Domar (Hd) Model Of Neo-Keynesian Theory

The Harrod-Domar (HD) model, which explains how capital and saving levels effect an economy's development, is described in Neo-Keynesian theory. This model illustrates how capital accumulation influences economic growth in addition to explaining technical advancement. This approach necessitates an additional capital stock for economic growth and development. This model presents a solution that is effective in understanding the underdevelopment of capital stock. As a consequence, it is just essential to increase the number of resources available to encourage investment. This strategy, according to the Harrod-Domar (HD) model, is insufficient to ensure full employment since it fixes the labour and capital stock, as well as the characteristics that are utilised.

2.2. Neoclassical Theory of Growth

The neoclassical (or marginalist) theory determines output and income distribution taking technology, consumer preferences, and endowments of productive factors as exogenous variables. This structure produces a few foundational elements common to both exogenous and endogenous growth. First, all models presuppose Say's law thus omitting any considerations about the role of aggregate demand in the growth process: Hence, growth is determined by supply factors alone. Moreover, the existence of a continuum of techniques of production ensures that it is possible to substitute one factor with another until their endowments are fully employed: In addition, excess supply of one input would produce a reduction in its price, thus favouring the adoption of a technique of production which employs the factor more intensively. Second, income distribution is determined by the relative scarcity of the productive factors. Moreover, the interaction between technology and factor endowments determines the equilibrium marginal product of each factor, this assumption is regarded as a source of neoclassical growth model's essential assumptions. As a result, they are referred to as exogenous to the model.

2.3. Endogenous Growth Theories

In this model, long economic growth is related to and viewed as an endogenous variable, allowing for infinite production per capita growth. It is able to do so because it has an infinite capacity for implementing new ideas. Furthermore, government policy can influence all government policy actions and growth rates, such as infrastructure provision, intellectual property protection, regulations, taxation, law and order enforcement, according to the endogenous growth framework, because it has the potential to influence the speed of creativity and activity (Johansson, Karlsson, & Stough, 2011). Furthermore, there are various benefits to employing these models in government. As a result, the nation's financial structure and policy, such as its taxes and regulatory systems, as well as

its macroeconomic distribution and financial structures, have a significant influence on saving decisions and investment distribution, such as whether or not to change long-term growth. Endogenous growth models, including neo-Keynesian and neo-classical growth models, give different definitions of growth, but they all agree that growth in total factor productivity is an important component of economic growth (Johansson et al., 2012). Furthermore, the development and preservation of an entrepreneurial spirit and a leadership culture are endogenous processes. Attracting university-educated labour and expanding the region's market potential are both endogenous processes that regional policy may help to promote and drive. Furthermore, regional expansion provides fresh resources for the development of educational programs and infrastructure.

2.4. Economic Growth and Economic Development

Three main trends are observed: firstly, GDP per capita and household incomes are rising steadily. Secondly, a higher share of household incomes is expected to be spent on consumption due to consumption-stimulating policies. Thirdly, most of the countries in the region demonstrate a tendency toward rising populations, which contributes to the higher consumer potential of the region. Similarly, Mishra (2011) reported that consumption may drive economic growth in developing nations rather than production or investment. The reason for that could be that private consumption accounts for 70 to 75 percent of GDP in these economies. As a result, with its major proportion of GDP, consumption expenditure is intended to contribute the most to real GDP growth. Furthermore, consumption itself would stimulate the private sector to generate more goods and services. Therefore, consumption-led growth would give way to production- and investment-led development, and the economy would subsequently reach a high growth rate. Moreover, it has been noticed that the rise in real private consumer expenditure over the period was supported by an increase in per capita income and an increase in inflows of workers' remittances as well. Hence, it could be said that the continued growth momentum was bolstered by greater consumer spending reflecting back into economic activity. So, it is concluded that the creation of a strong middle class with greater purchasing power is a positive indicator of and will lead to business growth and social development. However, in order to maintain the longer-term growth momentum, investment must be increased at a higher rate than consumption spending. Investors, on the other hand, took advantage of rising demand by expanding their operation of the company to fulfill it. There is no doubt that growth in the economy of the nation helps the country reduce its budget deficit, which improves its wealth simultaneously. The study of Agarwal (2020) stated that there are six factors of the economy of the nation that are presented in the below figure:

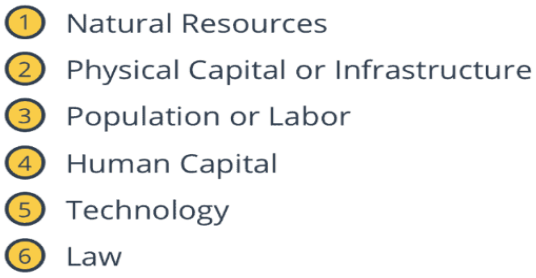

Figure 1. Six Factors of Economic Growth (Agarwal, 2020)

2.4.1. Technology, E-government & Manufacturing

In terms of technology as one of the factors affecting economic growth, Dhaoui (2021) conducted a study in 15 of the The Middle East and North Africa (MENA) Countries to examine the significance of e-government in MENA's economic and social development. The study found that putting digital technology and governance practices at the forefront of sustainable development initiatives and providing new and creative technical solutions may help achieve sustainable development in all aspects. Similarly, the study by Myovella, Karacuka, and Haucap (2020) examined the contribution of digitalization to the economic growth of sub-Saharan Africa in comparison with the economies of the Organization for Economic Cooperation and Development (OECD). The study stated that the advancement of technology and digitalization has changed the way individuals, consumers, and organizations behave, ways of work, and communication around the world. Moreover, this modern pattern can be linked to the introduction of information and communication technologies (ICT), for example, mobile phones and internet technologies, which result in new products and manufacturing processes, new marketing and supply chains, business complexities, as well as tremendous advancements in technology. The study concluded that digitization has a positive contribution to economic growth, regardless of a country's degree of development. However, although it is insignificant in OECD economies, the influence of mobile technology is positive and significant in Sub-Saharan African countries. In addition, the internet's effect on economic growth is strong.

In this context, Su and Yao (2017) utilized a broad range of globally comparable sectoral data to revisit the role of the manufacturing sector during the middle-income stage. The study revealed that industrialization is regarded as the most essential economic growth driver. Likewise, the study proves that manufacturing in middle-income economies is still the major growth driver. Furthermore, the research concluded that manufacturing has three primary characteristics: first, manufacturing expansion affects the growth of the services sector. Second, industrial development increases savings and accelerates technology accumulation. Third, a larger manufacturing sector in

middle-income nations may develop human capital and economic institutions.

In a similar way and from a different perspective, Aghion, Jones, & Jones (2019) analyzed the impact of artificial intelligence (AI) on innovative idea production and examined to what extent AI can boost growth temporarily or permanently. As AI is able to replace people in generating ideas, automation may supplant population growth as a driver of exponential growth. Hence, theoretically, AI could generate some form of singularity, possibly leading to the economy achieving infinite income in finite time. Indeed, singularity could occur even with less than full automation because nonrivalry of knowledge leads to increasing returns. However, even though many tasks have become computerized, growth may be constrained by areas that are hard to improve, for example, when some steps in the innovation process involve human R&D. The AI may impede or hinder growth by aggravating business theft, which inhibits human technology investments. The study found that capital share increases in several sectors (particularly outside services), which is consistent with automation. However, evidence connecting these patterns to sectoral automation measures is limited, and other various economic variables are at work in capital share movements.

Brooks, Wang, & Amback (2018) discussed another factor of the economy that is "law." The law that regulates economic activities, such as the rules of business, For example, solid waste management systems have found it difficult to keep up with the rapidly expanding usage and disposal of plastic products, which has negative effects on the environment and oceans. In addition, despite recycling and the circular economy being considered as possible answers, more than half of the plastic waste that was meant for recycling was shipped to hundreds of other nations. However, China has established a new policy that forbids the import of the majority of plastic garbage, which begs the issue of what will happen to the plastic waste that has been imported by China, which has brought in a total of 45% of plastic waste since 1992.

From a different perspective, Agarwal (2020) reflects those factors that may affect the growth of the economy of a nation if not worked in a proper manner. These factors are presented in the figure below:

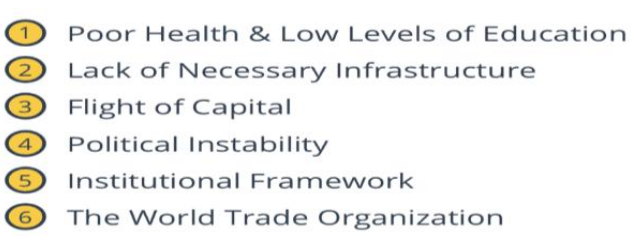

Figure 2. Factors Affecting the Growth of Economy (Agarwal & Zhang, 2020)

Agarwal (2020) discussed the institutional framework, such as rules and laws, that controls economic activity. Similarly, a study that was conducted by Welela (2018) states that economic growth could be increased by the profitability of firms, which could be achieved by reducing production costs or increasing the output of the companies. The study suggested that the government would be able to contribute to this process by investing more in infrastructural facilities, for example, electricity, gas, construction of roads, the health sector, education, research and development. The study of Shapirov (2015) showed that when the economy is in terrible condition and unemployment is going up, people spend less, save less, and invest less. So, John Keynes suggested that when there isn't enough market leverage to boost aggregate demand and get business going again, the government should intervene in macroeconomic policy, also called "fiscal policy," like cutting taxes or increasing government spending (UN, 2011). Furthermore, Keynes suggested that the best way to get the economy going again after the Great Depression was a mix of two things: lowering interest rates (monetary policy) and government investment in infrastructure (fiscal policy).

According to Nguyen and Bui (2019), numerous pieces of evidence point to a genuine and theoretically positive relationship between real per capita growth, GDP, and financial market development, which boosts a country's GDP investment and is strongly related to the performance of the stock market. Economic growth and economic development are terms that are commonly used interchangeably. Economic growth is the expansion of the economy as shown by physical change. On the other hand, economic development describes a process of significant progress in the degree of operations of an economy based on the acquiring of high-calibre skills (Rana, 2021). Similarly, Agrawal (2020) stated that economic development is different from economic growth. It can be said that economic development lifts people out of substandard living conditions and into appropriate jobs and housing, while economic growth disregards the loss of natural resources, which may result in pollution, congestion, and sickness. However, development is concerned with sustainability, which involves addressing present demands without sacrificing future needs.

Figure 3. Economic Growth and Economic Development

2.4.2. Sources of Economic Growth

A study by Błażejowski, Kwiatkowski, and Gazda (2019) identified the variables influencing global economic growth. Indeed, an essential component of a sustainable economic development strategy may be the determination of the sources of economic growth. It could be stated that gross national saving (as a percentage of GDP) and gross fixed capital formation (as a percentage of GDP) were the most likely drivers of economic growth.

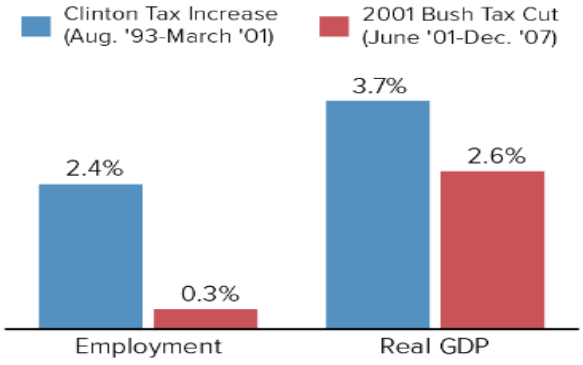

Figure 4. Employment and Real GDP Trend (Stone, 2017)

The above-presented figure 4, presented by Stone (2017), develops a relationship between different decisions taken by the federal government in the USA and their impacts on the performance of the GDP. From August 1993 to March 2001, the Clinton administration increased tax collections by raising taxes on the rich. Due to this reason, they began to offer more employment to the countrymen. As per the figure, the rate of employment during his tenure was 2.4%, while the country's real GDP was 3.7%. On the other hand, the Bush administration cut taxes between June 2001 and December 2007. During this period of time, the employment rate was only 0.3%, while real GDP was reduced and reached 2.4% (Stone, 2017).

From the analysis of the above-presented figure, it can be stated that the growth in a nation's economy depends on the direct relationship between job creation and the economy. On the other hand, the poor rate of employment has direct negative impacts on the real GDP. In addition, cutting taxes on the rich isn't a guarantee to spur growth, and strong economic and employment growth may occur even with higher taxes. Furthermore, small business job growth was also stronger under Clinton. The economy continued to grow and add employment after the Bush tax cuts for the very highest-income households expired at the end of 2012. On the other hand, according to economists Bill Gale and Andrew Samwick, who conducted a thorough analysis of the literature, "growth rates in the United States over extended periods of time have not changed in parallel with the huge changes in the structure and revenue yield of the tax system that have occurred."

Feng, Wang, Liu, & Huang (2017) describe the sources of economic growth as five variables that contribute to economic growth: the technology impact, the industrial structure effect, the regional development balance effect, the management effect, and the influence of the production factors. According to this study, these are the few important natural factors that indirectly give pace to the performance of business sectors and influence the growth of the economy. A study conducted by Moti (2019) stated that despite the availability of more resources in many resource-rich African nations, they have only seen minimal development from natural resource booms. Failure to execute the proper growth promotion policies and maintain strong institutions makes it difficult to diversify and expand manufacturing in resource-rich portions of Africa. Many African countries are not industrialized and are reliant on mineral exports.

The theory that having access to natural resources—especially those in the form of minerals or oil—does not guarantee economic success and that resource richness may even have structurally detrimental effects on long-term economic growth is known as the "resource curse." Although it may seem strange to suggest that a nation's access to a valuable and frequently necessary economic input could be detrimental to its ability to advance economically, scholars who believe in the "resource curse" contend that, more often than not, resource-rich or resource-dependent nations function worse than nations with few natural resources.

2.5. Factors Affecting the Performance of Stock Market

2.5.1. Capital Formation

Emeka, Idenyi, and Nweze (2017) determined whether there is a substantial long-term and causal relationship between domestic investment, capital formation, and economic growth in Nigeria. The study suggested that to finance investment for the purpose of achieving economic growth and development, every economy needs to mobilize capital. The study findings reveal that there is a significant long-term relationship between domestic investment and capital formation and that both of these factors contribute to economic growth. However, gross fixed capital formation in Nigeria has not kept pace with the rate of domestic investment growth. As explained in this study, gross capital formation contributes to technological advancement, which helps in realizing economies of scale or operation and promotes specialization in terms of providing machinery, tools, and equipment. As a result, the accumulated capital allows for the acquisition of additional productive capital equipment.

2.5.2. Capital Formation

Economic growth and economic development are used interchangeably; however, there is actually a distinction between both concepts: economic growth refers to improvement in output, while economic development refers to the quality of improving the production process, the efficient use of resources, and enhancements in the quality of life. Hence, the difference in measurement

methods could cause some kind of inequality and reward due to some economic sectors having enough resources while others don't. The negative effects of economic growth, such as pollution, environmental issues, etc., should be controlled and rectified to achieve economic development. Ruchika, Sikarwar, Middi, and Appalaraju (2018) investigated the relationship between the performance of the stock market and economic growth in India. The results revealed a uni-directional causal relationship between GDP and the return of the stock market. The study by Agarwal and Zhang (2020) measured economic growth as the increase in a nation's real gross domestic product (GDP) or gross national product (GNP). The gross domestic product (GDP) of a nation is the total value of all final goods and services produced in that nation over a given time period. Therefore, an increase in GDP indicates an increase in production. GDP is used to measure the performance of the economy of a country (Simionescu et al., 2017). Ho & Odhiambo (2018) conducted a study to analyze stock market macroeconomic factors. The study examined the impact of banking sector development, inflation, exchange rate, economic growth, trade openness, and stock market liquidity. The study concluded that such a policy will benefit the stock market's long-term development by raising exporters' desire for equity financing. Furthermore, policymakers should also stimulate banking sector expansion to boost short-term stock market growth. Policymakers should support local currency stability to foster short-term stock market growth.

The economy of a country includes many factors that combine to work for the growth of the nation. In this regard, a study conducted by Rodrigue (2021) depicts that there are only three important elements of the economy. These are regulations, manufacturing, and distribution. Moreover, economies are primarily concerned with the interrelationships between supply and demand. For a country, manufacturing and distribution are becoming increasingly intertwined as a result of the rise of logistics. To make things even more complicated, all of these aspects, particularly manufacturing, rely on inputs, which are more properly referred to as components of production. Land with the inclusion of natural resources, labour, and capital all falls under this category. Rodrigue (2021) added the fourth component, since its primary function is to organize the other factors of production. All these aspects, notably manufacturing, need inputs, sometimes called production factors. Land, money, and labour are the basics. In addition, the corporation is seen as another factor, as its role is crucial in organizing other factors of production into a manufacturing process.

In a similar context, Beattie (2021) explored four key elements that contribute to effective performance in the world market: supply and demand, scarcity, incentives, costs, and benefits. The study highlights the limited nature of global resources, requiring careful allocation to meet needs efficiently. Similarly, Kim (2018) analyzed supply and demand in relation to oil production, explaining dramatic oil price drops as driven by these factors. During the initial oil price decrease, genuine demand reduction had a larger impact, while the second decrease was influenced by both supply issues and speculative demand.

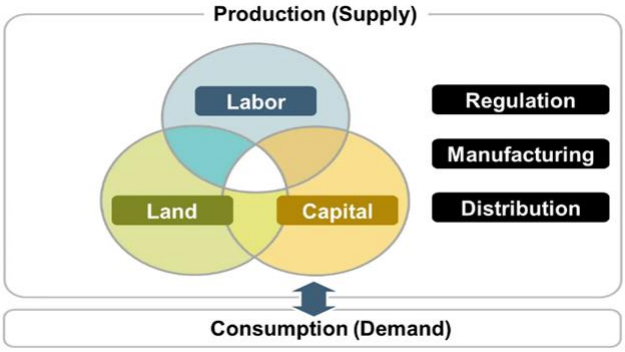

Figure 5. Elements of Economy (Rodrigue, 2021)

Bachner, Mayer, and Steininger (2019) examined the effect of costs and benefits on economic decisions, focusing on the transition from fossil fuels to renewable energy. They found that investors perceive renewable energy as more capital-intensive, suggesting that reducing financial risks for renewables could support long-term climate goals. Focusing on consumption, Arapova (2018) analyzed factors influencing household consumption expenditures in East Asian countries.

2.6. Linkages between Stock Market Development and Economic Growth

Economists have long been captivated by the relationship between financial development and economic growth, given that stock market expansion can drive economic progress. Banerjee et al. (2017) found a correlation between financial sector improvements and economic development, consistent with Schumpeter (1912). Tigari and Aishwarya (2019) emphasized that capital market development is a measure of economic growth, guiding savers' funds towards productive investments. Regulatory bodies such as the Bank of England and the US SEC ensure that capital markets operate ethically, which is crucial for industrial and economic growth.

2.6.1. Government Expenditure

Ayad (2020) proposed five theories explaining the link between economic development and government spending, including Wagner's law and Keynesian theory. These theories suggest that economic progress leads to increased government spending or vice versa. The findings have implications for MENA policymakers, where countries like Algeria, Egypt, and Iran should use government expenditure to foster long-term growth, while others like Tunisia and Turkey should leverage economic growth to enhance government spending.

Simionescu et al. (2017) linked economic prosperity in the Eurabian nations to integration and expansion, highlighting factors like government spending on education and FDI. Arayssi et al. (2019) examined the impact of the Arab

Spring, noting its adverse effects on economic stability and growth, particularly in non-oil-producing countries. Political instability has hindered financial progress, with regional economic development slowing post-2011.

Emara (2020) noted that while MENA economies experienced some growth, it was uneven across the region. Oil-exporting countries recovered faster from economic downturns, while non-oil nations faced challenges such as security concerns and refugee crises. Foreign investment in the region helped recovery but was hindered by conflicts and instability.

Kutan, Samargandi, and Sohag (2017) highlighted differing perspectives on the relationship between financial development and economic growth in MENA countries. Gwaison et al. (2021) also pointed out the benefits of capital markets but cautioned against over-reliance on them for boosting economic growth. Awdeh and Hamadi (2018) emphasized the role of natural resources and labor in driving growth in MENA, but noted that despite favorable conditions, sustained economic performance has been elusive.

2.6.2. Corruption & FDI

Corruption, defined as preferential treatment by public decision-makers, has negative implications for investment and economic growth (Krueger, 1974; Tullock, 1980, as referenced in Awdeh & Hamadi, 2018). It hampers business formation, distorts markets, and raises costs. Rogmans and Ebbers (2018) found that resource-rich nations often implement anti-FDI laws, contributing to the "Dutch Disease." Kutan et al. (2017) emphasized that FDI can support financial market development in MENA, but its impact is not uniform across all countries.

2.6.3. Labour Market Conditions

Awdeh and Hamadi (2018) identified key barriers to economic advancement in MENA, including state debt, military expenditure, and political instability. They argued that MENA countries need to focus on private-sector-led growth and improve educational programs to address labor market challenges. High population growth rates and brain drain are additional barriers to economic progress in the region.

2.6.4. Foreign Direct Investment

Qamruzzaman and Wei (2019) highlighted the role of FDI in enhancing capital flow, productive investment, and financial market efficiency. Abdelhadi et al. (2021) found that foreign investment positively impacts economic growth by transferring technology and know-how. Saidi and Mbarek (2015) noted that energy consumption and technological advancement are crucial for economic growth in MENA, while Sothan (2017) emphasized that FDI's impact varies based on country-specific factors.

2.6.5. Human Capital and Employment

Pasara and Garidzirai (2020) emphasized employment expansion as a means of promoting economic growth. They recommended increased government spending on capital goods to boost employment. Mckee et al. (2017) highlighted the challenges of regional integration and labor market issues in MENA, recommending education reforms to improve workforce skills.

2.6.6. Unemployment, Economic Growth, and Gross Capital Formation

Pasara and Garidzirai (2020) found that physical capital formation helps reduce unemployment and boost economic growth. Ogundari and Awokuse (2018) noted that both education and health positively impact economic growth in Sub-Saharan Africa, though health has a greater influence.

2.7. Relationship between Macroeconomic Factors and Economic Growth

The business cycle is crucial for understanding the relationship between macroeconomic conditions and economic growth.

2.7.1. The business cycles In the Holy Qur'an

The Holy Qur'an provides valuable insights into economic cycles and strategic planning. In Surah Yusuf (Ayat 43 to 56), Prophet Yusuf interpreted the Egyptian king's dream involving seven fat cows being eaten by seven thin cows, and seven green wheat bunches alongside seven dried ones. He advised storing the harvest from seven years of abundance to prepare for seven years of scarcity, followed by years of prosperity. This guidance enabled Egypt to navigate economic challenges effectively, emphasizing the importance of foresight, planning, and resource management during periods of both growth and hardship. The story demonstrates how strategic planning and preparedness can help stabilize economies and ensure sustainable development. Such wisdom is applicable in modern contexts, highlighting the importance of proactive economic policies to mitigate future crises and promote resilience.

2.7.2. The business cycles In the Holy Qur'an

Hall, West, and Gunn (2015) found that negative signals about future financial returns can lead to economic cycles, even without changes in domestic fundamentals like technical shocks or fiscal policies. Their research highlighted the role of uncertainty in causing business cycles and showed that recessions are often accompanied by increased microeconomic uncertainty. Uncertainty shocks can cause a 2.5% drop in GDP, and adding first-moment shocks helps explain consumption patterns across the cycle. Hall argued that negative first-moment shocks combined with positive second-moment shocks provide the best model for recessions, and increased uncertainty can also reduce the effectiveness of first-moment programs like wage subsidies.

Yıldırım-Karaman (2018) provided evidence of the negative impact of financial market volatility on real output, particularly during financial crises such as the 2008 Great Recession. The collapse of Lehman Brothers triggered widespread panic, increasing market volatility and reducing consumption, investment, employment, and production. This highlights how financial volatility can have a significant negative effect on aggregate demand and economic output.

Begenau (2018) examined how financial frictions influence firms' borrowing decisions over the business cycle, focusing on when firms seek loans versus equity capital. The study found that company dynamics and financial frictions interact to shape financing decisions, with small firms adopting a pro-cyclical debt and equity financing approach, while large firms shift between debt and equity based on economic conditions. Changes in funding capacity and needs determine firms' external financing behavior. During favorable periods, reduced debt costs may encourage firms to adjust their capital structure to include more debt. However, small firms unable to finance investments through debt alone may turn to equity issuance.

Schumpeter (1939) argued that analyzing business cycles is akin to analyzing the economic process of capitalism. His Theory of Economic Evolution laid the foundation for integrated growth and cycle analysis. Schumpeter emphasized the concept of Creative Destruction, where the liquidation and reallocation of productive resources during recessions are essential for long-term development. He believed that crises serve as a necessary "spring cleaning" to enable new economic growth, reflecting capitalism's inherent resilience.

2.7.3. Macroeconomic Factors

Chun, ho, and Ryu (2020) suggested that investors should rely on stock market indicators to evaluate daily market risk in order to anticipate the economy's performance. As a result, the researcher conducted an examination to validate the volatility index VKOSPI's usefulness as a daily trading indicator. VKOSPI is South Korea's largest stock market index. As a result, the study advises introducing volatility index (VKOSPI) futures contracts to raise the index's credibility, because greater openness and more information will improve the underlying market's efficiency and completeness. The study's findings suggest that implied volatility indices and stock market indicators can anticipate market volatility. Furthermore, a country's economy comprises several components that work together to promote national growth. Similarly, a study done by Rodrigue (2021) shows that there are just three key aspects of the economy. Regulations, production, and distribution are examples of these. Furthermore, economies are preoccupied with the interdependence between supply and demand. Furthermore, with the expansion of logistics, production and distribution are becoming increasingly interwoven for a country. Furthermore, all of these components, particularly manufacturing, rely on inputs, also known as production factors, to carry out their activities. In their most basic forms, they consist of land (including natural resources), capital, and labour. Because the organization's basic duty is to organize the other parts of production into a functioning unit, the corporation is sometimes seen as the fourth component.

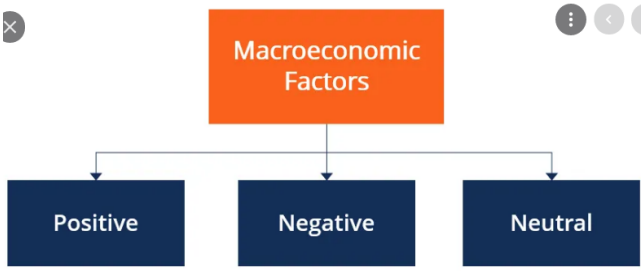

Figure 6. Macroeconomic Factors (Corporate Finance Institute, 2015)

Negative economic growth causes such as political upheavals in a country, unstable governments, financial crises, and high inflation rates are those that have a direct impact on a country's economy. With the aid of an example, if there is a worry of political instability in the worldwide market regarding a given country, there is a probability that an international conflict will occur or that their people would experience civil war. Furthermore, as Seyoum and Camargo (2020) discovered, political instability has a direct impact on a country's economy. This may be witnessed in Afghanistan, Yaman, Iraq, and Lebanon, which are some clear examples of nations whose economies have suffered as a result of political instability. A condition like this in a country not only increases economic volatility as a result of inadequate resource reallocation, but also promotes economic degradation, people flight (brain drain), low levels of inbound FDI, and economic decline.

In the same direction, but another research study undertaken by Maris, Sklias, and Maravegias (2021) focused on the other macroeconomic elements that influenced the economy's growth. This element is known as the economic crisis, and it primarily impacts the flow of commodities owing to a drop in demand caused by a shortage of liquid money in the market and a credit crunch, which reduces people's spending power. For example, the 2008 financial crisis primarily impacted US banking institutions, but it ultimately impacted the global economy. This is due to the interdependence of the economy of the countries. Furthermore, the study focused on the political causes of the crisis in order to determine whether they were the primary causes of the economic crisis (particularly over the last decade) as well as the primary causes of Greek and European officials' inability to overcome the crisis. Furthermore, Greece's macroeconomic data, such as GDP and budget deficits/surpluses, may have improved. It has not, however, enhanced the operation of its institutional mechanisms, which are critical to its efficient structure and

healthy operation.

Some economic elements are neutral in nature. Instead, the purpose of the action, such as trade regulation between states or nations, determines the exact repercussions. When a trade embargo is imposed or withdrawn, for example, it has a number of implications depending on the economy affected. Huy et al. (2020) carried out a study that revealed the favourable macroeconomic elements that promote economic growth. Macroeconomic and financial policy must take into consideration both internal and global effects, such as US inflation. Furthermore, the stock market, and hence the stock price, is positively associated with lending interest rates and exchange rates. As a result, banks and government agencies must monitor and balance capital sources in order to avoid using short-term funds to pay long-term projects. Similarly, due to the interconnectedness of the nations' economy, it has been seen that US inflation correlates favourably with stock prices and the Viet Nam stock market. As a result, if US inflation rises or declines, the government must adopt appropriate macroeconomic actions.

Islam, Alharthi, and Murad (2021) explored the effects of inflation on economic growth by adding the influence of population. They found that inflation and population have distinct effects on economic growth in the short term, but both are positive for economic growth in the long run. The study, on the other hand, indicated that inflation causes GDP to rise faster, but only marginally. Furthermore, as the economy is at full capacity, higher inflation is likely. A negative link between inflation and economic growth, on the other hand, may indicate that the economy is moving along the horizontal section of the long-run aggregate supply curve.

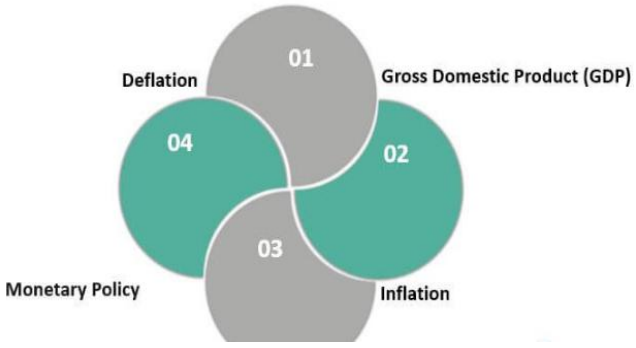

Figure 7. Economy and Macroeconomic Factors

Macroeconomic policies have played a key role in shaping the nation's economic development, combining liberalization, structural reforms, and interventionist measures to promote growth and stability. These policies address challenges such as inflation, fiscal deficits, unemployment, and infrastructure gaps, while fostering market-oriented reforms and encouraging foreign investment. Additionally, countercyclical measures have been adopted to mitigate economic downturns, and the Reserve Bank has ensured price stability through effective monetary policy. Overall, these efforts focus on achieving sustainable and inclusive growth, balancing industrial development, poverty reduction, and environmental sustainability (Srisiim, n.d.).

Similarly, in recent years, economic growth and financial development have been more prominent research topics, with various studies seeking to uncover the causal relationship between them. These research, for example, focused on two fundamental questions: Is there a causal relationship between economic growth and financial development, and what is its nature and direction? According to Qamruzzaman and Wei (2019), all financial processes may be accelerated to increase the economy, and financial innovation, in particular, supports economic growth. Financial innovation strengthens the financial system by diversifying banking services and mitigating investment risk through capital market financial instruments. The author discovered that capital flows impact productive investment, lowering capital constraints, and investment diversification by researching the relationship between capital flow and economic growth.

Several development economists, on the other hand, have acknowledged the relevance of finance in economic growth. Others argue that economic growth and development are a complex process influenced by the development of financial markets. Furthermore, capital movement improves market efficiency by exposing it to international competition and developing new financial goods and services that attract both domestic and foreign investors. Furthermore, all of these market imperfections can boost the efficiency with which resources are distributed. These studies also suggest that endogenous growth models have an effect on the link between financial growth and development. Endogenous growth suggests that a well-developed stock market may improve liquidity, information processing, diversification, and capital mobilization.

Furthermore, it has the ability to improve long-term economic growth and development. Proponents of this idea argue that the stock market may stimulate effective capital allocation due to its economic character. According to Nathaniel et al. (2020) the stock market capitalization ratio, the value of traded shares, and the market turnover ratio all had a significant influence on economic growth, however the value of traded shares had a negative impact. As a result, the determinants of stock market development are connected with economic growth in the long run.

3. Conclusion

The findings of this study underscore the significant influence of financial innovation and market capitalization on economic growth. Financial innovation, through advancements in fintech solutions such as mobile banking and electronic payments, has played a crucial role in enhancing financial inclusion and improving economic development, particularly in emerging markets. Market

capitalization is also a key contributor, especially in developed economies where a well-capitalized stock market promotes liquidity, attracts foreign investments, and provides businesses with access to much-needed equity financing.

Furthermore, ICTs and digital technologies are regarded as transformational, particularly in terms of good governance and sustainability. Similarly, financial and technical improvements have propelled modern economic expansion, as noted by Todaro and Smith (2012). In oil-dependent countries, economic growth is closely linked to fluctuations in oil prices, and these economies often face challenges such as low GDP per capita due to high population growth rates. Regional growth is mainly driven by capital accumulation rather than productivity improvements.

The study also highlights the importance of a stable macroeconomic environment in fostering investor confidence and promoting financial stability. The impact of financial innovation and market capitalization differs between global and emerging markets, with developed economies benefiting more due to their established financial infrastructure, while emerging markets gain through improved access to financial services.

Overall, the study concludes that both financial innovation and market capitalization are vital to economic growth, but the extent of their impact is contingent on the maturity and structure of the financial market in each region. Financial and technical breakthroughs are essential for emerging countries to maintain their economic success. Future research should focus on empirical studies that explore the specific factors driving these differences, particularly in individual countries.

4. Policy Recommendations

The study suggests policy measures to enhance market capitalization, improve access to banking for underserved populations, foster fintech startups, invest in financial market infrastructure, and improve market transparency to build investor confidence. Financial development has a positive influence on economic growth, especially in the pre-crisis period, and initiatives should be directed at reinforcing the banking sector, fostering financial inclusion, and ensuring the stability of financial markets.

5. Policy Recommendations

This study provides a comprehensive comparative literature review of financial innovation, market capitalization, and their effects on economic growth. However, there are limitations to consider. The literature review is inherently limited by the availability of peer-reviewed studies and economic reports, which may not cover all regions equally. Additionally, the study's reliance on secondary data restricts the ability to draw causal relationships, as the findings are based on correlations observed in existing literature.

Another limitation is the focus on both developed and emerging markets without delving deeply into individual country-specific contexts. Future research could expand on the findings by conducting empirical studies specific to particular countries or regions to validate and refine the conclusions drawn from this comparative review.

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Araştırma Makalesi ● Research Article

Leveraging AI for Sustainable Development: A Scoping Review on Social Work's Contribution to the SDGs

Sürdürülebilir Kalkınma İçin Yapay Zekadan Yararlanmak: Sosyal Hizmetin Sürdürülebilir Kalkınma Amaçlarına Katkısı Üzerine Kapsamlı Bir İnceleme

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ANAHTAR KELİMELER

Sürdürülebilir Kalkınma Amaçları
Yapay Zeka
Sosyal Hizmet
Sosyal Fayda

ÖZ

Yapay zeka (YZ) ile sosyal hizmetin kesişim noktası, özellikle Sürdürülebilir Kalkınma Amaçları (SKA'lar) doğrultusunda sosyal faydanın artırılmasına yönelik önemli olanaklar sunmaktadır. Bu derleme çalışması, YZ'nin sosyal hizmet alanındaki uygulamalarını ve SKA'lara olan katkılarını ele alan mevcut literatürü kapsamlı bir şekilde incelemeyi amaçlamaktadır. Literatür taraması, birden fazla veri tabanında yürütülen sistematik bir araştırma yoluyla gerçekleştirilmiş olup çocuk refahı, ruh sağlığı ve toplum geliştirme gibi YZ'nin uygulama alanlarını vurgulamaktadır. Çalışma, bu uygulamaların sağladığı faydaları, karşılaşılan zorlukları ve ilgili etik meseleleri detaylı bir şekilde tartışmaktadır. Elde edilen bulgular, YZ'nin SKA'lara ulaşmadaki potansiyelini daha etkin bir şekilde değerlendirebilmek için sosyal hizmet profesyonelleri ile YZ uzmanları arasında disiplinlerarası iş birliğinin ve daha fazla araştırmanın gerekliliğine dikkat çekmektedir.

KEYWORDS

Sustainable Development Goals
Artificial Intelligence
Social Work
Social Good

ABSTRACT

The intersection of artificial intelligence (AI) and social work presents significant opportunities for advancing social good, particularly in alignment with the Sustainable Development Goals (SDGs). This scoping review aims to map the existing literature on the application of AI in social work and its contributions to the SDGs. Conducting a comprehensive search across multiple databases to identify studies that explore the use of AI in various social work practices, the findings highlight key areas where AI has been utilized, including child welfare, mental health, and community development, and discuss the benefits, challenges, and ethical considerations associated with these applications. This review underscores the need for further research and collaboration between social work professionals and AI experts to harness AI's potential for achieving the SDGs.

1. Introduction

The United Nations' Sustainable Development Goals (SDGs) represent a global agenda to achieve a better and more sustainable future for all by 2030 (United Nations, 2015). Social work plays a crucial role in achieving the United Nations' Sustainable Development Goals (SDGs), a set of 17 global goals aimed at ending poverty, protecting the planet, and ensuring prosperity for all by 2030 (Smith, 2013). Social support activities carried out by public, private and other actors providing social support services should be permanent and sustainable (Abay and Abay Çelik, 2023). Social workers are at the forefront of efforts to address social determinants of health, advocate for human rights, and promote social justice—core elements that align with the SDGs.

Artificial Intelligence (AI) has increasingly become a transformative force across various sectors, including healthcare, education, and social services. In the field of social work, AI has the potential to revolutionize practice

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and enhance service delivery by providing innovative tools for data analysis, client management, and decision-making (Cariceo et al., 2018). AI technologies, such as machine learning algorithms, natural language processing, and predictive analytics, can assist social workers in identifying at-risk individuals, personalizing interventions, and optimizing resource allocation. These applications hold significant promise for improving outcomes in various areas of social work, including child welfare, mental health, elder care, and community development. The importance of AI in social work lies in its potential to enhance service delivery, improve client outcomes, and address complex social issues through data-driven approaches (Gillingham, 2019).

Despite the growing interest in AI, its integration into social work practice remains at an early stage. There are concerns about ethical implications, such as data privacy, algorithmic bias, and the potential reduction of human interaction in a profession traditionally centered on empathy and personal relationships (Fernando and Ranasinghe, 2023). These concerns necessitate a careful examination of how AI can be ethically and effectively integrated into social work to ensure that it aligns with the core values of the profession, such as social justice, human dignity, and respect for diversity.

Given the transformative potential of AI and the critical role of social work in achieving the SDGs, there is a need for a comprehensive scoping review to explore the intersection of these fields. Such a review would map existing research, identify gaps, and highlight best practices for leveraging AI to enhance social work's contributions to the SDGs. By understanding the current state of AI applications in social work, stakeholders can better harness these technologies for social good, ensuring that the profession remains at the forefront of efforts to create a more just and equitable world. This scoping review aims to map the current landscape of AI applications in social work and explore their contributions to the SDGs.

2. Methodology

Scoping reviews provide valuable insights into a concept's nature and its literature over time, helping decision-makers shape research agendas, advance the field, and identify areas for future systematic reviews or evidence synthesis (Peters, et al, 2020). Thus, scoping review methodology was employed to identify and analyze studies on the use of AI in social work that contribute to SDGs. We searched multiple databases, including Google Scholar, Scopus, Web of Science, Dergipark and TRDizin, using a combination of keywords related to AI, social work, and the SDGs in both English and Turkish articles. Studies were screened for relevance based on predefined inclusion and exclusion criteria.

To ensure that the review is focused and relevant, the following inclusion and exclusion criteria has been applied:

2.1. Inclusion Criteria

Relevance to AI and Social Work: Studies must focus on the application of AI technologies for social good or in social work practice, education, or research.

Contribution to SDGs: Studies must discuss how AI applications in social work related areas can contribute to one or more of the SDGs especially to 1 (No Poverty), 3 (Good Health and Well-being) and 16 (Peace, Justice, and Strong Institutions).

Study Types: Empirical studies, including quantitative, qualitative, and mixed-methods research, and systematic reviews and meta-analyses.

Publication Type: Peer-reviewed journal articles, conference proceedings, book chapters and reports from reputable organizations.

2.2. Exclusion Criteria

Lack of Focus on AI or Social Work: Studies that do not explicitly address AI applications in social work or their impact on the SDGs.

Non-Empirical Studies: Editorials, and commentaries.

Duplicate Publications: Duplicate studies from different databases have been removed, with the most recent and comprehensive version retained.

Non-English and Non-Turkish Language Publications: Studies not published in English or Turkish has been excluded.

Records have been screened via Rayyan, a web-based tool to expedite the initial screening of the abstracts and titles using a process of semi-automation (Ouzzani et al., 2016). Data extraction has been conducted using a standardized form to ensure consistency and accuracy. The following key information has been extracted from each included study. Study Identification: Author(s), year of publication, and country of study. Study Design: Type of study (e.g., quantitative, qualitative, mixed-methods, systematic review), methodology, and data collection methods. AI Technology: Description of the AI technology used (e.g., machine learning, natural language processing), purpose, and application in social work. SDG Addressed: Specific SDG(s) addressed by the study and how the AI application contributes to these goals. Contribution to SDGs: How the study contributed to SDGs. Key Findings: Key findings related to the impact of AI in social work and its contribution to the SDGs. Challenges: Identified ethical, technical, and practical challenges of using AI in social work. Conclusions and Suggestions: Conclusions drawn by the study and any suggestions for future research or practice.

3. Results

The PRISMA flow diagram based on this scoping review is as follows:

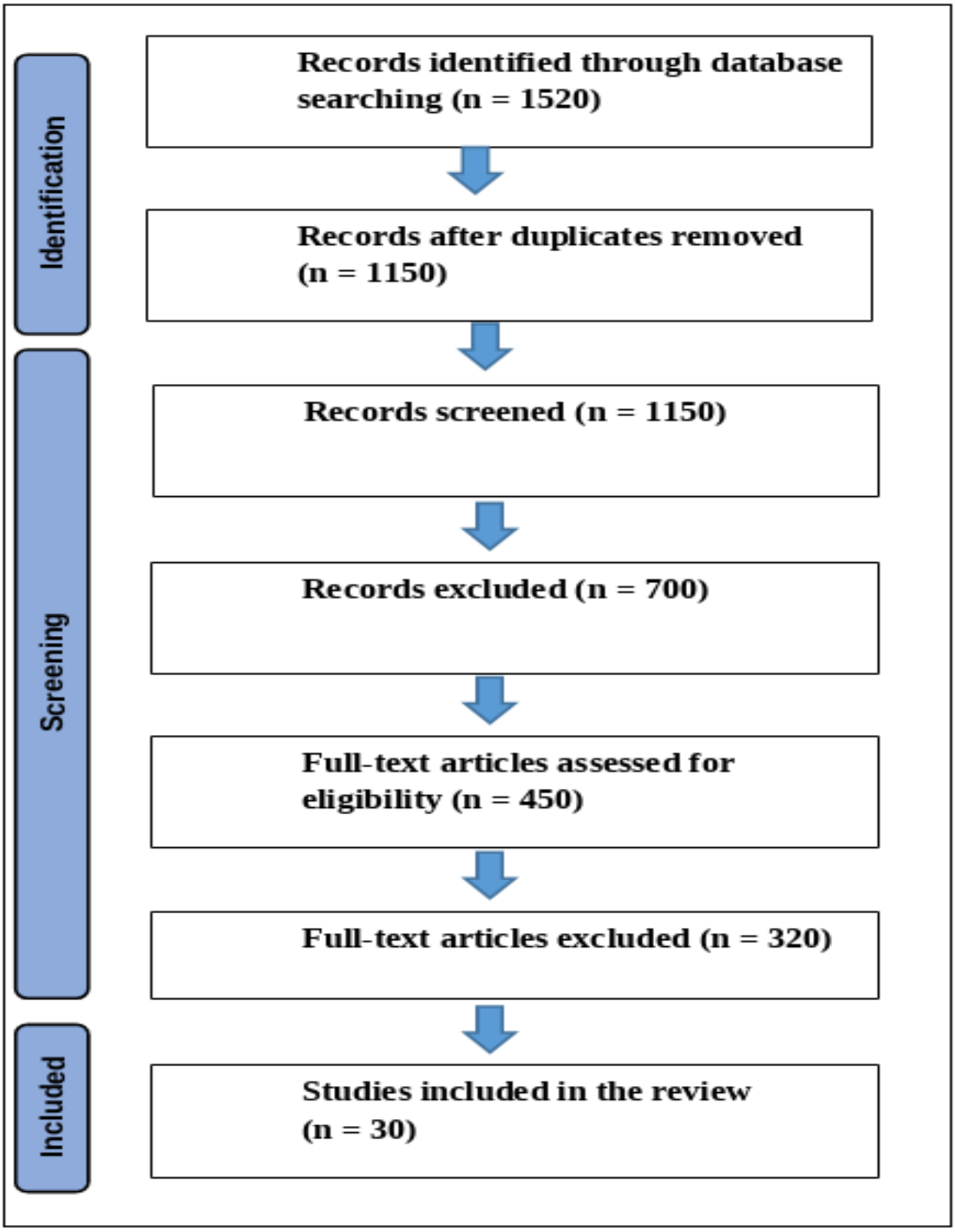
Identification
Screening
Included
Records identified through database searching (n = 1520)
Records after duplicates removed (n = 1150)
Records screened (n = 1150)
Records excluded (n = 700)
Full-text articles assessed for eligibility (n = 450)
Full-text articles excluded (n = 320)
Studies included in the review (n = 30)

Figure 1. The PRISMA flowchart of the study

Table 1, Table 2, Table 3, Table 4, Table 5 and Table 6 provide a comprehensive overview of the 30 studies included in the scoping review, highlighting their key characteristics, applications, and contributions to the SDGs.

Table 1. Overview of Included Studies: The Studies 1 to 5

Category	Study 1	Study 2	Study 3	Study 4	Study 5
Author(s), Year	Kawakami, A., et al. (2022)	Patton, D. U., et al. (2016)	Goralski, M. A. and Tan, T.K. (2022)	Özen, H. (2021)	Ngũnjiri, A., et al. (2023)
Title	Improving Human-AI Partnerships in Child Welfare: Understanding Worker Practices, Challenges, and Desires for Algorithmic Decision Support	Using Natural Language Processing and Qualitative Analysis to Intervene in Gang Violence: A Collaboration Between Social Work Researchers and Data Scientists	Artificial intelligence and poverty alleviation: Emerging innovations and their implications for management education and sustainable development	Evaluation of Digital Health Services in Terms of Sustainable Development Goals	Utilizing User Preferences in Designing the AGILE (Accelerating Access to Gender-Based Violence Information and Services Leveraging on Technology Enhanced) Chatbot
Journal	CHI Conference on Human Factors in Computing Systems (CHI '22)	Bloomberg Data for Good Exchange Conference	The International Journal of Management Education	OPUS International Journal of Society Researches	International Journal of Environmental Research and Public Health
Country	United States	United States	United States	Turkiye	Kenya
Study Design	Qualitative	Qualitative	Theoretical and Qualitative	Theoretical and Qualitative	Exploratory Qualitative Study
Methodology	Contextual inquiries and semi-structured interviews	Digital Urban Violence Analysis Approach (DUVAA), a collaborative qualitative analysis method combining grounded theory with natural language processing (NLP)	Review and analysis of AI applications in agriculture, integrating political economy analysis and business management strategy to assess their impact on poverty alleviation	Qualitative analysis of existing literature and digital health services in Turkey, with a focus on their alignment with the Sustainable Development Goals.	The study involved focus group discussions (FGDs) with 150 participants, including adolescents, young women, young men, and sexual and gender minorities, to gather insights on user preferences for the AGILE chatbot. The data were analyzed using thematic analysis grounded in theory.
Data Collection Methods	Observations of call screeners and supervisors during their work, semi-structured post-interviews with workers	Analysis of approximately 800 tweets from known gang-involved youth in Chicago; Human annotation of tweets by interdisciplinary team, including youth from violent neighborhoods, social work researchers, and	Literature review and analysis of existing AI applications in agriculture, focusing on innovations like FarmView, robot bees, and CRISPR technology	Review of secondary sources, including academic literature, reports, and existing digital health initiatives.	Focus Group Discussions (FGDs), Desk Review of LVCT Health one2one™ digital platform, Prototype Simulation Exercise, Engagement Questionnaire for AGILE Chatbot

		data scientists.			
AI Technology	Algorithmic Decision Support (ADS) tool called the Allegheny Family Screening Tool (AFST)	Natural Language Processing (NLP)	Machine Learning, Robotics (Robot Bees), Gene Editing (CRISPR)	Telemedicine, mobile health applications, and artificial intelligence in the context of digital health.	AGILE Chatbot designed to provide GBV-related information and advocate for health-seeking behavior change among users.
Purpose	To understand how social workers at a child welfare agency integrate AI-assisted decision support tools (AFST) into their decision-making processes and to identify design opportunities for more effective human-AI partnerships in child welfare.	To develop a suite of NLP tools to decode the high-stress language of urban, gang-involved youth on social media and predict clusters of aggressive language that may escalate into real-world violence.	To explore how AI innovations, particularly in agriculture, can contribute to poverty alleviation and sustainable development, and to examine their implications for management education.	To examine the impact and contribution of telemedicine and mobile health services, that are also spreading in Turkey, on sustainable development goals.	To understand user preferences, expectations, acceptability, and motivation for using the AGILE chatbot and to apply these insights in developing a human-centered design for the chatbot.
Application in Social Work	AI-assisted decision-making in child welfare, specifically for child maltreatment screening and risk assessment in a child welfare agency	Violence prevention and intervention by analyzing social media communications to detect and predict potential gang-related violence	AI applications in agriculture to alleviate poverty by enhancing agricultural productivity, supporting sustainable food systems, and reducing inequality	The study is focused on the broader field of public health and how digital health services can support social well-being.	The chatbot is intended to offer support and information related to gender-based violence (GBV) for vulnerable populations, including adolescents, young women, and young men, which aligns with the objectives of social work in providing resources.
SDGs Addressed	SDG 3 (Good Health and Well-being), SDG 16 (Peace, Justice, and Strong Institutions)	SDG 16 (Peace, Justice, and Strong Institutions)	SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action)	SDG 3 (Good Health and Well-being), SDG 10 (Reduced Inequalities), SDG 13 (Climate Action)	SDG 3 (Good Health and Well-being), SDG 5 (Gender Equality), SDG 10 (Reduced Inequalities)
Contribution to SDGs	Enhances decision-making accuracy and consistency in child welfare, potentially reducing biases and improving outcomes for children.	Provides tools for early detection and intervention in violent behavior, contributing to the reduction of gang violence and promotion of safer communities.	Enhances food security, promotes sustainable agriculture, and supports economic growth by improving agricultural productivity and resilience to climate change	The study suggests that digital health services directly contribute to SDG 3 by improving access to healthcare and indirectly to SDG 10 by reducing inequalities in healthcare access. Additionally, it discusses the potential environmental benefits of digital	The AGILE chatbot aims to improve access to GBV services and information, contributing to better health and well-being (SDG 3), promoting gender equality (SDG 5), and reducing inequalities in access to critical services (SDG 10).

				health services, contributing to SDG 13.	
Key Findings	Social Workers rely on both AI recommendations and their contextual knowledge to make decisions. There is tension between AI recommendations and social workers' own judgment, indicating a need for better integration and design of AI tools.	The study developed an NLP tool that could classify tweets into categories of aggression, grief, or other. It highlighted the complexity of gang-related communication on social media and the need for combining qualitative insights with machine learning for effective violence intervention tools.	AI technologies such as FarmView, robot bees, and CRISPR can significantly impact poverty alleviation by increasing food production, enhancing sustainable agricultural practices, and improving access to nutrition and economic opportunities for the poor.	Digital health services can significantly improve healthcare access and efficiency. Telemedicine and mobile health applications are particularly effective in overcoming geographical and temporal barriers to healthcare. The study concludes that these technologies have direct implications for SDG 3 and indirect implications for SDGs 10 and 13.	The study identified 14 salient themes related to GBV and sexual and reproductive health. Users expressed a preference for chatbots that offer privacy, and accurate information. The AGILE chatbot could potentially address barriers to healthcare access for vulnerable groups by providing discreet, non-judgmental, and accessible services.
Challenges	Ethical concerns about data privacy and bias, lack of transparency in the AI tool's decision-making process, and organizational pressures that influence social workers' reliance on AI recommendations.	The diverse and complex nature of language used by gang-involved youth, including non-standard English and specific cultural references, poses challenges for NLP. Ethical concerns about the use of social media data and the privacy of individuals involved.	Ethical concerns regarding gene editing, technological access disparities, potential ecological impacts, and the need for inclusive policies that ensure benefits reach marginalized communities.	Challenges include digital inequalities, the need for legal frameworks to support telemedicine, and the integration of these services into existing healthcare systems.	Challenges included the need for accurate and reliable information, ensuring confidentiality, addressing technological barriers (e.g., access to digital devices and internet), and integrating the chatbot with human support services.
Conclusions and Suggestions	The study suggests the need for more training for social workers on AI tools, enhanced transparency of AI models, and the development of ethical guidelines for AI use in social work. It also highlights opportunities for improving human-AI partnerships.	There is a need for continued development of AI tools that integrate both qualitative and quantitative data to better understand and predict gang violence. Future work should focus on refining NLP models and expanding datasets to improve the accuracy and applicability of the tools in various social contexts.	The study concludes that AI has significant potential to support poverty alleviation through sustainable agriculture. It suggests more interdisciplinary collaboration, inclusive policy-making, and integration of AI ethics into education and practice.	The study concludes that while digital health services offer significant potential, there is a need for more inclusive access and supportive policies to fully realize their benefits. The author suggests that these services should be expanded and integrated more widely into public health strategies to maximize their contribution to the SDGs.	The study concluded that a human-centered approach is essential for the design and effectiveness of digital health interventions like the AGILE chatbot. It suggests incorporating features such as emotional awareness, multilingual support, and integration with human services to enhance user engagement and service delivery.

Table 2. Overview of Included Studies: The Studies 6 to 10

Category	Study 6	Study 7	Study 8	Study 9	Study 10
Author(s), Year	Mackenzie Hall, S. (2023)	Lehtiniemi, T. (2024)	Yurttabir, H. H. (2023)	Tuğaç, Ç. (2023)	Tulğan, B. and Pak Güre, M. (2024)
Title	Accelerating AI in an Unequal World – What Should We Do?	Contextual Social Valences for Artificial Intelligence: Anticipation that Matters in Social Work	Integrating Artificial Intelligence into Social Work Education: Opportunities and Challenges	The Role of Artificial Intelligence Applications in the Realization of the United Nations Sustainable Development Goals	In the Echoes of Tomorrow: The Intersection of Social Work and Artificial Intelligence Through the Eyes of Turkish Students
Journal	The Graduate Inequality Review	Information, Communication & Society	The International Conference on Social Work & Social Research	Journal of Turkish Court of Accounts	Journal of Social Service Research
Country	England	Finland	Turkiye	Turkiye	Turkiye
Study Design	Qualitative	Qualitative study based on interviews	Qualitative	Qualitative	Qualitative
Methodology	Analysis of existing literature and case studies on AI's impact on inequality	Analysis of pilot trials in Finnish child welfare services using an AI tool for risk prediction	Review of existing literature and expert opinions on AI integration into social work education	Qualitative analysis focusing on the impacts of AI on SDGs	Qualitative analysis of Focus Group Sessions
Data Collection Methods	Review of secondary sources such as research papers and reports	Semi-structured interviews with caseworkers and professionals involved in the pilot trials	Compilation and analysis of secondary data sources such as articles and reports	Literature review and analysis of existing AI applications relevant to SDGs.	Socio - demographic information form and a semi-structured interview form
AI Technology	General AI technologies, including ChatGPT, facial recognition, automated recruitment pipelines, and cars without drivers.	AI tool for predicting severe risks in child welfare (e.g., emergency placement or custody).	General AI technologies, with a focus on big data analysis, predictive and automatic decision-making, and AI language models (e.g., ChatGPT).	Various AI applications, particularly those used in decision-making and policy development.	AI applications in social work
Purpose	To discuss the accelerating use of AI in the world and the inequalities it introduces, especially for marginalized groups.	To explore the expectations and value of AI in social work, specifically how AI can support or hinder professional knowledge-making processes.	To examine the potential, opportunities, and challenges of integrating AI into social work education, and to encourage reflection on future directions and applications.	To evaluate how AI applications can support the realization of the SDGs, while also addressing the potential risks and ethical considerations involved.	To examine the views of social work students on the impact of AI on social work.
Application in Social Work	AI impacts areas like recruitment, healthcare and surveillance, affecting social work by influencing fairness in service distribution and decision-making.	The AI tool was used in child welfare services to predict risks and support early intervention efforts.	The study discusses how AI can be used in social work education to prepare professionals for dealing with complex social issues, enhance decision-making,	The study discusses the transformative role of AI in various sectors, including social work, highlighting its potential to improve decision-making processes and service	Development of client-centered systems; Risk analysis; Evidence-based practices; Alternative interventions

			and support social good.	delivery.	
SDGs Addressed	SDG 10 (Reduced Inequalities)	SDG 10 (Reduced Inequalities)	SDG 4 (Quality Education) SDG 10 (Reduced Inequalities)	SDG 3 (Good Health and Well-being) SDG 4 (Quality Education) SDG 6 (Clean Water and Sanitation) SDG 8 (Decent Work and Economic Growth) SDG 10 (Reduced Inequalities) SDG 11 (Sustainable Cities) SDG 12 (Responsible Consumption) SDG 13 (Climate Action) SDG 17 (Partnerships for the Goals)	SDG 10 (Reduced Inequalities)
Contribution to SDGs	The article highlights how AI's unfair outcomes exacerbate inequality, especially for marginalized groups, making it relevant to reducing inequalities.	The study discusses how AI tools, if properly contextualized, can help reduce inequalities by improving decision-making processes in sensitive areas like child welfare.	The paper highlights how AI can contribute to social good by addressing social injustices, poverty, and discrimination, and emphasizes the importance of preparing social work professionals to use AI ethically and effectively.	AI is positioned as a powerful tool that can enhance the effectiveness and efficiency of achieving SDGs by providing actionable insights and fostering inclusive access to technology.	Using AI in social work provides time and resource savings.
Key Findings	AI systems often reflect societal biases; Fairness in AI is context-dependent, and current methods of debiasing AI are insufficient.	Caseworkers expect AI to support, not replace, their professional judgment by providing contextually relevant information; AI's predictions should be seen as tools to facilitate client interactions rather than as definitive outcomes; The use of AI in social work must consider the specific context and needs of the field, emphasizing the importance of human expertise.	AI has the potential to improve social work education by offering new tools for understanding and addressing social issues; The integration of AI into social work education must consider ethical issues, such as maintaining human-centric approaches and avoiding mechanical interactions; Interdisciplinary collaboration is essential to ensure AI is used ethically and equitably in social work.	AI can transform various sectors, but its implementation must consider ethical, legal, and social implications; Vulnerabilities, such as increased inequalities, must be addressed to harness AI's full potential for SDGs.	Perceived opportunities for AI in social work include time and resource savings, reducing bureaucratic tasks, and enhancing evidence-based practices; Challenges include concerns about emotional understanding, privacy, unemployment, and ethical issues.
Challenges	AI's black-box nature makes it difficult to enforce reliability; Addressing bias is complex due to	AI tools can miscategorize clients and provide irrelevant or excessive information,	Ethical concerns related to AI in social work, such as biases and the potential for exacerbating	The study identifies challenges including ethical dilemmas, potential biases in AI systems, and the	Inadequacy in understanding emotions and empathy; Privacy and confidentiality concerns; Increased

	static datasets, entrenched societal injustices, and a lack of flexibility in AI systems.	leading to potential ethical and professional issues; The reliance on historical data can lead to biased predictions that fail to account for individual client circumstances and changes over time.	inequalities; The need to adapt existing educational programs to incorporate AI technology effectively; Balancing the use of AI with the need for human interaction and empathy in social work practice.	need for equitable access to technology across different regions and societal segments.	unemployment; Deepened inequalities; Potential misuse of data; Ethical violations
Conclusions and Suggestions	Diverse voices, especially those from marginalized communities, must be included in AI development;A flexible, complex approach is required to address AI biases rather than relying on standardized metrics .	AI should be designed to support human knowledge-making processes, rather than replace them. Contextual AI valences should be considered to ensure that AI tools are effective and relevant in social work contexts. There is a need for careful contextualization and scaling down of AI-related expectations to align with the realities of social work.	The integration of AI into social work education presents both opportunities and challenges; careful consideration is required to ensure AI is used to enhance, rather than replace, human judgment. Educational programs must evolve to equip future social workers with the knowledge and skills to use AI responsibly. Further research and collaboration are needed to explore the full potential of AI in social work and to address the challenges it presents.	The study concludes that AI has a significant role in achieving the SDGs but stresses the importance of ethical frameworks and inclusive approaches to mitigate risks. Recommendations include enhancing research on AI solutions for SDGs and ensuring equitable access to technologies.	Integration of AI is seen as an opportunity for innovation in social work. Need for addressing ethical concerns and ensuring that AI complements rather than replaces human empathy in social work practice.

Table 3. Overview of Included Studies: The Studies 11 to 15

Category	Study 11	Study 12	Study 13	Study 14	Study 15
Author(s), Year	Brown, A., et al. (2019)	Steele, J. E., et al. (2017)	Umbrello, S., et al. (2021)	Bako, A. T., et al. (2021)	Pulsiri, N., et al. (2019)
Title	Toward Algorithmic Accountability in Public Services: A Qualitative Study of Affected Community Perspectives on Algorithmic Decision-Making in Child Welfare Services	Mapping Poverty Using Mobile Phone and Satellite Data	Value Sensitive Design to Achieve the UN SDGs with AI: A Case of Elderly Care Robots	Using Natural Language Processing to Classify Social Work Interventions	Achieving Sustainable Development Goals for People with Disabilities through Digital Technologies
Journal	CHI Conference on Human Factors in Computing Systems Proceedings	Journal of the Royal Society Interface	Minds and Machines	American Journal of Managed Care	Proceedings of PICMET '19
Country	New Zealand	Bangladesh	Italy	United States	Thailand
Study Design	Qualitative Study	Geostatistical Modeling Study	Theoretical and Conceptual Review	Empirical Study Using Machine Learning	Conceptual
Methodology	Workshops involving families, frontline child welfare providers, and specialists to gather perspectives on algorithmic decision-making in child welfare services. Data were analyzed using a grounded theory approach.	The study used hierarchical Bayesian geostatistical models (BGMs) to predict poverty across Bangladesh by integrating mobile phone call detail records (CDRs) and remote sensing (RS) data.	Value Sensitive Design (VSD) methodology combining empirical, conceptual, and technical investigations with the application of VSD principles to AI-driven care robots.	The study applied Natural Language Processing (NLP) and Machine Learning (ML) algorithms to extract and classify social work interventions from electronic health records (EHR) data. The classification involved a 10-category scheme based on literature and expert consultations.	The study involves reviewing digital technologies and their impact on achieving the Sustainable Development Goals (SDGs) for people with disabilities.
Data Collection Methods	Focus groups, participatory workshops, and scenario-based discussions with comfort maps to evaluate participants' trust and perceived benefits of algorithmic decision-making.	Mobile phone metadata (call detail records), remote sensing satellite data, household surveys (Demographic and Health Surveys, Progress out of Poverty Index, and income data collected by Grameenphone).	Review of existing literature and case studies on care robots for elderly patients, including ethical and design frameworks. No primary data collection.	The data were derived from Eskenazi Health's EHR system, including 815 social worker encounter notes from 408 patients. NLP was used to extract and classify these notes.	Review of various global reports and practices related to digital technologies for people with disabilities.
AI Technology	Algorithmic decision-making tools used in child welfare services, specifically risk assessment algorithms.	Bayesian geostatistical models combining AI and data from mobile phone metadata, satellite imagery, and geographic	Autonomous care robots designed to assist elderly people with daily tasks, provide medical care, and offer companionship	Natural Language Processing (NLP), Machine Learning (ML), and algorithms such as Support Vector Machine (SVM), logistic regression,	The document discusses various digital technologies used to assist people with disabilities.

		information systems (GIS).	using AI technologies such as machine learning, deep learning, and AI-driven decision-making.	and Naive Bayes were used to classify social work interventions.	
Purpose	To explore the comfort levels, concerns, and perceptions of affected communities regarding the use of algorithmic tools in child welfare decision-making and to offer insights for designing more accountable systems.	To develop high-resolution poverty maps for low- and middle-income countries by integrating mobile phone data and remote sensing data, offering a more frequent and granular poverty estimation method.	To examine how AI-driven care robots for elderly patients can be designed in a way that aligns with human values, ethics, and the United Nations Sustainable Development Goals (SDGs).	To automate the identification and classification of social work interventions using NLP and ML, improving understanding of social needs and enabling better resource allocation and staffing decisions in healthcare organizations.	To explore how digital technologies can contribute to achieving SDGs for individuals with disabilities by promoting social inclusion and independence.
Application in Social Work	The study directly applies to social work in child welfare, assessing how AI-based tools like risk algorithms affect decision-making processes involving families and social workers.	The study's focus on poverty mapping can assist social services in targeting resources more effectively to impoverished areas.	The study touches on the broader implications for social care, particularly the role of AI in improving care for vulnerable populations, such as the elderly, by offering companionship, safety, and personalized care.	The study directly applies to social work in healthcare settings, enabling automated classification of social work interventions such as care coordination, financial planning, and education. This facilitates better management of social needs in patient populations.	The application to social work involves improving the support systems for people with disabilities through enhanced access to technologies that address daily challenges, fostering inclusion and participation in society.
SDGs Addressed	SDG 10 (Reduced Inequalities)	SDG 1 (No Poverty) SDG 10 (Reduced Inequality)	SDG 3 (Good Health and Well-being) SDG 10 (Reduced Inequalities)	SDG 3 (Good Health and Well-being) SDG 10 (Reduced Inequalities)	SDG 3 (Good Health and Well-being) SDG 4 (Quality Education) SDG 8 (Decent Work and Economic Growth) SDG 10 (Reduced Inequality)
Contribution to SDGs	The study contributes by highlighting the need for equitable, transparent, and fair algorithmic systems that do not exacerbate existing inequalities in public services.	The study improves the capacity to monitor poverty in real-time and at a finer spatial scale, supporting efforts to achieve SDG 1 (No Poverty) and SDG 10 (Reduced Inequalities). It provides a framework to inform poverty reduction policies by identifying the most vulnerable areas.	The use of AI-driven care robots is seen as contributing to better healthcare outcomes (SDG 3) by improving care accessibility and reducing the burden on caregivers. Additionally, the deployment of care robots addresses inequalities in access to healthcare, especially for	The study contributes to better health outcomes (SDG 3) by improving the identification and delivery of social work interventions, and it helps reduce inequalities (SDG 10) by ensuring more accurate identification of patients' social needs.	Digital technologies support people with disabilities by reducing inequalities (SDG 10), improving access to healthcare and education (SDGs 3 and 4), and fostering economic inclusion through decent work opportunities (SDG 8).

			vulnerable elderly populations (SDG 10).		
Key Findings	Participants expressed low comfort levels with algorithmic decision-making due to distrust in the system, concerns about bias in both the data and algorithms, and a lack of transparency in how decisions are made. They emphasized the importance of human involvement alongside algorithmic tools.	Models integrating mobile phone data with satellite data yielded the best predictive accuracy ($R^2 = 0.78$ in urban areas) for poverty mapping. Mobile data alone was effective in urban areas but not as much in rural areas. The models showed that mobile phone top-up patterns and nighttime lights were significant indicators of poverty.	AI-driven care robots, when designed with ethical considerations, can enhance care quality, autonomy, and companionship for elderly patients. However, the study emphasizes that human values such as attentiveness, responsibility, competence, and reciprocity must be integrated into the design process.	The most common interventions identified were care coordination (21.5%), education (21.0%), and financial planning (18.5%). The study showed that NLP and ML techniques can be effectively used to classify social work interventions with high accuracy (SVM: 97% accuracy).	Digital technologies are increasingly important for the inclusion of people with disabilities. These technologies provide greater access to healthcare, education, and employment, while also helping to overcome physical and social barriers.
Challenges	Systemic distrust in public services, potential biases in the data used by algorithms, lack of transparency in decision-making processes, and concerns over the fairness and accuracy of algorithmic decisions.	The main challenge lies in the variation of data availability and the potential noise in mobile phone data, especially in less connected or rural areas. Integrating multiple data sources is essential for more accurate predictions.	Challenges include ethical concerns regarding privacy, data security, and the potential for over-reliance on robots at the expense of human interaction. There is also the challenge of ensuring fairness and avoiding harm in AI decision-making processes.	Challenges include the complexity of unstructured EHR data, variability in documentation practices, and the small sample size, which limited the performance of some algorithms.	The primary challenges include accessibility issues related to technology, unequal access to digital tools, and the need for regulatory frameworks to ensure that digital solutions are inclusive.
Conclusions and Suggestions	The study recommends addressing system-level concerns about public services, improving transparency, weighing both positive and negative data in algorithms, and enhancing communication between social workers and affected families to increase trust in algorithmic tools.	The study concludes that mobile phone and satellite data can significantly enhance the accuracy of poverty mapping, especially in low- and middle-income countries with limited traditional census data. It suggests expanding the use of these data sources to monitor poverty trends in real-time and at a granular level to inform effective policymaking.	The paper concludes that care robots, designed through a Value Sensitive Design approach, can promote well-being and autonomy for elderly populations. The authors recommend a multi-tiered approach combining ethical guidelines, human values, and the SDGs to ensure AI systems contribute positively to society.	NLP and ML can be used to automate the identification of social work interventions, improving healthcare organizations' ability to address patients' social needs. Future research should focus on expanding the classification scheme and improving algorithm performance with larger datasets.	The study concludes that while digital technologies can significantly support individuals with disabilities in achieving independence and inclusion, there is a need for continued efforts to ensure equitable access and implementation. Suggestions include increasing investment in accessible technologies and creating policies that promote digital inclusion.

Table 4. Overview of Included Studies: The Studies 16 to 20

Category	Study 16	Study 17	Study 18	Study 19	Study 20
Author(s), Year	Molala, T.S. & Mbaya, T.W. (2023)	Gillingham, P. (2019)	Goldkind, L., et al. (2021)	Nadarzynski, T., et al. (2021)	Reamer, F. G. (2023)
Title	Social Work and Artificial Intelligence: Towards the Electronic Social Work Field of Specialisation	Decision Support Systems, Social Justice and Algorithmic Accountability in Social Work: A New Challenge	Data Justice: Social Work and a More Just Future	Barriers and Facilitators to Engagement with Artificial Intelligence (AI)-based Chatbots for Sexual and Reproductive Health Advice: A Qualitative Analysis	Artificial Intelligence in Social Work: Emerging Ethical Issues
Journal	International Journal of Social Science Research and Review	Practice: Social Work in Action	Journal of Community Practice	Sexual Health	International Journal of Social Work Values and Ethics
Country	South Africa	Australia	United States	United Kingdom	United States
Study Design	Conceptual	Critical review	Conceptual	Qualitative Study	Literature review
Methodology	Integrative literature review, summarizing existing studies on the use of AI in social work	The study involves a combination of published research articles and gray literature to review examples of DSS in different contexts.	Review of data justice frameworks and critical examination of how data-driven systems affect marginalized communities.	Semi-structured interviews exploring participants' interactions with AI-based chatbots for sexual and reproductive health advice.	Comprehensive examination of AI's ethical issues in social work based on existing literature and guidelines.
Data Collection Methods	Literature review of peer-reviewed journals and credible corporate publications on AI and digital capabilities of social workers.	Literature review (published and gray literature)	Literature review and case examples.	Face-to-face and online interviews with 40 participants from Southeast England, who interacted with the "PAT" chatbot for 10 minutes.	Existing studies, ethical standards, and protocols.
AI Technology	Chatbots, Predictive Analysis, and AI-assisted tools like SCU-B, Woebot, and Help4Mood for mental health support.	Decision Support Systems (DSS), Predictive Risk Modelling, Algorithmic Decision-Making Tools.	The paper discusses various forms of data-driven automation, including algorithmic decision systems and predictive policing tools.	AI-led chatbots, particularly "PAT," a chatbot designed for sexual and reproductive health advice using natural language processing.	Various AI applications such as Woebot, Wysa, and predictive analytics tools like The Trevor Project's Crisis Contact Simulator.
Purpose	To explore the intersection of AI and social work, propose educational and professional development programs for e-social work, and recommend how AI can ethically and effectively be integrated into social work	To explore the challenges of DSS in social work, focusing on how algorithms can perpetuate social injustice and how social workers can apply principles of algorithmic accountability to challenge DSS recommendations.	To explore the implications of data justice for social work and advocate for practices that align with social justice principles, emphasizing the need for transparency, accountability, and nondiscrimination in the use of data technologies.	To identify the barriers and facilitators to engagement with AI-based chatbots for sexual and reproductive health advice and to inform the development of such technologies.	To examine ethical issues related to AI use in social work, apply relevant ethical standards, and propose strategies for ethical AI integration in the profession.

	practice.				
Application in Social Work	The paper advocates for the use of AI in areas like mental health interventions, early detection of conditions like depression and anxiety, and improving social work practices through digital technologies.	The application of DSS in social work is particularly discussed in child welfare services, where DSS tools are used to predict child maltreatment and support decision-making. The article also highlights the role of DSS in criminal justice.	The article highlights the use of data in social work practice, particularly in systems like welfare benefits, policing, and human services. It examines how these data systems impact service provision and outcomes for marginalized communities.	AI-based chatbots like "PAT" can be used in sexual health education and signposting to relevant services. They could also help increase engagement with services by providing anonymous, non-judgmental advice.	AI is used in clinical practice (risk assessment, crisis intervention), administrative tasks (data management), and policy development (predictive analytics).
SDGs Addressed	SDG 3 (Good Health and Well-being) SDG 4 (Quality Education) SDG 10 (Reduced Inequalities)	SDG 10 (Reduced Inequalities) SDG 16 (Peace, Justice, and Strong Institutions)	SDG 10 (Reduced Inequalities) SDG 16 (Peace, Justice, and Strong Institutions).	SDG 3 (Good Health and Well-being)	SDG 10 (Reducing Inequalities)
Contribution to SDGs	By integrating AI into social work, the paper contributes to improved healthcare access (SDG 3), digital training for social workers (SDG 4), and reducing disparities in mental health care (SDG 10).	The article contributes to the discussion on how technology in social work can both promote and hinder social justice, emphasizing the need for accountability in algorithmic decision-making to avoid deepening social inequalities.	The article emphasizes the need for data justice in social work, addressing how data-driven technologies can either mitigate or exacerbate social inequalities. It advocates for practices that protect human rights and promote equity.	The use of AI chatbots in sexual health services could improve accessibility to health information and services, particularly for marginalized or embarrassed individuals. This could contribute to better health outcomes and reduced health inequalities.	AI in social work contributes by improving service delivery to vulnerable populations and addressing systemic biases.
Key Findings	AI has the potential to significantly enhance social work practices, particularly in mental health. Predictive models and chatbots could help in early detection and intervention, improving overall service delivery. However, digital skills among social workers are lacking, highlighting the need for specialized training.	DSS can perpetuate social injustices if not properly scrutinized and held accountable. There is a lack of guidance for social workers on how to challenge DSS recommendations. Algorithms can reinforce biases present in the data they are trained on. There is an emerging critique of the limitations of big data and algorithmic decision-making in social welfare.	Data-driven systems can perpetuate harm, especially in marginalized communities, through biased algorithms and lack of transparency. The privatization of data systems and algorithms limits accountability and exacerbates inequality. Social workers need to engage with data justice frameworks to address these issues and protect clients' rights.	Chatbots are perceived as useful for providing anonymous and convenient sexual health advice.; They are considered helpful for sensitive topics, such as STI risks, and can improve access to services.; However, participants expressed concerns about the lack of empathy, limited interactivity, and insufficient content offered by chatbots.	AI has significant potential to enhance social work but also raises ethical issues such as informed consent, privacy, transparency, and algorithmic bias.
Challenges	The profession has been slow to adopt AI, and there is concern about	The opacity of algorithmic decision-making, making it difficult	Lack of transparency in how data-driven decisions are made.	Participants were concerned about privacy, trust, and data security when	Ethical challenges include misdiagnosis, client abandonment,

	maintaining ethical standards such as confidentiality, informed consent, and professional boundaries when using AI technologies.	for social workers to understand and challenge DSS recommendations. Biases in the datasets used to train DSS, which can lead to inaccurate or unjust outcomes. Lack of clear guidance for social workers on how to navigate DSS in practice.	The challenge of advocating for clients in a system dominated by proprietary algorithms. Data poverty and inequality in access to data technologies for smaller organizations.	using chatbots for sexual health matters. Chatbots were seen as less effective than human health professionals, particularly for complex or emotionally sensitive issues. The technology was perceived as underdeveloped and lacking in providing personalized, detailed advice.	surveillance risks, algorithmic bias, and issues of transparency.
Conclusions and Suggestions	The paper suggests developing interdisciplinary educational programs that integrate AI into social work. It also calls for continuous professional development (CPD) on the ethical use of AI in practice and suggests that institutions of higher learning and professional bodies create policies and guidelines for e-social work.	Social workers must adopt principles of algorithmic accountability to challenge unjust recommendations made by DSS. More training is needed for social workers to understand how DSS algorithms work. DSS designers should anticipate challenges to their systems and build transparency into the algorithmic processes.	Social workers must embrace data justice frameworks to ensure that data technologies are used in ways that promote equity and justice. Advocacy for transparency, accountability, and community involvement in data processes is critical to safeguarding human rights in a data-driven society. Social work education should integrate computational and data science tools to prepare practitioners for the challenges of working in a data-rich environment.	AI-based chatbots could serve as a supplementary tool for sexual health education and service access but are not seen as a replacement for human professionals. Future development of chatbots should focus on improving interactivity, empathy, and trustworthiness. More research is needed to assess the impact of chatbots on health outcomes and service utilization.	The paper suggests developing comprehensive ethical guidelines, forming steering committees, conducting peer reviews of AI protocols, and integrating AI training into social work education.

Table 5. Overview of Included Studies: The Studies 21 to 25

Category	Study 21	Study 22	Study 23	Study 24	Study 25
Author(s), Year	Iqbal, F., et al. (2023)	Upreti, N.C. et al. (2023)	McBride, L and Nichols, A.(2016)	Aldkheel, A. M., & Zhou, L. (2023)	Rodriguez, M.Y., et al. (2019)
Title	Predictive Analytics in Smart Healthcare for Child Mortality Prediction Using a Machine Learning Approach	Towards a Healthier Future: The Transformative Role of AI in Promoting Good Health and Well-being (SDG-3)	Retooling Poverty Targeting Using Out-of-Sample Validation and Machine Learning	How to Support Domestic Violence Survivors with Conversational Agents: Meta Requirements and Design Principles	Bridging the Gap: Social Work Insights for Ethical Algorithmic Decision-Making in Human Services
Journal	Open Life Sciences	Conference paper presented at the First International Workshop on Artificial Intelligence: Empowering Sustainable Development (AISD 2023)	Policy Research	PACIS 2023 Proceedings	IBM Journal of Research and Development
Country	Pakistan	India	United States	United States	United States
Study Design	Predictive analytics framework development using machine learning models	Review and analysis of AI's role in healthcare aligned with SDG-3	Machine learning techniques.	Qualitative research	Predictive modeling
Methodology	Machine learning algorithms such as Decision Tree (DT), Random Forest (RF), Naive Bayes (NB), and Extreme Gradient Boosting (XGB) were applied to child mortality data.	Comprehensive literature review of AI applications in healthcare and their impact on achieving SDG-3	Use of quantile regression and stochastic ensemble methods for PMT development.	In-depth interviews with 11 professionals working with domestic violence survivors, followed by thematic analysis to develop meta-requirements and design principles	The study employs a risk and resilience framework, using Random Forest models to examine child welfare data, focusing on both risk and protective factors
Data Collection Methods	Data were collected from the Pakistan Demographic Health Survey (PDHS), involving a total of 12,479 children under the age of five. The dataset was pre-processed using methods like multiple imputation for missing values and synthetic minority over-sampling technique (SMOTE) to balance the dataset.	Analysis of scholarly publications, case studies, and healthcare applications of AI	Replication of USAID and LSMS datasets for PMT tool development.	Semi-structured interviews, thematic analysis of transcripts	Data from the 2017 National Child Abuse and Neglect Data System
AI Technology	Machine learning techniques—Decision Tree (DT), Random Forest (RF), Naive Bayes (NB),	Machine learning, natural language processing (NLP), computer vision, predictive analytics, robotics	Use of stochastic ensemble methods and quantile regression forests.	Conversational agents (CAs) designed to interact with domestic violence survivors using natural	Random Forest models and predictive analytics were used for decision-making in child welfare cases.

	Extreme Gradient Boosting (XGB)			language processing	
Purpose	To develop a predictive model that can accurately predict child mortality in Pakistan using machine learning methods, allowing health professionals to make timely interventions and reduce child mortality rates.	To explore how AI can contribute to achieving SDG-3 by improving healthcare access, enhancing diagnostics, and addressing global health challenges	To improve the accuracy of poverty targeting tools using advanced statistical methods and machine learning techniques.	To identify meta-requirements and develop design principles for conversational agents that support domestic violence survivors	To explore how AI models, combined with social work insights, can be used ethically in child welfare services, particularly by considering protective factors to improve predictive models .
Application in Social Work	Improving healthcare outcomes and enabling timely interventions to reduce child mortality, which can guide social policies in public health.	AI can improve healthcare outcomes by supporting marginalized populations through better diagnostics, personalized care, and equitable access to medical services	Mainly in poverty assessment and targeting for social safety nets and microenterprise projects.	Supports domestic violence survivors through conversational agents to provide emotional, informational, and practical assistance .	The application of AI aims to enhance decision-making in child welfare by considering both risk and protective factors, improving outcomes for children .
SDGs Addressed	SDG 3 (Good Health and Well-being)	SDG 3 (Good Health and Well-being)	SDG 1 (No Poverty)	SDG 5 (Gender Equality)	SDG 16 (Peace, Justice, and Strong Institutions)
Contribution to SDGs	The study aims to contribute to SDG 3 by providing insights into the risk factors influencing child mortality and creating predictive models that allow for timely interventions, thus reducing under-five mortality.	AI's transformative role in healthcare helps reduce mortality, improve maternal health, optimize resource distribution, and enhance overall well-being.	The proposed methods could significantly enhance poverty alleviation efforts by improving the precision of targeting interventions to those in need.	By developing CAs for supporting domestic violence survivors, this research contributes to improving gender equality and empowerment .	By improving the accuracy and fairness of decision-making in child welfare, the study contributes to reducing inequality and protecting vulnerable children .
Key Findings	Random Forest outperformed other machine learning models with 93.8% accuracy, identifying key risk factors such as the number of under-five children in a household, preceding birth interval, antenatal care visits, breastfeeding, and place of delivery as crucial predictors of child mortality.	AI technologies are capable of early disease detection, personalized treatment, and optimizing healthcare services, but ethical concerns such as data privacy and algorithmic bias need to be addressed.	Cross-validation and stochastic ensemble methods outperform traditional methods for PMT tool development in terms of poverty accuracy and reducing undercoverage.	Meta-requirements for CAs include conversational design, language use, support provision, and trust building. These inform the development of CAs that can provide emotional, informational, and instrumental support.	The inclusion of protective factors in predictive models helps mitigate bias, providing more equitable outcomes in child welfare decisions.
Challenges	Key challenges include data limitations such as recall bias in mothers' reporting	Ethical considerations around data privacy, algorithmic bias,	The need for publicly available datasets with comparable variables across	Lack of explicit discussion of CA design principles for domestic violence survivors,	The study highlights the challenge of ensuring equitable model performance

	and the inability to identify specific causes of mortality from the dataset. Additionally, achieving equitable healthcare access remains a challenge.	equitable access, and integration of AI tools in healthcare systems.	countries limits the tool's broader applicability.	and limitations in existing conversational agents that offer standardized information.	across demographic groups and the issue of data accuracy and contemporality.
Conclusions and Suggestions	The predictive analytics framework developed using Random Forest provides an efficient tool for predicting child mortality. It is suggested that further enhancements, such as using AutoML for more accurate predictions and reducing user-computer interaction, could improve the system. Additionally, expanding the study to explore specific causes of child mortality would further inform interventions.	AI can revolutionize healthcare if challenges related to privacy, bias, and equitable implementation are addressed. It is crucial for stakeholders to collaborate to ensure responsible AI integration that supports healthcare professionals and enhances patient care.	There is significant potential for using machine learning methods in poverty assessment, and further exploration in this area is encouraged.	The study offers design principles to enhance CA effectiveness in supporting survivors, emphasizing empathy, confidentiality, and appropriate information provision .	The authors suggest that human services should incorporate strengths-based perspectives and protective factors in AI models to reduce bias and improve fairness in decision-making .

Table 6. Overview of Included Studies: The Studies 26 to 30

Category	Study 26	Study 27	Study 28	Study 29	Study 30
Author(s), Year	Grant, D. G. (2018)	Palomares, I., et al. (2021)	Cariceo, et al. (2018)	Victor, B. G., et al. (2021)	Yigit, P. (2023)
Title	Ethics and Artificial Intelligence in Public Health Social Work	A panoramic view and SWOT analysis of artificial intelligence for achieving the sustainable development goals by 2030: progress and prospects	Data Science for Social Work Practice	Automated Identification of Domestic Violence in Written Child Welfare Records: Leveraging Text Mining and Machine Learning to Enhance Social Work Research and Evaluation	Self-Organizing Maps Approach for Clustering OECD Countries Using Sustainable Development Indicators
Journal	Artificial Intelligence and Social Work (Book)	Applied Intelligence	Methodological Innovations	Journal of the Society for Social Work and Research	Journal of the Human and Social Science Researches
Country	United States	Spain	Chile	United States	Turkiye
Study Design	Case study	Review study with SWOT analysis	Conceptual	Feasibility study for text mining and machine learning	Two-stage clustering method using Self-Organizing Map (SOM) and hierarchical clustering methods
Methodology	Ethical analysis of AI interventions in social work, using moral philosophy and theoretical computer science to understand ethical dilemmas.	A comprehensive literature review and SWOT analysis of AI technologies in relation to the Sustainable Development Goals (SDGs).	The paper synthesizes key data science concepts and applies them to social work. It focuses on a conceptual discussion.	Machine learning and text mining to classify documents for identifying domestic violence.	Descriptive statistics and Spearman rank correlation analysis, followed by SOM and hierarchical clustering analysis
Data Collection Methods	Interviews and social network analysis; collecting information about participants' past drug use and social networks.	Literature review, analysis of scientific publications, SWOT analysis.	Review of secondary sources such as research papers and reports	Narrative text summaries from child welfare investigation records, manually labeled by human coders and then analyzed using machine learning models.	Data was collected from 38 OECD member countries for 11 variables spanning 2019-2021
AI Technology	Autonomous software agents, specifically designed to optimize groupings of participants in social work interventions	Various AI technologies, including machine learning, big data, IoT, blockchain, and robotics, as applied to address the SDGs.	Machine learning and data-driven approaches, emphasizing predictive modeling and algorithms.	Text mining and machine learning, particularly using k-nearest neighbor and rule-based models.	Self-Organizing Map (SOM), a type of artificial neural network (ANN) used for clustering analysis
Purpose	To address ethical dilemmas in the use of AI in public health social work interventions, particularly those involving homeless youth and drug	To provide a comprehensive analysis of how AI technologies can contribute to achieving the SDGs, focusing on progress,	To explore how data science, including big data and machine learning, can enhance social work practices and evidence-based	To evaluate the feasibility of using machine learning and text mining for identifying domestic violence within child welfare records.	To examine the impact of COVID-19 on selected Sustainable Development (SD) indicators in OECD countries.

	prevention.	challenges, and prospects.	interventions.		
Application in Social Work	AI is used to plan interventions, such as dividing groups of at-risk youth for drug prevention programs.	AI's application across sectors can influence social work-related SDGs like poverty reduction, health, education, and gender equality.	The paper suggests that data science can improve decision-making, predict outcomes, and enhance evidence-based practice in fields such as public health, child welfare, and domestic violence interventions.	The study analyzes child welfare records, improving the identification of domestic violence cases to aid in service provision and decision-making in social work.	The study offers insights into how clustering methods can be used to understand social and economic disparities, which could inform social policy interventions.
SDGs Addressed	SDG 3 (Good Health and Well-being)	all 17 SDGs	SDG 3 (Good Health and Well-being), SDG 4 (Quality Education), and SDG 16 (Peace, Justice, and Strong Institutions)	SDG 16 (Peace, Justice, and Strong Institutions)	SDG 3 (Good Health and Well-being), SDG 8 (Decent Work and Economic Growth), and SDG 2 (Zero Hunger)
Contribution to SDGs	The AI intervention aims to improve the effectiveness of public health interventions, particularly in reducing drug use among vulnerable populations like homeless youth.	The study identifies how AI technologies can be leveraged to accelerate progress toward the SDGs and provides a roadmap for future applications.	The article discusses how data science can support evidence-based social interventions that contribute to improving well-being, reducing inequalities, and enhancing institutional effectiveness.	The study enhances the efficiency and accuracy of identifying domestic violence, supporting stronger child welfare interventions.	The study identifies how countries' performances on various SD indicators (such as health expenditure and life expectancy) were affected by the COVID-19 pandemic, informing policy decisions to improve these areas.
Key Findings	AI interventions can optimize the grouping of participants, but ethical dilemmas arise when maximizing overall benefits causes harm to some individuals.	AI has great potential to contribute to the SDGs, but challenges such as data availability, ethical concerns, and technology adoption must be addressed.	Data science and machine learning offer significant potential to improve social work practice, particularly in prediction, decision-making, and evidence-based interventions. However, challenges related to biases in algorithms and ethical concerns must be addressed.	Machine learning models can identify domestic violence in child welfare records with over 90% accuracy, suggesting this method could substantially improve the use of text data in social work.	The convergence of GDP increased over the years, showing greater variability across OECD countries. Life expectancy decreased during the pandemic, while health expenditures, unemployment rates, and consumer price indexes increased.
Challenges	Balancing the ethical duties of avoiding harm and benefit maximizing population-wide benefits, especially when some individuals may be harmed by	Ethical dilemmas, the digital divide, environmental impacts of AI, regulatory challenges, and the need for trustworthy AI.	Bias in machine learning algorithms; The tension between predictive data use and understanding causal relationships; Ethical concerns	The reliance on caseworkers' summaries may underreport the prevalence of domestic violence, and the models cannot be used for individual case	The study highlights the disparity in economic and health-related indicators across OECD countries, exacerbated by the COVID-19

	interventions that benefit others.		related to privacy and the potential for reinforcing social inequalities.	decision-making due to some classification errors.	pandemic.
Conclusions and Suggestions	AI interventions in public health must be designed with careful attention to ethical principles, including minimizing harm to individuals while achieving overall benefits for the population. Specific modifications to AI systems (e.g., adding safety constraints) are suggested to address these challenges.	The study recommends a balanced and responsible implementation of AI technologies, ensuring ethical considerations, data security, and inclusivity to maximize their positive impact on achieving the SDGs by 2030.	The paper concludes that social workers need to adopt data science techniques to improve their practice, but they must also critically evaluate and address the ethical implications of these technologies.	Machine learning can enhance social work research by scaling the analysis of large datasets. It is suggested that further qualitative reviews and improvements to caseworker documentation be made to improve the models' accuracy.	The study concludes that OECD countries showed similar characteristics over the studied years, except for some outliers like the USA. It calls for more robust clustering methods and further research to better understand the impact of global crises like COVID-19 on SDGs .

4. Discussion

The findings from this scoping review highlight the emerging role of artificial intelligence (AI) in social work and its potential contributions to achieving the Sustainable Development Goals (SDGs). By examining various studies that applied AI technologies across different social work practices, this review underscores the transformative potential of AI for enhancing social services, improving client outcomes, and fostering social good. However, the integration of AI in social work also presents significant challenges, particularly concerning ethical considerations, the need for appropriate training, and policy implications.

The reviewed studies demonstrate that AI can significantly enhance the effectiveness and efficiency of social work interventions. For instance, the use of machine learning algorithms in child welfare (as shown in Study 1, Study 11 and Study 21) enables more accurate predictions of risk factors, allowing social workers to prioritize cases and allocate resources more effectively. Similarly, the application of natural language processing (NLP) and sentiment analysis (as in Study 2, Study 14 and Study 29) provide valuable insights into client narratives, facilitating better needs assessments and tailored interventions.

These AI applications directly contribute to several SDGs, such as SDG 1 (No Poverty) by optimizing resource allocation and improving access to services for vulnerable populations (as in Study 3, Study 12, Study 23 and Study 27), and SDG 3 (Good Health and Well-being) by enhancing the early detection of social and mental health issues (as in Study 4, Study 13, Study 22 and Study 30). Additionally, AI tools like chatbots in crisis intervention (Study 5) support SDG 5 (Gender Equality) by providing immediate assistance and resources to individuals facing domestic violence and other forms of gender-based violence (as in Study 19, and Study 24).

AI technologies also play a crucial role in promoting SDG 16 (Peace, Justice, and Strong Institutions) by enhancing decision-making processes and promoting transparency and accountability in social service delivery (Study 6, Study 15 and Study 17). These technologies offer a data-driven approach to understanding complex social issues, which can inform policy-making and foster stronger, more equitable institutions.

The integration of AI into social work practice necessitates a paradigm shift in how services are delivered and how social workers are trained. The findings suggest that while AI can enhance service delivery, it requires social workers to develop new skills and competencies in technology use (Study 7, Study 10, Study 16 and Study 28). This shift underscores the need for comprehensive training programs that equip social workers with the necessary knowledge to effectively use AI tools. As suggested by Study 8, incorporating AI and data literacy into social work education curricula could prepare future practitioners to leverage these technologies responsibly and ethically.

Moreover, the studies highlight several ethical challenges that arise with AI use in social work. Issues such as data privacy, algorithmic bias, and the transparency of AI models (as discussed in Study 9, Study 20, Study 26) are critical concerns that need to be addressed. There is a pressing need for ethical guidelines that govern the use of AI in social work to ensure that these technologies do not inadvertently harm clients or reinforce existing inequalities. Developing frameworks for ethical AI use, as recommended by almost all studies, is essential for safeguarding the rights and dignity of clients while

maximizing the benefits of AI.

The implications of AI use also extend to social work policy. Policymakers need to consider the potential of AI to improve social services and create policies that support the integration of these technologies in a way that aligns with social work values and principles. Policies should promote equitable access to AI tools and address the digital divide that may prevent certain populations from benefiting from AI-enhanced services (as highlighted in Study 18, Study 25 and Study 30). Furthermore, there should be a focus on developing public-private partnerships that foster innovation in AI applications for social work, ensuring that these advancements are accessible and affordable to all service providers.

5. Conclusion and Suggestions

The findings of this scoping review underscore the transformative potential of artificial intelligence (AI) in social work and its ability to contribute significantly to achieving the Sustainable Development Goals (SDGs). By leveraging AI technologies, social work professionals can enhance their practices, improve service delivery, and address complex social challenges more effectively. However, the integration of AI into social work is not without challenges. It necessitates careful consideration of ethical, technical, and practical issues to ensure that these technologies are used in ways that align with the core values and principles of social work. Given the rapid advancement of AI technologies and their increasing application in social work, the need for ongoing training and professional development cannot be overstated. Social workers must be equipped with technical skills and an understanding of the ethical implications of AI. Training programs should focus on developing competencies in data management, algorithmic literacy, and ethical decision-making, ensuring that social workers are prepared to navigate the complexities of AI-enhanced practice.

Additionally, the development of clear ethical guidelines for AI use in social work is crucial. These guidelines should address issues of consent, privacy, and data security, ensuring that AI tools are used in a manner that respects the autonomy and rights of clients. Guidelines should also include strategies for mitigating algorithmic bias and ensuring that AI applications do not perpetuate social inequities. To address algorithmic bias in social services, organizations should ensure that AI training data includes diverse populations and conduct regular bias audits to identify discriminatory outcomes. Involving stakeholders from various backgrounds in the design and testing of AI tools can help uncover potential biases, while transparency in algorithmic processes allows for scrutiny and accountability. Continuous monitoring of AI performance is essential to swiftly address any biased outcomes that may arise. Regarding data privacy, implementing data minimization practices, where only necessary data is collected, is crucial. Organizations should ensure informed consent from clients about data usage, adopt strong cyber security measures to protect sensitive information, provide ongoing training for staff on data privacy laws, and empower clients by giving them control over their personal data. By incorporating these strategies, social services can navigate the ethical challenges posed by AI, safeguard clients' rights, and promote equity. As the studies reviewed suggest, a collaborative approach involving social work practitioners, AI developers, and policymakers is needed to develop robust ethical frameworks that safeguard both clients and practitioners.

Maximizing the benefits of AI in social work requires a collaborative approach that brings together AI experts, social work professionals, and policymakers. This interdisciplinary collaboration is crucial for developing AI tools that are not only technically robust but also ethically sound and culturally sensitive. AI experts bring technical knowledge and skills necessary for developing and implementing AI technologies, while social work professionals offer insights into the ethical, social, and cultural dimensions of their use. Together, these experts can co-create AI applications that are responsive to the unique needs of social work clients and practitioners, ensuring that AI tools enhance rather than undermine the profession's commitment to social justice and human rights. To foster such collaboration, there should be ongoing dialogues and partnerships between universities, research institutions, social service agencies, and technology companies. These collaborations can help bridge the gap between technical innovation and practical application, ensuring that AI technologies are designed and used in ways that are truly beneficial to social work practice. Furthermore, interdisciplinary training programs and workshops can help social work professionals acquire the technical skills needed to engage with AI technologies effectively while also sensitizing AI developers to the ethical considerations unique to social work.

In conclusion, the integration of AI into social work offers a unique opportunity to enhance the profession's impact on achieving the SDGs and promoting social good. However, to maximize these benefits, it is crucial to continue investing in research, fostering collaboration between AI experts and social work professionals, and developing robust ethical guidelines and policies. As AI technologies evolve, social work must also evolve, embracing innovation while staying true to its core values of social justice, equity, and respect for human dignity. Moving forward, the social work profession should advocate for a balanced approach that harnesses the power of AI while remaining vigilant about its potential risks. By doing so, social work can position itself as a leader in the ethical and effective use of AI, contributing not only to the advancement of the profession but also to the broader goal of achieving sustainable development for all. Through continued research, collaboration, and ethical vigilance, social work can play a pivotal role in shaping the future of AI in ways that are inclusive, equitable, and aligned with

the global pursuit of social justice and human well-being.

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Sustainable Governance in the Digital Age: E-Government Innovations for Climate Action*

Dijital Çağda Sürdürülebilir Yönetişim: İklim Eylemi için E-Devlet Yenilikleri

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ANAHTAR KELİMELER

Çevresel sürdürülebilirlik
Teknolojik çözümler
Veri odaklı karar alma
Vatandaş Katılımı
İklim dayanıklılığı

ÖZ

İklim değişikliği tehdidi giderek büyürken, çevresel zorluklarla başa çıkmak için etkili yönetişim ihtiyacı her zamankinden daha acil hale gelmektedir. Bu çalışma, sürdürülebilir yönetişim ile dijital yeniliklerin kesişimini ele alarak, E-Devlet'in iklim eylemini hızlandırmadaki kritik rolüne odaklanmaktadır. Hızla ilerleyen teknolojik gelişmeler çağında, E-Devlet, hükümetlere süreçleri kolaylaştırma, şeffaflığı artırma ve vatandaşları çevresel sürdürülebilirliğe yönelik ortak çabalara dahil etme konusunda benzersiz fırsatlar sunmaktadır. Vaka çalışmaları, teorik çerçeveler ve ampirik analizler aracılığıyla bu çalışma, dijital teknolojilerden yararlanarak iklim dayanıklılığı sağlamak için yenilikçi stratejileri ve en iyi uygulamaları sergilemeyi amaçlamaktadır. Veri odaklı karar alma süreçlerinden açık yönetişim girişimlerine, vatandaş bilimi ve katılımcı platformlara kadar çalışma, E-Devlet yeniliklerinin iklim yönetişimi alanında nasıl dönüşüm yarattığını inceleyecektir. Politika yapıcılar, araştırmacılar ve uygulayıcılar arasında diyalog geliştirmeyi hedefleyen bu çalışma, eyleme geçirilebilir içgörüler ilham vermeyi ve dijital çağda sürdürülebilir bir geleceğe yönelik yollar oluşturmayı amaçlamaktadır.

KEYWORDS

Environmental sustainability
Technological solutions
Data-driven decision-making
Citizen Engagement
Climate resilience

ABSTRACT

As the specter of climate change looms larger, the imperative for effective governance in addressing environmental challenges becomes ever more pressing. This study delves into the intersection of sustainable governance and digital innovation, focusing on the pivotal role of E-Government in catalyzing climate action. In an era defined by rapid technological advancement, E-Government offers unprecedented opportunities for governments to streamline processes, enhance transparency, and engage citizens in collaborative efforts toward environmental sustainability. Through case studies, theoretical frameworks, and empirical analyses, this study aims to showcase innovative strategies and best practices in leveraging digital technologies for climate resilience. From data-driven decision-making and open governance initiatives to citizen science and participatory platforms, the study will explore how E-Government innovations are reshaping the landscape of climate governance. By fostering dialogue among policymakers, researchers, and practitioners, this study seeks to inspire actionable insights and forge pathways toward a sustainable future in the digital age.

1. Introduction and Context

The global climate crisis stands as one of the most pressing and complex challenges of the 21st century (United Nations 2024), necessitating urgent and coordinated action from governments across the world. The growing impacts of climate change—ranging from rising temperatures and extreme weather events to the loss of biodiversity and disruptions in ecosystems—demand an immediate response that balances environmental preservation with economic and

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social development. To tackle these interconnected challenges, innovative and adaptive governance strategies are crucial for mitigating environmental degradation while promoting sustainable growth. Among the 17 goals established by the United Nations General Assembly in 2015, SDG 13 (United Nations 2015) focuses on combating climate change and its impacts, which affect every country and continent. Among the most promising solutions is the integration of digital technologies into governance frameworks, particularly through the adoption of E-Government. The transformative potential of E-Government lies in its capacity to harness advanced technological solutions, such as artificial intelligence (AI), big data analytics, blockchain, and the Internet of Things (IoT). These technologies play a crucial role in enhancing the efficiency of governance, streamlining processes, and fostering greater transparency in decision-making. In a neoliberal framework, where market-driven approaches often dominate, E-Government innovations can provide a counterbalance by embedding more data-driven, inclusive, and transparent governance structures. These tools not only enhance government responsiveness but also promote citizen engagement by creating platforms for public participation in climate action efforts, thus ensuring that communities are actively involved in the decision-making process. Moreover, digital solutions facilitate the development of adaptive systems that are vital for monitoring environmental indicators, implementing climate policies, and addressing emerging challenges in real-time. In the context of an environmental Leviathan, governments are expected to take a dominant, centralized role in managing environmental issues. E-Government can empower governments with the data and tools needed to fulfill this role effectively, ensuring the robust implementation of policies aimed at tackling climate change. In line with the goals of the Green Deal, E-Government innovations enable the acceleration of decision-making processes and the formulation of data-driven policies that address environmental concerns while fostering economic sustainability. These advancements support governments in creating more collaborative, solutions-oriented climate actions by improving citizen engagement and trust. As governments embed digital solutions into public administration, they not only improve their capacity to address the climate crisis but also build stronger relationships with the public, promoting shared responsibility for sustainability efforts and enhancing the overall effectiveness of climate action.

1.1 The Urgency of Climate Action

Climate change is no longer a distant threat but an immediate concern that demands swift action. The impact of rising global temperatures, extreme weather events, and the degradation of natural resources is already being felt around the world. Governments, international organizations, and local communities must collaborate to develop solutions that not only mitigate the effects of climate change but also promote resilience and sustainability. Paragraph 31 of 2030 Agenda for Sustainable Development (United Nations 2015) and Paragraph 91 of the Future We Want (United Nations. 2012) underscore the urgency of global cooperation to reduce greenhouse gas emissions and bridge the gap between current mitigation pledges and pathways needed to limit global temperature rise to 2°C or 1.5°C above pre-industrial levels. Earlier, Paragraph 38 of the Johannesburg Plan of Implementation (United Nations. 1992) highlighted the adverse effects of climate change, reaffirming commitments under the United Nations Framework Convention on Climate Change (UNFCCC) (United Nations. 1992) to stabilize greenhouse gas concentrations at levels preventing dangerous interference with the climate system while ensuring food security, ecosystem adaptation, and sustainable development. The Plan emphasized systematic Earth observation, improved monitoring systems, and international strategies for integrated data collection, with support from specialized agencies. Complementing these efforts, the Commission on Sustainable Development and Agenda 21(United Nations. 2013) addressed atmospheric protection as a multidimensional challenge linked to economic and social development, advocating for integrated approaches that prioritize sustainable growth and poverty eradication in developing countries. In this context, E-Government innovations play a critical role in accelerating climate action by providing the tools necessary for better decision-making, resource management, and citizen participation. These digital solutions can help ensure that policies are implemented effectively, monitored in real time, and adjusted according to emerging environmental challenges.

1.2 The Role of Digital Innovation in Governance

The transformative power of digital technologies in governance is undeniable, yet their growing risks necessitate robust oversight and regulation. While these tools revolutionize public administration—enhancing efficiency, inclusivity, and transparency—they are far from neutral, often introducing complexities that could undermine their developmental promise. This paper underscores the dual nature of digital technologies, documenting their benefits and inherent risks, and advocates for a strategic governance framework to maximize their potential while mitigating their challenges. Three core recommendations emerge: adopting politically informed strategies for digital transformation, closing governance gaps, and building resilient digital public infrastructure to serve the public good. Digital technologies are reshaping governance paradigms, unlocking unprecedented opportunities to modernize public administration and address pressing global challenges like climate action. Advanced E-Government systems, leveraging artificial intelligence (AI), blockchain, big data analytics, and the Internet of Things (IoT), are streamlining operations, fostering participatory decision-making, and enhancing accountability (UNDP 2024). These innovations empower governments to harness real-time

environmental data, enabling proactive and adaptive responses to climate risks. By integrating digital solutions into governance frameworks, policymakers can create agile systems capable of navigating the complexities of climate resilience and sustainability, ultimately driving a greener, more equitable future.

1.3 Purpose and Scope of the Study

This research aims to explore the intersection of sustainable governance and digital innovation, specifically focusing on the role of E-Government in advancing climate action. The study examines how digital technologies can be leveraged to address the global climate crisis, drawing on case studies from Europe and Turkey to highlight successful strategies and best practices. By analyzing the integration of E-Government innovations in climate governance, this research seeks to provide actionable insights that can guide the development of digital solutions for environmental sustainability. Additionally, the study emphasizes the importance of international collaboration, recognizing that addressing the climate crisis requires a collective effort in a digitalized, interconnected world. Through this exploration, the paper aims to contribute to the broader discourse on how digital transformation can drive sustainable governance and help achieve global climate goals. This research examines the role of E-Government innovations in advancing sustainable governance and climate action, drawing on examples from Europe and Turkey. It identifies actionable insights and best practices for harnessing digital transformation to address the global climate crisis. Furthermore, the study emphasizes the critical importance of international collaboration to achieve collective environmental goals in a digitalized and interconnected world.

2. Conceptual Foundations

Sustainable governance in the digital age hinges on understanding the intersection of technology, governance, and climate action. As governments worldwide seek to address the pressing challenges of climate change, the role of digital innovations, especially e-government, becomes increasingly crucial. In this section, we explore the foundational concepts that underpin the integration of e-government innovations within sustainable governance frameworks, particularly in the context of climate action. By defining key terms and analyzing theoretical frameworks, we establish the conceptual groundwork for understanding how digital technologies can contribute to more effective, transparent, and inclusive climate governance.

2.1 Defining Sustainable Governance

Sustainable governance refers to the process of managing societal resources and policy decisions in a way that ensures long-term ecological balance, social equity, and economic stability. It is a framework that not only addresses present challenges but also anticipates future needs, ensuring that future generations inherit a planet capable of sustaining life. Small Island Developing States (SIDS) face unique vulnerabilities, including small size, remoteness, limited resources, and heightened exposure to climate change impacts and economic shocks, as highlighted in "The Future We Want" (Rio+20) (United Nations. 2012). Recognizing these challenges, the Barbados Program of Action (BPOA) (United Nations. 1994), the Mauritius Strategy of Implementation (MSI), and the SAMOA (United Nations. 2005) Pathway outline frameworks for sustainable development through genuine partnerships and targeted actions. The SAMOA Pathway, adopted at the Third International Conference on SIDS in 2014 (United Nations. 2014), identifies priority areas and calls for urgent global support. UN-DESA plays a pivotal role in coordinating inter-agency efforts, providing technical assistance, and monitoring the implementation of these frameworks to advance sustainable development for SIDS. Sustainable governance goes beyond traditional models by integrating environmental, social, and economic pillars into every level of policy-making and public administration. It emphasizes participatory decision-making, transparency, and accountability, particularly in the face of global challenges such as climate change. In the digital age, the effective implementation of sustainable governance requires leveraging innovations like e-government to facilitate real-time data sharing, stakeholder engagement, and global cooperation, thereby ensuring the robust implementation of climate action strategies.

2.2 Understanding E-Government

E-government, often referred to as the use of digital tools and platforms to improve public administration, has revolutionized the relationship between governments and citizens. At its core, e-government encompasses a broad range of technologies, from online service portals to data-driven decision-making systems that enhance the efficiency, transparency, and accessibility of government functions (Mamakou, X. J., & Cohen, S. 2023). It allows for the digitization of administrative processes, enabling governments to deliver services more quickly, efficiently, and in a more citizen-centered manner. In the context of climate action, e-government innovations are crucial for tracking emissions, implementing policy measures, and enhancing public participation in decision-making processes. By promoting the use of technology, e-government enables the creation of more agile, responsive, and collaborative governance structures capable of addressing the multifaceted challenges of climate change.

2.3 Theoretical Frameworks for Climate Governance

The theoretical underpinnings of climate governance draw from a variety of disciplines, combining elements of political science, environmental economics, and sociology. One of the most influential frameworks in climate governance is the polycentric governance model, which

advocates for multi-level, decentralized approaches to addressing climate change. This model recognizes the complexity of climate issues, which require coordination and cooperation across multiple stakeholders, from local governments to international organizations. Additionally, the framework of adaptive governance emphasizes flexibility, learning, and responsiveness in the face of unpredictable environmental challenges. In a digital era, these frameworks must evolve to integrate technological tools that enable dynamic decision-making and the real-time exchange of information across governmental and non-governmental actors. Technology not only enhances the transparency and inclusiveness of governance but also strengthens the capacity to monitor, report, and verify climate actions, enabling more accurate assessments of progress toward sustainability goals.

3. Literature Review

Digital government plays a critical role in accelerating the achievement of the SDGs by leveraging technology to enhance government efficiency, inclusivity, and accountability. While top-ranked countries lead in digital innovation, such as AI and IoT, bridging the digital divide requires strategic investments in ICT infrastructure, digital identity, and fostering regional collaborations to ensure universal access to e-government services (UNDESA. 2024). ICTs play a dual role in climate change: while contributing to environmental challenges, they offer transformative potential in monitoring, mitigation, and adaptation efforts, such as early warning systems and sustainable urban solutions. Strategic deployment and awareness are essential to maximize their benefits while minimizing their environmental footprint, ensuring an equitable and sustainable response to the climate crisis. Turning digital technology innovation into climate action. *(International Telecommunication Union Report 2024)*. The 2024 AI Act marks a significant advancement in AI regulation, establishing ethical standards and accountability mechanisms to align AI with societal values and human rights. It sets a global precedent for AI governance, encouraging innovation while ensuring safeguards against potential harms, and will require continuous updates to stay relevant in the face of evolving technologies and societal expectations *(Butt. J 2024)*. *Huichao, H., et. al., (2023)* investigates the impact of e-government on air quality in 226 Chinese cities from 2012 to 2016, finding that a 1% increase in e-government scores leads to a 6.71% reduction in PM2.5 concentration. Their study highlights the role of e-government in fostering innovation, optimizing industrial structures, and enhancing green productivity, with a stronger effect observed in non-capital and market-oriented cities. This aligns with the broader discourse on the effectiveness of digital governance in addressing environmental issues, emphasizing the need for integrating e-government initiatives into climate policies to drive sustainable outcomes. Such findings could enrich the theoretical foundation of the present study by explicitly connecting the positive impacts of e-government in improving environmental governance. *Butt, J. (2024)* explores AI has the potential to revolutionize productivity, but its impact has been uneven, with factors such as implementation delays, measurement issues, and macroeconomic policies influencing its effectiveness. Policymakers must adopt comprehensive strategies for AI that prioritize ethical considerations, support innovation, and ensure equitable access to its benefits, particularly for low-income countries and emerging economies. *Acerete, B., et. al., (2023)* underscore the development of e-participation tools for environmental topics remains limited, with efforts concentrated on transparency rather than interactive citizen engagement. While some advancements are evident, they are mostly restricted to regions with established e-government frameworks and a culture of transparency, indicating that significant changes in government-citizen relationships are unlikely in the short term. *Kayode, A. A. (2022)* highlights the positive relationship between e-government systems and environmental sustainability, contributing to the understanding of this connection through the lens of PVES. However, its findings are limited by the developing-country context and require further empirical validation, particularly in high-income nations with advanced e-government adoption. *Yan and Lyu (2023)* highlight how E-government has revolutionized public service delivery, increasing transparency and operational efficiency. Similarly, *Hochstetter et al. (2023)* emphasize that enhanced transparency through digital governance mechanisms significantly improves trust in public institutions. *Buchholz (2024)* emphasizes that youth engagement is pivotal in addressing the climate crisis, given their role as future leaders and the generation most affected by climate change's impacts. She outlines six strategies governments can adopt, including fostering equity in youth policies, integrating climate education into school curricula, and involving young people in transparent, co-owned decision-making processes. *Bostancı, S., Vasilev , V., & Yıldırım, S. (2024)* study examines food waste as an environmental, health, and social justice issue, highlighting its persistence despite global hunger. It provides a policy framework that includes statistical data on food waste trends, product-specific increases, and country-specific awareness, aimed at guiding long-term food security strategies. The study also explores innovative recycling techniques like composting, anaerobic digestion, upcycling, and food-to-energy systems, emphasizing the need for policy changes and shifts in consumer habits to reduce food waste and its adverse effects. *Shao et al. (2023)* further underscore the efficiency gains that E-government brings to government operations, streamlining processes and reducing redundancies. From an environmental perspective, *Yang et al. (2023)* identify regional disparities in green development levels in China, illustrating how E-government initiatives can help bridge gaps by ensuring equitable resource distribution and monitoring. *United Nations Framework Convention on Climate Change. (2024)* highlights the critical role of Action for Climate Empowerment (ACE) as

a crosscutting enabler for achieving the Paris Agreement's goals, enhancing coordination and implementation across all stages of the Nationally Determined Contributions (NDC) process. Scaling up investment in ACE tools and addressing barriers such as limited resources and coordination is vital to strengthen its effectiveness in meeting 1.5°C pathways. *Lubis, S., et. al., (2024)* highlights the crucial role of e-governance in advancing SDG 9 and SDG 16, emphasizing its potential to drive technological innovation, infrastructure development, and enhance governance transparency. However, challenges like the digital divide and concerns over data privacy and algorithmic bias necessitate policy measures prioritizing digital inclusion and comprehensive regulatory frameworks for ethical governance. *Lorentz, B. (2024)* report highlights Digital technologies offer significant potential to enhance climate action, but effective implementation remains a key challenge for the EU and UK. Policymakers should focus on overcoming barriers such as data access, societal reservations, and lack of cooperation, while pursuing objectives like building a single data market, promoting education, and incentivizing digital solutions to drive sustainable growth. *Prabhakar , A. (2024)* explores the challenges hindering the achievement of Sustainable Development Goals (SDGs) by 2030, emphasizing the need for enhanced multilateral cooperation, innovative financing mechanisms, and targeted support for vulnerable populations to drive sustainable and inclusive economic development. *Tabe-Ojong, et. al., (2024)* explores digital innovations hold transformative potential for agricultural markets and climate resilience in the CWANA region, but their adoption remains limited due to supply and demand-side constraints. To fully realize this potential, governments must invest in improving digital infrastructure, creating stable regulatory frameworks, and fostering public-private partnerships to scale up digital innovations effectively. *(Communities of Practice. Report 2024)* highlights that Data plays a critical role in climate action, but challenges related to access, exchange, and usage hinder its potential. To overcome these barriers, governments must improve data governance, invest in digital public infrastructure, and foster inclusive data-sharing ecosystems to support effective climate adaptation and response. *Kousar, F. & Butt, J. (2024)* found economic implications of climate change in Fjord Norway highlight significant challenges, emphasizing the need for climate-resilient policies and collaborative frameworks to transform vulnerabilities into sustainable opportunities. The study underscores that while adaptation is crucial, global mitigation efforts remain indispensable for long-term economic and ecological stability. In conclusion, the integration of digital governance and e-government innovations offers a promising pathway to enhance climate action and sustainable development. As the literature demonstrates, strategic investments in ICT infrastructure, ethical AI regulations, and inclusive digital frameworks are essential to overcoming challenges such as the digital divide and data accessibility. By fostering collaboration across regions, supporting innovation, and ensuring ethical implementation, governments can harness the transformative potential of digital technologies to accelerate climate action. Ultimately, a comprehensive approach that combines technological advancements with strong regulatory frameworks will be crucial in achieving sustainable governance in the digital age and addressing the urgent climate crisis.

4. The Interplay Between E-Government and Climate Action

The accelerating climate crisis, driven by a 1.2°C rise in global temperatures since 1880 and record-high CO2 levels, has led to widespread atmospheric, oceanic, and biosphere changes, with catastrophic weather-related disasters multiplying fivefold in 50 years (United Nations. 2024). The IPCC warns that exceeding 1.5°C of warming could cause irreversible damage, but equitable adaptation and mitigation under the Paris Agreement—a landmark in legally binding climate action—offer pathways to resilience (United Nations. 2015). Aligning the Paris Agreement with the 2030 Agenda for Sustainable Development and leveraging synergies between climate action and SDGs can drive progress on both fronts, addressing critical goals like poverty, hunger, water access, and ecosystem preservation (United Nations. 2015). UN DESA plays a pivotal role by fostering integrated approaches to climate and development efforts (United Nations. 2024), using the 2030 Agenda as a unifying framework to ensure a sustainable, inclusive future. In the face of escalating climate challenges, the integration of e-government initiatives offers a promising avenue for enhancing climate action. E-government, through the digitization of public services, governance processes, and data management, holds significant potential for addressing climate change in a more efficient, transparent, and inclusive manner. By leveraging technology, governments can not only optimize the management of climate data but also empower citizens, enhance accountability, and streamline decision-making processes. As the digital landscape continues to evolve, understanding the multifaceted role e-government plays in climate action is paramount for sustainable governance in the digital age.

4.1 Technological Opportunities in E-Governance

The technological advancements inherent in e-government systems offer profound opportunities to advance climate action strategies. Through big data analytics, artificial intelligence (AI), and cloud computing, governments can improve the accuracy of climate models, predict extreme weather events, and create data-driven policies *(Butt. J. 2024)*. These tools enable governments to make more informed, timely decisions regarding disaster management, resource allocation, and climate adaptation strategies. Furthermore, blockchain technology has the potential to enhance transparency in carbon emissions tracking and climate finance, ensuring that resources are allocated effectively and that climate commitments are met with accountability. By embracing these technological opportunities, governments can become more proactive and

responsive to climate risks.

4.2 Barriers and Challenges in Digital Integration

Despite the numerous advantages, the digital integration of e-government systems to support climate action is not without its challenges. One of the primary barriers is the digital divide, particularly in developing countries where internet access, digital literacy, and technological infrastructure may be lacking (IEEE. 2023). Without equitable access to digital tools and platforms, marginalized communities may remain excluded from climate action initiatives, exacerbating existing social inequalities. Moreover, the complexity of integrating diverse technologies into existing governance frameworks can lead to significant delays, budgetary constraints, and political resistance. Security and privacy concerns also pose critical risks in the digital realm, as governments must ensure that climate data, which can be highly sensitive, is protected from misuse or cyberattacks (Butt, J. 2024). Overcoming these barriers requires targeted investments in digital infrastructure, public education, and international collaboration to bridge the gap between technological capabilities and implementation.

4.3 Benefits of E-Government for Climate Resilience

The implementation of e-government systems offers numerous benefits in building climate resilience, particularly in terms of enhancing adaptive capacities, promoting sustainability, and fostering greater collaboration (Butt, J., & Kousar, F. 2024). Digitally enhanced governance systems allow for real-time monitoring of environmental conditions, facilitating quicker responses to climate-related disasters. This is crucial for mitigating the impacts of extreme weather events and protecting vulnerable communities. Moreover, e-government platforms can support the transition to sustainable practices by promoting the use of renewable energy, waste management, and efficient resource allocation. By enabling greater citizen engagement through digital platforms, e-government can also foster community-driven climate action, amplifying the impact of local-level sustainability efforts. As such, e-government serves not only as a tool for immediate climate adaptation but also as a strategic framework for long-term climate resilience and sustainable development.

5. Case Studies: Best Practices in E-Government for Climate Action

In the context of sustainable governance, e-government innovations offer transformative opportunities to advance climate action. Through data-driven decision-making, open governance, participatory platforms, and international collaborations, digital technologies can enhance environmental policy, foster transparency, and empower citizens to engage in climate action (Butt, J. 2024). The following case studies highlight best practices and showcase how e-government initiatives are driving meaningful progress in the fight against climate change. In Austria, digital platforms like e-mobility tools (AIT Austrian Institute of Technology. 2024) are leading the charge for greener transportation solutions. Belgium's "BeConnect" initiative is making waves by harnessing digital platforms to boost public involvement in sustainability projects (B-Connected. 2024), complemented by smart energy monitoring systems that enhance efficiency. Meanwhile, Bulgaria is turning the tide on electronic waste with a nationwide e-waste management system that tracks and recycles with precision (PPF Group. 2024). Croatia is setting an example with e-solutions for real-time air quality monitoring, providing accessible data for both citizens and decision-makers (Croatian Environment Agency - Agencija Za Zaštitu Okoliša. 2024). Cyprus is leveraging geographic information systems (GIS) to map renewable energy assets, driving forward a sustainable energy revolution (Ministry of Agriculture, Natural Resources and Environment. 2024). The Czech Republic is pioneering e-agriculture platforms, fusing precision farming with data analytics to cultivate climate-resilient practices (FAO 2024). Denmark's innovative use of digital twin technology in urban planning is a game-changer (Digital Twins for Large-Scale Heat Pump and Refrigeration Systems. 2024), allowing for simulations of eco-friendly city designs to reduce carbon footprints. Estonia, a digital trailblazer, is championing green governance through e-residency programs and eco-conscious digital ID systems (e-Estonia. 2024). Finland is utilizing advanced e-tools for climate modeling (Finnish Meteorological Institute. 2024), enabling policymakers to align national strategies with global sustainability goals. France is empowering citizens through online platforms for participatory budgeting on climate initiatives (Office for Democratic Innovation and Participation. 2024). In Germany, the "Smart City Charter" integrates IoT-based e-systems for optimized urban energy management and sustainable mobility (Plug-In. 2024). Greece is advancing renewable energy efforts with a platform that tracks and manages green projects (International Trade Administration. 2024), while Hungary's e-government platforms are revolutionizing green procurement (European Commission. 2014, December 10). Ireland is tackling rising sea levels with e-solutions for coastal management (Engineers Ireland. 2018), using data visualization to forecast and mitigate risks. Italy's e-waste app is encouraging responsible recycling by offering reward incentives. Latvia is safeguarding its forests and biodiversity through an e-system that delivers real-time deforestation alerts (Forest Stewardship Council. 2023, April 18). Lithuania is on the forefront of emission tracking with digital tools aligned with EU sustainability benchmarks. Luxembourg's e-governance platforms are driving energy efficiency in buildings (Ministry for Digitalisation. 2024), while Malta's e-mobility initiatives incentivize the adoption of electric vehicles with digital grants (Transport Malta. 2024). The Netherlands is pushing transparency to new heights with blockchain-based e-

solutions for sustainable supply chain management (Ernst & Young. 2024). Poland's air quality monitoring tools are raising awareness and catalyzing policy interventions (Evertop. 2024). Portugal's water management systems are revolutionizing resource optimization in response to climate challenges (Council of the European Union. 2024). Romania is championing energy efficiency with a platform for certifying green buildings (United Nations Environment Programme Copenhagen Climate Centre. 2024), while Slovakia employs AI-driven flood forecasting tools for proactive disaster management. Slovenia's e-government systems are streamlining eco-friendly public transport networks (e-Uprava. 2024). Spain's smart grids are enhancing renewable energy distribution (Smart Energy International. 2024), and Sweden is spearheading circular economy initiatives with e-platforms that promote recycling and sustainable consumption (e-Tailize. 2024). In the Global South, countries are increasingly leveraging AI-driven e-government innovations to address climate change, yet face challenges due to infrastructure, digital literacy, and financial constraints (Brookings. 2023). In Kenya, AI is being used to improve agricultural practices by providing farmers with weather data and crop recommendations, which helps mitigate the impacts of erratic rainfall and droughts (BMZ Digital). In India, AI is applied to disaster management and climate forecasting, with machine learning algorithms predicting flood-prone areas, though rural areas struggle with infrastructure gaps (BMZ Digital. 2024). South Africa is utilizing AI to optimize energy distribution and promote renewable energy, but financial and digital barriers remain (BMZ Digital). Brazil is using AI for deforestation monitoring and biodiversity conservation, though data infrastructure issues in remote areas limit effectiveness (Olawade, D. B., et. al., 2024). In Nigeria, AI models for water management help address water scarcity, particularly in agriculture, but the lack of internet access in rural regions complicates implementation (Adeniran, A., et. al., 2021). Bangladesh is applying AI to enhance the resilience of infrastructure in flood-prone areas, while Colombia uses AI for sustainable urban mobility and reducing carbon emissions (Ahmad, T. 2023, July 12). Mexico is monitoring the impacts of climate change on coastal ecosystems through AI, yet lacks reliable internet access in remote coastal regions (NDC Partnership. 2018). Despite these efforts, the digital divide and lack of localized data and infrastructure pose significant hurdles. To ensure these AI applications reach their full potential, it is critical to invest in local capacity-building, develop tailored solutions, and promote South-South knowledge exchange and strategic partnerships. These case studies exemplify the transformative potential of e-government innovations in addressing climate challenges. By leveraging digital tools, nations are fostering sustainable governance, enhancing transparency, and empowering citizen participation in environmental initiatives. Each example showcases unique approaches to integrating technology into climate action, offering valuable insights and best practices for global adaptation. Collectively, they underline the critical role of e-government in driving the transition towards a more sustainable and resilient future.

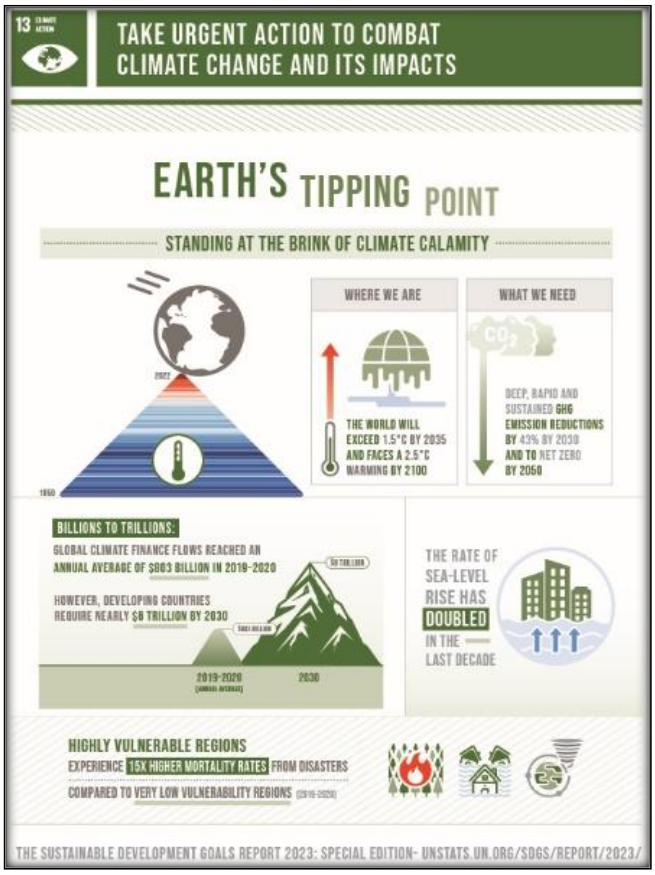
6. Sustainable Development Goal 13: Climate Action

Climate Action is a rallying cry for urgent and transformative efforts to combat the escalating and interconnected impacts of climate change (United Nations. 2024). As one of the most pressing global challenges, climate change threatens ecosystems, human health, and economies, demanding immediate and coordinated responses at local, national, and international levels. The accompanying diagram vividly illustrates the critical need for action, as the planet approaches multiple tipping points with irreversible consequences. The data projects that the world is likely to exceed a 1.5°C rise in global temperatures by 2035, and, if unmitigated, could face a staggering 2.5°C increase by 2100 (World Meteorological Organization. 2024, June 5). Such warming scenarios would result in catastrophic outcomes, including more frequent and severe weather events, rising sea levels, and loss of biodiversity, disproportionately affecting the most vulnerable populations. To counter these threats, the global community must implement deep and rapid greenhouse gas (GHG) emission reductions, aiming for a 43% decrease by 2030 and achieving net-zero emissions by 2050 (United Nations. 2024). However, achieving these targets requires not only technological advancements but also substantial financial investments. The diagram highlights a significant financial disparity (United Nations. 2015), while current climate finance flows have reached an annual average of $803 billion (2019–2020) (United Nations. 2024), developing nations face a funding gap of approximately $6 trillion by 2030 to effectively address climate adaptation and mitigation needs. This gap underscores the necessity of equitable resource allocation to support vulnerable nations that lack the financial and technical capacity to implement robust climate solutions. The diagram further draws attention to alarming trends, such as the doubling of the rate of sea-level rise over the last decade, which exacerbates the risk of flooding and displacement for coastal communities. Additionally, highly vulnerable regions experience mortality rates 15 times higher due to climate-related disasters compared to regions with low vulnerability (10 Insights Climate. 2022). These disparities highlight the inequities in climate resilience and the urgent need for targeted interventions to protect the most at-risk populations.

In this context, innovative governance strategies play a pivotal role in addressing these challenges. E-government systems, in particular, offer transformative potential to drive effective and equitable climate action. By leveraging digital technologies, e-government can enhance climate data collection, monitoring, and analysis, enabling policymakers to make informed decisions. Digital platforms can also improve the transparency and efficiency of resource allocation, ensuring that climate finance reaches the regions

and communities that need it most. Furthermore, e-government innovations can foster international collaboration by creating virtual spaces for knowledge sharing, consensus-building, and coordinated climate policies.

As the digital age continues to reshape governance



frameworks, integrating e-government solutions into climate action strategies provides an opportunity to amplify the impact of SDG13. By bridging the gap between data-driven insights and actionable policies, digital tools can help mitigate environmental degradation, build climate resilience, and promote sustainable development globally. The intersection of technology and governance thus represents a critical pathway to addressing the complex and urgent challenges posed by climate change.

7. Innovations and Emerging Trends in E-Government

In the digital age, e-government has emerged as a critical framework for advancing sustainable governance, particularly in the realm of climate action (UNDESA. 2024). Governments are increasingly integrating digital technologies into their policy-making, resource management, and environmental monitoring systems. These innovations are not only improving the efficiency and transparency of public administration but are also fostering better outcomes for climate governance. With the intersection of AI, Big Data, Blockchain, and the Internet of Things (IoT), the potential for transformative changes in environmental policy and climate action is substantial. In this section, I explore three key innovations that are redefining how governments approach climate challenges: AI and Big Data for climate governance, Blockchain for transparent environmental monitoring, and IoT in resource and climate management.

7.1 AI and Big Data for Climate Governance

Artificial Intelligence (AI) and Big Data are profoundly transforming the way governments handle climate-related data and decision-making processes, creating opportunities for more effective and efficient governance. This technological revolution enables governments to analyze vast amounts of environmental data in real-time, providing them with powerful tools to predict climate patterns, identify environmental risks, and design evidence-based policies for sustainable development. AI algorithms, particularly machine learning models, are increasingly utilized to process complex climate data sets, enhancing the accuracy of climate forecasting, improving disaster response mechanisms, and optimizing resource allocation. In a neoliberal context, where market-driven approaches often dominate policy-making, AI and Big Data offer governments a way to overcome the limitations of traditional regulatory frameworks by providing more data-driven, scalable solutions to address climate change. However, this raises concerns about the potential for market forces to influence or overshadow environmental goals, particularly if AI solutions are developed or controlled by private entities with profit motives, which could exacerbate inequalities and hinder inclusive climate action. AI-powered tools also help governments create more precise environmental models, track greenhouse gas emissions, and monitor the effectiveness of climate policies, supporting the transition to a more data-driven and transparent approach to climate governance. This aligns with the concept of the environmental Leviathan, where governments are expected to take a leading, centralized role in managing environmental issues. AI systems can enhance this role by providing the data necessary for governments to act decisively and efficiently, ensuring the effectiveness of large-scale climate strategies. Moreover, AI-driven platforms can support real-time monitoring of critical environmental factors such as deforestation, pollution levels, and biodiversity loss. These technologies provide actionable insights that can inform not only immediate climate action but also long-term environmental protection strategies. These innovations also align with the Green Deal initiatives, particularly those seen in the European Union, which aim to promote sustainability, reduce carbon footprints, and drive economic growth through green technologies. By integrating AI and Big Data into these frameworks, governments can better assess the effectiveness of their climate policies, ensuring they meet the ambitious goals set forth in global agreements while simultaneously fostering economic resilience and social inclusivity.

7.2 Blockchain for Transparent Environmental Monitoring

Blockchain technology offers an innovative solution for ensuring transparency, accountability, and traceability in environmental governance. By providing a decentralized and immutable ledger, Blockchain enhances trust in the collection, storage, and sharing of climate-related data. This is particularly important for monitoring environmental policies, tracking carbon credits, and ensuring the integrity of climate-related financial transactions. For example, Blockchain can be used to securely record carbon offset transactions, ensuring that the environmental impacts of various initiatives are verifiable and trustworthy. Moreover, in the context of international climate agreements, Blockchain can help create transparent and auditable systems for monitoring countries' compliance with emissions reduction targets. This innovation not only increases the credibility of climate governance efforts but also fosters greater collaboration between stakeholders, from governments to NGOs and the private sector.

7.3 IoT in Resource and Climate Management

The Internet of Things (IoT) plays a pivotal role in advancing climate action by providing real-time data on resource usage and environmental conditions (Sumatosoft. 2024). Through the deployment of interconnected sensors and devices, IoT enables continuous monitoring of natural resources such as water, energy, and air quality. This data is invaluable for optimizing resource management, reducing waste, and ensuring sustainable practices. For instance, IoT-enabled smart grids can efficiently manage energy consumption, leading to significant reductions in carbon emissions. Similarly, IoT sensors in agriculture can help track soil moisture levels, providing farmers with real-time insights to improve water usage efficiency and mitigate the impact of climate change on food production. As governments embrace IoT in their climate governance strategies, the real-time data generated through IoT systems will allow for more responsive and adaptive climate policies, driving progress towards sustainability. These innovations, through the integration of advanced technologies into e-government frameworks, are reshaping the future of climate governance. By harnessing the power of AI, Big Data, Blockchain, and IoT, governments can enhance their ability to address climate change, monitor environmental conditions, and promote sustainable practices on a global scale (Butt, J. 2024, April 29). As the digital age continues to evolve, these emerging trends will remain at the forefront of efforts to build a more resilient and sustainable future.

8. Stakeholder Engagement in Digital Climate Governance

In the context of climate action, stakeholder engagement is a critical component for fostering inclusive, transparent, and effective governance. As climate change presents increasingly complex and multifaceted challenges, the need for a coordinated approach that brings together diverse stakeholders—ranging from citizens to private enterprises and non-governmental organizations (NGOs)—has never been more urgent. Digital technologies, particularly e-government platforms, have the potential to revolutionize how these stakeholders interact, participate, and contribute to climate policy. Stakeholder engagement in digital climate governance not only facilitates information sharing and decision-making but also empowers communities and organizations to co-create solutions in a collaborative, data-driven environment. This section explores the importance of stakeholder engagement in digital climate governance, examining citizen participation, the role of public-private partnerships, and the collaborative efforts of governments and NGOs to advance climate action in a digital era.

8.1 Citizen Engagement in Policy Development

Citizen engagement is a cornerstone of democratic governance, particularly in the realm of climate policy development. The digital age has provided new opportunities for citizens to participate in policymaking, enhancing the responsiveness and legitimacy of climate actions. Through e-government platforms, citizens can actively engage in consultations, provide feedback on proposed policies, and contribute data that reflects local environmental concerns. Furthermore, digital tools enable real-time monitoring and transparent reporting of climate-related progress, fostering a sense of accountability and collective responsibility. By leveraging digital technologies, governments can move beyond traditional top-down approaches and create more participatory, citizen-driven climate policies. This enhances the overall inclusivity of decision-making processes, ensuring that policies not only reflect the scientific consensus but also the diverse needs and priorities of local communities.

8.2 Role of Public-Private Partnerships

Public-private partnerships (PPPs) play an instrumental role in driving innovation and scaling up climate solutions. In the digital climate governance landscape, these collaborations can bridge the gap between government regulation and technological innovation. Governments, through e-government platforms, can facilitate private sector involvement by providing the necessary infrastructure and regulatory frameworks for green technologies and climate solutions. In turn, the private sector brings in expertise, financial resources, and cutting-edge technologies essential for addressing climate change. PPPs can enhance the implementation of sustainable development goals by fostering cross-sectoral collaboration on issues such as renewable energy, carbon emissions reductions, and climate resilience (Casady, C. B., et., al. 2024). Digital platforms further enable these partnerships by providing efficient channels for data sharing, collaborative project management, and the real-time monitoring of outcomes. In this way, public-private partnerships emerge as a crucial

enabler of sustainable climate action in the digital era.

8.3 Collaborative Approaches Among Governments and NGOs

In addressing the climate crisis, fostering collaboration between governments and non-governmental organizations (NGOs) is crucial for driving effective and comprehensive solutions. Governments hold legislative and regulatory authority, enabling them to implement large-scale climate policies, set ambitious climate goals, and allocate necessary resources. However, the role of NGOs is equally critical, as they bring grassroots expertise, innovative solutions, and direct engagement with local communities that are often most vulnerable to climate change. NGOs can bridge the gap between top-down policy frameworks and bottom-up climate action, offering valuable insights into the needs and challenges of affected populations. Digital platforms serve as powerful tools in facilitating this collaboration by enabling real-time communication, the coordination of joint initiatives, and the pooling of resources and knowledge across borders. Through the adoption of e-government innovations, governments and NGOs can synchronize their efforts more effectively, creating a seamless exchange of information that enhances policy implementation and amplifies collective action. These platforms support transparency, accountability, and greater participation by all stakeholders, enabling governments to align their climate policies with on-the-ground realities. For instance, in disaster relief efforts or the implementation of climate adaptation strategies, digital tools such as data-sharing systems, geographic information systems (GIS), and collaborative decision-making platforms enable a more synchronized, responsive, and inclusive approach. Governments can track real-time data, while NGOs can mobilize community-level responses and offer expertise in areas such as local adaptation needs and resilience-building. Through these mechanisms, both sectors can leverage their respective strengths: governments provide the legislative and financial backing, while NGOs contribute innovative, context-specific solutions and facilitate community mobilization. Furthermore, NGOs play an indispensable role in raising awareness, advocating for policy change, and ensuring that marginalized groups are not left behind in the transition to climate resilience. Their ability to mobilize local communities and act as intermediaries between citizens and decision-makers is a powerful force in driving both the adoption of climate policies and tangible, on-the-ground action. Whether through community-based projects or global advocacy campaigns, NGOs are often at the forefront of translating high-level climate commitments into actionable, localized solutions. In this context, it is essential to acknowledge the broader frameworks within which these collaborations occur. Concepts like "neoliberalism" and the "environmental Leviathan" influence the roles of governments and NGOs in climate governance. Neoliberalism, a term often used to describe market-oriented policies that prioritize privatization, deregulation, and free-market mechanisms, can sometimes limit the scope of governmental action on climate change by privileging market solutions over state-driven interventions. This dynamic can create challenges for NGOs working in partnership with governments, as NGOs may be required to operate within a neoliberal context that limits their ability to advocate for more robust, state-led climate interventions. On the other hand, the "environmental Leviathan" refers to a concept where governments play a dominant, centralized role in addressing environmental issues. In such a framework, NGOs often find themselves navigating complex regulatory landscapes while striving to advocate for environmental justice and inclusive policies. Understanding these ideological constructs can help clarify the structural challenges faced by both governments and NGOs in their collaborative efforts. A more inclusive approach, such as the European Green Deal, aims to address climate change while promoting economic growth and social equity. While such agreements are critical, they must also ensure that they do not inadvertently exclude local and marginalized communities from the decision-making processes. This is where NGOs, with their deep-rooted connections to affected communities, play an indispensable role in advocating for policies that are both environmentally sustainable and socially inclusive. Ultimately, through effective digital governance structures and the strategic collaboration between governments and NGOs, it is possible to amplify the impact of climate action initiatives. By combining the regulatory power and resources of governments with the community-based knowledge and mobilization capacity of NGOs, these partnerships can drive both policy adoption and grassroots action, making a significant contribution to the global fight against climate change. Such collaborative frameworks, enabled by digital tools, not only enhance the efficiency of climate action but also ensure that the voices of all stakeholders, especially the most vulnerable, are heard and considered in the development and execution of climate policies.

9. Challenges and Ethical Considerations

In exploring the intersection of digital governance and climate action, it is essential to address the inherent challenges and ethical considerations that arise with the rapid adoption of e-government innovations. While digital technologies offer significant potential for improving governance, enhancing transparency, and driving climate action, their implementation is not without complications. From data privacy concerns to the risks of deepening digital inequalities, and the delicate balance between technological advancement and environmental justice, these issues require careful scrutiny. In this section, I will examine three key challenges that must be navigated in the pursuit of sustainable governance in the digital age.

9.1 Data Privacy and Security in Digital Governance

As e-government platforms collect, store, and process vast amounts of data to enhance public services and promote climate action, the issue of data privacy and security becomes a critical concern. Citizens' personal and sensitive data are increasingly integrated into digital systems, raising questions about how governments ensure the protection of this information. In the context of climate action, data related to energy consumption, transportation habits, and environmental impacts are essential for informed decision-making. However, without robust privacy safeguards, this data could be vulnerable to unauthorized access, misuse, or exploitation. The challenge, therefore, lies in balancing the need for comprehensive data collection to support sustainability goals with the protection of individual privacy rights. Governments must implement transparent data governance frameworks that foster trust and accountability while minimizing risks to data security.

9.2 Digital Inequalities and Accessibility Issues

One of the most pressing concerns in the digital age is the growing divide between those who have access to the internet and digital tools and those who do not. In many regions, particularly in developing countries, access to digital technologies remains limited due to infrastructural deficits, socioeconomic barriers, and digital literacy gaps (Nosike, R. C. 2024). This digital divide has significant implications for climate action efforts, as marginalized communities may be excluded from the benefits of e-government innovations. When digital platforms become the primary mode of governance and participation, these groups risk being further marginalized, with their voices not being heard in climate policy discussions. Addressing digital inequalities is not just about increasing access to technology but also about ensuring that digital governance is inclusive, equitable, and capable of addressing the diverse needs of all citizens.

9.3 Balancing Innovation with Environmental Justice

While digital technologies can contribute to more efficient resource management and support climate action, their environmental footprint must also be considered. The growing demand for data centers, cloud computing, and the production of digital devices has led to significant energy consumption and electronic waste, contributing to environmental degradation (Ukpanah, I. 2024, May 8). In this context, a key ethical challenge is balancing the drive for technological innovation with the imperative of environmental justice. Sustainable digital governance must prioritize innovations that align with environmental goals, ensuring that the pursuit of e-government solutions does not exacerbate the very environmental problems it seeks to address. Additionally, efforts must be made to ensure that the benefits of digital innovations are equitably distributed, preventing the overburdening of already vulnerable populations with the negative environmental consequences of new technologies.

10. Recommendations and Policy Implications

As we move toward a more digitalized future, integrating e-government strategies into climate action plans is essential for fostering sustainable governance. The growing need for transparent, efficient, and scalable climate solutions requires governments to leverage digital technologies to enhance policy implementation, improve public engagement, and streamline decision-making processes. The following recommendations outline key strategies for embedding e-government innovations into climate action frameworks and provide actionable pathways for policymakers to build a resilient digital infrastructure that supports climate goals. Additionally, a critical examination of the broader implications of these technologies, particularly their potential negative environmental impacts and their applicability to developing countries, will ensure that these strategies are comprehensive and equitable.

10.1 Strategies for Integrating E-Government in Climate Action Plans

Integrating e-government tools into climate action plans is crucial for improving efficiency and transparency in policy execution. Governments must prioritize the digitalization of environmental data collection and analysis, utilizing technologies such as remote sensing, geographic information systems (GIS), and artificial intelligence to monitor environmental changes in real time. These data-driven insights can inform better decision-making, streamline reporting mechanisms, and offer predictive analysis on climate risks and mitigation strategies. However, it is important to recognize that the environmental impacts of maintaining and operating these technologies must be considered critically, particularly in terms of energy consumption and electronic waste. Furthermore, digital platforms should be created to facilitate public participation in policymaking, enabling citizens to engage in decision-making processes related to climate action. Through open data portals and participatory platforms, governments can foster greater accountability and inclusivity in shaping climate policies. Strengthening cybersecurity measures is essential to ensure the integrity and confidentiality of climate-related data and user contributions. Governments should also establish digital governance frameworks that connect climate action policies with sectoral digital transformation, particularly in energy, transportation, and agriculture. By using e-government solutions, governments can create integrated, cross-sectoral strategies that promote synergies between climate change mitigation and sectoral sustainability goals.

10.2 Capacity Building for Digital Governance

To effectively implement e-government solutions in climate action, robust capacity building across governmental institutions and society is essential. Policymakers must invest in the digital literacy of civil servants and stakeholders in climate governance, ensuring they possess the skills to manage and utilize advanced digital tools. This can be achieved through targeted training programs, workshops, and cross-institutional knowledge-sharing platforms. Furthermore, governments should collaborate with educational institutions, tech companies, and international organizations to enhance the digital competency of public servants, bridging the knowledge gap and facilitating access to state-of-the-art technological solutions. These collaborations can help establish a culture of innovation within government departments and foster public-private partnerships that incentivize the development of digital climate solutions. On a broader scale, capacity building efforts should also extend to the general public, especially in vulnerable communities. Providing access to digital platforms, training in climate awareness, and empowering local leaders to advocate for sustainable practices can cultivate grassroots support for digital governance initiatives. Equipping communities with digital tools to monitor and report climate impacts enhances the overall effectiveness of national climate action plans. Moreover, the findings from developed countries should be critically assessed for their generalizability to developing nations, where digital infrastructure and capacities may be limited. Policymakers must ensure that solutions are tailored to local contexts to avoid exacerbating existing inequalities.

10.3 Fostering International Cooperation on Digital Climate Solutions

The global nature of climate change necessitates that nations work collaboratively to develop and implement digital solutions to address shared challenges. Establishing international frameworks for digital cooperation on climate action is thus crucial. Governments should actively participate in multilateral initiatives such as the United Nations Framework Convention on Climate Change (UNFCCC) and other international climate agreements to foster digital climate solutions. Cooperation between governments, international organizations, and tech companies is essential to ensure the development of scalable and adaptable digital solutions. Joint research projects, data-sharing agreements, and collaborative policy development can accelerate the implementation of digital climate technologies worldwide. Countries should also create platforms for sharing best practices and successful digital governance models, serving as references for nations at varying stages of digital maturity. Another avenue for fostering international cooperation is the establishment of global digital climate innovation hubs, where countries can exchange resources, expertise, and technology solutions to address specific climate-related challenges. These hubs could act as incubators for digital climate solutions, helping scale successful innovations and accelerate the adoption of e-government tools across borders. However, while fostering such cooperation, it is important to acknowledge the potential negative environmental impacts of scaling up digital technologies, such as energy consumption associated with data centers and the carbon footprint of digital infrastructure. International collaboration must consider these factors to ensure that the pursuit of digital solutions does not inadvertently contribute to environmental degradation. Ultimately, fostering international collaboration in the digital space for climate action will not only enhance the impact of climate policies but also facilitate the transfer of knowledge and resources necessary to tackle the global climate crisis. By aligning digital governance strategies with sustainable development goals, countries can ensure a more resilient and equitable future for all.

11. Conclusion and Future Directions

The intersection of e-government innovations and climate governance has emerged as a transformative frontier in achieving sustainable governance in the digital age. As digital technologies advance, they provide governments with the tools to enhance efficiency, transparency, and public participation, thereby facilitating effective climate action. This research highlights how e-government initiatives, when integrated with climate policies, have the potential to revolutionize decision-making processes, foster inclusivity, and accelerate the implementation of climate goals. However, there remains considerable scope for improvement in the adoption and scalability of these innovations, especially in developing regions and less digitally advanced nations.

This study illustrates the critical role that e-government plays in addressing climate change challenges. Key findings underscore the significance of digital platforms in promoting real-time data sharing, enabling better monitoring and evaluation of climate policies, and empowering citizens to engage in climate actions. Furthermore, the research reveals the growing importance of intergovernmental collaborations facilitated by e-government tools, enabling countries to collectively tackle global environmental issues. The examination of case studies also suggests that successful implementation of e-government innovations depends on factors such as digital literacy, infrastructure, and political will. These elements, when aligned, pave the way for more sustainable and adaptive governance models.

Looking ahead, the future of e-government in climate governance is promising, but it requires a forward-thinking approach to ensure its integration into global and national climate frameworks. The rise of Artificial Intelligence (AI), Internet of Things (IoT), and blockchain presents new avenues to enhance data transparency, optimize resource management, and predict climate patterns with unprecedented accuracy. Governments must prioritize the

development of digital infrastructures that are both scalable and resilient, ensuring that e-government solutions are accessible and beneficial across all sectors of society. Additionally, the future of e-government in climate action lies in fostering partnerships between the public sector, private enterprises, and civil society, which will enable collective climate action supported by innovative technological solutions.

Despite the promising findings, several research gaps persist in this area. Future studies could delve deeper into the socio-economic impacts of e-government initiatives on climate governance, particularly in underserved regions where digital access is limited. Further research is also needed to explore the role of e-government in fostering climate justice, ensuring that marginalized communities benefit equally from digital solutions. Additionally, there is an opportunity to investigate the long-term sustainability of e-government tools and their ability to adapt to rapid technological changes and evolving climate challenges. Another promising direction is the exploration of cross-border collaborations facilitated by e-government, which could play a pivotal role in tackling transnational environmental issues.

This study, while providing valuable insights, also has its limitations. First, the research primarily focuses on a limited number of case studies, which may not fully represent the diverse approaches and challenges encountered by different nations in implementing e-government solutions for climate governance. The scope of the research also did not include in-depth analysis of the technological barriers faced by governments in the Global South, where digital infrastructure and expertise are still developing. Additionally, the rapidly evolving nature of both climate science and digital technologies means that the findings may require continual updates to remain relevant.

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Taxation Of Artificial Intelligence Solutions – A Chinese Approach

Yapay Zeka Çözümlerinin Vergilendirilmesi - Çin Yaklaşımı

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A N A H T A R K E L İ M E L E R

Teknoloji Vergilendirme
Otomasyon Vergilendirme
Çin Vergilendirme
Yapay Zeka
Robot Vergilendirme

Ö Z

Yapay zekanın (YZ) hızlı büyümesi, hükümetleri düzenleyici ve vergi politikaları yoluyla ekonomik, sosyal ve etik etkilerini ele almaya teşvik ediyor. Çin'de YZ, yüksek teknoloji işletmeleri için indirimli kurumlar vergisi oranları, Ar-Ge gider kesintileri ve YZ ile ilgili yazılım hizmetlerinde KDV muafiyetleri gibi vergi teşvikleri ile inovasyon stratejisinin merkezinde yer almaktadır. Shenzhen ve Hangzhou gibi bölgesel merkezler, sübvansiyonlar ve vergi tatilleri yoluyla YZ büyümesini daha da desteklemektedir. Bununla birlikte, YZ şirketleri karmaşık vergi kodları, uyum maliyetleri ve sınıflandırma belirsizlikleri gibi zorluklarla karşı karşıyadır. Küresel olarak, YZ vergilendirme tartışmaları, "robot vergileri", otomasyon vergileri gibi çözümleri araştırmakta ve adil katkılar sağlarken azalan insan istihdamından kaynaklanan gelir kayıplarını ele almak için kurumlar vergisi yapılarını uyarlamaktadır. Alternatifler arasında, işletmelerin işgücü azaltımı için vergilendirilmesi veya insan işe alımına öncelik verilmesi için kredi sağlanması yer almaktadır. Etkili YZ vergilendirme politikaları, tarafsızlık, basitlik ve gelecekteki değişimlere uyarlanabilirlik sağlayarak yenilik, sosyal eşitlik ve ekonomik sürdürülebilirliği dengelemelidir. Bu çalışma, Çin'in YZ vergi çerçevesini bu küresel bağlamda incelemektedir.

K E Y W O R D S

Technology Taxation
Automation Tax
China Taxation
Artificial Intelligence
Robot Tax

A B S T R A C T

The rapid growth of artificial intelligence (AI) is prompting governments to address its economic, social, and ethical impacts through regulatory and tax policies. In China, AI is central to its innovation strategy, with tax incentives like reduced corporate income tax rates for high-tech enterprises, R&D expense deductions, and VAT exemptions on AI-related software services. Regional hubs such as Shenzhen and Hangzhou further support AI growth through subsidies and tax holidays. However, AI companies face challenges like complex tax codes, compliance costs, and classification ambiguities. Globally, AI taxation debates explore solutions like "robot taxes," automation levies, and adapting corporate tax structures to address revenue losses from reduced human employment while ensuring equitable contributions. Alternatives include taxing businesses for workforce reductions or providing credits for prioritizing human hiring. Effective AI taxation policies must balance innovation, social equity, and economic sustainability by ensuring neutrality, simplicity, and adaptability to future shifts. This paper examines China's AI tax framework within this global context.

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1. Introduction

The intersection of automation, mainly through artificial intelligence (AI) and ensuing tax policy, is an emerging and complex field. Research on this subject remains in its infancy despite AI's profound implications for economic structures and the taxation of labour and capital. The financial efficiency brought by AI extends beyond simple productivity gains. It influences national income distributions, wage dynamics, and the design of tax systems to incentivize innovation and entrepreneurship. Simultaneously, governments are compelled to explore innovative forms of taxation due to the disruptive potential of AI while ensuring revenue collection for social services etc.

AI stands at the centre of the digital transformation defining the socio-economic norms within the 21st century and beyond. The AI deployment pace and mechanisms vary across regions and industries. Public and private policymakers face the challenges of determining the role of AI for taxation purposes. Key challenges include designing taxes on labour and capital to promote AI-driven growth while minimizing social harm, such as economic inequality, privacy breaches, and algorithmic bias.

While AI offers efficiency and cost-saving benefits, its challenges require careful tax policy interventions. Tax policies targeting AI can be effective when coordinated on a regional, multi-jurisdictional or global level. The rapid pace of AI innovations also complicates the creation of timely and effective bilateral tax disclosure agreements between jurisdictions. Due to these challenges, public policymakers are likely to respond reactively, imposing taxes after harmful effects manifest. This ad hoc approach risks being slow and inconsistent, potentially undermining global efforts to manage AI's socio-economic impacts (Clarke, 2019; Cheng & Zeng, 2023).

Taxation on AI can potentially address several economic and social challenges. Governments can impose taxes on capital income generated from the use of AI to offset declining labour-driven income and rising wealth inequality. Such measures require careful economic and political analysis on the part of public policymakers. Literature suggests that policymakers' views are often informed by high-profile incidents or growing evidence of AI's harmful socio-economic effects. Such policies would fund essential social services such as senior citizen care, child benefits, social housing, and education while addressing disparities exacerbated by AI's economic disruption (Chen & Tillmann, 2021).

AI benefits can be assured and broadly shared by measures that can help prevent societal fractures and maintain social stability. Timing is critical in tax policy adjustments as a response to disruptive technologies such as AI. Governments are known to act reactively, often driven by political expediency rather than strategic foresight. Imposing an AI tax expeditiously can enable wealth redistribution to fund crucial societal needs. The timely action for AI taxes must align with a broader strategy to mitigate AI's disruptive effects and enhance societal well-being. AI taxation could also be pivotal in shaping the "future of work." Part of the AI Tax proceeds can go toward retraining workforce development initiatives. Governments can ensure that technological advancements bolster, rather than undermine, human welfare. However, precipitous taxation risks stifling innovation and creating stakeholder resistance (Erdélyi & Goldsmith, 2018).

Implementing effective AI taxation is fraught with challenges. AI technologies' rapid and unpredictable evolution makes it difficult to design policies that adhere to neutrality, simplicity, and fairness. Overly aggressive taxation could deter innovation across critical fields, from healthcare to environmental science, diminishing AI's benefits. Moreover, AI taxation risks exacerbating economic uncertainty and could hinder society's ability to harness AI's transformative potential. Governments must navigate these challenges carefully, balancing the need to mitigate harm with the imperative to encourage progress (Gill, et al., 2022).

AI represents both an opportunity and a challenge for policymakers, particularly in the context of taxation. Western governments face mounting pressures to address unemployment, wealth disparities, and societal tensions exacerbated by AI's disruptive potential. Institutions that have historically maintained social cohesion are increasingly strained, and AI could further destabilize these foundations. As governments grapple with these issues, proactive and nuanced policies are essential. Taxation may be a tool to redistribute AI-generated wealth and address societal imbalances, but it must be implemented thoughtfully to avoid stifling innovation. The ultimate goal is to ensure that AI strengthens human welfare and promotes a peaceful, balanced society (Clarke, 2019). This article explores China's tax regulations related to AI, highlighting incentives, compliance requirements, and challenges for companies operating in this sector.

2. China Enterprise Income Taxation Law

The Law of the People's Republic of China on Enterprise Income Tax (EIT), promulgated on March 16, 2007, and effective from January 1, 2008, establishes a framework for enterprise income tax. It applies to incorporated enterprises in China that generate income but excludes individual proprietorships and partnerships. Enterprises are classified as resident or non-resident, with resident enterprises taxed on global income and non-resident enterprises taxed on income from within China. The standard tax rate is 25%, with a reduced rate of 20% for certain non-resident enterprises. Taxable income is determined by subtracting allowable deductions, such as costs, losses, and public welfare donations (up to 12% of annual profits), from gross income, which includes income from sales, services, investments, and royalties. Certain incomes, like government appropriations, are exempt. Specific rules

govern deductions, including depreciation and amortization, and restrict deductions for items like fines and unrelated expenses (People's Republic of China, 2024).

Losses may be carried forward for up to five years. Special provisions address taxation for non-resident enterprises and financial methods inconsistent with tax laws, ensuring compliance with established regulations. The Order of the President of the People's Republic of China No. 63, promulgated by President Hu Jintao on March 16, 2007, officially announces the adoption of the Law of the People's Republic of China on Enterprise Income Tax (EIT) during the Fifth Session of the Tenth National People's Congress. Effective January 1, 2008, this law established the legal framework for EIT in China. It applies to enterprises and other organizations earning income within China, except for individual proprietorships and partnerships (PWC, 2024).

The law categorizes enterprises as resident or non-resident, defining their tax obligations based on their administrative location and the origin of their income. Resident enterprises are subject to income tax on their global earnings, while non-resident enterprises are taxed on income generated within China. The standard tax rate is 25%, although a reduced rate of 20% applies to certain non-resident enterprises under specified conditions. Taxable income is determined by deducting allowable expenses, such as costs, fees, losses, and public welfare donations (up to 12% of annual profits), from gross income, which includes earnings from goods sales, labour services, investments, royalties, and other sources. Certain types of income, such as government appropriations, are exempt from taxation. The law also details the criteria for deductions, depreciation of fixed assets, amortization of intangible assets, and allowable expenses while excluding specific items like fines and non-relevant costs.

Additionally, enterprises may offset losses incurred within a tax year against profits in subsequent years for up to five years. Special provisions address non-resident enterprises' income tax calculations and the treatment of financial practices inconsistent with tax laws. The law comprises eight chapters, covering general provisions, taxable income calculations, preferential tax policies, tax withholding, special tax adjustments, and administrative procedures, ensuring a comprehensive and structured approach to enterprise income taxation in China (Chen, He, Liu, Serrato, & Xu, 2021).

Articles 2, 3, and 4 of China EIT, classify enterprises (incorporations) as either resident or non-resident. Resident enterprises are those established within China following its laws or those founded under the laws of foreign countries but effectively managed by institutions in China. Conversely, non-resident enterprises are those incorporated under foreign laws, with their seats of management outside China. Non-resident enterprises either maintain operations within China or derive income from within China with foreign seats of administration. Resident enterprises are subject to enterprise income tax on their local and worldwide income, encompassing domestic and foreign earnings. Non-resident enterprises with operations in China are taxed on income derived from their Chinese establishments, including income from abroad attributable to these establishments. Tax is levied solely on income generated within China for non-resident enterprises without establishments in China or when income is unrelated to their Chinese operations. The standard enterprise income tax rate is 25%, while income specified under the third paragraph of Article 3 for non-resident enterprises is subject to a reduced rate of 20%.

China EIT explains taxable income in Articles 5 through 9. Article 5 stipulates that taxable income for each tax year is the gross income of an enterprise minus the untaxed and tax-exempt amounts, allowable deductions, and prior-year losses eligible for offset. Article 6 defines gross income for all monetary and non-monetary earnings from various sources, including income from goods sales, labour services, property transfers, equity investments (such as dividends and bonuses), interest, rentals, royalties, donations, and other sources. Certain types of income are designated as untaxed under Article 7, which include government appropriations, administrative fees, government funds collected according to EIT Law and managed by the government, and other untaxed income specified by the State Council. Article 8 permits enterprises to deduct reasonable expenses related to earning their income, such as costs, fees, tax payments, and losses. Article 9 further allows deductions for donations made for public welfare purposes, provided these do not exceed 12% of the enterprise's annual profits. These provisions collectively ensure a comprehensive and precise approach to determining the taxable income of enterprises operating within China.

Articles 10 and 11 of China's EIT Law outline specific expenses that are not deductible when calculating taxable income and detail rules for deducting depreciation of fixed assets. Article 10 identifies non-deductible expenses, including equity investment payments to investors (such as dividends and bonuses), enterprise income tax payments, fines for delayed tax payments, losses from penalties, fines, and property confiscations, donations outside the scope defined in Article 9, sponsorship costs, non-verified reserves, and other expenses unrelated to income generation. These exclusions ensure that deductions are limited to expenses directly associated with income production and compliance with tax regulations (Li, Wang, & Wu, 2020).

Article 11 permits enterprises to deduct fixed asset depreciation costs, provided these are calculated in line with relevant regulations. However, specific fixed assets are excluded from this deduction, such as unused houses and structures, fixed assets subleased for profits, those rented out through financial leasing, fully depreciated but still operational fixed assets, assets unrelated to business activities, separately valued land recorded as fixed assets, and other categories specified by law. These provisions establish clear boundaries for allowable depreciation

deductions, ensuring consistency and accuracy in tax calculations. Articles 12 and 13 detail the rules for calculating taxable income related to amortized expenses. Under Article 12, enterprises may deduct amortized expenses for intangible assets if these calculations adhere to relevant regulations. However, certain intangible assets are excluded from deductions, including those whose development costs have already been accounted for during taxable income calculations, self-created goodwill, assets unrelated to business operations, and other intangible assets ineligible for amortization deductions. Article 13 permits enterprises to deduct anticipated long-term amortized expenses, provided they are amortized according to the relevant regulations. These include costs associated with reconstructing fully depreciated fixed assets, reconstructing leased fixed assets, conducting significant repairs on fixed assets, and other expenses identified as anticipated long-term amortized costs.

Articles 14 through 18 outline specific rules for calculating taxable income and handling deductions for enterprises. According to Article 14, an enterprise may not deduct the cost of investments made in the form of assets during the period of external investment when calculating taxable income. Article 15 states that the inventory cost intended for use or sale may be deducted, provided it is calculated per relevant regulations. Article 16 allows an enterprise to deduct the net value of transferred assets when determining taxable income. Article 17 specifies that losses incurred by an enterprise's business institutions outside China may not be offset against profits generated by its business institutions within China for income tax purposes.

Article 18 permits an enterprise to carry forward losses incurred in a tax year to subsequent years, allowing these losses to be offset by future income. Still, the carryover period is limited to a maximum of five years. Articles 19 through 21 establish the rules for calculating taxable income for non-resident enterprises and address the handling of financial methods related to taxation (STA General Office, 2024). Article 19 specifies that non-resident enterprises must calculate taxable income based on the nature of the income. The total amount of income is considered taxable for equity investments, such as dividends, bonuses, interest, rent, and royalties. For income from property transfers, the taxable amount is the remainder after deducting the net value of the property from the total income. Taxable amounts are calculated by applying similar methods for other types of income. Article 20 provides that the specific scope of deductible income, criteria for deductions, and tax administration procedures regarding assets shall be determined by the financial and taxation authorities under the State Council. Article 21 states that if an enterprise's financial and accounting methods conflict with tax laws and administrative regulations, the calculation of taxable income must comply with those laws and regulations (People's Republic of China, 2024).

Articles 22 through 24 establish the methods for calculating taxable income and the rules for offsetting income tax paid outside China. Article 22 states that an enterprise's taxable income is determined by multiplying the taxable income by the applicable tax rate and then subtracting any tax reductions, exemptions, or offsets provided under the preferential tax policies outlined in this law. Article 23 allows enterprises to offset income tax paid outside China on specific types of income against the tax payable for the current period. This includes taxable income earned outside China by resident enterprises and by non-resident enterprises with establishments in China, provided the income is linked to those establishments. The offset amount is limited to the tax payable on the income as calculated under this law, and any excess may be carried forward and offset against taxes in the next five years. Article 24 further permits resident enterprises to offset income tax on dividends and bonuses from foreign enterprises under their control. The offset includes the income tax the controlled foreign enterprises paid outside China and must align with the offset limits specified in Article 23.

Articles 25 through 27 outline the preferential tax policies implemented by the State to support and encourage specific industries and projects. Article 25 emphasizes that the State provides tax incentives for industries and projects that receive significant government support and are prioritized for development. Article 26 specifies income exempt from tax categories, including interest on government bonds, dividends and bonuses from equity investments between qualified resident enterprises, dividends and bonuses received by non-resident enterprises with establishments in China connected to such establishments, and income earned by qualified non-profit organizations. Article 27 provides for tax exemptions or reductions on income derived from certain activities, such as farming, forestry, animal husbandry, and fisheries; investments in and operation of State-supported infrastructure projects; qualified projects focused on environmental protection, energy conservation, or water conservation; income from qualified technology transfers; and other income as specified under Article 3 of this Law.

Articles 28 through 32 outline various preferential tax policies to support specific enterprises, activities, and investments. Article 28 establishes reduced income tax rates for qualified enterprises: small enterprises with low profits are taxed at a reduced rate of 20%. In comparison, high-technology enterprises requiring key State support are taxed at a reduced rate of 15%. Article 29 allows the autonomous authorities of national autonomous regions to reduce or exempt the portion of enterprise income tax allocated to local governments. However, exemptions or reductions at the prefecture or county level require approval from higher-level provincial, regional, or municipal authorities. Article 30 permits weighted deductions for specific expenses when calculating taxable income, including research and development costs for new technologies, products, or techniques and wages paid to disabled employees and other individuals encouraged by State policies. Article 31

provides that investment ventures in pioneering projects prioritized by the State may offset taxable income by a certain proportion of their investment amount. Lastly, Article 32 allows enterprises to accelerate the depreciation of fixed assets when necessary due to technological advancements or other justifiable reasons, either by reducing the depreciation period or adopting accelerated methods.

Articles 33 through 36 outline additional preferential tax policies to encourage environmentally friendly practices, economic development, and flexibility in response to national needs. Article 33 allows enterprises to deduct income earned from manufacturing products that comprehensively utilize resources and comply with State industrial policies when calculating taxable income. Article 34 provides that enterprises investing in special equipment for environmental protection, energy, and water conservation or safe production may offset a portion of their tax payable based on a specified ratio. Article 35 determines that the State Council is responsible for formulating detailed preferential tax policies as this law outlines. Article 36 grants the State Council the authority to develop special preferential tax policies in response to national economic and social development needs or significant unforeseen events impacting business activities, with the requirement to submit such policies to the Standing Committee of the National People's Congress for record-keeping.

Articles 37 to 40 outline regulations on tax withholding for income earned by non-resident enterprises in China. Article 37 mandates that income tax on such earnings, as described in Article 3, must be withheld at the source by the income provider, who acts as the withholding obligor. Payment of the withheld tax is required at the time or when the payment is due. Article 38 extends this obligation to income derived from engineering operations or labour services, allowing tax authorities to designate the payment provider as the withholding obligor. Article 39 stipulates that if the withholding obligor fails to fulfil their duty or cannot withhold taxes, the taxpayer must pay the tax where the income is generated. Should the taxpayer neglect this duty, tax authorities are empowered to recover the tax from paying the taxpayer for other projects in China (People's Republic of China, 2024).

Article 40 requires the withholding obligor to remit the tax to the Treasury within seven days of withholding and submit a corresponding enterprise income tax return to the local taxation authority. Articles 41 to 48 address the adjustment of special tax payments for enterprises involved in affiliated business transactions. Article 41 empowers tax authorities to adjust if transactions between an enterprise and its affiliate deviate from the arm's-length principle, reducing taxable income. Costs related to the joint development or transfer of intangible assets or services must align with independent transaction principles for taxable income calculation. Article 42 allows enterprises to propose pricing principles and calculation methods for affiliate transactions, potentially leading to an advance pricing agreement after consultation with tax authorities. Article 43 requires that enterprises must include a statement of affiliate transactions in their annual tax returns and provide relevant information during tax investigations. Article 44 grants tax authorities the right to verify taxable income if an enterprise fails to disclose or provides false or incomplete affiliate transaction data. Article 45 requires profits of foreign-controlled enterprises with low tax burdens to be included in the income of resident enterprises if such profits are not distributed for reasons unrelated to legitimate business needs (STA General Office, 2024).

Article 46 disallows interest expense deductions when affiliates' bond or equity investments exceed prescribed ratios. Article 47 enables tax authorities to adjust taxable income when enterprises adopt plans that do not serve legitimate business objectives. Finally, Article 48 stipulates that additional taxes and interest may be imposed following tax adjustments, per State Council regulations. Articles 49 to 52 outline the administration of enterprise income tax levying and collection in China. Article 49 states that in addition to EIT law, tax administration complies with the provisions of China's Law on the Administration of Tax Collection. Article 50 specifies that resident enterprises must pay tax at their registration location or, if registered outside China, at the location of their actual administrative institution. Resident enterprises with non-legal personal branches in China must consolidate income tax calculations and payments (Law of China, 2019).

Article 51 states that non-resident enterprise income for purposes of Paragraph 2, Article 3, are required to pay tax where their enterprises are registered. Establishments with multiple in China may, with the tax authority's approval, designate one as the headquarters for consolidated tax payment. Non-resident enterprises earning income under Article 3, Paragraph 3 must pay tax at the registered location. Article 52 prevents enterprises from consolidating tax payments with other locations unless explicitly authorized by the State Council. Articles 53 to 56 define the rules for calculating, reporting, and settling enterprise income tax in China. Article 53 establishes that the tax year spans from January 1 to December 31. The actual operating period is the tax year for enterprises starting or ceasing operations during a tax year. During liquidation, the liquidation period is treated as the tax year.

Article 54 requires enterprises to prepay income tax monthly or quarterly, submitting prepayment returns within 15 days after the end of each period. Annual returns for consolidated tax payments are due within five months after the tax year ends, accompanied by financial statements and relevant information. Article 55 mandates that enterprises terminating operations during a tax year must settle taxes within 60 days of cessation. Before deregistering, enterprises must file a final tax return and pay any outstanding taxes. Article 56 stipulates that taxes are calculated in Renminbi, with foreign currency income converted accordingly for tax payment. These provisions

ensure systematic tax calculation, collection, and compliance for enterprises operating in China (STA General Office, 2024).

Articles 57 to 59 provide supplementary provisions for implementing China's EIT law. Article 57 allows enterprises established before the law's promulgation that benefit from preferential tax rates or exemptions to transition gradually to the prescribed rates or continue enjoying their benefits under regulations set by the State Council. The period begins from the law's effective year for enterprises with unused preferential periods due to lack of profits. High-tech enterprises in zones designated for economic and technological exchange and newly established areas with special policies may receive transitional preferential tax treatment, with details determined by the State Council. Encouraged enterprises confirmed by the State may also qualify for tax exemptions or reductions under relevant State Council regulations. Article 58 establishes that provisions in international tax agreements between China and other countries precede the law if inconsistencies arise. Article 59 authorizes the State Council to formulate regulations to implement the law. These provisions aim to balance transitional benefits for existing enterprises with the broader goals of the new tax regime while respecting international agreements.

3. Fostering AI Development- Special AI Taxation in China

The rapid development of artificial intelligence (AI) has prompted governments worldwide to establish regulatory frameworks addressing its economic, social, and ethical impacts. AI is central to China's innovation-driven development strategy. Chinese AI tax policies have evolved to encourage growth and ensure appropriate revenue collection from this burgeoning industry. The Chinese government has identified AI as a core industrial and technological advancement driver. The State Council's 2017 "Next Generation Artificial Intelligence Development Plan" set ambitious goals to make China a global leader in AI by 2030. This strategic importance has led to favourable policies, including tax incentives, to stimulate AI research and application (Kim, 2023).

China offers several tax incentives to promote AI innovation and adoption.

These policies target key players in AI, including research institutions, startups, and established technology firms. The High-Technology Enterprise (HTE) legal status enables AI companies to qualify as HETs, to benefit from an EIT rate of 15% compared to the standard EIT rate of 25%. There are additional deductions for R&D expenses such as 200% of qualifying expenditures that can be deducted from taxable enterprise income. Startups in the AI space can take advantage of various preferential policies offered in innovation hubs such as Beijing, Shanghai, and Shenzhen, which aim to foster growth and innovation in the sector. These policies include exemptions from value-added tax (VAT) for specific AI software services and subsidies designed to offset tax liabilities, particularly for small and micro-enterprises focusing on AI research.

Moreover, the government provides targeted support for AI applications in key sectors like healthcare, manufacturing, and transportation. This includes tax reductions on the import of advanced equipment essential for AI research and development, along with VAT exemptions for the sale of AI-driven technologies in agriculture and education, further encouraging the integration of AI into diverse industries and enhancing its role in driving technological advancement (Čejková, 2023).

Despite the numerous incentives available, AI companies operating in China must navigate a complex tax landscape encompassing various obligations. As explained earlier, EIT is set at a standard rate of 25%, but businesses benefiting from AI preferential policies must maintain meticulous documentation to prove their eligibility. Value-added tax (VAT) applies to AI-related products and services, ranging from 6% for software services to 13% for hardware and equipment. However, companies can reduce their overall tax liability by claiming input VAT credits. Additionally, foreign AI companies that provide technology services or license intellectual property to Chinese entities face withholding tax, typically 10%, with potential reductions under double taxation agreements. The Individual Income Tax (IIT) system imposes progressive rates from 3% to 45% for AI professionals, particularly expatriates. However, specific allowances like housing and education may qualify for exemptions, easing the overall tax burden.

China's decentralized governance enables local authorities to provide additional tax incentives tailored to regional priorities, fostering innovation and growth in AI ecosystems. Cities such as Shenzhen and Hangzhou, known for their dynamic AI industries, have introduced tax holidays for new AI startups and local subsidies to support research and development personnel. However, despite these efforts, the AI industry in China encounters several challenges in navigating tax regulations. One major issue is the ambiguity in defining AI-related activities, which complicates tax classification. Additionally, the compliance burden is significant, as companies must compile and maintain extensive documentation to qualify for tax benefits, consuming considerable resources. Furthermore, the global nature of AI operations introduces complexities in aligning China's tax policies with international frameworks, including the OECD's guidelines on digital taxation, creating potential hurdles for companies operating across borders.

China's approach to AI taxation is anticipated to evolve in alignment with ongoing technological advancements and international trends, paving the way for several potential developments. One possibility is the introduction of AI-specific taxation measures designed to address the disruptions caused by automation and robotics in traditional industries. At the same time, there may be an increased focus

on incentivizing environmentally sustainable AI technologies through tax breaks, reflecting China's commitment to achieving its carbon neutrality goals. Additionally, enhanced cross-border tax coordination could emerge as a priority, fostering collaboration with global tax bodies to harmonize rules governing AI-related income generated across multiple jurisdictions.

AI companies in China must adopt strategic approaches to navigate the country's complex tax landscape effectively. Staying informed about regulatory changes at national and local levels is crucial as tax policies evolve with technological advancements. Companies should also proactively identify and leverage available tax incentives, particularly those targeting R&D and innovation activities, to optimize their financial position. Additionally, investing in compliance is essential; this includes maintaining meticulous records and collaborating with tax advisors to ensure adherence to stringent documentation requirements. These steps will help companies remain agile and competitive in a dynamic regulatory environment.

China's tax regulations for AI demonstrate the government's dedication to promoting innovation while maintaining economic accountability. By effectively utilizing available incentives and adhering to tax requirements, AI companies can secure a foundation for sustainable growth in one of the most dynamic markets globally. As AI continues to revolutionize industries, China's regulatory & tax framework is expected to evolve in tandem, offering opportunities and challenges for businesses navigating this transformative era. Before exploring the various options for taxing AI and robots, it is crucial to emphasize that any such tax proposal should be grounded in a solid policy rationale and adhere to well-established tax policy principles, such as those outlined in the Ottawa E-Commerce Tax Framework.

4. Ottawa E-Commerce Framework & Global AI Tax Initiatives

Ottawa E-Commerce Tax Framework is particularly relevant as OECD countries and beyond have adopted the framework in their e-commerce tax strategies. The first principle of the framework addresses neutrality, meaning that a tax should apply universally and not discriminate between electronic and conventional commerce. While achieving complete neutrality is challenging, introducing a new tax should aim to minimize distortions. The second principle, simplicity or certainty, is closely tied to the third principle of efficiency. A new tax must be straightforward to apply, as excessive complexity can result in higher compliance costs for taxpayers and tax authorities. In this context, efficiency should not be confused with the economic concept of efficiency related to the location of production or output factors. The fourth principle, effectiveness, and fairness requires that the tax system enables the government to collect the correct amount of taxes at the right time while minimizing opportunities for tax evasion and avoidance and reducing the potential for profit shifting. The fifth principle of flexibility ensures that the tax system can adapt to meet the government's current and future revenue needs. It is important to note that no single principle should be prioritized over the others. Instead, a balance must be struck among them.

Taxing AI and robotics have gained significant attention in recent years, particularly following remarks by Bill Gates, co-founder of Microsoft, in 2017. In an interview with Quartz, Gates sparked the debate by questioning why robots performing the same work as human employees wouldn't be taxed similarly (Kovacev, 2020). He pointed out that human workers who earn, for example, $50,000 in a factory, are subject to income tax and social security contributions and suggested that robots should face the same level of taxation if they replace human workers. Some commentators propose that AI and robots should be treated as separate taxable entities, to ensure that state revenues are not significantly impacted. For income tax purposes, one suggestion is to treat AI or robots as individual taxpayers, while another proposal is to classify them as taxable legal entities.

In indirect taxation, particularly VAT, there have been proposals that if AI and robots are granted legal personality and tax capacity, they could also be considered taxable persons and, therefore, subject to VAT.

The proposal for taxing AI and robots suggests that the technology owner should be held responsible for paying the taxes associated with its use. These taxes would be based on fictional salaries attributed to the AI or robots, with these salaries being deemed equivalent to what a human worker would earn performing the same task. The salary would be determined by comparing it to similar wages in the market. This approach would help neutralize the loss of tax and social security revenue caused by automation. For this system to be effective, the legislation would need to recognize a relationship between the AI/robot and its owner, akin to the employer-employee relationship, which could require changes to labour laws.

Some political figures have put forward similar proposals to tax imputed income for robots. For example, Bill de Blasio, Mayor of New York, advocated for a federal robot tax during his 2020 Democratic presidential campaign. His proposal would require companies that replace workers with automation to pay an amount equal to five years' worth of payroll taxes for each worker displaced. Additionally, de Blasio proposed the creation of a regulatory body, the Federal Automation and Worker Protection Agency (FAWPA), to oversee advanced robotics and AI. In Canada, the Green Party also proposed a robot tax in 2019, suggesting that companies replacing workers with machines must pay a tax equivalent to the income tax the laid-off employees would have paid (Merola, 2022).

An object tax could be levied on the ownership of a robot, either through a flat rate or one that varies based on the type of robot, similar to how assets are taxed in certain jurisdictions. However, this approach's main challenge is

treating robots as property, typically applied to tangible assets lacking autonomy or intelligence. This creates a conflict with the rationale for taxing robots in the first place. Since robots are intelligent machines capable of replacing human labour, the argument is that they should be taxed as subjects—like humans—rather than as objects.

This distinction raises the question of whether robots, due to their capabilities, should be considered taxable entities like people. Many jurisdictions currently offer tax advantages to companies that invest in technology and acquire machines to enhance efficiency and productivity. According to the latest data from the OECD, several countries have reinforced corporate tax incentives to encourage innovation, such as allowing the deductibility of invested capital for tax purposes. In some cases, these measures can facilitate the replacement of human workers. One potential solution to slow down this automation-driven displacement of workers could be to eliminate or restrict such tax advantages based on a reported level of automation within a company.

In 217 South Korea became the first country in the world to pass a robot tax law. South Korea is renowned for its high-level use of robotics within its various industries. South Korean Robot Tax is aimed at slowing down the growth of automation in the country. Previously, companies were allowed corporate tax deductions ranging from 3% to 7% of their investment, depending on the business size. The Robot Tax reduced the deduction rate to 2%. Dimitropoulou, in analyzing the South Korean tax system, pointed to the Robot Tax as a measure to limit tax incentives for businesses using technologies such as AI and robots that closely substitute human labour (Joseph & Falana, 2021).

Vincent Ooi and Glendon Goh proposed "reverse depreciation," which aims to adjust tax incentives based on the level of human workforce replacement caused by automation. According to their proposal, companies adopting automation as a complementary function, meaning those replacing few or no human workers, would be allowed to deduct higher amounts related to capital expenditure. On the other hand, companies whose automation investments result in significant human workforce replacements would be allowed to deduct only a small portion of their capital investment. This proposal seeks to balance the promotion of innovation with the need to mitigate the societal impact of widespread job displacement.

An alternative to the "robot tax" concept is increasing corporate income tax rates for businesses that heavily automate their operations. The rationale is that companies replacing human workers with AI and robots are expected to become more productive, leading to higher profits. Consequently, these businesses would be taxed more due to their more considerable taxable income, increasing government revenue. This approach would shift the tax burden from labour to capital, encouraging companies to balance automation with human employment.

Another potential approach is the implementation of automation taxes, specifically aimed at businesses that reduce their workforce by replacing employees with AI and robots. The goal of these taxes would be to discourage mass layoffs and the widespread replacement of human workers. One way to structure such a tax could involve charging employers for unemployment insurance based on their human employment rate. In other words, the more employees a company lays off or replaces with automation, the higher the taxes they would be required to pay. This system would compensate for the unemployment caused by automation, ensuring that companies contributing to workforce displacement help fund the support needed for displaced workers. An agency could be established to manage this system, collecting data on layoffs and workforce replacements, which would then be shared with tax authorities to inform tax assessments.

Another potential approach to taxing automation is the concept of a corporate self-employment tax, which would increase the tax burden on companies that produce goods or provide services without relying on human labour. This model is analogous to the self-employment tax imposed on individuals in certain jurisdictions, where small business owners must contribute to social security, similar to the taxes paid on their wages if they were employees. The primary goal of this tax is to generate additional revenue to support workers displaced by automation. One method of calculating this tax could involve using a ratio of corporate profits to gross employee compensation expenses. If this ratio exceeds a government-set threshold, additional taxes could be levied on the company's profits, reflecting the amount the company has avoided paying by replacing human labour with automation. Alternatively, a sales ratio could be used instead of a profit ratio.

An alternative proposal to discourage excessive investment in automation is to extend tax benefits to companies that hire people. These benefits could include reductions or exemptions from social contributions or payroll taxes, such as those levied on Medicare systems. Another possible benefit is the super-deduction of wages paid to human workers. These measures would ensure that human employees and machines are treated similarly for tax purposes, or at least in a comparable way, as machines do not receive wages subject to taxation. At the same time, many jurisdictions grant accelerated tax deductions for technology investments aimed at increasing productivity.

Another solution that has been proposed involves introducing narrowly targeted taxes. For example, in 2017, the Grand Council of the Canton of Geneva in Switzerland proposed a tax on automated cashiers in the retail sector, defined as any device that allows customers to pay for their purchases without the intervention of store personnel. While this proposal was rejected, it highlights the concept of taxing specific types of automation. Similarly, in 2018, San Francisco enacted AB1184, which imposed a tax on rides provided by autonomous vehicles, applying a tax of up to 3.25% of net rider fares for a ride and 1.5% for shared rides.

Both proposals focus on taxing specific automation or services rather than imposing a general tax on AI or robots. Such taxes aim to create a direct link between the tax imposed and the remediation of job losses caused by automation, ensuring that the funds collected help mitigate the economic impact on displaced workers (Pavlova & Knyazeva, 2022).

Sam Mitha suggests a proposal for taxing the value added by implementing AI and robots based on the idea that these technologies are expected to make companies more profitable. According to this proposal, businesses would need to monitor the value generated through AI and robots, and any additional value-added would be subject to a higher VAT rate. Alternatively, Mitha proposes that companies whose turnover ratio to the number of employees exceeds a predetermined threshold could also be subject to an increased VAT rate on the goods and services they provide. Another option mentioned is disallowing VAT input on automation-related purchases, effectively limiting the tax benefits businesses can receive from investing in automation technologies.

5. Conclusion

The rapid development of artificial intelligence (AI) has driven governments worldwide to address its economic, social, and ethical implications through regulatory frameworks, with tax policies playing a pivotal role. In China, where AI is a cornerstone of its innovation strategy, the government has implemented various tax incentives to stimulate AI research and development while ensuring revenue collection. These include reduced corporate income tax rates for qualifying High-Technology Enterprises, substantial R&D deductions, and VAT exemptions for AI-related software services and technologies.

Regional policies in cities like Shenzhen and Hangzhou further bolster these efforts through tax holidays and subsidies for startups and research institutions. Despite these benefits, AI companies face challenges navigating China's complex tax system, including compliance burdens and ambiguities in defining AI activities. Globally, the taxation of AI and robots has sparked debates, with proposals ranging from taxing AI as separate entities to imposing automation-specific levies or adjusting existing corporate tax structures to offset job displacement caused by automation. Notable suggestions include robot taxes, automation taxes, and value-added taxation linked to AI-generated value, aiming to neutralize revenue loss from reduced human employment and promote equitable economic contributions. Proposals such as limiting tax incentives for automation, taxing companies based on reduced workforce levels, or rewarding human hiring through tax breaks also seek to balance innovation with societal needs. These frameworks align with neutrality, simplicity, and fairness, ensuring flexibility to adapt to future technological and economic developments. As AI continues to evolve, its integration into global taxation systems will necessitate careful consideration of innovation, equity, and sustainability to foster growth while addressing the disruptive impacts of automation.

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Sustainability and Smart Cities: Linking Renewable Energy with Gender-inclusive Urban Policies

Sürdürülebilirlik ve Akıllı Şehirler: Yenilenebilir Enerjiyi Cinsiyet Ayrımcılığına Sahip Kentsel Politikalarla Bağlantılandırmak

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ANAHTAR KELİMELER

Yenilenebilir enerji
Akıllı şehirler
Karbonsuzlaştırma
Toplumsal cinsiyet eşitliği

ÖZ

Kentsel ekonomiler, sera gazı emisyonlarının büyük bir bölümünü oluşturdukları ve sürdürülebilir enerji geçişini sağlama kapasitesine sahip oldukları için küresel karbonsuzlaşmaya büyük katkı sağlamaktadır. Akıllı şehirler, yenilenebilir enerji sistemlerini benzersiz bir şekilde entegre eden dijital teknolojiler aracılığıyla yenilenebilir enerji kaynaklarının verimli şebekelere, ademi merkeziyetçiliğe ve yeşil altyapıya nasıl dayanabileceğinin farkına varacaktır. Eşitlikçi enerji erişimi ve işgücüne katılımın önünde engeller bulunmaktadır. Toplumsal cinsiyete duyarlı politikalar, kentsel enerji planlamasına eşitliğin yerleştirilmesine, çeşitli işgücü katılımına ve son olarak yetersiz hizmet alan toplulukların entegrasyonuna yönelik kapsayıcı geçişler sağlayabilir. En iyi uygulamalar Kopenhag, Amsterdam ve Fujisawa'dan alınmıştır. Odak noktası, kentsel kalkınmayı küresel iklim hedeflerine bağlayacak ve dünya çapında sürdürülebilir, kapsayıcı ve dirençli şehirler için çevresel ve ekonomik politikaları sosyal eşitliğe doğru dönüştürecektir.

KEYWORDS

Renewable energy
Smart Cities
Decarbonization
Gender Equity

ABSTRACT

Urban economies contribute greatly to global decarbonization because they account for a huge volume of greenhouse gas emissions, and they can drive sustainable energy transition. Smart cities would recognize the way renewables can rely on efficient grids, decentralization, and green infrastructure altogether through digital technologies that uniquely integrate renewable energy systems. There exist obstacles to equitable energy access and workforce inclusion. Gender-responsive policies can ensure inclusive transitions into embedding equity in urban energy planning, diverse workforce participation, and finally integrating underserved communities. Best practices are drawn from Copenhagen, Amsterdam, and Fujisawa. The focus will link urban development to global climate goals and transform environmental and economic policies toward social equity for sustainable, inclusive, and resilient cities worldwide.

1. Introduction: The Imperative for Decarbonization in Urban Economies

The urban areas are at the forefront of the global decarbonization agenda simply because they are great contributors to greenhouse gas emissions yet hold enormous potential in driving sustainable energy transitions. In that regard, smart cities—urban ecosystems harnessing digital technologies for efficiency and innovation—are uniquely positioned to lead this transformation. There is an imperative to integrate renewable energy into urban systems to reduce carbon footprints, increase energy security, and assure economic sustainability. Most urban decarbonization strategies, however, overlook this critical intersection of technology, energy, and social equity—especially how gender shapes both access to, and benefits from, energy

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innovation (Bibri et al., 2023). Gender equity in access to energy and employment is an increasingly recognized ingredient of successful comesble energy policy. Women, especially in developing and underserved communities, face disproportionate barriers to accessing clean energy solutions and are underrepresented in the renewable energy workforce. Systemic changes in policy frameworks, urban planning, and energy governance would be needed to bridge these gaps. One of the opportunities offered by smart cities is that of addressing these discrepancies by including inclusive design principles in their energy strategies.

The purpose of the research is to answer how smart cities optimize renewable energy systems concerning dealing with disparities regarding gender. This paper contributes toward an integral comprehension of how decarbonization efforts may balance economic, environmental, and social goals based on case studies, regulatory frameworks, and the exploration of new technologies by exploring policy and technological innovations necessary to ensure energy equity integration within urban planning. A very important publication because, through the book, come urban development, energy systems, and gender equity all on one single platform. Cities globally, committed to goals of net-zero emissions, ensure energy transition leaves no one behind—is no longer going to be an issue of morality but, if anything, purely economic and environmental necessities. This paper is very instrumental in calling for collaboration among policies, technologies, innovation, and gender-inclusive practices towards decarbonized urban economies.

2. Literature review

Cornerstones of urban decarbonisation strategies now include renewable energy systems: solar, wind, and geothermal. Further, research has shown that decentralized energy systems, including microgrids and rooftop solar panels, can contribute significantly toward improving energy resilience in urban areas and reducing carbon footprints. Muttaqee et al. (2023) examined microgrid installations in American communities to show how the systems might help energy equity by supplying dependable, locally produced electricity to underprivileged areas. Non-renewable energy sources can be defined as energy sources that are finite in nature and do not regenerate at a sustainable rate. These include petroleum, natural gas, and coal. The word "non-renewable" suggests that these energy sources could be depleted and that such energy resources are available only in limited amounts in the Earth's reserves. These resources are often referred to as fossil fuels, named after the processes that formed them, whereby parts of living organisms have been broken down over millions of years. Dependency on non-renewable energy always tends to throw significant questions on sustainability; for their depletion and hazardous influence on the environment shout for a transition to more renewable and sustainable energy systems (Altun & İşleyen, 2018). For instance, by implementing community solar programs and microgrid installations, Boulder, Colorado, and New York City have led the way in renewable energy transitions and provided scalable models for urban decarbonization (Benson et al., 2023).

Magnusson (2012) and Ben Amer et al. (2019) looked at district heating system adoption in Europe and found that Copenhagen, Stockholm, and Helsinki were the top cities for renewable-powered urban heat networks. While Stockholm's district heating system has used waste heat and biofuels to almost achieve zero carbon emissions, Copenhagen's achievement is credited to policy alignment between the municipal governments and the renewable energy source. The majority of cities, particularly those in Central and Eastern Europe, like Warsaw, have outdated infrastructure, which makes it difficult to replicate such models, which demand a significant initial outlay of funds (Markard & Rosenbloom, 2020).

Bahuet (2024) elucidates transforming city governance would be necessary to have resilient, equal, and sustainable urban environments. Imprinting into the minds of people that tomorrow's cities are a result of their today decisions is especially important as inclusive policies are needed for any urban settlement today economically, socially, and environmentally. The newly envisaged type of city leadership proposed in the paper would advocate transformation beyond just urban management.

The development and testing of a methodology for assessing gender equality of urban climate policies were undertaken with women's groups from India, Indonesia, Mexico and South Africa. The GAMMA [Gender Assessment and Monitoring of Mitigation and Adaptation] methodology engages in a thorough contextual and institutional examination of cities' mitigation and adaptation policies. Application of GAMMA by women's organizations in 14 pilot cities produced policy recommendations for achieving gender equality in urban mitigation and adaptation actions. Evidence from a monitoring exercise confirmed that the project has advanced significantly in raising awareness on gender issues and action at the urban level. This empowers civil society organizations for climate justice to demand local government action towards cities that are low carbon, resilient, gender-just and inclusive. It also allows local governments to self-assess (Alber, 2024).

In the Asia-Pacific, Japan has equally led in the integration of renewable energy sources. Solar power, hydrogen fuel cells, and modern large-scale energy storage have been incorporated within the urban infrastructural frameworks of cities such as Yokohama and Tokyo (Yamaguchi et al., 2022). The Fujisawa Sustainable Smart Town demonstrates how renewable energy can be integrated with optimization into the planning of urban use, through a combination of solar panels, battery storage, and energy management systems. Land-use constraints and high population densities remain, however, large barriers to the deployment of renewable energies in Japanese cities.

While these examples show success, persistent barriers,

such as regulatory inconsistencies, high up-front costs, and technological limitations, remain substantial hurdles globally. For instance, there is no national policy framework in the United States to integrate renewable energy into cities, which results in varied approaches across different states (Sovacool et al., 2022). In comparison, the European Union's Renewable Energy Directive (RED II) and Japan's Feed-in Tariff (FIT) system have more holistic frameworks in place. However, these also face challenges in aligning with urban planning goals (Daphne, 2020).

2.1. Smart Cities as Catalysts for Decarbonization

The smart city paradigm leverages digital technologies, including IoT, AI, and big data, to optimize urban energy consumption and reduce emissions. As such, a study by Sharma and Gupta (2022) stated that integration with real-time energy monitoring systems in some pilot cities reduces energy consumption in India by up to 25%. In Europe, Amsterdam and Barcelona have been among the frontrunners in embedding renewable energy technologies within city planning. Under its Smart City initiative, Amsterdam has integrated IoT technologies in the monitoring and optimization of energy use in transportation, buildings, and public spaces, which has yielded considerable carbon reductions (Hassebo and Tealab, 2023). Barcelona has mandated solar panel installations on new buildings and decentralized energy systems to enhance grid resilience (Scordato and Gulbrandsen, 2024). In Japan, under the Society 5.0 framework, many initiatives focus on the integration of digital technologies with urban planning. In Tokyo, for example, AI-driven platforms have been used for demand prediction to optimize renewable energy use, while in Yokohama, efforts have been channelled toward integrating smart grids with solar and wind energy systems (Yamaguchi et al., 2022). Still, this has not overcome the challenge of scalability. Fragmented governance, high costs, and unequal technological adoption rates complicate the widespread implementation of smart city solutions (Sovacool et al., 2020). In the United States, New York City and San Diego have shown what smart city technologies can do to drive renewable energy adoption. On the other side, New York's "Smart City, Clean Energy" initiative aims at managing the distribution of energy using AI and IoT; on its part, the Climate Action Plan of San Diego integrates renewable with urban planning for a 100% renewable electricity vision by 2035 (Furszyfer Del Rio et al., 2021).

2.2. Gender Equity in Renewable Energy and Urban Planning

One of the most critical, yet underexplored, dimensions in urban decarbonization is gender equity. Evidence has been found of wide gender gaps in energy access, employment in renewable energy, and participation in urban planning. Indeed, women, especially in poor communities, face a disproportionately higher energy burden because of the lack of access to clean and affordable energy (Sovacool and Griffiths, 2020). This situation is rather acute in countries like the United States where energy poverty hits the marginalized groups within those communities (Koffka, 2023). In Europe, gender equity initiatives have taken hold with programs such as the EU's Horizon Europe, which provides funding for gender-responsive research and innovation in renewable energy and urban planning. For instance, Poland's "Energy for Women" program trains women in clean energy technologies, providing a model for addressing workforce disparities. Globally, according to IRENA (2021), women make up only 32% of the renewable energy workforce, with even lower representation in technical and leadership positions. Similarly, Japan has taken steps to address disparities in renewable energy on grounds of gender. The Women in Energy initiative aims at training and supporting women entering the sector, in line with broader national goals to increase gender equality within STEM fields (Yamaguchi et al., 2022). However, cultural and structural barriers remain for women to participate meaningfully in decision-making processes around urban energy planning.

While previous research has investigated the role of renewable energy and smart technologies in urban decarbonization, few works exist at the intersection of these areas with gender equity. Most research tends to treat the domains of social equity, technological innovation, and urban planning in isolation, overlooking the systemic interdependencies that shape policy outcomes. For instance, while decentralized energy systems have been studied for their importance, few analyzed how such systems can help address gender disparities in both energy access and employment. This paper tries to fill these gaps by integrating gender-responsive frameworks into analyses of renewable energy adoption and smart city development. The study thus makes a contribution toward more holistic understanding of sustainable urban development by addressing the interlinkages between renewable energy, smart technologies, and gender equity.

3. Smart Cities and Renewable Energy Integration

The use of digital technologies, added to IoI, AI, and big data, makes up the optimization of energy consumption and waste reduction in achieving increased urban efficiency. At the heart of this model is renewable energy: it powers smart grids, electric vehicle infrastructure, and decentralized energy systems. Cities like Amsterdam and Copenhagen have proven it can be done: by integrating renewables into urban design through solar housing, wind farms, and highly efficient district heating systems. However, replication of such solutions in multiple cities faces financial, technological, and regulatory barriers. A very important area of integration is in the development of energy-efficient buildings and microgrids. Smart buildings with energy management systems can reduce consumption and generate renewable energy on-site, creating self-sustaining units within the urban fabric (Bibri et al., 2023). Cities like Barcelona have adopted policies that make it compulsory to include renewable energy technologies in new urban

developments. These developments give the smart city a role as a test bed for sustainable energy solutions, but this also requires intense collaboration among authorities, private businesses, and the general public (Ince Palamutoğlu, 2023).

Incorporating renewable energy into smart cities is a governance issue more than a technological one. The goals of renewable energy should be aligned with urban planning through effective collaboration between the local government and energy providers. Poland's energy policies, for instance, are increasingly centered on renewable energy sources, but they frequently do not match urban planning objectives, which restricts the possibility of developing smart cities on a big scale (De Jong et al., 2015, Seng et al., 2022). Unlocking the full potential of renewables in cities requires closing these governance gaps. Lastly, public involvement is a vital component of a successful integration of renewable energy. Incorporating a diverse range of stakeholders, such as underserved groups, into urban energy planning ensures that solutions are both efficient and fair. This is especially pertinent in Poland, where urban and rural residents have different access to energy. Smart cities must embrace strategies that give every citizen the chance to gain from the switch to renewable energy (Bibri and Krogstie, 2017, Bibri et al., 2023).

In examining different behavior in green consumerism among men and women, Zahoa et al. (2021) discussed the reasons for the differences. Generally, women have more positive intentions toward green consumption, carbon emissions are less of a concern for them, and they purchase green products more frequently. In contrast, quite a few studies show that men seem to possess greater knowledge of environmental issues than women, and in some contexts, they show greater concern for these issues. This looks at the reason for such divergences in green consumer behavior through the VBN theory, bringing in the other angle of gender. It also highlighted a few obstacles for both men and women to buy into green consumption and present some suggestions intended to inspire more public interest in green consumption.

3.1. Ensuring Gender Equity in Renewable Energy and Smart City Development

Despite being one of the most important components for genuinely sustainable urban development, gender equity has been one of the most marginalized topics in the discussion about smart cities and renewable energy. Women encounter the majority of barriers to energy access, particularly in disadvantaged and low-income regions. The good news is that by emphasizing gender-responsive policies and technologies, smart cities may alleviate this inequality. For example, to guarantee that both men and women have equal access to sustainable energy solutions, such as community-based microgrids or solar-powered cookstoves, urban energy projects might incorporate gender impact evaluations (Koumetio Tekouabou et al, 2023). The use of renewable energy is another sector where gender differences exist. The proportion of women in the renewable energy workforce worldwide is less than one-third, and the proportions are significantly lower in technical and leadership roles. By developing specialized programs, educating, and hiring women for positions in the renewable energy industry, smart cities may aid in closing this gap. Polish initiatives such as "Energy for Women" demonstrate how a nation may train women in sustainable energy technologies. Increasing the scale of programs like these could promote greater gender and employment diversity in the smart city workforce.

Inclusive urban planning needs to consider the intersectional barriers that women face in access to energy infrastructure. For instance, public lighting from renewable sources can enhance women's safety, given that many areas of cities are poorly lit. Similarly, smart city projects that include electrification of public transport will enhance mobility for women, who often are the primary caregivers and have more dependency on public transportation. These interventions show why it is so important to embed gender considerations into urban energy strategies (Kenworthy, 2006, Toli and Murtagh, 2020).

The question of gender equity in smart cities, in the final analysis, calls for a change in governance and policy priorities. Such integration of gender perspectives in energy policies and urban planning frameworks should be included in national and local levels of government, which apply to countries like Poland. International organizations and NGOs in this regard might help further by providing their resources and expertise to compile reports to accelerate the process toward renewable energies and make the city smart, resilient, and sustainable (Nesti,2019).

3.2. Policy Implications and Pathways for the Future

The combination of renewable energy with smart city technologies opens up a perspective for decarbonized urban economies, but strong policy frameworks and strategic investments are needed to make this vision a reality. The first important policy implication is regulatory harmonization, aligning urban development with national and EU-level renewable energy objectives. For instance, the European Green Deal is a broad pathway toward carbon neutrality, but its implementation needs to be very effective at the municipal level. Poland's cities, like Warsaw and Krakow, have taken steps toward adopting renewable energy solutions, but much more alignment with EU policies is necessary if this sector is to reach its potential impact. Mechanisms for targeted funding are in place to accelerate the transition towards smart, renewable-powered cities. EU programs such as the Cohesion Fund and Horizon Europe can be used to finance innovative urban energy projects, especially in regions with lower uptakes of renewable energies. For Poland, these funds would be highly valuable in modernizing infrastructure and developing sustainable urban energy systems. Mechanisms to incentivize private sector investments in renewable energy projects may, in

addition, complement public funding and drive innovation (Florkowski and Rakowska, 2022).

Another key priority area soon will be the closure of gender gaps in energy access and employment. Governments and city planners must adapt gender-responsive energy policies that address particular needs and challenges faced by women in very specific terms: promotion of participation in decision-making processes, including training targeted at women, ensuring equitable access to energy infrastructure, and supporting efforts through international cooperation in sharing good practices and funding gender-focused initiatives in urban energy transitions. Looking ahead, the success of decarbonized urban economies will depend on integrating social equity into environmental and economic policies (Darıcı et al., 2019). Sustainable and equitable urban settings will require smart cities to strike a balance between inclusive governance and technological innovation. For the shift to renewable energy to benefit all urban dwellers, governments must address gender inequality, promote public-private partnerships, and coordinate local efforts with global climate goals (Elie et al., 2021). These initiatives will position smart cities as global leaders in sustainable development, establishing the standard for inclusive, carbon-free urban economies everywhere.

4. Integration of Renewable Energy in Smart Cities

4.1. Defining Smart Cities: Technologies, Policies, and Energy Systems

The term "smart city" refers to the new phase of urban development at a time of rapid technological advancement. This vision relies heavily on the integration and use of renewable energy sources, made possible by blockchain, artificial intelligence, and the Internet of Things. Smart grids and energy-efficient technologies, for example, have been installed in American towns like Boston and San Francisco as part of larger urban sustainability initiatives (Hua et al., 2022). Alternatively, Japan's Society 5.0 framework highlighted the integration of digital technologies with energy-efficient and renewable energy-focused urban development. EU policies, such as the European Green Deal, offer standardized rules for integrating renewable energy into smart cities that guarantee carbon neutrality and sustainable urban development (Costantini et al., 2023). This is particularly true when creating and executing a smart city built on networked systems that could lower carbon emissions, like employing real-time IoT sensors that track energy usage and enable demand response management to ensure efficient energy distribution. Because AI-driven platforms anticipate energy requirements and maximize the use of renewable resources, waste is decreased and grid resilience is increased. Financial tools and public-private partnerships are used in policies like the EU's Smart Cities Marketplace to encourage their adoption. To smoothly connect renewable energy sources and urban energy demand, Japan's National Energy Strategy incorporates smart energy technologies into the city's infrastructure (De Pascale and Romagno, 2024).

Even while technology has advanced significantly, there are still obstacles in the way of the shift to smart cities. Widespread implementation is hampered by fragmented legislation, expensive upfront expenditures, and disparities in technical uptake. For instance, there is no national framework for smart cities in the United States; instead, state and local projects are frequently disorganized. On the other hand, the EU's all-encompassing strategy offers cities a more straightforward route to using smart Technologies (Peng et al., 2024). Another practical example that ensures consistency in the deployment of smart city technologies across cities is Japan's centralized energy regulations. It is crucial to combat gender discrepancies in smart city projects to provide equal access to jobs and energy. This is why gender-responsive policies, such as training programs tailored to women in the field of renewable energy technologies, are essential for smart cities (Ren et al., 2024). The inclusion of gender equity in urban development initiatives is emphasized by Horizon Europe, which is the best framework for incorporating this element into smart city design. Japan promotes women's involvement in technology-based fields, particularly in the field of renewable energy.

4.2. Renewable Energy in Urban Infrastructure: Opportunities and Challenges

There are numerous opportunities to reduce greenhouse gas emissions and enhance energy security by incorporating renewable energy into urban infrastructure. In an effort to promote localized energy generation and grid resilience, smart cities make use of technology such as energy storage systems, wind turbines, and rooftop solar panels. Boulder, Colorado's municipal energy policy, for instance, aims to reach 100% renewable electricity by 2030 via deploying renewable energy. Thus, in Europe, cities such as Copenhagen and Amsterdam have heavily invested in renewable energy infrastructures, setting good examples for the development of sustainable urban development. Similarly, it underlines the potential of hydrogen energy and the integration of solar power into urban grids by Japan's focus on these aspects of smart cities (Noori et al., 2020).

Among the barriers to the deployment of renewable energy in cities are land-use constraints, regulatory hurdles, and financial barriers. Open space for large-scale renewable energy projects is often not available in urban centers, so innovative solutions such as floating solar farms or vertical-axis wind turbines may be needed (Abbasi et al.,2024). Progress is also slowed by inconsistent regulation, such as in the United States, where energy policies at the state level are highly varied. The EU's RED II aims at removing these kinds of barriers to the harmonization of regulations and to cross-border cooperation. The FIT system of the government has elicited investment in renewable energy in Japan; however, the effect has been somewhat mitigated by

high prices and dwindling public support (Joss et al., 2019).

Urban energy transitions will also have to grapple with social and economic inequalities, particularly in energy access. In many cities, low-income households and marginalized communities are disproportionately affected by a lack of access to clean energy. The Just Transition Mechanism is one of the policies under the EU that ensures the benefits of renewable energy are fairly shared to support vulnerable populations in the transition towards a low-carbon economy. Similarly, the United States has also taken some similar programs with the main motive of making energy affordable for unserved and underserved communities by launching an Energy Justice program (Aiyar and Ebeke, 2020).

Lastly, gender-based differences in employment and energy access make the shift to renewable energy even more challenging. Due to economic disparities, the majority of women are underrepresented in the workforce for renewable energy, and their energy costs are greater. It is necessary to overcome these disparities by focused laws and initiatives, such as Japan's Women in Energy project, which educates and assists women in the renewable energy industry. For inclusive and fair urban growth, smart cities' energy strategies must take these factors into account.

4.3. Case Studies: Successful Implementations of Renewable Energy in Smart Cities

Successful renewable energy deployments in smart cities offer scalable solutions and best practices. In the United States, the "Smart City, Clean Energy" effort in New York City has demonstrated how smart technologies can maximize the usage of renewable energy. By implementing microgrids with solar and wind energy systems, the city has been able to lower greenhouse gas emissions and improve energy resiliency. By 2035, San Diego's Climate Action Plan aims to generate all of its electricity from renewable sources by incorporating renewable energy into urban development. There are several excellent examples of smart city integration of renewable energy in the EU. One of the most notable instances of urban energy efficiency is Copenhagen's district heating system, which is powered by renewable energy. By optimizing energy use in buildings, public areas, and transportation, Amsterdam's Smart City effort significantly lowers the city's carbon footprint. In addition to providing significant funds, the EU's dedication to cross-border cooperation has been crucial in enabling these programs to grow and remain sustainable (Acheampong et al., 2024).

The Fujisawa Sustainable Smart Town in Japan is another excellent example; it integrates different cutting-edge technologies with renewable energy to create an urban ecology that is almost self-sufficient. The community uses an integrated energy system that minimizes emissions and maximizes consumption. This system includes solar panels, battery storage, and energy management technology. Japan has demonstrated leadership in incorporating renewable energy into urban infrastructure with similar projects in Tokyo and Yokohama, which are fueled by robust government funding and private sector cooperation. For sustainable urban growth, these case studies emphasize how crucial it is to match technological innovation with legislative frameworks. For example, Denmark's aggressive renewable energy targets and supportive regulatory framework may have contributed to Copenhagen's success; similarly, Japan's centralized energy regulations and emphasis on innovation have made smart city development easier. Future attempts to alleviate social and gender inequalities while incorporating renewable energy into urban systems will be guided by these lessons (Wang et al., 2023).

5. Policy and Technological Innovations to Enhance Urban Energy Efficiency

Innovations in technology and policy are therefore crucial for improving urban energy efficiency and incorporating renewable energy into smart cities. One such all-encompassing policy approach is the EU's Clean Energy for All Europeans package, which encourages energy efficiency, the use of renewable energy sources, and consumer empowerment. It includes steps to assist energy communities where residents can produce and distribute renewable energy. Similar initiatives exist in the United States, including the Smart Energy program, which stresses the role of technology in reducing energy consumption and lowering emissions (Sankaran, 2019, OECD, 2020).

Technological innovations, such as AI, blockchain, and energy storage systems, are increasingly taking the place of urban energy systems. AI-powered platforms make possible the prediction of energy demand and optimization of grid operations by integrating renewable sources of energy seamlessly. Blockchain technology makes energy transactions secure and provides peer-to-peer energy trading within smart cities. For example, the blockchain-based Brooklyn Microgrid in the United States enables residents to buy and sell solar energy locally. This shows just how technological advancement could very well drive sustainable urban transitions in energy. Only gender-inclusive policies and programs will make sure that both technological and policy innovations succeed, allowing all urban dwellers to benefit from them (Xuan and Ocone,2022). The EU's Gender Equality Strategy called for inclusion of more women in energy policies for renewables. In Japan's case, focusing on STEM education for women enables their participation in sectors driven by technology, such as smart cities. Some of the indicators that point to this very need in considering gender through the process of devising urban energy strategies create smart and sustainable cities.

The key to improving urban energy efficiency lies at the confluence of policy innovation, technological advancement, and social equity. Linking the strategies for renewable energy with smart city development thus allows

policymakers to develop urban environments that are sustainable and inclusive. Successful case studies from the United States, Europe, and Japan yield important lessons on how this could be replicated globally. Integrating gender equity into such initiatives will ensure the benefits of renewable energy transitions accrue to all, creating a more just and sustainable urban future.

5.1. Addressing Gender Equity in Renewable Energy and Smart City Development

Women still face unequal access to energy globally, especially in urban centres transitioning to renewable energy. The most affected are women in low-income households, who bear higher energy costs related to income, have inadequate access to modern energy solutions, and are excluded from decision-making on energy. Single mothers and women-led households are overrepresented among the energy poor, while studies show this group pays more for utilities than any other demographic concerning income earned. EU policies, such as the Just Transition Mechanism, target disparities and promote equitable access to renewable energy resources (O'Dwyer et al., 2019). While initiatives such as the Basic Energy Plan in Japan do recognize the need for an inclusive energy strategy, it still lacks attention to the specific gender barriers. The urban areas in smart cities amplify these inequalities if renewable energy systems are engineered without consideration for socio-economic and gender dynamics. Transition to solar energy, for instance, is normally associated with up-front costs, which could be a significant barrier, particularly for women in financially constrained households. This has been the case in Europe, where targeted subsidies and financing mechanisms have been put in place to incentivize this aim—for example, Germany's energy-efficient housing incentives. In Japan, the subsidies for household solar panel installations indirectly support gender equity by improving access for households led by women. However, such programs must be expanded to account explicitly for gendered barriers to access (Oladosu et al., 2024).

The intersection of gender and energy access requires policies tailored to address cultural, economic, and systemic barriers. For instance, the EU's Gender Equality Strategy has acknowledged the requirement for gender mainstreaming in energy policies and ensures that women are involved in decision-making. Programs like the U.S.-based Energy Equity Initiative have started evening out the playing field of these disparities, but challenges persist in reaching marginalized women (. Japan has not yet fully incorporated gender considerations into its energy access policies, even with the advancement of renewable energy technologies. Addressing these disparities is central to smart city success, as access to renewable energy has direct impacts on urban sustainability and social equity. International frameworks, such as the United Nations' Sustainable Development Goal (SDG) 5, focused on gender equality, should guide policymakers in adopting gender-responsive energy policies. Bringing a gender lens to energy access strategies not only enhances equity but also boosts general adoption rates, leading to smart city success (Arévalo et al., 2024).

5.2. Job Opportunities in Renewable Energies and in Smart City Sector

The renewable energy and smart city sectors also show large gaps in employment, with underrepresentation of women in technical, managerial, and policymaking positions. According to the International Renewable Energy Agency, women make up only 32% of the workforce in renewable energy worldwide. In technical and leadership roles, which are primarily occupied by men, the disparity grows even more. Women still only make up 25% of the solar energy workforce in the United States, despite the industry's explosive growth. Initiatives like the Women in Renewable Energy—WOMEN-IN-RE program have helped the EU make some progress, but there are still systemic obstacles to overcome; Japan faces comparable difficulties. Although the government is working to increase the number of women in the workforce, women make up a very small percentage of workers in STEM fields related to energy (Raman et al.,2024). These are caused by cultural prejudices and restricted educational and training opportunities. Social norms discourage women from pursuing STEM fields, so excluding them from the potential pool for projects related to smart cities and renewable energy. The EU budget's Horizon Europe program, for example, funds training and research initiatives that target women in an effort to close this gap. Targeting young women from underrepresented groups, the U.S. Department of Energy has also provided funding for programs like STEM Rising. In the same vein, Japan's Women in Science and Technology program, which aims to boost female involvement in STEM subjects, is still lagging behind in terms of notable employment inclusion (IMF, 2023).

The gender equity gap in smart cities' development frameworks, including job possibilities, could be filled. For example, Barcelona's Smart City initiative has prioritized gender inclusion in the creation of jobs for women in the planning of cities and in renewable energy initiatives. Another example is San Diego's Climate Action Plan, which includes workforce diversity objectives that include minorities and women in training programs for renewable energy Technologies (Wang et al., 2019). Japan's Yokohama Smart City Project has recently begun incorporating gender concerns but is at the nascent stages. Such gender-sensitive approaches might include providing scholarships, mentorship programs, or targeted recruitment of women in STEM fields for workforce development within the renewable energy and smart city sectors. International bodies like IRENA and the United Nations Development Program also indicate that gender parity is one of the significant enablers of SDGs. Hence, by closing the gap in employment, smart cities would be able to maximize their potential while ensuring equitable social and economic growth (Pearl-Martinez and Stephens, 2016).

5.3. Inclusive Urban Planning: Bringing Gender Perspectives into Smart Cities

In the heart of ensuring that smart cities address the needs of all residents, especially women, lies inclusive urban planning. Gender-sensitive urban planning entails bringing in women's perspectives in areas such as transportation, housing, and access to energy. In the United States, for instance, cities such as New York and San Francisco have come up with gender-responsive urban policies, including better public transportation and access to affordable energy solutions for women-led households. The EU has been proactive with its Urban Agenda for the EU, which contains a thematic objective of gender equality. Japan's urban development policies have also started integrating gender considerations into their actions, especially in disaster-resilient infrastructure.

Energy infrastructure in smart cities has to be designed considering diverse needs: for example, women use public transportation more, and energy outages affect them more. For example, Vienna in Europe has implemented gender-sensitive transport planning, including improved lighting and safe access to energy-efficient public transport. In Tokyo, Japan, the city has approached gender-inclusive urban design under the Tokyo Smart Energy Project, although again, this hasn't made a broader impact on energy policy at large. US cities like Portland, Oregon, have brought a gender analysis into urban planning by looking at issues of affordable housing and energy efficiency among low-income women.

An integrative approach to gender in smart cities would demand participatory planning processes. That involves including women at all levels, from the highest decision-making body at the local government down to the lowest and smallest community-based organization. Under Horizon Europe, EU funding covers those projects entailing participatory planning and, as such, incorporating women's voices in urban development. Japan is trying to involve itself in citizen-led urban planning initiatives inclusively of diversity, but still, a long way is going for complete gender parity. U.S. cities have followed suit with similar participatory approaches, including Chicago's community energy planning workshops that specifically target the inclusion of women and minorities.

Inclusive urban planning not only promotes gender equality but also leads to more effective smart cities. This might lead to energy efficiency, and reduction in carbon emissions, and create safer, more just urban environments. It is, therefore, relevant that policymakers adopt gender-responsive planning frameworks so that smart cities are sustainable and inclusive for all residents.

5.4. Frameworks and policies to promote gender-equitable decarbonization.

A holistic policy framework that puts gender at the core of renewable energy and smart city initiatives is necessary to achieve gender-equitable decarbonization. One of the most influential models is, of course, the EU Gender Equality Strategy. This underlines the principle of inclusiveness across all policy fields, including energy and urban development (Farla et al., 2012, Lindberg et al., 2019). Another commitment is that the European Green Deal is highly reinforcing in terms of social equity. In the U.S., the Biden administration's Justice40 Initiative provides for 40% of federal climate investments to be made in disadvantaged communities, including women and minorities. Japan's Fifth Basic Energy Plan includes gender considerations but does not have specific mechanisms for implementation (Velut, 2024).

Financial incentives and support mechanisms are a critical enabler of gender-equitable decarbonization. The EU has its Just Transition Fund, which explicitly includes targeted funding directed at projects catering to social and gender inequalities as part of the energy transition; in the U.S., programs like the Weatherization Assistance Program target energy efficiency upgrades for low-income households—most of these are run by women—and, in Japan, some of the subsidies now being made available for renewable energy projects targeting gender equity, though it is still relatively early days for those (European Commission , 2021, Siksnelyte-Butkiene, et al., 2021).

Collaboration among governments, private sector entities, and international organizations is imperative to drive gender-equitable decarbonization. For instance, the UNDP's Gender and Climate Change program works with countries to integrate gender considerations into national climate policies. In an effort to promote gender parity in renewable energy initiatives, the United States has partnered with organizations like the Clean Energy States Alliance. Gender inclusion in urban development is the subject of cross-border collaboration funded by the EU's Horizon Europe initiative. Though more targeted efforts are required, gender issues are beginning to be taken into account in Japan's public-private partnerships in renewable energy. Social, economic, and environmental factors must all be integrated if policymakers are to take a comprehensive strategy to gender-equitable decarbonization. By coordinating renewable energy and smart city projects with gender equity objectives, governments may expedite the shift to a low-carbon economy and foster more inclusive urban settings. Future initiatives to accomplish sustainable and equitable urban development can be guided by the lessons learned from the EU, US, and Japanese effective policies.

5.5. Synergizing Renewable Energy Policies with Smart City Strategies

Integration of renewable energy in smart cities presents a transformational opportunity for decarbonizing urban economies. Smart cities use technologies to increase energy efficiency, manage resources sustainably, and achieve sustainability. In this urban framework, the adoption of renewable sources of energy—solar, wind, biomass—shall

be one of the major steps that can be considered indispensable to the attainment of sustainability objectives. For instance, U.S. cities like San Diego have shown steps towards 100% renewable energy by the year 2035 by being integrated with smart grid systems that enhance better energy management (City of San Diego, 2020). The alignment of renewable energy policies to strategies for smart cities enables the cities to reduce carbon emissions, decrease energy expenditure, and improve the quality of life among citizens. For example, in Europe, Amsterdam has ambitious renewable energy targets under its Smart City program, including energy efficiency, carbon neutrality, and smart infrastructure. Japan, always leading in innovation, incorporates renewable energy into its smart cities through technological advances in the smart grid and advanced energy storage systems—seen in the city of Fujisawa. This will not only help in reducing the GHG emissions but also contribute to the urban resilience in facing climate change.

However, the implementation of smart cities and renewable energy strategies must address the already existing gender gaps in energy access and employment. Women, especially in low-income communities, face huge barriers in accessing technologies and benefits from renewable energy. In many countries, gendered roles in energy production and consumption limit women's participation in decision-making and leadership roles within the energy sector (Kabeer, 2021). Integration of gender-sensitive policies in renewable energy planning within smart cities is going to ensure that the transition towards clean energy is inclusive and equitable. This includes fostering female participation in the green economy through targeted training programs, subsidies for women-led renewable energy enterprises, and gender-responsive energy policies.

6. Strategies for Closing Gender Gaps in Urban Energy Systems

There is a need for a set of policy interventions that will guarantee women equal access to all benefits accruing from renewable energy while empowering them within energy-related jobs. Similarly, professional development opportunities and mentorship for women, through programs such as WEN in the U.S., work to bridge the energy gender gap, while in Europe, the same kind of activities aim at increasing female participation in the energy-related decision-making process by supporting projects to this effect (IRENA, 2019). These programs are very important to address the underrepresentation of women in the energy industry, more so in technical and leadership positions. Japan has also made efforts toward improving gender equality in the energy sector through policies, which will increase the participation of women in the renewable energy workforce. For example, Japan's "Next Generation Energy Technology Innovation Strategy" contains a gender equality dimension, aimed at ensuring diverse human resources for the clean energy sector (Japan Ministry of Economy, Trade and Industry, 2020).

Besides professional development opportunities, addressing the energy access gender gaps also means women can and do participate in the design and implementation of renewable energy projects. Most women, especially in rural and marginalized communities, lack access to clean and affordable energy. In response, some countries have initiated programs to ensure that renewable energy projects are gender-inclusive. For instance, under the World Bank's "Energy Sector Management Assistance Program," several projects have been funded that empower women in rural communities with access to affordable solar energy technologies. By targeting energy access in underserved regions and creating opportunities for women to contribute to energy solutions, smart cities can reduce gender disparities in energy access while promoting sustainability (Fernandez Núnez et al, 2022).

6.1. Sustainable Urban Growth: Balancing Economic, Social, and Environmental Goals

Smart growth in cities requires balancing economic, social, and environmental objectives to achieve sustainable urban growth with renewable sources of energy. Urban growth has to be decoupled from the old model of dependence on fossil fuels and towards inclusive and sustainable development. Particularly regarding energy systems, planning and developing urban cities should take on board environmental sustainability. Assessments of urban ecological footprints, in tandem with the carrying capacity, should therefore be considered in strategic urban energy and sustainability modeling to ensure balanced growth limited by environmental considerations. Promoting green certifications and standards of social accountability for urban industries can be used as an effective policy instrument in promoting sustainable practices. Alongside launching other psychosocial aspects, increasing the provision of financial and technical support for energy efficiency and environmentally compliant businesses is an important key to operating good urban sustainability schemes, which incorporate both the transition to cleaner energy systems and the development of ecological resilience (Türkcan, 2024). In the United States, the Green New Deal is a policy to stimulate job creation in clean energy, focusing on high-quality, green jobs with benefits accruing to all segments of society, including women. In contrast, the European Green Deal maps out a path to net-zero emissions by 2050, focusing on economic recovery through clean energy innovation (Kremer et al., 2019, Demir et al., 2021). The Just Transition Mechanism of the European Union will ensure that the transition towards renewable energy is inclusive and provides financial support to the most affected regions and sectors by the shift to a green economy. In Japan, alongside the government's "Carbon Neutrality 2050" goal, policies stimulating innovation and green entrepreneurship may open more opportunities for women in the renewable energy sector (UN-Habitat, 2021). At the heart of sustainable urban growth is social equity. Therefore, as cities transition to renewable energy systems, it will be

very important for policymakers to ensure that all residents, and more so, women in marginalized communities, get to participate in the new opportunities that come with this change. It involves investment in education and training programs that will assist women in entering the renewable energy workforce and ensuring the ability of women to access affordable energy technologies in their homes. Inclusive urban planning should be a must, providing equal access to jobs, resources, and services while maintaining environmental sustainability. Some cities, such as Oslo, have already successfully integrated sustainability with social equity in their urban planning, fostering the adoption of renewable energies together with inclusive social policies (Sanchez de Madariaga and Neuman, 2020).

6.2. Recommendations for Policymakers, Urban Planners, and Stakeholders

Gender-responsive strategies must be used by stakeholders, policymakers, and urban planners when creating and deploying renewable energy and smart city initiatives. First and foremost, the laws must be formulated in a way that guarantees all citizens fair access to energy, with a particular emphasis on women in low-income and rural areas. This could involve increasing access to funding for women-led green economy enterprises, promoting digital literacy, and providing subsidies for renewable energy Technologies (Ateria et al., 2020). By providing specialized training, networking opportunities, and mentorship, governments should implement initiatives that will promote women's involvement in energy-related decision-making positions.

The special demands of women should also be taken into consideration by urban planners when creating smart cities that integrate renewable energy into all facets of urban life. It can be achieved by implementing gender-sensitive urban design, which guarantees women leadership positions in smart city initiatives, economic possibilities, and access to sustainable energy. For instance, the "Smart Cities Japan" effort in Japan is a model for other nations and places a strong emphasis on integrating renewable energy sources while also advancing gender equality. Likewise, European cities should continue to expand such initiatives where there is collaboration with the government, businesses, and local communities towards achieving goals of gender and sustainability altogether. International organizations like the United Nations can catalyze knowledge sharing and give the impetus for developing and implementing gender-sensitive renewable energy policies across national borders (Torrens et al., 2022). Cities, through global partnership, can execute localized efforts in their pursuit of gender equity, mitigation of carbon emissions, and fostering inclusive economic growth. Such a holistic approach, bringing together renewable energy, smart city strategies, and gender equity, truly will help cities around the world set a sustainable and equitable scene for the future.

7. Conclusion

The policies to be discussed in this paper bring into focus how the integration of renewable energy systems with digital technologies and inclusive urban planning can aid in sustainable urban development. Smart cities, therefore, provide an unprecedented opportunity for leading the global decarbonization agenda through IoT, AI, and big data that optimize energy systems while enhancing grid reliability and waste reduction. Successful examples from cities like Amsterdam, Copenhagen, and Tokyo prove it is possible to combine this with urban planning through smart grids, energy-efficient buildings, and decentralized systems. However, financial, regulatory, and technological barriers remain a significant hindrance to widespread implementation.

Gender parity in municipal energy planning and jobs in the renewable energy industry are also essential to the decarbonization agenda. Accessing clean energy solutions and finding employment in this sector are disproportionately difficult for women, particularly in underprivileged areas. Although initiatives like Japan's "Women in Energy" programs and the EU's Horizon Europe initiative offer valuable templates for tackling these inequities, more coordinated efforts are required on a worldwide scale. To guarantee that everyone benefits from urban transitions to renewable energy, they include policies that support the integration of gender-responsive policies into energy strategies, such as focused training initiatives, inclusive governance frameworks, and fair access to clean energy infrastructure.

Future research and policy efforts should focus on these systemic interdependencies of technology, energy, and social equity. It will need far more coordination among the local, national, and international frameworks and increased collaboration between the public and private sectors. International cooperation and funding support throughout the process would be incorporated into urban planning so as to remove the gaps already there and bring about more access in representation. Looking ahead, the success of smart cities in achieving decarbonized urban economies will depend on the balance between technological innovation and inclusive governance. Policymakers can create an urban environment that is sustainable and equitable by addressing gender disparities, fostering public-private partnerships, and aligning local initiatives with global climate goals. Such efforts will make smart cities true leaders in sustainable development and lay the groundwork for a future that combines renewable energies with gender equality and urban planning throughout the world.

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RESP

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Araştırma Makalesi ● Research Article

Yenilenebilir Enerji Tüketiminin Ekonomik Büyüme Üzerinde Etkisi: Türkiye Örneğinde Amprik Bulgular (1990-2022)

The Impact of Renewable Energy Consumption on Economic Growth: Empirical Findings for Türkiye (1990-2022)

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ANAHTAR KELİMELER

Yenilenebilir enerji tüketimi
Ekonomik büyüme
Bayer-Hanck Eşbütünleşme Analizi
Granger Nedensellik Analizi

ÖZ

Enerji önemli bir üretim faktörüdür. Bu faktörün verimli kullanımı ülkelerin ekonomik büyümesi ile yakından ilgilidir. Ekonomik büyümeyi etkileyen birçok unsur olmakla beraber, enerji son dönemlerde diğer üretim faktörlerinden daha da dikakate değer hale gelmiştir. Teknoloji ve sanayileşme ile birlikte enerji kullanımı giderek artış göstermiş ve önemli hale gelmiştir. Ekonomik büyüme için enerji tüketimi giderek önem kazanmaya başlamıştır. Yenilenebilir enerji üretimi ve tüketimi bütün ekonomiler için göz ardı edilemeyecek kadar etkinlik kazanmış bir değişken olmuştur. Bu çalışmanın amacı 1990-2022 dönemi yıllık verilerine yönelik, yenilenebilir enerji tüketiminin ekonomik büyüme üzerindeki uzun dönem ve kısa dönem ilişkilerini araştırmaktır. Çalışmada, Augmented Dickey-Fuller (ADF) ve Phillips-Perron (PP) durağanlık testleri sonucunda değişkenlerin birinci mertebe fark için durağan oldukları belirlenmiştir. Uzun dönem ilişkinin araştırılması için Bayer-Hanck Eşbütünleşme Analizi uygulanmış ve değişkenlerin uzun dönemde birlikte hareket ettikleri, eşbütünleşik oldukları belirlenmiştir. FMOLS yöntemiyle elde edilen katsayı tahmin sonuçlarına göre, uzun dönemde yenilenebilir enerji tüketiminin toplam enerji tüketimi içindeki payı %1 arttığında, büyüme değişkeni %5.7 artış göstererek olumlu tepki vermektedir. Hata düzeltme modeli sonucunda kısa dönemde de değişkenlerin ilişkili olduğu belirlenmiştir. Uzun dönemde beraber seyreden seriler arasında kısa dönemde meydana gelen sapmaların %40.5'i ortadan kalkmakta ve seriler tekrar uzun dönem denge değerine yakınsamaktadır. Ayrıca, yenilenebilir enerji tüketimi ile ekonomik büyüme arasında çift yönlü bir nedensellik ilişkisi belirlenmiştir.

KEYWORDS

Renewable energy consumption
Economic growth
Bayer-Hanck Cointegration Analysis
Granger Causality Analysis

ABSTRACT

Energy is an important factor of production. The efficient use of this factor is closely related to the economic growth of countries. There are many factors that affect economic growth; however, energy has recently become even more significant than other factors of production With technology and industrialization, energy use has gradually increased and become more important. Energy consumption has become increasingly important for economic growth. Renewable energy production and consumption have become crucial variables that no economy can afford to ignore. The aim of this study is to investigate the long-term and short-term effects of renewable energy consumption on economic growth using annual data from 1990 to 2022. In the study, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) stationarity tests revealed that the variables are stationary at first difference. Bayer-Hanck Cointegration Analysis was applied to investigate the long-run relationship, revealing that the variables move together in the long run and are cointegrated. According to the coefficient estimation results obtained by the FMOLS method, a 1% increase in the share of renewable energy consumption in total energy consumption leads to a 5.7% increase in the growth variable in the long run. As a result of the error correction model, it is determined that the variables are also correlated in the short run. In the long run, 40.5% of the short-run deviations between the co-moving series disappear and the series converge back to the long-run equilibrium value. Moreover, a bidirectional causality relationship between renewable energy consumption and economic growth has been identified.

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1. Giriş

İktisadi büyümeyi etkileyen birden çok bağımsız değişken bulunmaktadır. Bu bağımsız değişkenlerden bazıları doğrudan, bazıları dolayı etkiler barındırmaktadır. Bu değişkenlerden olan enerjinin rolü özellikle sanayileşme ile birlikte büyük önem arz etmektedir. Bununla birlikte enerji tüketiminin iktisadi büyümeyi ne kadar etkileyip etkilemediği tartışma konusudur. Çünkü enerjinin hangi kaynaktan elde edildiği sorusu büyük önem taşımaktadır. Bu açıdan özellikle yenilenebilir enerji kaynakların iktisadi büyümede anahtar rolü taşıması gerekliliği ön plana çıkmaktadır. Ekonomik büyümenin meydana getirdiği çevresel problemlerin ne kadar olduğu ve çevreyi ne kadar etkilediği diğer tartışma konusudur. Enerji tedariki sadece ekonomik büyüme ekseninde ele alınmamalı, aynı zamanda enerjinin kullanılmasından sonra ortaya çıkan emisyonların kontrolünü de sağlamalıdır. Teknolojik gelişmeler enerjide alternatif alanlar oluşturmuştur. Özellikle yenilenebilir enerji kullanımı günümüzde daha verimli ve sonuçları açısından daha tercih edilebilir bir düzeydedir. Hem iktisadi büyümeye olan katkısı hem de çevreye verdiği zarar açısından bakıldığında yenilenebilir enerji geleneksel enerjilere karşı güçlü bir konuma gelmiştir (Mahmood vd., 2019 ve Sohail vd., 2021).

Enerji, üretim ve tüketim süreçleri göz önüne alındığında hem bireylerin yaşamlarını sürdürmeleri hem de iktisadi açıdan ele alındığında önemli bir parametredir. İktisadi açıdan bakıldığında enerjinin büyümeyle olan ilişkisi göz ardı edilemeyecek kadar önemlidir. Teknoloji ve sanayileşmede meydana gelen ilerlemelere paralel olarak nüfus artışı ve yaşam standartların gelişimi enerjiye olan talebi arttırmakla beraber, yeni enerji kaynaklarının yaratılmasını da öncelikli hale getirmiştir. Özellikle geleneksel enerji kaynaklarının hızla tüketilmesi yenilenebilir enerji sahasının gelişimini daha da hızlandırmıştır. Ülkelerin enerji açısından dışa bağımlılıklarını en aza indirmek için yenilenebilir enerji kaynaklarına olan yatırımları aynı zamanda iktisadi olarak da geri dönüşümü hızlı olan ekonomik yatırımlardır. Yenilenebilir enerjinin iktisadi büyümeyle sonuçlandığı ve bununla birlikte yerli üretim kapasitelerinin arttırılması gerekliliği son çalışmalarda ortaya konulmuştur (Coester vd., 2018)

Enerji kaynakları sadece temel ihtiyaçların giderilmesi olarak görülmemelidir. Aynı zamanda iktisadi büyüme ve kalkınmayı da pozitif etkilemektedir (Xiong vd., 2014). Böylelikle hem bireysel hem de toplumsal refaha katkıda bulunan temel unsurlardan biri haline gelebilmektedir. Bu sonucun ortaya çıkması için fosil kaynaklardan yenilenebilir enerji kaynaklarına doğru geçişin gerekliliği sağlanmalıdır. Ancak yenilenebilir enerji kaynaklarının yatırım ve üretim aşamalarında dışsal zararları en aza indirgenmek zorundadır.

İktisadi büyüme kavramı ele alınırken; yapısal değişimler, kişi başına düşen gelirlerde meydana gelen artışlar, teknolojik gelişmeler, sermaye birikimi, işgücü artışlar göz önünde bulundurulmaktadır. İktisadi büyümeyi esas olarak ifade ederken; yatırım, sermaye, istihdam ve inovasyonda meydana gelen gelişmeler takip edilmelidir. Gelişmiş ülkeler iktisadi politikalarını belirlerken temel çıkış noktaları olarak büyümeyi hedef çıpa olarak belirlemişlerdir. Bu açıdan gelişen teknoloji ile birlikte enerjinin büyüme üzerinde etkisi önemli bir noktaya gelmiştir. Enerjiye olan yeni yatırımların hızlı geri dönüşümü ile birlikte iktisadi büyüme üzerinde etkisinin varlığı son dönemde araştırmacılar tarafından titizlikle incelenmektedir.

Çalışmamızın amacı 1990-2022 dönemi içerisinde yenilenebilir enerji tüketiminin iktisadi büyüme üzerindeki uzun dönem ve kısa dönem ilişkilerinin Türkiye sahasında araştırılmasına yöneliktir. Araştırmamızın birinci bölümü teorik çerçeve, ikinci bölümü amprik literatür araştırmaları ve son bölümde ekonometrik analiz çalışmalarından meydana gelmektedir. Araştırma kapsamında öncelikle durağanlık testlerine bakılarak; Phillips-Perron (PP) ve Augmented Dickey-Fuller (ADF) testleri gerçekleştirilmiştir. Denkleme bakıldığında sistemde mevcut olan değişkenlerin ortak gecikme uzunluğu belirlemek için literatürde çoğunlukla kullanılan standartlar vardır. Bu standartlara bakıldığında; Hannan-Quinn (HQ), Likelihood Ratio (LR), Akaike Information Criteria (AIC), Final Prediction Error (FPE) ve Schwarz (SW) ön plana çıkmaktadır. Bu standartlara göre gecikme uzunluğunun belirlenmesinde belirli standartlar öne çıkmış ve kararlaştırılmıştır. Daha sonra uzun dönem ilişkisinin incelenmesi amaçlanarak Bayer-Hanck (2013) Eşbütünleşme Analizinden faydalanılmıştır. Sonraki aşamada ise; kısa dönem ilişkilere bakılarak zaman hata düzeltme modeli gerçekleştirilmiştir. Nedensellik ilişkisi için Granger nedensellik testi uygulanmıştır. Çalışmamızın ayırt edici yönü, Türkiye için 1990-2022 yıllarını kapsayan uzun dönemli veriler kullanılarak Bayer-Hanck (2013) eşbütünleşme testi uygulanması ve uzun/kısa dönem ilişkilerin detaylı şekilde analiz edilmesidir. Ayrıca FMOLS yöntemiyle elde edilen bulgular, yenilenebilir enerji tüketiminin ekonomik büyüme üzerindeki pozitif etkisini güncel verilerle ortaya koymakta ve Granger nedensellik analiziyle değişkenler arasında çift yönlü bir ilişki belirlenmektedir.

2. Teorik Çerçeve

Ekonomik büyüme bir ülke ekonomi için önemli parametrelerden bir tanesidir. İktisadi ve sosyal refah artışı ekonomik büyümenin önemli göstergelerindendir. Bu açıdan bakıldığında iktisadi tartışmalarda bu kavramlar sürekli göz önünde bulundurulmaktadır. GSYİH'nin sürekli artışı bir ülke ekonomisi için büyümenin meydana geldiğini göstermektedir. Bir ülke ekonomisinde ekonomik büyüme artışının tespiti yapılırken ortalama büyüme hızı ile yıllık bazda büyüme hızı verileri baz alınarak bu verilerden faydalanılmaktadır. Ortalama büyüme oranına bakıldığında; bir zaman dilimi içerisinde reel GSYİH'nin artışını ölçmektedir.

Ülkeler arası ekonomik karşılaştırma yapılırken ve ekonomik büyüme hesaplamalarında Reel Gayri Safi Yurt İçi Hasıla en önemli göstergelerdendir. Bu açıdan Reel GSYİH ele alınırken ülkelerin sahip olduğu nüfus göz ardı edilmemelidir. Günümüzde enerji talebinin arttığı ve tüketimlerin yoğunluğundan kaynaklı enerji arzının önemli bir noktaya evrildiği görülmektedir. Birey ve toplumların artan talep artışlarının enerji kullanımını arttırması üretimin artmasını tetiklemiştir. Üretim artışlarının ülke ekonomisine katkısı yadsınamaz. Konuya bütüncül bakıldığında enerji ekonomik büyümenin önemli alt başlığı olarak karşımıza çıkmaktadır. Ülkeler yüksek büyüme çıtasını yakalayabilmeleri için üretimi arttırmak ve bununla birlikte enerji kullanımını arttırmayı gerçekleştirmek zorunluluğunu kabul etmek zorundalar. Bazı iktisadi görüşlere göre üretim faaliyetlerin tümünde enerjinin temel girdi olarak kabul edilmesi hususu söz konusudur. Böylelikle enerji sanayileşme, şehirleşme ve ekonomik büyümenin kaynağını oluşturduğu tezini ortaya koymaktadır. Enerjinin ülkelerin kalkınmasında da önemli bir girdi olduğunu kabul etmek gerekir (Efeoğlu ve Pehlivan, 2018: 104).

Enerji tüketimi ve iktisadi büyümeye bakıldığında teorik açıdan değerlendirme yapılırsa bu iki kavram arasında bir nedenselliğin olduğu kabul görmektedir. Büyümenin gerçekleşmesinden sonra ulusal gelir artmakta ve bu artan gelir, yatırım ve tüketim harcamalarını artırmaktadır. Bu harcamalar ile birlikte enerjiye olan talebin artması kaçınılmazdır. Birbirini tetikleyen bu süreç, enerjinin teknik gelişmeleri teşvik etmesi ve daha fazla üretimin gerçekleşmesiyle sonuçlanmaktadır. Konuya bu bakış açışı ile bakıldığında; yenilenebilir enerjinin hem sermaye-yoğun hem de emek-yoğun üretim teknolojilerinin geliştirilmesine pozitif yansımalarının sonucu olarak ekonomik büyümenin ortaya çıkmasına katkıda bulunmaktadır. Yenilenebilir enerji teknolojilerinin gelişmesi ile birlikte istihdamın artması ve işsizliğin düşmesi sağlanarak birey ve toplumların refah düzeylerinin yükselmesine katkı sunacaktır. Yenilenebilir enerji kaynak kullanımı açısından yerli unsurlar barındırdığı için enerjinin ithalatı azalmaktadır. Böylelikle yurt içinde yatırım ve tüketim harcamaları artmaktadır (NREL, 1997: 2)

İktisadi büyüme ve yenilenebilir enerji tüketimi arasında nasıl bir bağlantının bulunduğu araştırmacılar tarafından tartışılmaktadır. Bu ilişkinin iktisadi anlamda pozitif olduğu, iktisadi anlamda negatif olduğu ve nötr olduğu sonucunu savunan araştırmacılar bazı çalışmalar ile görüşlerini ortaya koymuşlardır. Aşağıdaki tabloda iktisadi büyüme ve yenilenebilir enerji tüketimi arasındaki bağlantının niteliğini ortaya koymaya çalışan araştırmacıların ampirik bulgularının sonucu özet halinde verilmiştir.

Tablo 1: Yenilenebilir Enerji Tüketimi ve Ekonomik Büyüme Arasındaki Farklı Görüşler

Başlıca Görüşler	**Yazarlar**
Yenilenebilir Enerji Tüketiminin Artış Göstermesi İktisadi Büyümeyi Artırır	Khan vd. (2020), yenilenebilir enerji tüketiminin ekonomiye etkisinin pozitif olduğu, ekonominin ise yeşil teknolojiyi teşvik ederek yenilenebilir enerji tüketimini olumlu bir şekilde etkilediğini ifade eder. Zafar vd. (2020), fosil yakıt enerji tüketimi ne kadar azalırsa ekonomik büyüme için o kadar avantaj sağlayacaktır.
Yenilenebilir Enerji Tüketiminin Artması Ekonomik Büyüme Aleyhine Olur	Shahbaz vd. (2020), araştırmaya göre yenilenebilir enerji tüketimi iktisadi büyümeyi engellemektedir. Bu sonuç yenilenebilir enerjinin fosil enerji ile değiştirme aşamasının maliyetli olmasından kaynaklıdır. Maji vd. (2019), çalışmada yenilenebilir enerji tüketimi toplumda var olan faktör verimliliğini azaltarak iktisadi büyüme hızını düşürdüğü sonucuna ulaşılmıştır.
İktisadi Büyümeyi Yenilenebilir Enerji Tüketiminde Meydana Gelen Artışlar Kayda Değer Bir Şekilde Etkilememektedir.	Menegaki (2011), çalışmada iktisadi büyüme ve yenilenebilir enerji tüketimi arasındaki bağlantının belirli bir kayda değer sonuç doğurmadığı şeklindedir. Çalışma, bu iki kavram arasında Granger nedenselliği bulunmadığını Avrupa üzerindeki çalışma sonucunda ulaşmıştır. Chang vd. (2015), farklı ülke veya bölge örnekleri, zaman dilimleri ve ekonometrik modeller temelinde iktisadi büyüme ve yenilenebilir enerji tüketimi arasında nötr bir ilişkinin varlığı sonucunu desteklemişlerdir.
İktisadi Büyüme Üzerinde Etkili Olan Yenilenebilir Enerji Tüketiminin Bölgesel Farklılıkları Vardır	Yan vd. (2022), yenilenebilir enerji tüketiminin istihdam üzerindeki etkisini araştırmış ve farklı bölgelerde bu etkinin heterojen olduğunu sonucuna varmışlardır. Guo vd. (2022), çalışmasında ulaşım, iktisadi büyüme, turizm ve yenilenebilir enerji bağımsız değişkenleri arasında doğrusal olmayan bağlantıyı ele almışlardır. Araştırmaya göre, yenilenebilir enerjinin düzenleyici etkisine bakıldığında kayda değer bölgesel farklılıklar olduğu sonucuna ulaşılmıştır. Chen vd. (2021), yaptıkları çalışmada Çin'de geleneksel enerji kaynakları ile birlikte yenilenebilir enerji kaynaklarından elektrik üretiminin iktisadi büyüme bağlantısını incelemişlerdir. Araştırma sonucuna bakıldığında; iktisadi büyüme ve elektrik üretimi değişkenleri arasında bölgesel farklılıklar olduğu sonucuna ulaşmışlardır.

Kaynak: Feng and Zhao, 2022

3. Literatür Araştırması

Pao ve Fu (2013), Brezilya'da 1980-2010 tarihleri arası yenilenebilir enerji tüketimi değişkeninden iktisadi büyüme değişkenine doğru tek taraflı nedensellik ilişkisi saptamışlardır. Bu ilişkiyi ortaya çıkarmak için Granger nedensellik testi ile Johansen Eşbütünleşme testi kullanmışlardır. Pao, ayrıca iktisadi büyüme ve toplam yenilenebilir enerji arasında bulunan nedenselliğin çift taraflı olduğunu ortaya çıkarmıştır.

Sebri ve Salha (2014), yaptıkları bir çalışmada 1971-2010 yılları arasında iktisadi büyüme ve yenilenebilir enerji tüketimi arasındaki bağlantının ne olduğunu ortaya çıkarmayı amaçlamışlardır. BRICS ülkeleri ele alınarak, Vecm Granger nedensellik testi ve Ardl Sınır testinden faydalanılmıştır. Çalışmanın nihayetinde ele alınan iki değişkenin arasında çift yönlü nedensellik bağlantısının olduğu sonucu ortaya çıkmıştır.

Singh vd. (2019), gelişmiş ve gelişmekte olan 20 ülkede 1995-2016 dönemleri ele alınarak iktisadi büyüme ve yenilenebilir enerji tüketiminin nasıl bir bağlantısının olduğunu En Küçük Kare Resresyon (FMOLS) modelinden yararlanarak incelemişlerdir. Bu araştırmanın sonuç kısmına bakıldığında ele alınan iki değişken(iktisadi büyüme ve yenilenebilir enerji üretimi) arasında anlamlı bir ilişkinin varlığına ulaşmışlardır. Çalışmada gelişmekte olan ülkelerin gelişmiş olan ülkelere kıyasla yenilenebilir enerji üretiminin iktisadi büyüme üzerinde etkisinin daha fazla meydana geldiği görülmüştür.

Apergis ve Payne (2010b), 20 OECD ülkesini kapsayan ve 1985-2005 yılları arasında yaptıkları çalışmalarda panel eşbütünleşme yöntemini kullanmışlardır. Bu çalışmada işgücünün, sabit sermaye stokunun ve yenilenebilir enerjinin iktisadi büyüme üzerinde etkileri ele alınmıştır. Araştırma sonucuna göre; yenilenebilir enerjideki artış reel olarak GSYH'yi arttırdığı görülmüştür. Bununla birlikte iki değişken arasında hem uzun hem de kısa dönemde iki taraflı bir nedensellik kullandıkları Vektör Hata Düzeltme modeli ile tespit edilmiştir.

Durğun ve Durğun (2018), 1980-2015 dönemlerinde iktisadi büyüme ve yenilenebilir enerji tüketiminin Türkiye ölçeğinde incelemişlerdir. Çalışmada Toda Yamamoto yöntemi ve ARDL sınır testi metodunu temel alarak Granger nedensellik testlerinden faydalanmışlardır. Araştırma bulgularına göre; yenilenebilir enerji tüketiminden iktisadi büyümeye yönelik tek taraflı Granger nedensellik ilişkisi sonucu elde edilmiştir.

Apergis ve Payne (2011), 1980-2006 dönemlerine ait verileri kullanmışlardır. Bu verilerle 6 Orta Amerika ülkesinde yenilenebilir enerji tüketimi ve iktisadi büyüme arasında ilişkinin niteliğini ortaya koymaya çalışmışlardır. Hata düzeltme modeli ve Panel veri analiz yöntemi analiz sonuçlarına bakıldığında iktisadi büyüme ve yenilenebilir enerji tüketimi bağımsız değişkenleri uzun vadeli ve karşılıklı bir bağlantının olduğunu ortaya koymuşlardır.

Apergis ve Danuletiu (2014), gelişmekte olan ve gelişmiş toplam 80 ülkenin verilerinin analizi gerçekleştirmişlerdir. Bu ülkeler arasında Türkiye'de bulunmakta ve 1990-2012 dönemlerini kapsamaktadır. Araştırmada Canning-Pedroni nedensellik testleri ve Panel veri analiz yöntemlerinden faydalanılmıştır. Çalışmanın sonuç kısmına bakıldığında; yenilenebilir enerji tüketiminin ekonomik büyüme için önem arz etmekle birlikte, iktisadi büyümeden hareketle yenilenebilir enerji tüketimine yönelik nedensellik bağlantısının varlığı saptanmıştır.

Inglesi- Lotz (2016), yaptıkları çalışmada 1990-2010 dönemlerinde gelişmekte olan ve gelişmiş 34 OECD ülkesinin iktisadi büyüme ve yenilenebilir enerji tüketiminin birbirleri ile ilişkisinin sonucunu ortaya çıkarmak için uzun süreli bağlantılarını incelemişlerdir. Araştırmada ekonomik büyüme ve yenilenebilir enerji tüketimi bağımsız değişkenlerinin arasında pozitif ve anlamlı ilişkinin var olduğunu ortaya çıkarmışlardır.

Rafindandi ve Öztürk (2017), yaptıkları çalışmada Almanya'da 1971-2013 dönemleri arasını incelemişlerdir. Çalışmada faydalanılan Bayer-Hanck eşbütünleşme testi ve ARDL sınır testleri kullanılarak yenilenebilir enerji tüketimi ile iktisadi büyüme arasında nasıl bir etkinin olduğunu belirlemeye çalışmışlardır. Elde ettikleri sonuçlara göre; iktisadi büyümenin belirli bir kısmı yenilenebilir enerji tüketiminden kaynaklı olduğu saptanmıştır. Değişkenler arasında karşılıklı bir nedensellik ilişkisinin bulunduğu tespit edilmiştir.

Alper (2018), Türkiye ekonomisi üzerinde yaptığı çalışmada 1990-2017 dönemini incelemiştir. Çalışmada Toda-Yamamoto nedensellik analizi ve Bayer-Hanck eşbütünleşme testi kullanılmıştır. Araştırmada birçok değişken arasında eşbütünleşme ilişkisi sonucu ortaya çıkmakla beraber, iktisadi büyümeden kaynaklı yenilenebilir enerji tüketimine yönelik nedensellik bağlantısının varlığı tespit edilmiştir. Enerji kullanımında % 1'lik bir artmanın iktisadi büyümeye olan etkisi % 0,19 seviyesinde olduğu sonucuna ulaşılmıştır.

Omri (2013), çalışmasında 1990-2001 dönemleri için Ortadoğu ve Kuzey Afrika Ülkelerinin karbondioksit emisyonları, iktisadi büyüme ile enerji tüketimi arasındaki bağlantıyı incelemiştir. Çalışmada; iktisadi büyüme ve enerji tüketimi değişkenlerine yönelik elde edilen sonuçlara göre iki yönlü nedensellik ilişkisinin varlığı ortaya çıkarılmıştır.

Block vd. (2015), Çin üzerine yaptıkları araştırmada 1977-2013 ve 1965-2011 yılları arasında iktisadi büyüme ve yenilenebilir enerji tüketimi bağlantısını araştırmışlardır. Araştırmada ARDL Eşbütünleşme, VECM Granger Nedensellik ve Yapısal Kırılma Testi yöntemleri kullanılmıştır. Çalışmaya bakıldığında; iktisadi büyüme ve yenilenebilir enerji kullanımı arasında uzun vadede iki taraflı bir nedensellik ilişkisi ortaya konulmuştur.

Ibrahiem (2015), 1980- 2011 yılları arasında Mısır üzerinde yaptığı çalışmada iktisadi büyüme ve yenilenebilir elektrik tüketimi arasındaki bağlantı ele almıştır. Bu ilişki tespit edilirken Granger Nedensellik ve ARDL Sınır Testi yöntemleri kullanılmıştır. Araştırmanın sonucuna göre; yenilenebilir elektrik tüketiminin uzun vadede iktisadi büyüme üzerinde olumlu bir etkiyle sonuçlandığı ve bu iki değişkenin çift yönlü bir nedensellik ilişkisinin varlığı sonuç olarak karşımıza çıkmaktadır.

Bu doğrultuda, mevcut literatürde yenilenebilir enerji tüketimi ile ekonomik büyüme arasındaki ilişki üzerine farklı bulgular elde edildiği görülmektedir. Bir grup çalışma, bu iki değişken arasında pozitif bir ilişkiyi desteklerken (Sebri ve Salha, 2014; Singh vd., 2019), bazı çalışmalar nötr ya da negatif ilişkiler tespit etmiştir (Maji vd., 2019; Menegaki, 2011). Türkiye üzerine yapılan çalışmalar bulunmakla birlikte, özellikle uzun dönemli veri seti kullanılarak ve Bayer-Hanck eşbütünleşme testi gibi alternatif yöntemlerle yapılan araştırmaların sınırlı olduğu dikkat çekmektedir. Bu bağlamda çalışmamız, Türkiye özelinde uzun dönemli veri seti kullanarak ve farklı ekonometrik yöntemleri uygulayarak literatüre hem metodolojik hem de güncel dönem açısından katkı sunmayı amaçlamaktadır.

4. Ekonometrik Analiz

4.1. Verilerin Tanıtımı

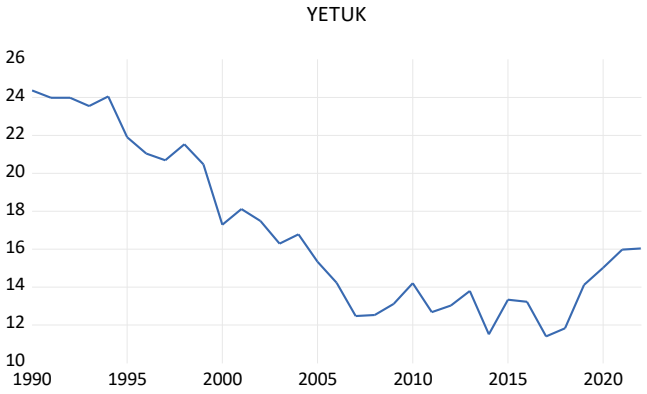
Çalışmamızda analizde kullanmak üzere, 1990-2022 dönemi yıllık verilerine yönelik, yenilenebilir enerji tüketiminin büyüme üzerindeki hem kısa dönem hem de uzun dönem bağlantıları incelenerek, gerekli bulgular elde edilmiştir. Veriler https://data.worldbank.org/ veri tabanından sağlanmıştır. Değişkenlerin tanıtımına bakıldığında aşağıda Tablo 2'de gösterilmiştir. Sonrasında analizler için Eviews 12.0 sürümünden yardım alınmıştır.

Tablo 2: Analizde Yararlanılan Değişkenlerin Tanıtımları

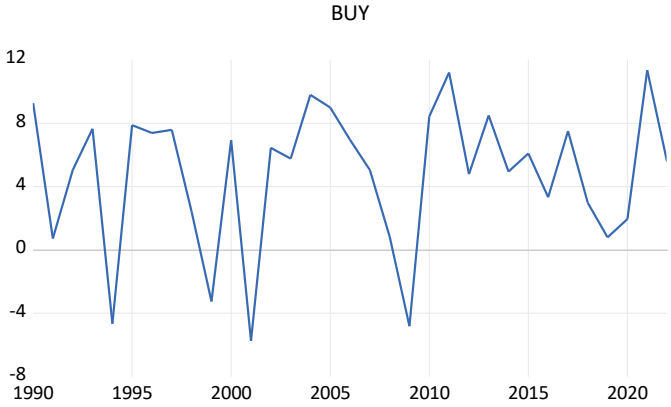
Değişken	Gösterimi	Tanımı
Gayrisafi yurtiçi hasıla büyüme oranı (%)	BUY	Bağımlı değişken
Yenilenebilir enerji tüketiminin toplam enerji tüketimindeki payı (%)	YETUK	Bağımsız değişken

Değişkenlerin zaman içindeki seyrine yönelik grafikler aşağıdadır.

Türkiye'de yenilenebilir enerji kullanımın toplam enerji tüketimindeki oranı 2009 yılına kadar azalan bir seviyede yol almıştır, 2010-2015 arası yatay bir seyir izlemiş, 2017 yılında artış eğilimi kazanmıştır.



Şekil 1. Yenilenebilir enerji kullanımın toplam enerji tüketimindeki oranı (%)



Şekil 2. Gayrisafi yurtiçi hasıla büyüme oranı (%)

Türkiye için GSYİH büyüme verileri dönem boyunca artış ve azalışlar göstererek yatay bir seyir izlemiştir. Kriz dönemleri için azalışların (negatif değer) olduğu görülmektedir. Verilere dair tanımlayıcı bilgiler aşağıdaki Tablo 3'de sunulmuştur.

Tablo 3: Verilere İlişkin Tanımlayıcı Bilgiler

İstatistikler	YETUK	BUY
Ortalama	16.83091	4.773370
Medyan	15.98000	5.763206
Maksimum	24.37000	11.35350
Minimum	11.40000	-5.750007
St.sapma	4.258872	4.521479

Ele alınan YETUK değişkeninin ortalama değeri 16.83±4.25, medyan ortalaması 15.98, maksimum değeri 24.37, minimum değeri 11.40 olarak belirlenmiştir. BUY değişkeni ortalama değeri 4.77±4.52, medyan ortalaması 5.76, maksimum değeri 11.35, minimum değeri -5.75 olarak elde edilmiştir.

4.2 Ekonometrik Yöntem

Durağanlık testlerine bakıldığında; bu analizler için Phillips-Perron (PP) ve Augmented Dickey-Fuller (ADF) testleri gerçekleştirilmiştir. Literatürde sıklıkla kullanılan kriterlere göre; denklem sisteminde mevcut olan değişkenler açısından ortak gecikme uzunluğu tespit edilebilmektedir.

Kriterlere göz önüne alındığında; Akaike Information Criteria (AIC), Schwarz (SW), Final Prediction Error (FPE), Likelihood Ratio (LR) ve Hannan-Quinn (HQ) sıralanmaktadır. Sıralanan kriterlere göre gecikme uzunluğu saptanmıştır. Bayer-Hanck (2013) Eşbütünleşme Analizi kullanılarak uzun dönem ilişkinin araştırılması yapılmıştır. Hata düzeltme modeli uygulanarak kısa dönem ilişkiler ele alınmıştır. Nedensellik ilişkisi için Granger nedensellik testi uygulanmıştır.

4.3 Analiz Sonuçları ve Yorumlama

Başlangıçta elde edilen veriler üzerinde durağanlık testleri analizi yapılmıştır. Analizlerin her biri için "sabit+trend" ile "sabit" alternatifleri tercih edilmiştir. Verilerin mevsimsellikten arındırılması için Eviews 10.0 sürümünde kullanılan Hodrick-Prescott filtresinden faydalanılmıştır. Uygulamada bazı dönemlerde negatif değer alan (düşüş) ZEW verisinin mevsimsel etkilerini ortadan kaldırmak için logaritması alınamamıştır. Mevsimsel etkileri ortadan kaldırılan zaman serisi verilerinin trend ve döngüsel hareketleri bileşenlerine bölünmesi amacıyla bazı metotlar geliştirilmiştir. Ancak yoğun şekilde istifade edilen yöntem Hodrick-Prescott (1980) aracılığıyla tasarlanmış filtredir. Bu tasarlanmış filtreye bakıldığında, bir zaman serisindeki trend ve döngüsel bileşenleri minimize edecek form şeklinde tercih edilmektedir:

$$\sum_{t=1}^{T}(y_t-\tau_t)^2+\lambda\sum_{t=2}^{T-1}[(\tau_{t+1}-\tau_t)-(\tau_t-\tau_{t-1})]^2 \quad (1)$$

Yukarıdaki denkleme bakıldığında; denklemde τ_t parametresi eğilim bileşenini göstermektedir. Bununla birlikte λ parametresi, eğilimdeki dalgalanmaları azaltan "düzgünleştirme parametresini" (smoothing parameter) ifade etmektedir. λ parametresi, döngüsel hareketlerdeki oynaklık ile trend bileşeninin ikinci farkının oynaklığı arasındaki oranı belirtir. Bununla birlikte veride tespit edilen gürültü/sinyal oranını ifade eder. Filtre kullanımından önce λ değerinin saptanması zorunludur. λ parametresi [0, ∞] aralığında değerler alabilir ve λ parametresinin sıfır olması, veride döngüsel hareketlerin bulunmadığını; artı sonsuz değerini alması ise serinin zaman içinde doğrusal bir trend bileşeni içerdiğini belirtir (Hodrick ve Prescott,1980). Çalışmamızda, kuramcıların uygulamacılara önerdiği günlük veri setleri için λ=1600 kullanılarak faydalanılmıştır. Diğer veride olumsuz bir sonuç bulunmamasına karşın, homojenliği sağlamak amacı ile serilerin tümünde filtre kullanılması uygun görülmüştür. Mevsimsel etkiler ortadan kaldırıldıktan sonra trend etkilerinin saptanması amaçlı birim kök testleri gerçekleştirilmiştir.

Başlangıçta verilerin kullanımında sağlıklı sonuçlara ulaşmak için durağanlık testleri analizi yapılmıştır. Testlerin her biri için "sabit+trend" ve "sabit" alternatifleri tercih edilmiştir. Mevsimsel etkilerini ortadan kaldırmak için değişkenlerin logaritmik değerleri hesaplanmıştır.

Tablo 4: ADF ve PP Birim Kök Test Bulguları

Değişkenler	ADF		PP	
	Sabit	Sabit+trend	Sabit	Sabit+trend
YETUK	-1.413(0.109)	-1.714(0.116)	-1.563(0.129)	-1.670(0.137)
BUY	-1.256(0.112)	-1.320(0.123)	-1.411(0.132)	-1.488(0.145)
ΔYETUK	-9.589(0.014)*	-9.905(0.000)*	-10.087(0.001)*	-10.531(0.004)*
ΔBUY	-8.215(0.007)*	-8.811(0.000)*	-9.314(0.004)*	-9.815(0.002)*

*0.05 için durağan değişken,

Not: parantez içi değerler (p) değerleridir ve Δ gösterimi birinci derece farkı ifade etmektedir.

Tablo 4'e bakıldığında; değişkenlerin düzey seviyesinde durağan olmadığı görülmektedir. Değişkenler göz önüne alındığında birinci derece fark için durağandır ve I(1) seviyesinde durağanlık tespit edilir. Elde edilen sonuçla birlikte eşbütünleşme analizi için değişkenlerin birinci derece farkları hesaplanacaktır. Tablo 5'de eşbütünleşme analizini yapmak için gerekli gecikme uzunluklarını saptamak amacıyla kriterlerin değerleri verilmiştir.

Tablo 5: Değişkenlerin Gecikme Düzeylerinin Tespit Etmek İçin Kullanılan Ölçütler

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1377.826	NA	4.35e+12	46.12753	46.33696	46.20945
1	-1149.816	402.8167	7.27e+09	38.02721*	41.19325*	40.30066*
2	-1108.519	64.69981	6.31e+09	39.55062	42.27327	40.61560
3	-1057.890	69.19177	4.25e+09	39.06301	43.04227	40.61952
4	-1006.031	60.50262*	3.03e+09	38.53437	43.77023	40.58240
5	-954.6107	49.70627	2.54e+09*	38.92036	44.51283	40.55992

Tablo 5'e bakıldığında, gecikme uzunlukları kriterlerinin çoğu 1 gecikme için uygunluk sağlamıştır. Bu nedenle, eşbütünleşme analizi değişkenlerin birinci derece farkları ve 1 gecikme seviyesi ile incelenecektir.

Bayer- Hanck (2013) Eşbütünleşme Analizi

Engle-Granger (1987) eşbütünleşme analizi uzun vadeli regresyon modelinin kalıntıları üzerinden hesaplanmaktadır. Bu açıdan bu testin birim köke sahip olan serilerin durağanlık kazandırmadan seriler arasında uzun vadeli ilişkileri açıklamaya yönelik özellikleri vardır. Fakat bu durum analiz edilirken çoklu açıklayıcı farklı değişkenlerde çalışan modellerde Engle-Granger eşbütünleşme analizinin güçlü olmadığı görülmekle beraber, bu sonucun tersi olarak araştırmacılar açısından zayıf görüldüğü belirtilmektedir (Govindaraju ve Tang, 2013:314). Bu aşamadan sonra gecikme uzunluğuna son derece duyarlı olan Johansen (1991) eşbütünleşme testi, sonradan geliştirilmiştir. İlerleyen dönemlerde hata düzeltme modelini temel alan ve F istatistiğiyle gerçekleştirilen başka bir eşbütünleşme testi geliştirmiştir (Boswijk, 1994). Başka bir test olan Banerjee vd. (1998) analizi hata düzeltme modelli ve t istatistiğine dayanan bir testtir. İfade edilen eşbütünleşme analizlerini tamamen güçlü ve mükemmele yakın değildir. Bundan dolayı Bayer ve Hanck (2013) yeni bir test meydana getirmiştir. Bu testi geliştirirken Johansen (1991), Boswijk (1994), Engle ve Granger (1987) ve Banerjee vd. (1998) eşbütünleşme testlerinden faydalanarak, meydana getirdiği testi bu testlerle birlikte değerlendirmiştir. Bayer ve Hanck (2013) tarafından geliştirilen yeni testin yukarıda sayılan analizlerin olasılık değerlerini birleştirerek daha kuvvetli bir eşbütünleşme testi elde etmiştir. Bayer ve Hanck (2013) tarafından geliştirilen testin uygulanması ile birlikte; Boswijk (1994)'ın hata düzeltme terimiyle çalışan testi, Engle-Granger (1987)'in tek denklemli ve Banerjee vd. (1998)'in testleri ile Johansen (1991)'in çok denklemli testlerinin istatistiksel olasılıklarını değerlerini göz önünde bulundurarak testin uygulamasını sağlamıştır (Shahbaz, vd. 2013: 10). Bayer-Hanck (2013) eşbütünleşme testi, Fisher'in ki-kare dağılımı formülünü takip ederek ayrı ayrı olasılık değerlerini bir araya getirmiştir (Arı, 2016: 61):

$$EG - JOH = -2[In\,(P_{EG}) + In\,(P_{JOH})] \quad (2)$$

$$EG-JOH-BO-BDM = -2\,[In\,(P_{EG}) + In\,(P_{JOH}) + In\,(P_{BO}) + In\,(P_{BDM})] \quad (3)$$

Denklem (2) ve Denklem (3)'ye bakıldığında P_{EG}, P_{JOH}, P_{BO}, P_{BDM}, Boswijk (1994), Banerjee vd. (1998), Engle-Granger (1987) ve Johansen (1991) eşbütünleşme testlerinin olasılık değerlerini göstermektedir. Hesaplanan test istatistiğine bakıldığında, Bayer-Hanck (2013) aracılığıyla geliştirilen ve uygulanan bu test istatistiği kritik değerden büyük olduğunda eşbütünleşme bağlantısının bulunmadığı temel hipotez reddedilerek, eşbütünleşme bağlantısının serilerin birbirleri arasında varlığı kabul edilmektedir. Aşağıdaki tabloda Bayer-Hanck eşbütünleşme testi sonuçları tablolaştırılmıştır.

Tablo 6: Bayer-Hanck (2013) Eşbütünleşme Testi Bulguları

Model	EG-JOH	EG-JOH-BO-BDM	Eşbütünleşme
FBUY = f (FYETUK)	19.462*	32.587*	
Anlamlılık Düzeyi	Kritik değer	Kritik değer	
%1 düzeyi	20.671	36.277	Var
%5 düzeyi	17.598	29.813	
%10 düzeyi	13.513	18.692	

Not: * %5 anlamlılık düzeyinde eşbütünleşme olduğunu göstermektedir. "F" gösterimi birinci derece farkı ifade etmektedir.

Bayer ve Hanck (2013) tarafından geliştirilen eşbütünleşme testi sonuçlarına bakıldığı zaman, ölçülen 2 Fisher Test istatistiği değerinin kritik değer olan 0.05'i aştığından değişkenler arasında eşbütünleşme bağlantısının bulunduğu tespit edilmiştir.

Eşbütünleşme bağlantısı tespit edilen modelin uzun vadeli eşbütünleşme katsayı varsayımları Tam Değiştirilmiş En Küçük Kareler Yöntemi (Fully Modified Ordinary Least Square: FMOLS) ile tamamlanmıştır.

Tablo 7: FMOLS Uzun Dönem Eşbütünleşme Katsayı Tahmini

Model	FYETUK
FBUY = f (FYETUK)	0.057*

*0.05 için istatistik anlamlı değişken, varsayımlardaki otokorelasyon ve değişen varyans problemleri, Newey-West yöntemi ile telafi edilmeye çalışılmıştır.

FMOLS yöntemi analizleri yapıldığı zaman, otokorelasyon ve değişen varyans sorunları Newey-West yöntemi ile telafi edilmeye çalışılmıştır. Varsayım testlerinin sonucuna bakıldığında hiçbir varsayım sapması meydana gelmemiştir.

Tablo 7'ya göre; YETUK değişkeni BUY üzerinde pozitif yönde anlamlı ilişkilidir ($p<0.05$). Uzun dönemde yenilenebilir enerji tüketiminin toplam enerji tüketimi içindeki oranı %1 arttığında, büyüme değişkeni %5.7 artış göstererek olumlu tepki vermektedir.

Uzun vadede uyumlu olan değişkenlerin kısa vadede dinamiklerini analiz etmek için hata düzeltme modeli (Vector Error Correction Model: VECM) öngörülmüştür. Elde edilen sonuçlar aşağıda tablolaştırılmıştır.

Tablo 8: Kısa Dönem Hata Düzeltme Modeli Tahmin Bulguları

Bağımlı Değişken: ΔBUYt	Katsayı	Diagnostik Testler
ΔYETUKt	0.036*	R^2 =0.623, Adj. R^2 =0.619, F(p)=0.000*,
ECTt-1	-0.405*	Breusch-Godfrey LM Test (p)= 0.114*,
Sabit	1.612*	White Test (p)=0.128*, Ramsey RESET Test (p)= 0.139* , JB test (p)=0.286

Not: *0.05 düzeyinde istatistiksel anlamlılığı, JB; Jarque-Bera normallik testi olasılık değerini göstermektedir. Varsayımlardaki otokorelasyon ve değişen varyans problemleri, Newey-West yöntemi ile telafi edilmeye çalışılmıştır.

Modeldeki hata düzeltme terimi negatif bir katsayıya ve istatistiksel anlamlılığa sahiptir. Başka bir deyişle; modelin hata düzeltme mekanizması işlevseldir. Uzun vadede birlikte hareket eden seriler arasında kısa vadede oluşan sapmaların %40.5'i giderilmektedir ve seriler yeniden uzun vadeli denge seviyesine yaklaşmaktadır. Kısa vadede katsayılar uzun vadeli katsayıları ile karşılaştırıldığında daha düşük değerler göstermiştir. Diğer bir ifade ile; YETUK değişkeni kısa vadede BUY üzerinde etkisi daha az olmaktadır ve dönem uzadıkça etkinin artış gösterdiği gözlemlenmektedir.

Çalışmada değişkenlerin nedensellik ilişkilerini göstermek için Granger nedensellik testi gerçekleştirilmiştir.

Tablo 9: Granger Nedensellik Analizi

Boş hipotez	F-ist	p	Karar
FYETUK → FBUY	7.4832	0.0000	Nedensellik var
FBUY → FYETUK	9.3619	0.0036	Nedensellik var

YETUK değişkeninden BUY değişkenine doğru nedensellik vardır, aynı zamanda BUY değişkeninden YETUK değişkenine doğru nedensellik elde edilmiştir, bu durumda çift yönlü bir nedensellik belirlenmiştir (YETUK↔BUY). YETUK değişkeninin önceki dönem değerleri BUY değişkeninin cari değerini üzerinde etkili iken, BUY değişkeninin önceki dönem değerleri YETUK değişkeninin cari değerini üzerinde etkilidir.

5. Sonuç ve Öneriler

Ekonomik faaliyetlerin dengeli ve arzu edilen şekilde yerine getirilmesi için enerjinin önemi her geçen gün daha da artmaktadır. Enerjide dışa bağımlılık iktisadi faaliyetleri olumsuz etkileyerek, iktisadi ve sosyal hedeflere ulaşmayı güçleştirmektedir. Fosil kaynakların coğrafik dağılımındaki dengesizlik, ülkelerin yenilenebilir enerji yatırımlarını zorunlu hale getirmiştir. Bu açıdan yenilenebilir enerji ekonomiler için bir tercih değil, zorunluluk haline gelmiştir.

Yenilenebilir enerji tüketiminin büyüme oranını araştırmak, sürdürülebilir kalkınma ve çevresel koruma hedefleri açısından büyük bir önem taşımaktadır. Dünya genelinde fosil yakıtların kullanımının neden olduğu karbon emisyonları, iklim değişikliği ve çevresel tahribat gibi sorunlar giderek daha belirgin hale gelmektedir. Bu bağlamda, yenilenebilir enerji kaynaklarının benimsenmesi, bu olumsuz etkilerin azaltılmasına katkıda bulunabilir. Yenilenebilir enerji tüketiminin büyüme oranını izlemek, enerji politikalarının etkinliğini değerlendirmeye, yeni stratejiler geliştirmeye ve küresel iklim hedeflerine ulaşma yolunda ilerlemeyi sağlamaya yardımcı olur. Aynı zamanda, yenilenebilir enerji sektöründeki büyümenin ekonomik, sosyal ve çevresel faydalarını belirlemek, sürdürülebilir bir enerji geleceği inşa etmek için kritik bilgiler sunar.

Araştırmalar, yenilenebilir enerji tüketiminin artmasının ekonomik büyümeye, istihdam yaratılmasına ve enerji bağımsızlığının artırılmasına katkıda bulunduğunu göstermektedir. Yenilenebilir enerji projeleri, yerel ekonomileri canlandırarak yeni iş fırsatları yaratır ve enerji güvenliğini artırarak dışa bağımlılığı azaltır. Bu durum, ülkelerin enerji arzını daha sürdürülebilir ve güvenli hale getirir. Ayrıca, yenilenebilir enerji teknolojilerine yapılan yatırımlar, inovasyon ve teknolojik ilerlemeyi teşvik eder, bu da uzun vadede ekonomik büyümeyi destekler. Yenilenebilir enerji tüketiminin büyüme oranını araştırmak, bu dinamikleri anlamak ve gelecekteki enerji politikalarını şekillendirmek için gereklidir. Böylece, hem çevresel hem de ekonomik sürdürülebilirlik sağlanarak, toplumların refahı ve geleceği için önemli adımlar atılabilir.

Bu çalışmada, 1990-2022 dönemi Türkiye verileri kullanılarak yenilenebilir enerji tüketiminin ekonomik büyüme üzerindeki etkileri analiz edilmiştir. Araştırmada öncelikle Phillips-Perron (PP) ve Augmented Dickey-Fuller (ADF) testleri ile değişkenlerin durağanlık seviyeleri incelenmiş, ardından Bayer-Hanck (2013) eşbütünleşme testi kullanılarak uzun dönem ilişkilerin varlığı belirlenmiştir. FMOLS yöntemi ile yapılan tahminler, yenilenebilir enerji tüketimindeki artışın ekonomik büyüme üzerinde pozitif bir etkisinin olduğunu göstermiştir. Ayrıca, hata düzeltme modeli sonuçlarına göre kısa dönem uyum süreçleri doğrulanmış ve Granger nedensellik testi ile değişkenler arasında çift yönlü bir nedensellik ilişkisi tespit edilmiştir. Genel bulgulara bakıldığında, Türkiye'de yenilenebilir enerji tüketiminin artırılmasının ekonomik büyümeye katkı sağladığını göstermektedir. Bu doğrultuda, enerji arz güvenliğini desteklemek ve sürdürülebilir kalkınma hedeflerine ulaşmak amacıyla yenilenebilir enerji yatırımlarının artırılması, yerli üretim kapasitesinin güçlendirilmesi ve Ar-Ge çalışmalarının teşvik edilmesi önem arz etmektedir. Ayrıca, yenilenebilir enerji kullanımının yaygınlaştırılması çevresel sürdürülebilirlik açısından da desteklenmelidir. Gelecek çalışmalarda, sektörel düzeyde analizler yapılması ve farklı ülke örnekleriyle karşılaştırmalı çalışmalar gerçekleştirilmesi önerilmektedir.

Çalışmamızın sonucuna bakıldığında; literatürde yenilenebilir enerji ve büyüme arasında pozitif nedensellik

ilişkisini açıklayan Sebri ve Salha (2014), Singh vd. (2019), Ibrahiem (2015), Inglesi- Lotz (2016) ile aynı paralelde sonuçlara ulaşılmıştır. Diğer yandan, Apergis and Payne (2011), Can and Korkmaz (2019), Chen vd., (2020), Li vd., (2022), Ravichandran vd., (2022) çalışmalarında yenilenebilir enerji ve büyüme arasında pozitif yönde anlamlı uzun ve kısa dönem ilişkiler belirlenmiştir.

Çalışmamızın literatüre katkısı 1990-2022 dönemi yıllık verilerine yönelik, yenilenebilir enerji tüketiminin büyüme üzerindeki uzun dönem ve kısa dönem ilişkilerinin Türkiye üzerinde pozitif nedensellik ilişkisinin varlığıdır. Türkiye'nin yenilenebilir enerji yatırımlarını arttırarak, enerji tüketiminde yenilenebilir enerji tüketimini önceleyerek ekonomik büyümeye daha fazla katkı sağlayacak adımlar atmalıdır.

Yenilenebilir enerji tüketiminin büyüme oranını artırmak için çeşitli stratejiler ve politikalar benimsenebilir. Genel olarak önerileri şöyle sıralayabiliriz;

Teşvik ve Destek Programları:

- **Mali Teşvikler:** Bu teşviklerde yenilenebilir enerji yatırımlarını arttırmak için sübvansiyon, vergi indirimleri ve düşük faizli krediler ön plana çıkmaktadır.
- **Araştırma ve Geliştirme (Ar-Ge) Destekleri:** Yenilenebilir enerji yatırımları için bu alandaki teknolojik yatırımların arttırılması ve Ar-Ge projelerine gerekli fonların verilmesi

Yasal ve Düzenleyici Reformlar:

- **Yenilenebilir Enerji Kotaları:** Enerji şirketlerine yönelik yaptıkları üretimlerin belli bir oranını yenilenebilir kaynaklardan oluşturma zorunluluğu konulabilir.
- **Yönetmelikler ve Standartlar:** Yenilenebilir enerji kullanımı için gerekli teşvikler verilerek, yasal zemine oturtulmalıdır.

Altyapı Yatırımları:

- **Akıllı Şebekeler:** Akıllı şebeke teknolojilerine gerekli yatırım yapılarak yenilenebilir enerji kaynaklarının entegrasyonu yapılmalıdır.
- **Depolama Çözümleri:** Yenilenebilir enerji kaynaklarının verimliliğini arttırmak için enerji depolama teknolojilerinin geliştirilmesi gereklidir.

Eğitim ve Farkındalık:

- **Kamu Farkındalığı Kampanyaları:** Yenilenebilir enerjinin avantajları konuyla ilgili tüm taraflara detaylı aktarılmalıdır.
- **Eğitim Programları:** Bu alanda gerekli eğitimler verilerek yetişmiş insan kaynağı oluşturulmalıdır.

Uluslararası İşbirlikleri:

- **Teknoloji Transferi:** Yenilenebilir enerji teknolojisine sahip ülkelerden gerekli teknoloji transferi yapılabilir.
- **Finansman:** Yenilenebilir enerji projeleri için uluslararası finans kuruluşlarından gerekli fonlar sağlanabilir.
- **Yerel Üretim Teşvikleri:** Yenilenebilir enerji yatırımlarında kullanılan malzemelerin yerel düzeyde üretilerek, maliyetlerin düşürülmesi ve istihdamın arttırılması sağlanabilir.
- **İnovasyon Teşvikleri:** Yenilenebilir enerji alanında yenilikçi çözümler geliştiren firmalar desteklenebilir.

Bu stratejiler ve politikalar, yenilenebilir enerji tüketiminin artmasına ve sürdürülebilir bir enerji geleceğinin sağlanmasına katkıda bulunabilir. Bununla birlikte bundan sonra yapılacak çalışmalarda yenilenebilir enerji tüketimi farklı değişkenler ile ve farklı yöntemler kullanılarak ülke grupları için incelenebilir.

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RESP

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Araştırma Makalesi ● Research Article

The Expenditure-Based Energy Pricing as an Example of Sustainable Carbon Tax in Turkey

Türkiye'de Sürdürülebilir Karbon Vergisi Örneği Olarak Harcama Bazlı Enerji Fiyatlandırması

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ANAHTAR KELİMELER

Karbon Vergisi
Emisyon Ticaret Sistemi
Gökyüzü Güven Programı
Enerji Adaleti

ÖZ

Türkiye gelişmekte olan bir ülkedir ve dünyanın önde gelen ekonomilerinden birine sahiptir. Karbon emisyonlarının ortadan kaldırılması açısından Emisyon Ticaret Sistemi için hazırlıklar yapılmaktadır. Bu çalışmada, karbon emisyonlarını azaltma yöntemlerinden biri olan karbon vergisi hane harcamalarına bağlı olarak uygulanmaktadır. Yöntemin prensibi, karbon vergisinden elde edilen gelirin hane harcamalarına orantılı ve eşit olarak dağıtılmasıdır. En düşük gelir grubundaki hanelerin karbon vergisi gelirleri %7,79 iken, en yüksek gelir grubundaki haneler %2,4 daha fazla ödeme yapmaktadır. Sonuç olarak yakıt ve elektrik enerjisi bazında gelir eşitliği sağlanmaktadır.

KEYWORDS

Carbon Tax
Emission Trading System
Sky-Trust Program
Energy Justice

ABSTRACT

Turkey is a developing country and has one of the world's leading economies. Preparations are currently being made for the Emissions Trading System in terms of elimination of carbon emissions. In this study, carbon tax, one of the methods of reducing carbon emissions, is applied to households depending on expenditure. The principle of the method is as follow the income obtained from carbon tax is distributed equally to households in proportion to their expenses. While the carbon tax revenues of households in the lowest income group are 7.79%, households in the highest income group pay 2.4% more. Therefore, income equality is achieved on the basis of fuel and electricity energy.

1. Introduction

Turkey's contribution to global carbon emissions is less than 1%, but due to its geographical location, it is among the countries most affected by climate change. Turkey became a party to the United Nations Framework Convention on Climate Change in 2004 and to the Kyoto Protocol in 2009. The Paris Agreement, which was prepared to accelerate efforts to combat climate change and set more ambitious targets, was accepted by 196 Parties at the UN Climate Change Conference of the Parties (COP21) held in Paris, 2015. The agreement entered into force on in 2016. The Paris Agreement, whose general goal is to keep the global average temperature increase below 2°C compared to the pre-industrial period and, if possible, to 1.5 degrees, is a legally binding international agreement on climate change. Turkey is pursuing a green growth policy and contributing to global efforts to combat climate change (T.C Çevre, Şehircilik ve İklim Değişikliği Bakanlığı , 2025). Believing that the Paris Agreement offers a unique opportunity to implement a green and just transition, Turkey supports the implementation of the mitigation and adaptation policies

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included in this Agreement. In addition, as a candidate country for the European Union (EU), Turkey closely monitors EU policies and develops legislation on climate change and the environment in order to comply with the relevant acquis. There is Turkey's 12th National Development Plan prepared for the 2024-2028 period and long-term economic development plans and climate reform studies for 2053 (T.C Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı, 2025).

The Government of the Republic of Turkey is presenting its updated First Nationally Determined Contribution (NDC) in the context of the Glasgow Climate Consensus, which was adopted by the Parties at the 26th Conference of the Parties as a supplement to the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement. With this statement, Turkey confirms that it will reduce its greenhouse gas emissions by 41% (695 Mt CO_2 equivalent in 2030) by 2030, compared to the reference scenario specified in the First Nationally Determined Contribution (and the Intended Nationally Determined Contribution), where 2012 is accepted as the base year. Turkey's updated First Nationally Determined Contribution covers the entire economy and includes comprehensive mitigation and adaptation actions as well as assessments of means of implementation. Turkey intends to reach its peak emissions by 2038 at the latest. The new reduction target represents a significantly more ambitious approach based on science and equity, and is one of the steps forward towards achieving net zero by 2053 (UNFCCC, 2023).

As in all developing countries, Turkey's carbon emissions have been increasing over the years. The most important factors in this are the increase in industrialization and the increase in the welfare of people. As shown in Fig. 1 carbon emissions have increased approximately 2.5 times from 1990 to 2022 (TÜİK Gas Emission, 1990-2022).

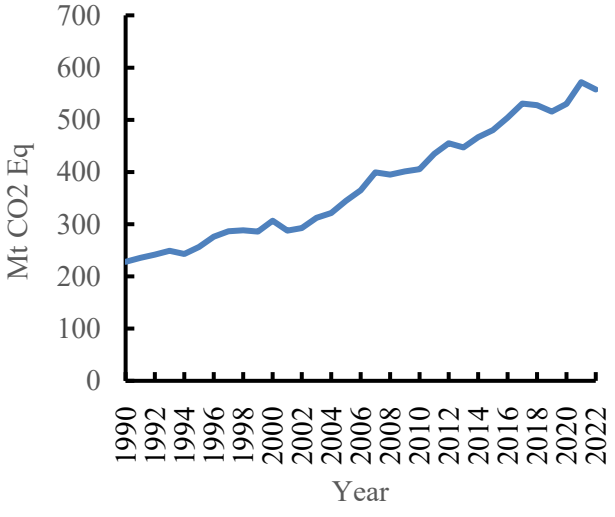

Figure 1. The total amount of greenhouse gases emitted by Turkey between 1990-2022

The way to reduce carbon emissions is to set up a carbon fee system by increasing the price of fossil fuels. The first carbon price was implemented in Finland in 1990 and later spread to many European countries (Beck et al. 2015). Studies show that carbon taxes can be an effective policy option and that their major negative impacts can be offset through the design of the tax and the use of the resulting fiscal revenues. Although governments at the national level have several policy tools to choose from, locally implemented carbon taxes are also important for decarbonization. There will be winners and losers in these local regulations. Since carbon taxes are based on the carbon energy balance, they are harder to apply to a system than other environmental taxes. The distribution of carbon tax is very important for both welfare impact and policy payoff for a country. There are two problems at here one of them how high taxes will affect the public and other is how the revenue collected will be used.

The reason for the innovation in this study is that environmental taxes tend to be regressive, meaning that poor people pay a disproportionate share of their income in these taxes compared to rich people, which is a disadvantage. The methodologies used in these studies vary from simple calculations to general equilibrium models based on the shares of energy products in household expenditures (Baranzini et al. 2000).

The distributional impact of a carbon fee depends not only on its impacts on households but also on the use of the revenue generated. The carbon money collected can be used to reduce public spending or other taxes. Here, the income is distributed back to households. This is also called "energy right" or "sky trust".

The right to energy was first made known with the establishment of the United Nations in 1950 (Shyu C.W., 2021).

This right was established to ensure and support to have access to energy at affordable prices in particular citizens in EU countries. Although the right to energy is widely discussed in politics, theoretical and academic studies are few (Hesselman et al. 2019).

In this study, the transition to renewable energy will be encouraged by taking the right to energy as a basis and ensuring that everyone has access to energy. The carbon tax collected here is distributed to low-income households, thus preventing from using high-carbon fossil fuels of these households.

The first similar study was Pollin and Chakraborty's study on India in 2015. Here, emissions were significantly reduced while low-carbon energy investment increased by 1.5% of GDP. The paper finds that by undertaking clean energy investments, India will achieve significant CO_2 emission reductions and make significant gains in employment opportunities. (Pollin, R., Chakraborty, S. 2015)

In Azad et al.'s 2020 study on energy policy in India, there

is a free fuel and electricity allowance of 2268 kWh per household per year and a travel pass of $17.9 per person per year for public transport (Azad, R., Chakraborty, S., 2020).

In a study conducted by Dinan and his colleagues in the United States in 2002, there were two ways to evaluate the carbon revenues collected. The first of these was to distribute the collected revenue to facilities that consume high amounts of fossil fuels, and the second was to distribute it equally to households. Since the first was difficult to calculate, the second application was implemented. According to this application, the incomes of the lowest income groups increased by 3.5%, while the incomes of the highest income groups decreased by 1.6% (Dinan, T. M., Rogers, D. L., 2002).

Climate change and economic inequality are closely linked. This inequality is especially evident as low-income households spend a large portion of their income on carbon-intensive products. In a study conducted by Fremstad et al. in 2019, the carbon footprints of households in the United States where a $50 tax was applied were calculated. Accordingly, dividing the carbon tax into dividends reduced inequalities between groups. It benefited 84% of people in the lower income group and 56% of all people. As a result, it was accepted that the distribution of the carbon tax was insufficient for the purchasing power of Americans Fremstad, A., Paul, M., 2019).

The world is moving towards increasingly small households. The number of people living alone is increasing. In this case, it would be more appropriate to conduct these studies on an individual basis rather than on a household basis.

2. Household expenditures and energy use in Turkey

As of the end of November 2024, Turkey's installed capacity has reached 115.144 MW. The distribution of our installed capacity by resources is 28% hydroelectric energy, 21.4% natural gas, 19% coal, 10.9% wind, 16.8% solar, 1.5% geothermal and 2.3% other resources (TC. Enerji ve Tabii Kaynaklar Bakanlığı, 2025).

Share of environmental protection expenditure in GDP was 0.85% in 2023 and 63.3% of environmental protection expenditures realized for waste management services (TÜİK Expenditure, 2025).

Turkey has the 17th largest economy in the world according to IMF reports. Turkey's GDP value in 2023 is 1.024 trillion dollars. Turkey, which is a member of the OECD and G20, needs to solve poverty and economic problems in order to continue its development and progress. For this reason, the combating fossil fuels should be among the priorities. Turkey has a lot of trade with the EU and it is the 3rd largest country exporting to the EU. Turkey has to prioritize carbon studies due to the Border Carbon Adjustment Mechanism that the EU will implement. The society will get used to this system with the carbon tax application starting from households and it will be a fair solution to income distribution inequality (CBAM, 2025).

The most important condition for environmental protection revenues are fair and sustainable. Studies are developing various applications and researches to ensure that these revenues also have financial and socio-economic returns, one of which is the study in this article. According to previous research, environmental taxes can have unequal effects on income distribution, but progressive environmental taxes can reduce inequalities. Environmental tax reform can meet both distributional and environmental goals when properly designed to address distributional concerns. Environmental taxes and green tax reforms are powerful tools to promote the transition to sustainable economies and they can increase welfare by internalizing externalities, a fundamental principle of environmental economics (Domguia, E. N. 2023; Bercholz, M., Roantree, B. 2019; Labeaga, J. M., Xavier, L.,2020).

One method used in environmental taxes is the "Sky Trust" program. Entrepreneur Peter Barnes redefines the debate about climate change in his article. He argues that by treating the sky as a common asset, we can protect the atmosphere while paying every American cash. Barnes proposes a nongovernmental Sky Trust that would charge rent on carbon emissions and pay each of us equal annual dividends. The Sky Trust would also ease the burden on workers, firms, and households who are hardest hit by the transition to a lower-carbon economy. This study redefines the debate about the costs of addressing climate change and proposes a market-based institution called the Sky Trust that would set limits on carbon emissions and pay dividends to all of us who collectively own the atmosphere (Barnes, P., 2003). Some of the work done on this subject will be adapted to Turkey. Some of the studies conducted on this subject will be adapted to Turkey. In short, the aim here is the process of decarbonizing the sky that we all own.

In the methodology used in this study, carbon tax is calculated based on the amount of energy consumed by the household. Carbon tax is determined in proportion to the carbon content of the goods and services used. Household expenditures in developing and developed countries will differ from each other. For example, there is no house heating and fossil fuels such as wood are used more intensively for cooking in hot climate countries.

The household expenditures are grouped into 12 categories for Turkey as can be seen from the TÜİK data in Figure 2. These are food and non-alcoholic beverages, alcoholic beverages, cigarette and tobacco, clothing and footwear, housing and rent, furniture and houses appliances, health, transportation, communication, entertainment and culture, educational services, restaurant and hotels and various good and services. According to the results of the household budget survey for 2022, housing and rent expenditures have the highest share in consumption expenditures of households. Housing and rent expenditures have consumption expenditures with 22.4% of all consumptions,

followed by transportation expenditures with 21.3% and food and non-alcoholic beverage expenditures with 22.8%. The types of expenditures that had the lowest share in total consumption expenditures were education services with 1.4%, health with 2.2%, and entertainment and culture expenditures with 2.5% (TÜİK Household, 2022). As seen in Figure 2, household expenditures are divided into 20% segments from low to high. Accordingly, it is seen that low-income households allocate more than twice as much share to food as high-income households. When we look at the distribution of consumption expenditures in 2022 according to 20% groups ranked by income, households in the first 20% group, which is the lowest income group, allocated 35.8% to food and non-alcoholic beverage expenditures, 29.3% to housing and rent expenditures, 8.3% to transportation expenditures and 5.5% to furniture and household goods expenditures. Households in the fifth 20% group, which is the highest income group, allocated 28.5% to transportation expenditures, 19.3% to housing and rent expenditures, 16.6% to food and non-alcoholic beverage expenditures and 6.8% to restaurant and hotel expenditures.

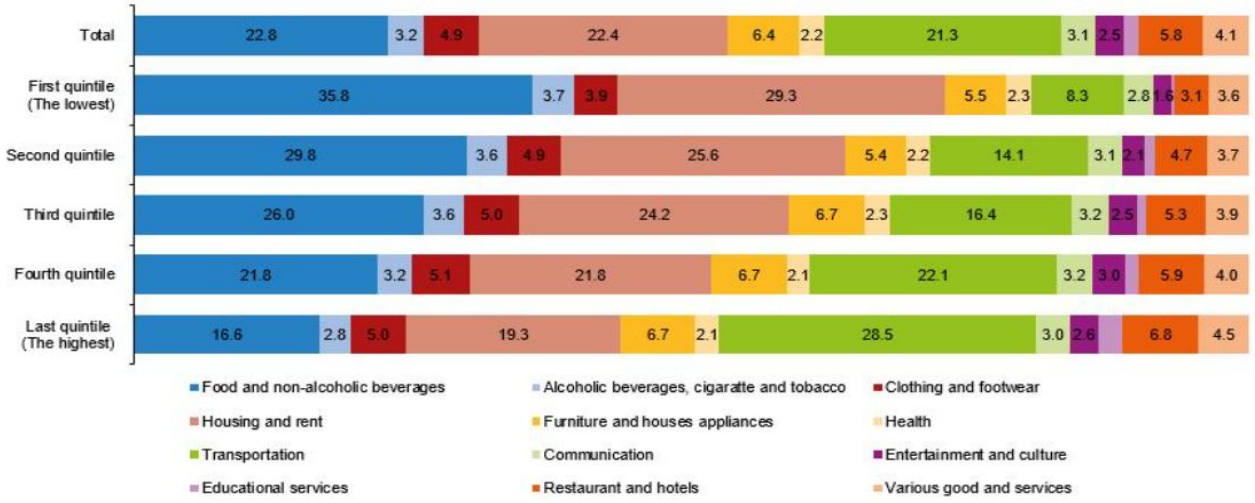

Figure 2. Distribution of consumption expenditure by quintiles ordered by income (%), 2022

3. Implementation of the Sky Trust Method

According to the results of the household budget survey in 2022, housing and rent expenditures ranked first in terms of the share allocated to total household expenditure. It was seen that two-thirds of housing expenditures consist of rent (Alomaliye, 2019). Since rents constitute a significant share of income in Turkey, rent and home maintenance expenses are excluded from the study, anyway, rent and home maintenance expenses are not very effective in carbon consumption. This study divides the above expenses, excluding rent and home maintenance, into 5 groups. Health, entertainment and culture, educational services, restaurant and hotels and various good and services are combined under the “other” group. Alcoholic beverages, cigarette and tobacco, clothing and footwear, furniture and houses appliances are combined under the “Industrial goods”. The values in the housing are named as fuel and electricity. The expenditures considered in this study are food and non-alcoholic beverages, industrial goods, fuel and electricity, transportation and communication and other expenditures. The proportion of food and fuel decreases in relation to total expenditure, while the proportion of transportation increases from the lowest income group to the highest income group.

In order to make household consumption expenditures comparable, the equivalent consumption expenditure per person obtained by taking into account household size and composition is used. The average monthly consumption expenditure per household in 2022 was estimated 12157 (including rent) and 9950 (excluding rent) Turkish Lira (TL).

In this study, the principles of the egalitarian energy policy studies conducted for China and India are taken as basis and applied to Turkey.

According to this method, Turkey's monthly spending amounts by household are obtained from 2022 Turkish Statistical Institute (TÜİK) household expenditure data (TÜİK 2022). As seen from Table 1, rent is deducted and only fuel and electricity are given as housing.

For the analysis of the energy policy proposed here, the carbon burden of households and the carbon footprint of each of these deciles are found. The amount of carbon used by households using carbon loading factors are shown in Table 2. Table 2 shows the corresponding TOE values and the GDP equivalents of these energy expenditures. TOE/10000 TL and ton carbon/10000 TL values are used for the sake of simplicity.

Table 1. Monthly household expenditure breakdowns for Turkey in 2022

From lowest income to highest group	Total monthly expenditure (TL)	Percentage of total expenditures (%)	Food (%)	Industrial goods (%)	Fuel and electricity (%)	Transport and communication (%)	Other (%)
1	3830.58	8.1	36	7.6	7.04	11.3	15.76
2	6542.4	13.5	29.9	8.5	5.6	17.6	18.5
3	8527.48	17.4	26	8.6	4.8	20.1	21.1
4	11838.44	24	21.8	8.3	4	25.7	22.4
5	18990.57	37	16.6	7.8	2.9	31.9	24.4

Turkey's population was 85 million 279 thousand 553 people and gross domestic product per capita was 176 thousand 651 TRY in 2022. According to the Turkish Statistical Institute (TÜİK) data, there were 26 million 75 thousand households in Turkey in 2022. The average household size was 3.17 people (TÜİK GSYİH, 2022).

Turkey's total GDP was 15 trillion 11 billion 776 million TL and the total final energy consumption of households was 1 million 287 thousand 738 tera joules for 2022 (TÜİK Energy Consumption, 2022).

Table 2. Carbon Loading Factors, 2022

Expenditure	**Energy (Bin TOE)**	**GDP (Billion)**	**TOE/10000 TL**	**Ton carbon/10000 TL**
Food	5129	480.352	0.106	0.338
Industrial goods	41614	855.627	0.486	1.541
Fuel and electricity	38121	330.242	0.115	0.365
Transport and communication	10456	450.033	0.232	0.736
Other	7717	225.165	0.342	1.084

1 Ton Oil Equivalent (TOE) releases 10 million kcal of energy. The carbon consumed for each expenditure is calculated assuming that 1 TOE emits 3.17 tons of CO_2 (Turkish Greenhouse Gas Inventory, 2022)

Carbon consumption per household is calculated with the following formula:

$$C=0.034*(EXP)_F+0.154*(EXP)_I+0.036*(EXP)_E+0.0736*(EXP)_T+0.11*(EXP)_O \quad (1)$$

For example, the monthly carbon consumption for the lowest income group is found as follows.

$$C=0{,}34(3830*36/100) + 1{,}54(3830*7{,}6/100) + 0{,}36(3830*7{,}04/100) + 0{,}74(3830*11{,}3/100) + 1{,}1(3830*15{,}76/100) = 1998 = 0{,}2 \text{ ton}$$

C indicates carbon consumption in kg. $(EXP)_F$, $(EXP)_I$, $(EXP)_E$, $(EXP)_T$ and $(EXP)_O$ indicate food, industrial goods, fuel electricity, transport communication and other expenditures, respectively.

Equation 1 is obtained from the last column of Table 2 and gives the carbon used by households in ton.

According to Table 3, low-income groups pay 3.55 percent of their total expenditures as carbon money, while high-income groups pay 4.7 percent. This confirms that higher income groups use more carbon intensively.

Table 3. Carbon distribution by households, 2022

Total monthly expenditure (TL)	Consumed CO_2 (ton)	Charge for CO_2 (TL)	Charge for CO_2/ total expenditure (%)
3830.58	0.2	136	3.55
6542.4	0.38	258.4	3.95
8527.48	0.53	359	4.2
11838.44	0.77	525.6	4.4
18990.57	1.31	892.8	4.7

The carbon price determined for Turkey is approximately 40 euros per ton. In the previous studies, a ton of carbon was taken as 40 euros. In Zhang's study in China in 1998, carbon reductions were examined over 20 years by determining the carbon ton as 205 yuan and 400 yuan, and a 20% and 30% reduction was observed, respectively (Zhang, Z., 1998).

The tax required to implement this program is €40 per ton of carbon. Calculations were made by taking 680 TL, which is the equivalent of 40 euros in Turkey for 2022. The carbon fee in the EU was around 60-70 euro in 2022 (Statista, 2025).

Table 4 shows the effect of the Sky Trust scheme, in which the money from the carbon fee is redistributed equally to households. The size of the dividend payment, 434.4 TL per house, is calculated by dividing total income by the number of house in Turkey. The net benefit of the method is obtained by deducting the carbon fee per house from the dividend. The last three columns of Table 4 show the dividend, net profit as a percentage of household expenditure and Turkish Lira respectively. 1% of total revenue should be deducted for administrative costs, but this deduction is ignored in this study.

As seen in Table 3, even without an egalitarian redistribution of income, the carbon burden will continue to increase. Households in the lowest 20% income group pay 3.55% of their total expenditures as carbon fees, while those in the highest income group pay 4.7% of their total expenditures. This shows that rich households use carbon more intensively than poor households. This study contradicts studies that state that the carbon burden has a neutral or regressive effect. As seen in Table 3, even if there is no equal redistribution of income, the carbon burden will continue to increase. The households in the lowest 20% income group pay 3.55% of

their total expenditures as carbon fees, while those in the highest income group pay 4.7% of their total expenditures. This shows that rich households use carbon more intensively than poor households. The effect will be stronger at lower carbon intensity in the consumption of poor households.

Table 4. Carbon dividend values by households, 2022

Income groups in 20% slices	Total monthly expenditure (TL)	Dividend (%)	Net profit (%)	Net profit (TL)
1 The lowest %20	3830.58	11.34	7.79	298.4
2	6542.4	6.64	2.69	176
3	8527.48	5.1	0.9	76.75
4	11838.44	3.67	-0.73	-86.42
5 The highest %20	18990.57	2.3	-2.4	-455.8

The most households receive more in refunds than they paid as a result of higher fuel prices as shown in Table 4. The flow diagram of the method is shown in Figure 2.

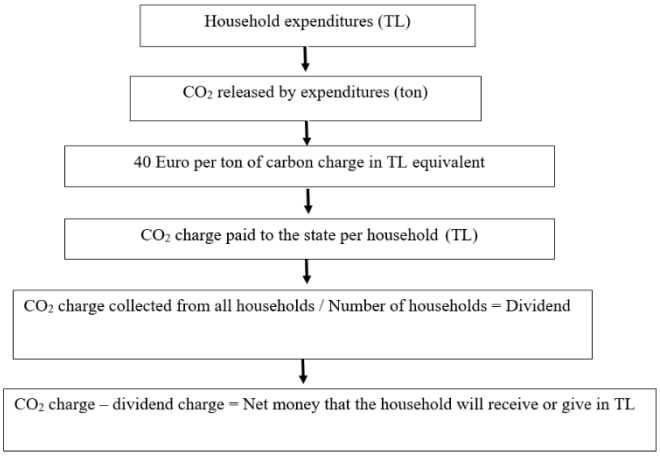

Figure 2. Flow chart of the method

This study contradicts studies that state that the carbon burden has a neutral or regressive effect. On the other hand, there are also studies that support this study, that is, that argue that the distribution of carbon taxes has a progressive effect (Ayu, P, 2018., Okonkwo, J. U," 2021).

Using the model, we find that the carbon tax is highly progressive, such that the negative impact of the carbon tax on households with below-average incomes is smaller than the negative impact on households with above-average incomes. We show that the welfare effects of a carbon tax are a result of a household's spending being determined primarily by the source of its income rather than its destination. Finally, we show that the current income recycling is progressive. Overall, the tax appears to be highly progressive. Whether carbon taxes are progressive, regressive or neutral depends on whether the application is fair and sustainable, where there is fair application without economic loss.

Especially in developing countries like Turkey, where the Gini Coefficient is not very low, such fair practices support green transformation (TÜİK, Income Distribution, 2022). This also contributes to the progressivity of the carbon tax, as lower-income households receive a larger share of their income from transfers.

The aim of this study is to direct expenditures from intensive carbon sources to low carbon sources. In a study conducted in the United States in 2002, low-income groups reduced their spending more than high-income groups due to a tax on gasoline prices (West, S. E., Williams, R. C. 2002). The focus point here is to ensure that carbon use is reduced for the high-income segment.

4. Conclusion

Total carbon emissions in Turkey in 2022 is 558.3 million tons. With this study, approximately 200 million ton of CO_2 per year was priced at 40 euro per ton. Thus, 1/3 of the total emissions were priced through households with this practice.

The aim of this method is to reduce the amount of carbon used by pricing carbon. The previous studies have shown that while the removal of subsidies has a negative effect, the distribution of carbon money has a positive effect (Brennera, M. et al. 2007). This study also supports this effect.

In this method, activities are carried out through a foundation established with state support, but without the use of the state budget. The foundation distributes the income from carbon fees back to households after making a small financial cut. One of the advantages of this system is that it is independent of public spending and fiscal policy issues. As a result, it is a fair system that rewards those who use less carbon and penalizes those who use more. This study only addresses household expenditures. There is no data on per capita expenditures. Also there is also no expenditure data for rural and urban households. The study can be expanded by assuming that there is an average of 3.17 people in each household in Turkey in 2022.

This study only addresses household expenditures. There is no data on per capita expenditures. Also there is also no expenditure data for rural and urban households. The study can be expanded by assuming that there is an average of 3.17 people in each household in Turkey in 2022.

As can be understood from the results, the "sky trust" project yields positive results on a household basis in Turkey.

This project may negatively affect people whose livelihoods depend on fossil fuels. This negative case can be eliminated if a fund from this income is allocated to these people. The carbon tax collected can also be used in other ways. A portion of the collected carbon tax can be used to invest in low-carbon technologies, while the rest can be distributed to households as fuel and electricity. Additionally, the carbon price can be increased to generate more revenue.

As a carbon tax, 666 million euros or 11.3 billion TL could be collected from households with the values in this study in 1 month in 2022.

According to the results of the household budget survey in 2022, housing and rent expenditures ranked first in terms of the share allocated to total household expenditures. It was observed that two-thirds of housing expenditures consisted of rent. In this study, rent is excluded from carbon calculations.

This article argues that an environmental policy that provides equitable and sustainable growth without compromising the growth rate can be designed. This study provides information on green growth, carbon tax and dividend policy, which have been extensively debated and politically evaluated in developed countries but less discussed in the context of the developing world. Here, the carbon tax not only controls the demand for fossil fuels but also makes the process of distributing tax revenue in the form of universal access to energy equitable.

Nationwide, there are gains for households in the bottom 3 income quintiles and losses for households in the top 2 income quintiles. For the year 2022, the carbon tax is calculated at around 40 euros, and the methodology for calculating the carbon tax for the year 2022 is around 26 euro (TL 434.4), which is calculated based on the value of the dividend, shows that this method is highly progressive.

The poorest 20 percent would see a net income gain equivalent to 7.79 percent of total spending, while the richest 20 percent would see a 2.4 percent decline with this carbon tax. Nationwide, roughly 60 percent of Turkey's population would gain from this policy, helping to eliminate economic inequality.

This study is also in line with the new regulation decision of the Energy Market Regulatory Authority regarding electricity consumption in Türkiye dated January 1, 2025. With the regulation that will be valid as of January 1, 2025, the limits are determined as 5 thousand kilowatt-hours (kWh) per year for residential subscribers. Places such as mosques, places of worship, associations, AFAD temporary shelter centers are excluded from the regulation. The Minister of Energy reports that only 1.2 million households will have a change in the cost of electricity in the new electricity regulation. In other words, 3% of subscribers will be affected by this situation. The bills of subscribers who will not benefit from state support will increase by a maximum of 93% according to the current Market Clearing Price. There will be a maximum increase of 11% in industrial and commercial electricity. Other subscribers will continue to receive state support. The aim here is to ensure a more equitable distribution of the support currently provided to all electricity subscribers and to encourage the efficient use of energy resources (Euronews, 2025).

In this study, a smoother transition is suggested by determining a more gradual level.

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RESP

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Araştırma Makalesi ● Research Article

A Review and a Case Study About Claim Management In Contracts During The Covid-19 Pandemic

Covid-19 Pandemi Sürecinde Sözleşmelerde Hak Talebi Yönetiminin Değerlendirilmesi Ve Örnek Olay Incelemesi

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ANAHTAR KELİMELER

COVID-19
Mücbir Sebep
Aşırı İfa Güçlüğü
Hak Talebi
Gecikme Analizi

ÖZ

Bu araştırma ile salgın hastalık (pandemi) olarak ilan edilen COVID-19 hadisesinin borçlunun sorumlu olmadığı yükümlülüklerin pandemi sonrası zorunlu yükümlülükleri arasına girmesi, sorumlu olduğu yükümlülüklerinin de imkansızlıklar ve aşırı ifa güçlüğü hükümleri doğrultusunda yerine getirilememesi ve/veya sözleşme süresi içerisinde tamamlanamaması hususları sözleşmelerde değerlendirilerek, bu doğrultuda sözleşmelerin mücbir sebep (force majeure) ve uyarlama (hardship) hükümleri ile yapılacak hak taleplerinin (Claim) irdelenmesi amaçlanmaktadır. Burada önemli olan sözleşme taraflarının karşılıklı uğradıkları olumsuz etkileri ortaya koyarak ve yine karşılıklı menfaatlerinin eşit olarak korunmasını esas alarak kazan-kazan ilkesinin (win win principle) işletilmesini sağlamak olduğundan, pandeminin ortaya çıkardığı riskin sözleşme tarafları arasında eşit şekilde paylaşılması önem arz etmektedir. Bunun ne şekilde yapılabileceği ise her bir somut sözleşme ilişkisinin özelliklerine göre ayrı ayrı tespit edilerek mümkün olabilir. Bu çalışmada; Sözleşmelerde bulunan mücbir sebep veya uyarlama maddelerinin, pandemi nedeniyle aşırı ifa güçlüğüne sebebiyet vermesi ve sözleşme tarafları üzerinde oluşan olumsuz etkilerin çözümleme uygulamalarının ve bu uygulamaların sürdürülebilirlikle olan ilişkisinin anlatılması amaçlanmaktadır.

KEYWORDS

COVID-19
Force Majeure
Hardship
Claim
Analysis Of Delay

ABSTRACT

This study aims to review the obligations in the contracts, which the obligor were not actually responsible for prior to the COVID-19 that was proclaimed as a pandemic, but which became mandatory obligations after the pandemic, as well as the failure to fulfill the obligations for which the obligor was responsible due to the impossibilities and hardship provisions and/or failure to complete these obligations within the contract term and to discuss the claims to be made based on force majeure and hardship provisions in the contracts. Since it is important here is to ensure that the win-win principle is applied by demonstrating the negative impacts mutually suffered by the contracting parties and protecting their mutual interests equally, it is essential to share the risk posed by the pandemic equally between the contracting parties. The method to be used to ensure such equal distribution is possible by determining it separately according to the characteristics of each concrete contractual relationship. This study aims to explain the force majeure or hardship provisions in contracts that cause impossibility of fulfillment of obligations due to the pandemic and the solutions that could be applied to solve the negative impacts on the contracting parties and the relationship of these practices with sustainability.

1. Introduction

An epidemic disease, which first broke out in December 2019 in Wuhan, Hubei, China and known as SARS-CoV-2, spread almost all around the world in March 2020. The outbreak, which was identified as the Coronavirus (Covid - 19) by the World Health Organization (WHO), caused the proclamation of the PANDEMIC. The outbreak, which was classified as a “public health emergency of international concern” by the World Health Organization, caused the

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proclamation of a state of emergency in Turkey with very significant impacts in every aspect of life.

All sectoral enterprises and public works and operations in the world were directly affected by the COVID-19 Pandemic that spread into many countries including Turkey and by the measures that were taken in this regard. While the public authority took a decision for the cessation or limited provision of work for certain service lines, it was decided to apply the restriction measures more flexibly for certain business lines/sectors. Due to the said breakdown and the measures taken by the public authority in this regard; the entire supply chain of products and services was disrupted, and the supply of products, materials, machines and equipment, workers and technical personnel required during the performance of the work under construction contracts and the realization of production and transportation were either not possible at all or realized with extraordinary difficulties. The same difficulties were also experienced in the supply of imported material inputs and qualified technical personnel.

On the other hand, we observed that contractors continued to operate by taking all types of health and safety measures in accordance with the provisions of the applicable occupational health and safety legislation and provided a healthy working environment to their employees according to the working conditions in accordance with the provisions of the legislation (cafeteria, camp sites, resting areas, working sites, offices, etc.).

The aim of this study is to obtain expert evaluations on the application of force majeure and adjustment clauses in the management of COVID-19 related claims in the construction sector. During this period, within the scope of contract management practices, official notifications, measures taken by central authorities, actions taken by companies during this process, and claim management processes will be examined through case studies. For this purpose, a case study will be conducted to address the following problems.

- How has the COVID-19 pandemic affected the construction industry and the project(s) you are involved in (i.e., general and adverse impacts)?
- Have there been new opportunities for the construction industry as a result of the COVID-19 pandemic? If so, what are they?
- What claims have been made in the construction industry to manage the challenges related to the COVID-19 pandemic?
- How has the COVID-19 pandemic affected the construction industry and sustainability criteria?
- Are construction contracts subject to force majeure or hardship provisions?

2. Impossibility of Fulfillment and Hardship Provisions in Contracts

Even if a contract covers all ordinary risks in detail, it should also contain sufficiently-defined force majeure risks for extraordinary and unforeseen risks. Indeed, certain issues that the parties or either party cannot foresee may arise during the contract term. Such unforeseen situations are among the most critical risks in contracts. For this reason, it is known that the contracts that do not contain sufficient details for unforeseen situations may cause major losses for the parties and even result in the failure to complete the project. We can briefly identify unforeseen situations, which are beyond the control of the contracting parties and which are an uncertain process, as force majeure events.

In the studies and doctrine, two possible impacts are discussed for such extraordinary events in terms of contracts:

(I) Impossibility of fulfillment due to force majeure

(II) Fulfillment of obligations does not become impossible, but the provision of products and services becomes excessively difficult.

Contracts contain provisions on force majeure and hardship regarding these two possibilities (Kolcuoğlu, 2020).

2.1. The Term Force Majeure

Force majeure is essentially a term that is shaped within the framework of judicial decisions and opinions in the doctrine. In its decision dated 18 January 2010 (Merits number 2009/8727, Decision number 2010/101), the 13th Civil Chamber of the Court of Appeal defined force majeure as "an unexpected, unpredictable and irresistible external event that prevents the fulfillment of the obligation and cannot be prevented despite the measures to be taken by anyone and occurs beyond the control of obligor" and "a phenomenon that cannot be generally perceived and resisted". When we review the recent decisions of the Court of Appeal, we conclude that the Court of Appeal examines whether a situation constitutes a force majeure event in each concrete event rather than making a clear definition of force majeure.

According to the Turkish Code of Obligations, force majeure events are actually events of permanent impossibility and they result in the termination of the obligation. In other words, in order to refer to force majeure in the Code of Obligations, the event must be an extraordinary event that cannot be prevented (irresistible) and cannot be foreseen (unpredictable). In this context, in order to treat an event as force majeure, it must contain the elements of being external, inevitable and unpredictable (Özçelik, 2016). The concept of unpreventability means irresistibility in terms of force majeure. In the element of unpredictability; the unforeseen matter is not the event itself, but the consequences that it will cause; sometimes it is possible to foresee the event to a certain extent.

In the doctrine, force majeure is generally defined as external events that are objectively impossible to be avoided or eliminated and that make the fulfillment of the contract impossible. In other words, force majeure is not an absolute concept, but a relative concept (Kolcuoğlu, 2020). The relative nature derives from the fact that certain events do not always constitute force majeure.

According to Ezeldin and Helw (2018), it is indicated that in most cases, force majeure only causes temporary impossibility of fulfillment. In other words, in this case, the fulfillment of the contract provisions is temporarily interrupted in general and it is foreseen that the fulfillment of the obligation can be resumed after the reasons or effects of the impossibility come to an end. In such a case, the contract is suspended instead of being terminated.

2.2. Hardship

According to the principle of loyalty to the contract, which is also recognized in Turkish Law, each obligor must fulfill the obligation stipulated in the contract in the same way despite the difficulties and obstacles that arise after the contract is concluded. This principle is a requirement in terms of the rule of legal security and integrity.

In certain cases, although the fulfillment of the obligation arising from the contract is not impossible, the fulfillment of the obligation may become very difficult and may become a much heavier financial burden than the obligation that would be fulfilled as a condition of the contract. As a result of this change, the balance in the contract may be disrupted to an unbearable extent against one party. In this case, the concept of "hardship" may arise.

In case of occurrence of an extraordinary situation which the obligor does not have any influence over and which cannot be expected to be foreseen; the fact that the creditor asking the obligor to fulfill the obligations and liabilities arising from the contract depending upon the circumstances existing at the time that the contract was concluded, and changing the contract provisions against the obligor would be in violation of the rules of equality and honesty under the contract. In this case, the obligor may request the competent court to adapt the contract to the new circumstances. The obligor may exercise this right before fulfilling its obligation or after fulfilling it by reserving its right to request adaptation. As a result, new adaptations may arise in the contract conditions in accordance with the Article 138 of the Turkish Code of Obligations.

According to the Article 138 of the Turkish Code of Obligations, in order to classify a situation as hardship, all of the following conditions must exist together.

(I) An extraordinary situation that could not be foreseen and could not be expected to be foreseen by the obligor must have occurred after the contract is concluded.

(II) The extraordinary situation that arose must not have been caused by the obligor.

(III) The extraordinary situation must have changed the facts existing at the time of the contract to the detriment of the obligor to such an extent that it would be against the rules of honesty to ask the obligor to fulfill the obligation.

(IV) The obligor must not have yet fulfilled its obligation or must have fulfilled it by reserving its rights arising from the hardship.

The conditions existing at the time of concluding the contract may subsequently change unpredictably, shaking the balance in terms of the obligations of the parties and causing hardship. This situation may indicate that the principle of pacta sunt servanda is not always fair. The balance of sharing the risk that has been disrupted under the changing conditions must be restored (Kolcuoğlu, 2020). In the cases not recognized as force majeure but considered as cas fortuit; if some other conditions have also realized, adaptation of the contract due to hardship might be possible (Tüzüner and Öz, 2015).

In other words, while force majeure is a problem of non-fulfillment and impossibility, the Article 138 of the Turkish Code of Obligations is applied if there is an obstacle encountered during the fulfillment and does not make fulfillment impossible, but makes it difficult. The boundary between them is quite blurred in terms of the COVID-19 pandemic (Yavuz & Uyanık,2029).

3. Perspective on The Pandemic as A Force Majeure Event in Contracts

Our world has faced various pandemics throughout the human history. The oldest recorded and known pandemic is the plague that affected the entire world in the 14th century causing the deaths of more than 200 million people according to the records. In the following years, the cholera epidemic that emerged in the 18th century is among the biggest epidemics in the history taking the lives of more than 100 million people. Our world, which was faced with various influenza epidemics in the 19th century, encountered another epidemic with the HIV/AIDS virus. Our world, which has faced epidemics such as the Swine Flu, Ebola virus, SARS virus etc. in the early 20th century, is currently experiencing its last epidemic period with the COVID-19 virus under the name of the CORONAVIRUS.

COVID-19, which is different than the other epidemics experienced in the world from the past to the present, has basically created different results than the other epidemics in terms of its ability to spread very quickly from person to person. The epidemic disease, which affected the entire world in a short period of 4 months, caused the states in the world to make extremely radical decisions, with an impact resulting in the cessation of all sectoral activities globally in a chain reaction.

According to the Turkish Code of Obligations, we conclude that in terms of commercial relationships, the coronavirus does not constitute a force majeure on its own. However, it can be considered that the practices implemented and/or to be implemented as a precaution in connection with the coronavirus may constitute a force majeure event. The measures such as quarantine, closure of country borders, import-export bans and travel bans, which were started to be imposed in almost all countries in the world, can be considered as force majeure event because they prevent the fulfillment of contractual obligations between the creditor and the debtor beyond the intention of the parties.

In order to qualify any measure as a force majeure event, the impacts of the implemented measure must be specifically assessed on the basis of each contract. For example, if the fulfillment of an obligation that was agreed upon within the framework of a contract becomes objectively impossible due to such measures, then the existence of force majeure can be mentioned. However, if the fulfillment of the relevant obligation is possible not in the agreed way, but by an alternative method or at a different time (in terms of temporary force majeure events), it can be qualified as hardship, in which avoiding the fulfillment based on force majeure would not be appropriate.

As mentioned in the Section 1.1., Force Majeure is defined in the Turkish Code of Obligations as a permanent impossibility of fulfillment. However, COVID-19 had different negative impacts on finalized costs, which were limited by contract periods, particularly in public or private enterprise investments and large construction projects. These impacts were both reflected to the contract process and brought additional expenses in addition to the contract value. We conclude that it made the execution of the work more difficult in certain work items, affected the temporary impossibility of the execution of the work in certain work items and completely changed the design, production and installation conditions in certain electromechanical work items that require special production and installation.

From this perspective, we can conclude that the COVID-19 Pandemic actually made the execution of the work more difficult temporarily, not permanently. This situation was reviewed in the case study described in this article, and the results were presented by following the steps below.

Pandemic Effects: Proving with the documents that the factors such as loss of workforce due to the pandemic, delays in the supply of materials and restrictions imposed in the project/worksite caused a delay,

Contract Review: Articles such as Delay, Force Majeure, Delivery obligations, limitation of responsibilities, penal clauses and indemnity conditions in the contract were reviewed and official notifications were sent in this regard,

Timeline Analysis: The timeline of the key milestones, along with the start and completion dates of the project, was reviewed and the phases in which the delays occurred were identified,

Calculation of Duration of Delays: The reasons and durations of the delays were determined and the impact of these durations on the total term of the project was calculated in terms of the both parties. At this point, the Main Contractor and the Subcontractor put forward different arguments.

Alternative Solutions: Alternative solutions and strategies were developed to compensate for the delays; Options such as additional workforce, increasing working hours or inclusion of technology were assessed.

Reporting: The delay analysis results were reported regularly to the relevant parties (management, investors, contractors). These reports include the progress in the project and the measures taken.

Communication: Maintaining constant communication with the project stakeholders is critical for the management of delays. It should be ensured that all parties understand the situation and contribute to the solution suggestions.

In this section of the study, the claim is defined regarding how much of the delay experienced during the commissioning of the signaling system as one of the subsystems of the metro project was caused by the pandemic, and the delays not attributed to the pandemic from the employer's perspective and their contractual position are discussed. After the examination, the reconciliation procedure followed by the parties is described in details.

4. Research Method

This section covers the research material and methodology used to conduct the study. The research explains how construction companies were affected during the pandemic period through a case study. In the application part of the research, a case analysis will be conducted, which can exemplify both force majeure and excessive difficulty in performance during the pandemic period in the construction sector. The case study describes the claims process between the Contractor and the Subcontractor in an ongoing metro project in Istanbul during the pandemic. By examining this claims process, the impact of the pandemic on construction work and the progress of the project will be analyzed.

4.1. Case Study

In this section of the article, a case study that can be demonstrated as an example for both force majeure and hardship during the pandemic period will be examined. First of all, the definitions section and general information about the project are provided in order to understand the delay experienced.

In this case study, the works that were ceased during the pandemic period, the works that continued to be executed and the method of managing the claim process were examined and the contractual positions are demonstrated. Following the examination, the claim management of contracting parties is compared with the situations explained

in the first section of the article.

4.2. Chronology of Events

Project: means the Metro Project to be executed under the main contract signed by and between the Main Contractor and the Administration.

Subcontractor: means the supplier that will provide the signaling system.

Company/Main Contractor: means the party purchasing the signaling system.

Administration: means the client of the Metro Project.

System: means the signaling system including the development of the software, provision of the hardware, installation, testing and commissioning, training and maintenance services.

Testing and Commissioning: means the execution of in-site tests of all systems and subsystems prior to the commercial operation according to the procedures.

SMB1: means the certificate confirming that the Project can be safely opened for operation without passengers.

SMB2: means the certificate confirming that the Project can be safely opened for operation with passengers.

Commercial Operation: means the date of opening of the metro system with passengers.

4.3. Project Information

A standard contract was signed by and between the Main Contractor undertaking the architectural and electro-mechanical works of the Istanbul metro line subject to the Public Procurement Law and the Administration. The works to be executed within the scope of the Project include architectural finishing works, energy system power supply and distribution, signaling, communication and automatic control systems, auxiliary facilities, escalator, elevator, environmental control system, track works, design services that would require minimum maintenance for all relevant systems and parts of the system, construction, procurement, installation, testing and commissioning works as well as provision of 24-month operation and maintenance supervision service related to the system, preparation of the operating and maintenance manuals, procurement of 2-year spare parts and consumables, special tools and equipment, provision of operational training in site and abroad.

A subcontract was signed by and between the Main Contractor and the Subcontractor for the execution of the Automatic Train Control (ATC) Signaling System, which is required to be provided for the control of train movements of the Metro System. This contract covers the execution of the design, installation, assembly, testing and commissioning processes of the Signaling System by the Subcontractor, which is also responsible for the safe operation of the System as a whole in terms of the hardware, software and data transmission systems.

4.4. Definition of Claim

According to the contract signed between the parties, the system procurement and installation, i.e. the assembly phase in the field, will be carried out after the completion of the system design and software process. Then, the system testing and commissioning process will be initiated for the safe operation of the system without any problems, and the testing activities are shown in the table below.

Table 1. Activity

ACTIVITY
Wayside installation test (PICO test)
Wayside ATC Installation Inspection Test Procedure - 401
Central Control Installation Inspection Test Procedure - 402
OCS950 Field Test Procedure - 404
Norming Point Civil Location Test Procedure – 710
Data Transmission System Test Procedure – 805
ATC Data Radio System Installation Verification - 810
ATC Field Cable Megger and Continuity - 001
Fiber Optic/Data Transmission Cable - 004
Vehicle ATC Installation Field Test Procedure for Trains
VATC TEST
VATC Static Field Test Procedure - 133
Vehicle ATC MDR System Installation Test - 141
VATC Qualification Field Test Procedure - 908 (Prototype Test)
VATC Dynamic Field Test Procedure - 904 (Series Test) -
SAT Test (Integration Test)
Vehicle ATC System Map Verification Test Procedure - 907
IO Data Test Procedure - 2001 -1
Train Initialization & Removal Test Procedure - 3951F
System Initialization Functionality Test Procedure - 3950F
Interlocking Test Procedure 3952F

Speed Restriction Test Procedure 3953F
Station Test Procedure 3955F
Automatic Train Supervision (ATS) Test Procedure 3960F
Automatic Train Supervision (ATS) Test Procedure 3960D
Routing Test Procedure 3956F
Failure Mode Functionality Test Procedure 3959F
Interlocking Test Procedure 3952D
Speed Restriction Test Procedure 3953D
Station Test Procedure 3955D
Routing Test Procedure 3956D
Failure Mode Functionality Test Procedure 3959D
Diagnostic Test Procedure 3961F
Diagnostic Test Procedure 3961D
External Interface Functionality Test Procedure - 3964F
Station Stopping Accuracy – 1008
External Interface Functionality Test Procedure - 3964D
SMA3 for Start Wayside SIT Test
SIT Test (Performance & Demonstration Test)
Performance Functionality - 3962F
System Demonstration Test - 4003-1
SM B1 (ISAR) Signaling System Safety Certificate
SM B2 Overall safety report

As indicated in the table below, the parties reached an agreement on this work schedule before the pandemic broke down, and the pre-conditions that must be fulfilled within the scope of the Project for the start of the Site Integration Tests indicated in the table above (hereinafter referred to as the "SAT Test") were agreed upon between the parties and signed in a list. (Annex-1).

Table 2. Work Schedule Before the COVID-19 Pandemic

Work Schedule Before the COVID-19 Pandemic			
SAT Test (Integration test)	42 Days	8.02.2020	20.03.2020
SMA 3 for start wayside SIT Stage 1	12 Days	21.03.2020	1.04.2020
SIT Test (Performance & Demonstration test)	7 Days	2.04.2020	8.04.2020
SM B1 (ISAR) (Signaling System Safety Certificate) *(A letter can be issued by indicating that the Project can be safely opened for operation without passengers)*	12 Days	9.04.2020	20.04.2019
Overall safety report (SM B2) - (A letter can be issued by indicating that the Project can be safely opened for operation with passengers)	30 Days	19.05.2020	
	15 Days (Reporting)	3.06.2020	

4.5. Development of the Claim

On February 04-07, 2020, the Administration and the Main Contractor conducted the ATS software testing of the signaling system at the Subcontractor's facilities; however, it was observed in the tests conducted that the software functions related to the ATS were still in the development phase in a laboratory environment, although there was a very little time left in terms of the opening target.

We learned from the notification sent by the Company on February 25, 2020 that the work schedule for the SAT Tests was not submitted, the other systems within the scope of the Project were ready for the integration tests and therefore, a testing plan had to be submitted and this caused a delay.

We learned from the relevant correspondence that deficiencies were identified in the Factory Acceptance Tests due the ATS software, and the ATS software had to be delivered on 17.02.2020 to avoid any disruptions in the working schedule of the Project, signal tests were negatively affected due to the deficiencies resulting from the software

and in this case, the SMB1 and SMB2 certification process was negatively affected, which also affected the commercial operation date of the Project.

In this period of time, the coronavirus (COVID-19), which broke out in Wuhan in the People's Republic of China, spread to many countries around the world including Turkey. The Company received notifications from its suppliers and partners regarding the impact of the restrictions imposed by local and / or central governments to prevent the spread of the COVID-19 outbreak (Supply chain interruptions, closure of offices / schools or other public institutions and travel or access restrictions to regions, etc.) on their capability to fulfill their contractual obligations.

The Subcontractor of the Signaling System also sent its first notification under the Force Majeure clause in its contract through an official letter dated 03.03.2020 that the COVID-19 Pandemic could be recognized as a force majeure event within the scope of the applicable contract between the parties and that this event could affect the services and/or products to be provided by the Subcontractor.

It was notified that this situation could affect the valid delivery date according to the actual project plan or schedule, and its full impact on the Project was being assessed at that time; however, such assessment was subject to rapidly-changing measures implemented and the sanctions imposed by many authorities.

Subsequently, entries and exits into and from Spain were immediately closed and restrictions were imposed on the movement of citizens within the entire territory of the country based on a decree approved by the government on 14 March 2020. Due to the existing conditions in Europe and the decision taken by government authorities; entry permits into Turkey were temporarily cancelled and as the foreign experts in Turkey returned to their own countries, their works in the site were suspended, and as a result, certain critical activities could not be carried out in the construction site.

In such an extraordinary period of time, we conclude that the compensation for the delay experienced in the recent work schedule submitted by the Administration and agreed upon between the parties was not a realistic and achievable target, the Company and other suppliers experienced significant delays, and it was unrealistic to achieve these deadlines, which required a time extension claim.

4.6. Assessment of the Claim from the Company's Perspective

- The deficiencies identified in the ATS software were not completed,
- The site integration test plan was actually submitted late due to the deficiencies existing in the software, and the tests did not progress at the expected speed,
- The trainings required to be provided prior to the commercial operation were not planned,
- Although there were delays caused by the COVID-19, the software-related delays and the delays in the submission of the documents could not be directly associated with the Covid-19,
- Although a time extension was granted due to the force majeure event, the Subcontractor did not compensate for the delay that was much long than this,
- Due to the international travel measures taken, the number of the local teams could be increased and the execution of the works could be maintained within the scope of the Project,
- The execution of the Project could be maintained by integrating technological means,
- The expected works in the software and documentation processes were not directly related to the Covid-19, there were many delays caused by the Subcontractor independent of the pandemic, and these delays would not constitute a reason for time extension due to the force majeure.

4.7. The Claim from the Subcontractor's Perspective

- A total of 37 days of delay analysis was conducted due to the reasons not attributable to the Subcontractor (flooding in the tunnel due to heavy rain, power outages, delays caused by other contractors and pending due to the insufficient site safety measures),
- Even if the software was delivered early, the site was not ready and the other subcontractors that would perform the subsequent works were delayed,
- Considering the fact that the total duration of the last compressed work schedule that was agreed upon between the parties was slightly less than 4 months, the delay caused by the above-mentioned external factors in terms of the Subcontractor corresponds to approximately 35 to 40% of the total duration,
- The pre-conditions for the commencement of the signaling works and the testing and commissioning phase were indicated in the work schedule enclosed to the contract, and these pre-conditions were not fulfilled by the Main Contractor,
- The delay experienced within the scope of the Project was not only due to the COVID-19, but also the delays caused by other subcontractors and started in the pre-pandemic period increased even more during this period of time,
- The experts that would perform the integration tests could not come to Turkey due to the international

travel bans, and it was possible to conduct the critical integration tests only by foreign specialized personnel.

4.8. Dispute Occurrence

When the situation is assessed in terms of the Main Contractor and the Subcontractor, the main reason for the dispute is that the both parties failed to accurately analyze the delays experienced until that day when an agreement was reached for the commercial operation date. The short-term delays which were seemed to be insignificant at the beginning reached a level that cannot be compensated in the post-pandemic period.

The first link in the chain of errors was the failure to reach an agreement regarding the deficiencies existing in the software and to identify the software errors or the expected developments in the software from the very beginning. The important detail at this point is that while software studies, which are electronic computer engineering services, are the studies conducted in an office environment, the hardware on which the software is installed constitutes an engineering service that requires in-site installation and testing of compatible operating conditions with the software.

To eliminate its own delay caused by the software, the Subcontractor sent a written notification for each of the events that could affect the works within its own scope of works during the in-site installation and integration process, and prior to the pandemic process, it executed a correct contract management structure for the completion of the works on time by conducting a delay analysis for these issues.

Following the software and in-site integration tests, which are the most critical processes of the Project in order to commission the metro system smoothly; the security certification process to be provided for the safe operation of the system was managed only by the foreign specialized teams of the Company. For this reason, due to the COVID-19 pandemic and the relevant restrictions imposed by the official authorities and institutional procedures, it became mandatory to suspend the signaling tests for a while due to the impossibility of the travel of the foreign specialists of the Subcontractor to Turkey (to the Project Site). As mentioned above, the approaches to be used to compensate for the minor time losses at the beginning of the work within the working schedule were disrupted due to the PANDEMIC effects, and the delay of the works became inevitable.

Particularly, the fact that the foreign specialists could not come to Turkey due to the travel restrictions and the Subcontractor was located in Spain as one of the countries that suffered the biggest damage due to the Coronavirus caused disruptions in the execution of certain signaling works within the scope of force majeure. In this process, technological means were integrated, coordination was ensured with the local teams through remote access method and digital communication tools, and the necessary studies were continued by eliminating the software errors, making additional developments, providing the testing plan procedures, training plans and even provision of the trainings by using online digital communication tools.

With the start of the normalization processes in Europe and in Turkey and the opening of border gates, the foreign specialists came to Istanbul on 08.07.2020. However, it was allowed to work at the offices of the Subcontractor with maximum 50% personnel capacity. The employees were also scheduled to work in rotation in line with this schedule. The restrictions were still valid in terms of the cross-border travel. Mask-wearing and social distancing obligations were still strictly enforced in Spain and in other European countries. These extraordinary circumstances prevented the frequent travels of specialists. With the normalization process, work performance was started to be carried out at 50% capacity. Accordingly, the work schedule was revised and an agreement was reached on the table below.

Table 3. Work Schedule After the COVID-19 Pandemic

SAT		08.02.2020	19.05.2020
Return of the foreign specialists to their country due to the COVID-19 Interaction	42 Days + Pandemic	***3.03.2020***	***8.07.2020***
SAT		9.07.2020	5.09.2020

1.1. Contractual Entitlement to the Claim

2.1.2 The Work Schedule is a dynamic (variable) schedule due to reason that, inter alia, some part of the tunneling works will not be performed by the Company under the Main Agreement. Therefore, the Work Schedule may change, some part maybe suspended or the activities may be shifted or priority may change. In consideration of the foregoing, the schedule of the Works i.e. Detailed Work Schedule, may be subject to rescheduling accordingly. The Subcontractor, as being an experienced company, shall consider such possible rescheduling possibility and perform the Works without delays in opening dates and milestones and at no additional cost to Company.

At the time of concluding the contract, the Company prepared the foregoing clause to prevent the subcontractors from expecting additional costs in the future in case of a possible delay in these activities by foreseeing the general situation of the Project and to get the metro system activities carried out by a different joint venture.

According to the interpretation of this clause in the contract, the Subcontractor refers to this clause and indicates that the work schedule in which the commercial operation date of the Project was determined is a dynamic and variable schedule, and that the period of time allocated for the signaling system works cannot be shortened due to the delays caused by other subcontractors. To put it more

clearly, even if the Subcontractor delivered the software on time 1, the site conditions must be suitable for the installation of the hardware and other subsystems must be ready for software integration tests. The signaling system is the last activity in the work schedule of the metro project, and it is impossible to carry out the installation and site tests before the preliminary activities are completed. For this reason, it was stated that the work schedule is dynamic and that the time agreed for the completion of the signaling works cannot be shortened. According to the interpretation of this clause in the contract, the work schedule is dynamic due to the delay in tunneling activities, and the commercial operation date may be changed during the continuation of the construction activities.

According to the defense of the Company, the common intention of the Parties at the time of preparing such an article was to touch upon the dynamic aspects of the work schedule by giving the example of tunneling works. The total time allocated for the signaling works was delayed due to the deficiencies arising from the software and the integration tests not progressing at the desired speed. All these issues should have been taken into consideration by the Subcontractor at the time of preparing the revised work schedule. It was expected that the Subcontractor would accelerate its works and achieve compliance with the revised work schedule.

1.4.1 The Subcontractor is solely responsible, for performance and execution of all works and actions related to and/or in connection with ***the Works, which are not expressly stated under this Agreement*** *but required for proper* ***and timely performance*** *of the Works as per provisions of this Agreement.*

The main reason for preparing this clause was to define the characteristic requirements of the complex and high-technology system. As the Main Contractor in the capacity of purchaser of the system does not know all the details of the system, it might need other system-related works or subsystem requirements for the operation of the signaling system as a whole. All these needs and requirements should not prevent the timely completion of the works.

The Subcontractor refers to this clause and states that the definition of the works specified in this clause is limited to the signaling system under the Agreement, and other works beyond the scope are required to be excluded.

It indicates that the Subcontractor is not responsible for proper or timely performance of the other activities beyond the scope. For this reason, it is emphasized that the delay experienced is caused by the other subcontractors that will perform the preliminary activities.

The Company emphasizes that this clause cannot be interpreted with this approach, and states that it has never requested the performance of works beyond the scope, and many delays occurred due to the software deficiencies determined in the factory acceptance test including training planning, test program, presentation and approval of the test documentation. It argues that any action plan (accelerating the works, increasing the workforce with additional resource, etc.) was not presented regarding the delay experienced.

13.4 Either Party effected by Force Majeure shall notify the other Party of the Force Majeure and its nature without delay and not later than 7 (seven) days from the occurrence of Force Majeure. Failure to notify the other Party within the said 7 (seven) days shall constitute waiver of the rights under this Article. Occurrence of Force Majeure shall be certified by the Chamber of Commerce or relevant official authorities where Force Majeure has taken place.

13.7 If any Force Majeure event lasts for more than 2 (two) months, the Parties to the Agreement shall negotiate with the aim of obtaining a mutually agreed settlement. If the Parties cannot mutually agree on a settlement, then the Company shall have the right at its own discretion (i) to terminate this Agreement without any compensation under any name to the Subcontractor or (ii) to postpone and extend completion dates of the Works under the conditions stipulated in the Agreement.

The Subcontractor sent the following notification to reserve its rights arising from the pandemic: “As it is widely reported, a virus outbreak arising from China and currently identified as the COVID-2019 by the World Health Organization is spreading through various countries. To prevent the spread, various national, federal and local governments have started to impose a wide range of restrictions such as supply chain disruptions, closures of offices/schools or other public institutions and restrictions on travel or access to regions. The Subcontractor is continuously receiving notifications from its own suppliers and partners regarding the impact that these measures have on their capability to fulfill their obligations towards the Subcontractor.

Therefore, this letter should be recognized as a notification that the above-mentioned situation can be accepted as a force majeure event within the scope of the contract in force between the Subcontractor and your company and this may affect the services and/or products to be provided by the Subcontractor.”

The Company stated that the delay arising from the software cannot be linked with the COVID-19, the relevant deficiencies were notified before the outbreak and there should not be any delays in the development of the software arising from the measures taken due to the outbreak. The obligations such as provision of software, documentation and training can be fulfilled by integrating technology into business processes. In fact, the hardware installation process and integration tests could not be started because the software was not delivered on time, and the COVID-19 pandemic occurred in this period of time. The failure to deliver the software on time is a breach of the contract and a penalty arises due to this delay.

5. Conclusion and Assessment

When we look at the sociological, economic and even security effects of the COVID-19 Pandemic that affected the entire world, it is an undeniable fact that it truly caused different effects than previous pandemics experienced in the world. The health administration of all countries, particularly the World Health Organization (WHO), had to take extraordinary radical measures both to protect the people within the country and to prevent dangers from abroad. These measures dragged the business world into irreparable conditions in terms of both employees and industrial production. It caused the cessation of the works by commercial enterprises that continue their business relationships under a specified work commitment, affecting both the contract completion times and causing an increase in committed costs. Due to these effects caused by the COVID-19 Pandemic, the ongoing work flow was unexpectedly restricted very quickly and even came to a standstill. To partly relieve the disrupted balance in global relationships in economic, sociological, security and psychological aspects and to support global stability, it was necessary to take extraordinary measures and as a result, it caused the economy administrations of countries to implement practices such as granting financial supports, workforce supports, tax exemption supports etc.

When we look at the negative effects of the COVID-19 pandemic on both the creditor and obligor sides regarding the works assumed under contracts, we see the provisions "Hardship" and "Force Majeure". It is clear that due to the pandemic, the fulfillment of the contractual obligation became impossible in certain business lines, and the fulfillment of the obligation became very difficult and turned into a much heavier financial burden than the obligation that would have been realized as a condition of the contract in certain business lines. As a result of this effect, the balance in the contract will have consequences to the detriment of the both parties. An extraordinary and unforeseeable event emerged beyond the control of both the obligor and the creditor. While the creditor was affected by the extension of the delivery period of the work under the contract and the operating losses, the obligor encountered an additional cost burden due to the difficulty and prevention of the fulfillment of the obligation. Therefore, it would be contrary to the equality and honesty rules of the contract for the parties to unilaterally demand from each other the fulfillment of their tasks and obligations arising from the contract.

As it was tried to be explained in the case studies, the delay experienced within the scope of the Project is not only due to the COVID-19, but the delays that started in the pre-pandemic period were also increasing even more in this period of time. The Parties executed their 'Claim' management in accordance with the provisions of the contract, and when the case study is examined, the following picture emerges:

By putting forward the delay experienced in the signaling-software works, which are electronic computer engineering services, the Main Contractor disregarded the effect of the PANDEMIC on the delays experienced in the hardware installation, testing and commissioning processes and demonstrated an approach such as "if there had been no delay in the software works, the hardware works would not be subject to the PANDEMIC process".

The Subcontractor claimed that it prepared a program that could compensate for the delay encountered in the software process for the works that it would carry out in terms of the hardware installation and tests, but it failed to use this program due to the PANDEMIC effect.

A debtor has fallen into default due to their own fault, and subsequently, the COVID-19 pandemic has made the performance of the contract excessively difficult. The debtor must bear the consequences of this situation because if the debtor had performed their obligation on time, the pandemic would not have affected the contract.

To eliminate such disputes arising from the contract, the most accurate approach for the Parties would be to use the win-win principle in their actions towards each other.

The binding principles of the provisions of the contract between contractors should be able to be managed according to this special situation when force majeure events or globally or locally unforeseen effects occur. For example, the contractor should make a claim for the delay suffered by the subcontractor in the software works, but it should waive the claim arising from the time losses experienced in the hardware process. Likewise, the subcontractor should accept the negative impacts of the delays attributable to itself on the works related to the successive (start to start or finish to start) relationship, and should cover the additional work costs arising from the prolonged work processes.

Another key point in the case study is that technological means were used more in order to mitigate the effects of the delay caused by the restrictions taken at local and global levels. We can say that the integration of technology into business processes significantly improved the delay analysis and overall project management processes during the pandemic period.

We can see in the case study that the digital communication tools that were used to ensure efficient communication between the project stakeholders accelerated the flow of information and in this way, the causes of delays and solution suggestions could be shared quickly.

During the pandemic, remote working and virtual training opportunities allowed the workforce to continue to develop their skills. These technological developments have supported overcoming the challenges of the pandemic by enabling projects to be managed more flexibly and efficiently.

When considering another impact of the pandemic on contracts, it is crucial to take sustainability principles into account. In addressing the economic and social challenges

faced by the parties to the contract, it is not only short-term solutions that are necessary but also long-term actions that align with environmental, social, and economic sustainability principles. In the uncertain environment created by COVID-19, paying attention to sustainability goals such as social responsibility for employees and the protection of natural resources in the face of disruptions in the supply chain not only safeguards the interests of the contracting parties but also ensures the long-term support of society and the environment. From this perspective, the application of force majeure and hardship provisions can lead to the creation of a more just, resilient, and sustainable contractual structure, where the interests of the parties are equally protected.

The pandemic has had a profound impact on the construction industry, and these effects, when combined with sustainability goals, have created new opportunities, as demonstrated in the case study. When examining the impact of the pandemic on the construction sector from a sustainability perspective, the following points stand out:

Environmental Impacts and Sustainable Practices: During the pandemic, the suspension or slowdown of many construction projects led to a reduction in environmental impacts. Air pollution and carbon emissions decreased, which in turn highlighted the importance of environmentally friendly, low-carbon, and energy-efficient practices within the construction industry.

Social Sustainability and Health and Safety: The pandemic has brought to the forefront the importance of health and safety measures in the construction sector. The health and safety of workers on construction sites became a top priority. From a social sustainability perspective, issues such as workers' rights, safe working conditions, and social distancing measures were emphasized. Along with the pandemic, the health status of workers was closely monitored, and additional hygiene and sanitation measures were implemented in the workplace. Moreover, social challenges such as workforce loss and unemployment necessitated the development of sustainable labor force strategies.

Economic Sustainability and Resource Management: The pandemic has brought about economic challenges and financial pressures for many construction companies. From a sustainability standpoint, efficient resource use, budget management, and cost control were key factors in maintaining economic sustainability during this period.

Digitalization and Technology Use: The pandemic accelerated digitalization in the construction industry and ensured that technology played a critical role in achieving sustainability goals. Remote monitoring of construction projects, digital planning, and management software have accelerated the process of building energy-efficient structures.

As a result, each case should be examined separately by considering whether the difficulty encountered due to the COVID-19 constitutes a force majeure event, how it has prevented the contractor from fulfilling its obligations, and what consequences it will bring. Cost benefits and even productivity increases have been achieved in business lines, where technological innovations could be integrated more, while negative impacts emerged against the Administration or the Contractor in the projects with manufacturing and site conditions depending upon labor. For this reason, I believe that each project should be examined based on its own conditions, technological innovations and contract provisions.

Annexes

Annex-1 Pre-Conditions for compliance with the Work Schedule

Annex-2 Work Schedule

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SIGNALLING TESTS COMMENCEMENT CERTIFICATE 3

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- Civil Works, Track Works, Catenary, Power Supply, PSD Doors (fully functional), Tetra System, UPS, and auxiliary systems in SER (S11, S12, S14, S15, S16, S18, S19) have been duly installed, completed and verified by the Company.
- Safety measures on the Track Section have been provided by the Company in full accordance with the applicable **ESSKMM14907D104** – "*Test Plan*" documentation and shall be maintained for the full duration of the Signaling Tests as deemed necessary.
- Permanent Health, Safety and Environment (HSE) Responsible for the Track Section have been assigned by the Company to coordinate all subcontractors joint work in a harmony and ensure good level of communication between all parties. Permanent HSE Responsible shall be maintained by the Company for the full duration of the Signaling Tests as deemed necessary in order to avoid any incidents or accidents that may happen due to miscommunication.
- Environmental conditions for the Track Section have been checked and verified to be within the acceptable range by the Company which shall continue to be monitored and controlled for the full duration of the Signaling Tests as deemed necessary.
- The Company shall pursue their rights stipulated in their main contract with IMM and ensure that the Drivers who successfully passed the Driver Trainings of the Vehicle Supplier have been arranged by Vehicle **Company** to attend each shift of Signaling Tests to be executed as deemed necessary.
- The Company shall pursue their rights stipulated in their main contract with IMM and ensure that the Vehicle needs for the Signaling Tests shall be provided by **Vehicle Company** in a timely manner as deemed necessary.

Company hereby declares and certifies that the Track Section together with all the preconditions as listed above have been fulfilled and ready for the Signaling Subcontractor to commence performing all necessary testing and commissioning activities included under the Signaling scope as of the execution date of this Certificate.

In Witness Whereof, this Certificate which has been signed and executed by the duly authorized officers of the Company hereto on 20 / 2 / 20 in 2 (two) original copy.

KMM - ACTUAL SUMMARY SCHEDULE FOR STAGE 1			
ACTIVITY	**DURATION**	**START**	**FINISH**
AL dependencies			
PSD System fully completed S09-S19			15.01.2020
Line available exclusive for signalling tests only S09 - S19			22.01.2020
OCCS ready			02.03.2020
Rolling Stock dependencies			
Train No.3-14 handing-over to AL/BT (in equal gradual steps)		03.12.2019	11.03.2020
Section S05-S09			
SMA 2 for start Wayside SAT S05 - S09	26 days	15.01.2020	**31.01.2020**
SAT Test (Integration test) S05 - S09	42 days	28.12.2019	07.02.2020
Section S09-S19			
DTS & Network test (805, 1282) S09 - S19	3 days	12.01.2020	14.01.2020
System initialization and I/O test (2001, 3950, 3951) S09 - S19	7 days	15.01.2020	21.01.2020
Map verification & Radio test (907, 811, 812)S09 - S19	10 days	22.01.2020	31.01.2020
SMA 2 for start Wayside SAT S09 - S19	5 days	03.02.2020	**07.02.2020**
Section S05-S19			
SAT Test (Integration test) S05 - S19	42 days	08.02.2020	20.03.2020
On board dynamic testing trains 3 to 14 (Test No. 904, either on temporary test track or a main line section) (in equal gradual steps)	90 days	18.12.2019	16.03.2020
SMA 3 for start wayside SIT Stage 1 (S05-S19)	12 days	21.03.2020	01.04. 2020
SIT Test (Performance & Demonstration test) (with 7 trains)	7 days	02.04.2020	08.04.2020
SMB1 (ISAR) for Stage 1 (S05-S19) (Signalling System Safety Certificate)	12 days	09.04.2020	20.04.2019

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RESP

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Araştırma Makalesi ● Research Article

A Research on the Relationship Between of Green Organizational Behaviour and Organizational Citizenship Behaviour

Yeşil Örgütsel Davranış İle Örgütsel Vatandaşlık Davranışı Arasındaki İlişkisi Üzerine Bir Araştırma

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ANAHTAR KELİMELER

Yeşil Yönetim
Yeşil Örgütsel Davranış
Örgütsel Vatandaşlık Davranışı

ÖZ

Yeşil örgütsel davranış, çevreye verilen zararı en aza indiren, aynı zamanda sergilenen bu davranışlarından fayda sağlanan örgüt içerisinde bulunan çalışanlar ve yöneticiler tarafından ortaya konulan tutumlar olarak ifade edilmektedir. Çalışma, yeşil örgütsel davranışları sergilemenin örgütsel vatandaşlık davranışı sergileme düzeyini arttıracağı görüşünden hareket etmektedir. Bu doğrultuda çalışma yeşil örgütsel davranış ile örgütsel vatandaşlık davranışı ilişkisini belirlemeyi amaçlamaktadır. Ayrıca yeşil örgütsel davranış alt boyutları ile örgütsel vatandaşlık davranış alt boyutları arasındaki ilişkilerin de ortaya çıkarmak amaçlanmıştır. Genel tarama modeli kapsamında ilişkisel tarama modeli ile gerçekleştirilen araştırmanın örneklemi Jandarma Genel Komutanlığının merkez ve taşra teşkilatında bulunan subay, astsubay, uzman jandarma, uzman erbaş ve memurlardan oluşmaktadır. Araştırmanın veri kümesi, demografik bilgiler, çalışanların yeşil örgütsel davranış sergileme düzeyleri ve çalışanların örgütsel vatandaşlık davranışı sergileme seviyelerine doğrultusunda elde edilmiştir. Elde edilen veriler, SPSS aracılığıyla tanımlayıcı analiz ve regresyon analizi ile değerlendirilmiştir. Bu doğrultuda elde edilen bulgular sonucunda orta düzeyde ve pozitif yönde bir ilişki tespit edilmiştir.

KEYWORDS

Green Management
Green Organizational Behavior
Organizational Citizenship Behavior

ABSTRACT

Green organizational behavior is expressed as the attitudes put forward by the employees and managers in the organization that minimize the damage to the environment and also benefit from these behaviors. The study is based on the view that exhibiting green organizational behaviors will increase the level of exhibiting organizational citizenship behavior. In this direction, the study aims to determine the relationship between green organizational behavior and organizational citizenship behavior. In addition, it is aimed to reveal the relations between green organizational behavior sub-dimensions and organizational citizenship behavior sub-dimensions. The sample of the research, which was carried out with the relational scanning model within the scope of the general scanning model, consists of officers, non-commissioned officers, specialist gendarmes, specialist non-commissioned officers and civil servants in the central and provincial organizations of The Gendarmerie General Command. The dataset of the research was obtained in line with demographic information, green organizational behavior levels of employees and organizational citizenship behavior levels of employees. The obtained data were evaluated with descriptive analysis and regression analysis via SPSS. As a result of the findings obtained in this direction, a moderate and positive relationship was determined.

* This study was produced from the master's thesis titled "The Relationship between Green Organizational Behavior and Organizational Citizenship Behavior: The Example of Gendarmerie General Command" prepared under the supervision of Assist.Prof.Dr. Esra Gökçen Kaygisiz. Ethics committee permission was given by Giresun University Rectorate Social Sciences Science and Engineering Sciences Research Ethics Committee for the survey application of this study, with the decision no. 18/05 dated 05 January 2022.

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1. Introduction

In today's world, environmentally conscious approaches and the concept of sustainability have gained increasing importance at individual, social and organizational levels. Society expects organizations to reduce their environmental impacts and integrate this responsibility into their production, consumption, and management strategies. In this context, aligning organizational behaviors with environmental sensitivity becomes crucial, and the concept of green management emerges.

Green management refers to the practices aimed at minimizing the negative environmental impacts caused by organizations during the production goods or services. It also entails voluntary internalization of environmentally friendly practices throughout all organizational processes. The presence of green management in an organization depends heavily on the demonstration of green organizational behaviors (GOB). GOB encompasses organizational behaviors that promote environmentally responsibility and aim to reduce ecological harm. These behaviors are shaped not only by top-down orders and formal policies but also by employees 'individual awareness and voluntary initiatives. This aligns with the principles of the Theory of Planned Behavior (Ajzen, 1991), which emphasizes the role of individual intentions and attitudes in shaping behavior. Furthermore, GOB is closely related to Organizational Citizenship Behavior (OCB), which represents employees' voluntary efforts that go beyond formal job responsibilities to support the organization. OCB generally enhances employee commitment and overall performance while positively influencing the organizational climate.

Recent studies have investigated the link between GOB and employee attitudes in various sectors. For example, Zientara and Zamojska (2022) found that GOB significantly contributes to organizational trust and job satisfaction. Similarly, Malik et al. (2022) emphasized the importance of environmental responsibility in promoting extra-role behaviors among employees. More recently, Nawaz et al. (2023) highlighted the role of green values in shaping organizational citizenship behavior in the public sector. However, there remains a gap in the literature regarding how these dynamics operate within hierarchical and hybrid structures such as the gendarmerie.

Grounded in the Theory of Planned Behavior and Social Exchange Theory (Blau,1964), this study investigates the relationship between GOB and OCB, particularly examining how environmentally responsible behaviors influence organizational citizenship behaviors. Specifically, it explores how employees' attitudes toward environmental practices affect key aspects such as collaboration, solidarity, and responsibility. The study seeks to provide recommendations that will promote the adoption of sustainable practices across organizations. This addresses a gap in the literature, as few studies have examined the GOB-OCB link within a military-influenced organizational culture. Given the growing urgency of climate change and environmental degradation, understanding how green behaviors relate to broader organizational outcomes has become a critical academic priority (Zientara & Zamojska, 2022; Malik et al., 2022).

The study first presents the theoretical framework underpinning these concepts. Then, empirical data from a survey will be analyzed to reveal the nature and strength of the relationship between GOB and OCB. This research is expected to make both theoretical and practical contributions. Theoretically, the study enriches interdisciplinary literature by integrating green behaviorist organizational psychology and management research. Examining the relationship between GOB and OCB contributes to a deeper understanding of how environmental concerns influence organizational functioning. Practically, the study aims to offer strategic recommendations that help organizations create greener work environments while encouraging pro-organizational behaviors among employees.

The exhibited behaviors include the voluntary dimension of OCB (Organ, 1988). Organizations that adopt green organizational behaviors and OCB will gain advantages. This study is limited to employees working in the central and provincial organizations of the Gendarmerie General Command, operating under the Ministry of the Interior. Although not all personnel have received formal environmental training, the organization implements various green practices, such as recycling, energy-saving campaigns, and environmental awareness. These practices make the selected sample appropriate for examining the relationship between GOB and OCB.

2. Literature Review

2.1. The Concept of Green Management and Green Organizational Behavior

The concept of green management, which focuses on resource conservation in all business processes, was first emphasized at the United Nations Conference on Environment & Development held in Rio in 1992 (Thomas, 1992). In this context, green management is broadly defined as the integration of environmental concerns into business strategies and operations with the goal of ensuring sustainable development (Freestone, 1994). This study adopts the definition provided by Haden et al. (2009), who describes green management as an organizational process that integrates environmental factors into corporate goals and strategies through innovation, sustainability, waste reduction, and continuous development, thereby aiming to gain competitive advantage. This definition aligns closely with the study's focus on environmentally responsible employee behaviors and their impact on organizational outcomes.

Green management not only ensures compliance with legal regulations but also aims to embed environmental values

into the organizational culture. In this context, green management promotes green organizational behavior (GOB) by encouraging employees to exhibit environmentally friendly behaviors within the organization.

Recent research underscores the strategic significance of GOB in both private and public organizations (Zhang & Tian, 2022; Lee et al., 2023). The relationship between green management and GOB can primarily be explained through the impact of organizational policies and leadership approaches on employee behavior. Green management practices enhance employees 'environmental awareness and facilitate their voluntary environmentally friendly behaviors. For example, encouraging practices such as energy conservation, recycling, and sustainable resource usage within the business increases environmental awareness among employees, thereby supporting GOB. Additionally, when leaders adopt an environmentally conscious management approach, it positively influences employees 'attitudes towards these behaviors. This, in turn, contributes to enhancing organizational citizenship behavior (OCB) elements such as cooperation, solidarity, and responsibility (Graves et al., 2013; Boral & Paille, 2012).

In addition to organizational efforts, expected positive behaviors of employees are referred to as green organizational behaviors (Steg & Vlek, 2009). Measurable actions and behaviors linked to environmental sustainability are also defined as green organizational behaviors by Ones and Dilchert (2012).

When the acquisition of green behavior is examined, it is expected that not only will individuals engage in green behaviors, but societal-level green behaviors will also emerge if individual green behavior becomes continuous (Eilam & Trop, 2012).

According to Robertson and Barling's (2013) study, environmentally specific transformational leadership contributes to the development of environmentally friendly behaviors both within the organization and among employees through adherence to environmental rules. Thus, green organizational behavior plays a significant role in fostering environmentally conscious attitudes and implementing sustainability principles while reducing environmental impacts.

Various authors address GOB in different dimensions. According to Erbası (2019) it includes five dimensions as environmental sensitivity, environmental participation, economic sensitivity, green purchasing, and technological sensitivity. Environmental sensitivity involves employees ' awareness of their potential environmental harm and their inclination to correct it, while environmental participation refers to employees suggesting eco-friendly practices to management. Other dimensions include economic sensitivity, which focuses on the efficient use of resources, green purchasing, where employees guide customers towards environmentally friendly products, and technological sensitivity, which refers to employees 'use and adoption of technology. Green organizational behaviors are also analyzed in five core dimensions by Ones and Dilchert (2012), which include sustainable work practices, resource conservation, influencing others, taking initiative, and avoiding damage. Another classification of green organizational behavior categorizes them into voluntary behaviors that contribute psychologically, socially, and organizationally, while other necessary behaviors are considered mandatory (Lewin, 1951). This study uses Erbası's (2019) classification, as it allows for a deeper analysis of organizational behavior from both environmental sustainability and employee behavior perspectives, while also providing a framework that is accepted in the literature and has been tested for validity, thereby supporting the scientific reliability and validity of the study.

2.2. The Concept of Organizational Citizenship Behavior

OCB refers to all voluntary positive behaviors performed by employees in an organization that go beyond their job descriptions. The concept was first introduced by Thomas S. Bateman and Dennis W. Organ in 1983 (Bateman & Organ, 1983). Organ defined the concept as employees voluntarily helping the organization to function efficiently, even though it is not specified in their job descriptions (Organ, 1988).

OCB refers to behaviors that are discretionary, go beyond employees 'defined tasks, and benefit the organization or aim to do so (Van Dyne et al., 1995). According to Dennis W. Organ, organizational citizenship behaviors are additional tasks that contribute to organizational effectiveness, which are categorized as extra-role behaviors.

OCB should also encompass altruism in addition to producing more work than others. To foster an altruistic environment within the organization, it is necessary to avoid unrest, conflicts, and behaviors that harm the organization. Behaviors such as not constantly complaining, getting along well with colleagues, and covering for each other's mistakes are also emphasized (Turnipseed & Murkinson, 1996).

To better understand organizational citizenship behavior, several related concepts can be found in the literature. These concepts include organizational spontaneity, psychological contracts, prosocial organizational behaviors, formal role behaviors, and role overload behaviors (Kaya, 2013).

Organizational spontaneity consists of helping colleagues, protecting the organization, making constructive suggestions, self-improvement, and spreading goodwill. A positive mood is important for the organization and is a precursor to organizational spontaneity. It is argued that it should be based on voluntary participation and contribution to organizational effectiveness (George & Brief, 1992).

Both organizational spontaneity and organizational citizenship behavior support the organization positively. The key difference is that organizational spontaneity only includes extra-role and active behaviors (İplik, 2015).

The concept of psychological contracts was informally introduced by Chris Argyris in the 1960s (Argyris, 1960). Psychological contracts are defined as the mutual work relationships between employees and employers, which include messages conveyed through observation and explicit promises made by the employer to the employee (Rousseau, 1989). Based on experiences, psychological contracts are characterized by being natural, involving commitment between the employee and employer, not being static, and being emotional. The strength of the relationship between the two parties and the mutual understanding of each other's roles are key factors explaining the relationship between psychological contracts and organizational citizenship behavior (Morrison & Robinson, 1997).

Another related concept to organizational citizenship behavior is prosocial organizational behaviors. These behaviors are actions performed by organizational members intended to benefit an individual, group, or the organization (Brief & Motowidlo, 1986). Prosocial organizational behaviors are defined as behaviors that do not necessarily have to be in the job description, extra-role behaviors that contribute voluntarily, and are crucial for organizational success (MacKenzie et al., 1991).

In 1964, Daniel Katz classified formal role behaviors as behaviors that reliably fulfill specific job or task requirements (Werner, 2000). Formal role behaviors are the technical behaviors that employees must perform according to their job descriptions to ensure the continuity of the organization (Williams & Anderson, 1991).

Today, despite fewer job descriptions due to adapting to the changing external environment, employers trust employees to fill the gap between necessary duties and urgent tasks. Role overload behaviors, such as individual behaviors and creativity, increase an organization's adaptability and responsibility (Amabile, 1996). Behaviors that encourage employees to do more than required are role overload behaviors. This proactive attitude also boosts employees ' self-confidence (Demerouti et al., 2015). Emerging literature suggests that pro-environmental behaviors may function as a specific form of citizenship behavior, thus blurring the boundaries between GOB and OCB (Arici et al., 2022; Luu, 2022).

Several studies in the literature examine the dimensions of organizational citizenship behavior in different ways. Organ (1988) addresses OCB in five dimensions, Jill W. Graham (1991) in three dimensions, Larry Williams and Stella Anderson (1991) in two dimensions, Walter Borman and Stephan Motowidlo (1993) in six dimensions, Robert H. Moorman and Gerard L. Blakely (1995) in four dimensions, and Philip M. Podsakoff et al. (2000) in seven dimensions.

Organ categorizes organizational citizenship behavior into five dimensions as altruism, courtesy, conscientiousness, sportsmanship, and civic virtue (Organ, 1997). Graham classifies it into three dimensions: compliance, loyalty, and participation (Graham, 1991). Williams and Anderson categorize it into two dimensions as individual-oriented OCB and organization-oriented OCB (Williams & Anderson, 1991). Borman and Motowidlo examine OCB in six dimensions as helping and cooperating with others, sportsmanship, supporting organizational goals, adhering to organizational rules and procedures, sustaining effort, and voluntarily performing tasks (Borman & Motowidlo, 1993). Moorman and Blakely address it in four dimensions: interpersonal help, supporting commitment, individual effort, and individual initiative (Moorman & Blakely, 1995). Podsakoff, MacKenzie, Paine, and Bachrach classify OCB into seven dimensions as helping behavior, sportsmanship, organizational loyalty, organizational compliance, individual initiative, civic virtue, and individual development (Podsakoff et al., 1995).

2.3. Studies Examining the Relationship Between Green Organizational Behavior and Organizational Citizenship Behavior

A growing body of research has examined the relationship between green organizational behavior (GOB) and organizational citizenship behavior (OCB), highlighting how voluntary, environmentally responsible actions within organizations can foster broader pro-social behaviors. For example, Lamm et al. (2013) noted that while GOB and OCB differ in motivational orientation—environmental concern versus organizational concern—they share common features such as voluntariness and alignment with organizational culture.

Studies suggest that green management practices and pro-environmental leadership foster employee engagement in voluntary environmental actions, which often translate into citizenship behaviors that go beyond formal job requirements. Ishaque et al. (2025) demonstrated that environmentally proactive and creative employees contribute significantly to green human resource management, enhancing both GOB and OCB. Similarly, Jia et al. (2023) and Khan et al. (2023) found that employees who engage in green behaviors tend to develop stronger organizational identification and intrinsic motivation—key drivers of OCB.

These findings collectively support the notion that GOB can act as a catalyst for OCB by promoting a shared sense of environmental responsibility, intrinsic motivation, and organizational engagement. The present study builds on this premise by empirically testing the relationship between the five dimensions of GOB (environmental sensitivity, environmental participation, economic sensitivity, green purchasing, and technological sensitivity) and the core dimensions of OCB (altruism, courtesy, conscientiousness, sportsmanship, and civic virtue), thereby offering a multidimensional and theory-driven analysis of their interaction within the context of public service.

3. Methodology

3.1. Research Sample and Population

In this study, the relational screening model of the general screening model was used. The screening model is often employed in quantitative research and involves studies that have great potential, derived from large samples (Fraenkel et al., 2009). The population of the research consists of senior officers, officers, non-commissioned officers, expert gendarmes, expert privates, and civilian staff working in the central and provincial organizations of the Gendarmerie General Command. The data set obtained from the study was gathered through a survey method. Surveys were administered face-to-face, via email, and by telephone to 2,500 individuals, and 1,150 responses were received. Out of the responses, 15 were eliminated due to being incomplete or erroneous. Given the diversity of ranks and roles included, the sample is considered representative of the target population, aligning with established criteria for generalizability in quantitative studies (Yıldırım and Şimşek, 2013). The data of 1,135 participants were analyzed using the SPSS software. This is particularly important, as the inclusion of a military-public sample fills a notable gap in the literature, especially considering recent calls for diversified sectoral representation in green behavior research Aboramadan et al., 2022; Liu & Lin, 2022).

The rationale for selecting gendarmerie personnel as the research sample lies in the distinctive organizational structure and dual-function nature of the gendarmerie, which blends military discipline with public service responsibilities. These features make the gendarmerie a particularly relevant context for examining both GOB and OCB. Gendarmerie personnel are generally expected to exhibit a high level of responsibility, collaboration, and commitment—characteristics that align closely with the voluntary dimensions of OCB and GOB. Furthermore, the institution's widespread presence across diverse geographical areas provides an ideal setting to explore varied environmental attitudes and behaviors. Although the Gendarmerie General Command does not officially publish a comprehensive environmental strategy document, it has increasingly adopted practices aligned with environmental responsibility, such as waste reduction campaigns, energy-saving measures in facilities, and collaborations with environmental NGOs during public events. These organizational tendencies foster an environment in which personnel are encouraged—both formally and informally—to exhibit environmentally responsible and citizenship-oriented behaviors. While not all personnel have received formal environmental training, various institutional efforts—such as awareness campaigns and participation in green initiatives—indicate a growing organizational orientation toward environmental responsibility.

The survey used in the study consists of three sections. The first section includes the "Green Organizational Behavior Scale" developed by Ali Erbası (2019), which consists of 27 items. The scale's questions were measured using a 5-point Likert scale ranging from "1. Never" to "5. Always." This scale is grounded in the theoretical framework of pro-environmental behavior in organizations and aims to assess individual-level contributions to environmental sustainability within the workplace (Erbaşı, 2019). The second section includes the "Organizational Citizenship Behavior Scale," consisting of 15 items, developed by Podsakoff, MacKenzie, Moorman, and Fetter (1990) and translated into Turkish by Karabey (2005). This scale has been found to have a high reliability level in various studies. The items for this scale were also measured using a 5-point Likert scale ranging from "1. Never" to "5. Always." This scale was developed to measure discretionary behaviors of employees that support organizational functioning beyond formal role expectations (Organ, 1988; Podsakoff et al., 2000). The third section of the survey contains five questions designed to determine the demographic characteristics of the participants. Ethics committee permission was given by Giresun University Rectorate Social Sciences Science and Engineering Sciences Research Ethics Committee for the survey application of this study, with the decision no. 18/05 dated 05 January 2022.

3.2. Research Hypotheses and Model

The main hypothesis of this study is that there is a positive relationship between the green organizational behavior and organizational citizenship behavior exhibited by employees working in the Gendarmerie General Command. Accordingly, the model of the study is presented below.

The theoretical foundation for this hypothesis is based on the notion that pro-environmental behaviors within organizations can foster positive attitudinal and behavioral outcomes among employees, including increased commitment, engagement, and voluntary contributions (Daily et al., 2009; Norton et al., 2015).

Moreover, OCB is closely tied to employees' internal motivations and value-driven actions, such as environmental sensitivity, which are part of GOB (Boiral & Paille, 2012).

In line with these hypotheses, the model of the research is presented in Figure 1.

The conceptual model aims to examine the multidimensional relationship between the five sub-dimensions of GOB (Environmental Sensitivity, Environmental Participation, Economic Sensitivity, Green Purchasing, Technological Sensitivity) and the five sub-dimensions of OCB (Altruism, Courtesy, Sportsmanship, Conscientiousness, Civic Virtue). Demographic variables such as gender, age, rank/status, tenure, and educational level are also analyzed to explore possible variations in both constructs.

Within the framework of the model, it is considered that the sub-dimensions of GOB and OCB are related to each other, and demographic variables affect both concepts. In this context, the following hypotheses are being tested:

H_A: There is a significant relationship between green organizational behavior and organizational citizenship behavior.

The hypothesis is supported by the Social Exchange Theory (Blau, 1964), which suggests that employees who perceive their organization as environmentally responsible may feel a moral obligation to reciprocate through positive discretionary behaviors such as OCB (Lamm et al., 2013; Kim et al., 2017).

H_{1a}: There is a significant relationship between environmental sensitivity and altruism.

H_{1b}: There is a significant relationship between environmental sensitivity and courtesy.

H_{1c}: There is a significant relationship between environmental sensitivity and sportsmanship.

H_{1d}: There is a significant relationship between environmental sensitivity and conscientiousness.

H_{1e}: There is a significant relationship between environmental sensitivity and civic virtue.

Environmental sensitivity refers to an employee's awareness and concern for the natural environment and its preservation in the workplace. Employees with high environmental sensitivity may feel a greater sense of personal responsibility, which translates into voluntary prosocial behaviors like altruism and courtesy (Robertson & Barling, 2013; Ones & Dilchert, 2012).

H_{2a}: There is a significant relationship between environmental participation and altruism.

H_{2b}: There is a significant relationship between environmental participation and courtesy.

H_{2c}: There is a significant relationship between environmental participation and sportsmanship.

H_{2d}: There is a significant relationship between environmental participation and conscientiousness.

H_{2e}: There is a significant relationship between environmental participation and civic virtue.

Environmental participation captures the degree to which employees actively engage in eco-initiatives at work. According to the Value-Belief-Norm theory (Stern, 2000), individuals who believe in the moral importance of sustainability are more likely to engage in voluntary behaviors, including OCB-related actions such as civic virtue and conscientiousness (Boiral, 2009; Paille & Boiral, 2013).

H_{3a}: There is a significant relationship between economic sensitivity and altruism.

H_{3b}: There is a significant relationship between economic sensitivity and courtesy.

H_{3c}: There is a significant relationship between economic sensitivity and sportsmanship.

H_{3d}: There is a significant relationship between economic sensitivity and conscientiousness.

H_{3e}: There is a significant relationship between economic sensitivity and civic virtue.

Economic sensitivity highlights the importance of conserving financial and natural resources simultaneously. Employees who show this sensitivity may demonstrate OCB by proposing efficiency solutions, being frugal with organizational resources, or supporting cost-effective eco-practices behaviors linked to conscientiousness and sportsmanship (Ramus & Killmer, 2007; Daily et al., 2009).

H_{4a}: There is a significant relationship between green purchasing and altruism.

H_{4b}: There is a significant relationship between green purchasing and courtesy.

H_{4c}: There is a significant relationship between green purchasing and sportsmanship.

H_{4d}: There is a significant relationship between green purchasing and conscientiousness.

Green purchasing behaviors reflect an individual's tendency to support and advocate for environmentally friendly procurement processes. Employees engaged in green purchasing may develop an enhanced sense of organizational identification, which has been linked to increased OCB levels (Mishra & Sharma, 2010).

H_{4e}: There is a significant relationship between green purchasing and civic virtue.

H_{5a}: There is a significant relationship between technological sensitivity and altruism.

H_{5b}: There is a significant relationship between technological sensitivity and courtesy.

H_{5c}: There is a significant relationship between technological sensitivity and sportsmanship.

H_{5d}: There is a significant relationship between technological sensitivity and conscientiousness.

H_{5e}: There is a significant relationship between technological sensitivity and civic virtue.

Technological sensitivity involves employees' openness to eco-friendly technologies and innovations. The Theory of Planned Behavior (Ajzen, 1991) supports the idea that attitudes toward sustainable technology influence voluntary behavior. Employees open to such technologies are more likely to engage in conscientious and civic behaviors (Chang & Chen, 2013; Norton et al., 2015).

In addition to the main hypotheses, the study investigates whether demographic characteristics—such as gender, age, status, years of service, and education level—affect participants' green organizational behavior and organizational citizenship behavior. Including demographic

variables in behavioral research is a common practice, especially in studies involving structured institutions such as the military and law enforcement.

Prior research has indicated that demographic variables can influence both pro-environmental and discretionary workplace behaviors. For example, Lambert et al. (2008) found that age and educational level were significantly related to OCB among correctional staff.

differences across status and demographic groups (Korkmaz & Ekmekçi, 2023; Gürbüz & Yüksel, 2017). Therefore, demographic-based hypotheses were developed to explore potential variances and enrich the interpretation of organizational behavior within the Gendarmerie General Command.

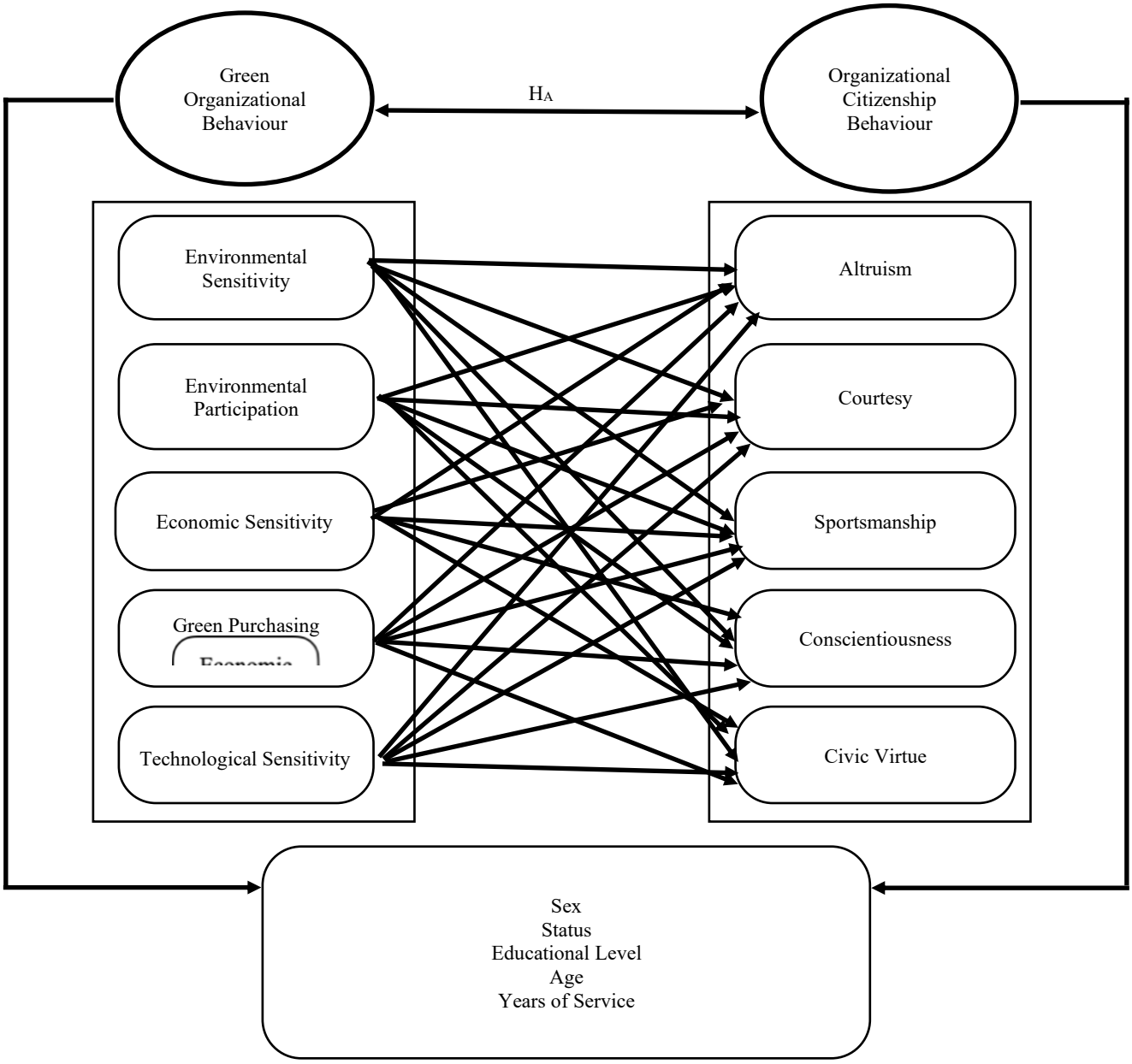

Figure 1: Research Model

Similarly, Kidder and Parks (2001) noted that gender could influence certain dimensions of OCB, such as altruism and courtesy. In the context of military and gendarmerie organizations, the hierarchical structure and unequal gender representation may also lead to perceptible behavioral

Within the scope of the study, the sub-hypotheses created to determine the relationship between the demographic characteristics of the participants and green organizational behavior as well as organizational citizenship behavior are as follows:

H_{6a}: There is no significant difference between gender and green organizational behavior.

H_{6b}: There is no significant difference between gender and organizational citizenship behavior.

H_{7a}: There is no significant difference between age groups and green organizational behavior.

H_{7b}: There is no significant difference between age groups and organizational citizenship behavior.

H_{8a}: There is no significant difference between status groups and green organizational behavior.

H_{8b}: There is no significant difference between status groups and organizational citizenship behavior.

H_{9a}: There is no significant difference between years of service and green organizational behavior.

H_{9b}: There is no significant difference between years of service and organizational citizenship behavior.

H_{10a}: There is no significant difference between education level and green organizational behavior.

H_{10b}: There is no significant difference between education level and organizational citizenship behavior.

3.3. Validity and Reliability of the Scales

Green Organizational Behavior (GOB) Scale

The Green Organizational Behavior Scale developed by Ali Erbaşı (2019) consists of 27 items measured on a 5-point Likert scale ranging from "1 = Never" to "5 = Always." This scale does not include any reverse-coded items. It is designed to assess pro-environmental behavior within organizational contexts. The scale has five dimensions identified through exploratory factor analysis: environmental awareness, environmental participation, ecological sensitivity, green purchasing, and technological sensitivity. Sample items include: "I participate in environmental protection activities in the organization" and "I prefer environmentally friendly products while purchasing for organizational needs."

The Cronbach's alpha value for this scale was found to be 0.949, indicating excellent internal consistency (Connelly, 2011). Cronbach's alpha values for the dimensions were as follows: environmental awareness (0.765), environmental participation (0.800), ecological sensitivity (0.672), green purchasing (0.742), and technological sensitivity (0.657). The KMO value was 0.949, and Bartlett's test of sphericity was significant (χ^2 = 11609.952, df = 351, p < .001), confirming the adequacy of the sample for factor analysis (Kaiser, 1974). Exploratory factor analysis (EFA) using principal component analysis with varimax rotation revealed a five-factor solution, explaining 53.61% of the total variance. Factor loadings ranged from .319 to .742.

Organizational Citizenship Behavior (OCB) Scale

The Organizational Citizenship Behavior Scale developed by Podsakoff, MacKenzie, Moorman, and Fetter (1990) and translated into Turkish by Karabey (2005) includes 15 items, also measured on a 5-point Likert scale ranging from "1 = Never" to "5 = Always." There are no reverse-coded items in this scale. Although the original model proposed five dimensions (altruism, courtesy, sportsmanship, conscientiousness, and civic virtue), the exploratory factor analysis in this study yielded a two-factor structure. Sample items include: "I help colleagues who have heavy workloads" and "I always comply with the organization's rules and procedures even when nobody is watching."

The Cronbach's alpha value was 0.902, and the KMO value was 0.937. Bartlett's test was also significant (χ^2 = 7158.652, df = 105, p < .001), indicating that the data were suitable for factor analysis. Cronbach's alpha values for the sub-dimensions were as follows: altruism (0.726), courtesy (0.744), sportsmanship (0.703), conscientiousness (0.648), and civic virtue (0.741). The EFA revealed a two-factor solution explaining 51.43% of the total variance, with factor loadings ranging from .345 to .712.

Overall Assessment

The overall Cronbach's alpha for the entire survey instrument was 0.943, indicating very high internal consistency reliability. To assess data normality, skewness and kurtosis values were examined and found to be within the range of -1 to +1, indicating normal distribution (Jondeau & Rockinger, 2003; Kline, 2011; George & Mallery, 2010; Hair et al., 2010; Tabachnick & Fidell, 2013). Based on these findings, the data were considered appropriate for parametric testing. Since the study is exploratory in nature, Confirmatory Factor Analysis (CFA) was not performed. Therefore, model fit indices are not reported. Future research is encouraged to conduct CFA to assess the structural validity of the scales.

4. Research Findings

4.1. Findings Related to Demographic Characteristics

Table 1: Demographic Distribution of the Participants

		Frequency	Percentage
Sex	Female	25	2,2
	Male	1110	97,8
	Total	1135	100,0
Status	Senior Officer	10	0,9

	Officer	198	17,4
	Non-commissioned Officer (NCO)	240	21,1
	Specialist Gendarme	49	4,3
	Specialist Sergeant	628	55,3
	Civil Servent	10	0,9
	Total	1135	100,0
Age	24 and Below	124	10,9
	25-30	635	55,9
	31-35	237	20,9
	36-40	68	6,0
	41 and Above	71	6,3
	Total	1135	100,0
Years of Service	1-5 Years	722	63,6
	6-10 Years	191	16,8
	11-15 Years	105	9,3
	16-20 Years	51	4,5
	20 Years Above	66	5,8
	Total	1135	100,0
Level of Education	Middle School	14	1,2
	High School	368	32,4
	Associate Degree	283	24,9
	Bachelor's Degree	415	36,6
	Master's Degree	53	4,7
	Doctorate	2	0,2
	Total	1135	100,0

In the surveys conducted with personnel serving in both the central and provincial units of the Gendarmerie General Command, demographic data, including gender, rank, age, years of service, and educational background, were collected. Most of the 1135 participants were male, young (aged 25–30), and had less than five years of service. Most participants held the position of specialist soldier and possessed at least a high school or bachelor's degree. Detailed demographic distributions are presented in Table 1.

The mean and standard deviation values regarding employees' levels of green organizational behavior were calculated. The results indicate that employees demonstrate high levels of environmentally responsible behavior across various dimensions. In the environmental sensitivity dimension, the highest average was for the statement "I pay attention to using electricity efficiently". In the environmental participation dimension, the top-rated item was "I follow the eco-friendly rules in my organization". For the ecological sensitivity, employees most strongly agreed with the statement "I make sure not to open the window while the heating system is running". In terms of green purchasing, the statement "I pay attention to the expiration dates of consumed products" had the highest score. Finally, in the technological sensitivity dimension, the most emphasized behavior devices, "When I am not using technological devices, I put them in power-saving/sleep mode, turn them off, or unplug them". These findings suggest that employees are highly attentive to energy-saving practices, environmental rules, product safety, and efficient use of technology.

The mean and standard deviation values regarding employees' levels of green organizational behavior were calculated. Among the sub-dimensions, the highest average score in the altruism dimension was associated with the statement "I help new employees adapt to the organization", indicating a strong culture of peer support. In the courtesy dimension, employees reported the highest agreement with the statement "I make an effort not to exploit others 'rights", reflecting a high level of interpersonal respect and

awareness. In the sportsmanship dimension, the statement "I aim to stay in the organization long-term rather than quitting the job" received the highest score, suggesting employee loyalty and commitment to organizational continuity. In the conscientiousness dimension, the highest average was observed for the statement "Even in the absence of my supervisors, I comply with the organization's rules and procedures", indicating a strong sense of personal responsibility and internalized organizational discipline. Finally, in the civic virtue dimension, the highest average score was related to the statement "I keep up with the developments in my organization and adapt quickly", emphasizing employees' engagement with organizational change and adaptability. These findings suggest that employees with the Gendarmerie General Command demonstrate a high level of organizational citizenship behavior, characterized by mutual support, rule compliance, professional responsibility, and a proactive attitude toward institutional developments.

Pearson correlation analysis was conducted to examine the relationship between GOB and OCB along with their sub-dimensions. The correlation coefficient ranges from -1 to +1 and indicates the strength and direction (negative or positive) of the relationship between variables. The interpretation of the coefficient is as follows: 0.00–0.20 very weak correlation, 0.21–0.40 weak correlation, 0.41–0.60 moderate correlation, 0.61–0.80 strong correlation, and 0.81–1.00 very strong correlation (Salkind, 2019). The Pearson correlation coefficient between GOB and OCB was found to be 0.680, indicating a strong positive relationship. Based on the results of the correlation analysis, regression analysis was conducted to further support and complement the study (Güler et al., 2008).

According to the regression analysis results, GOB has a significant and positive effect on OCB ($\beta = 1.886$, $p < .001$), explaining 46.3% of the variance ($R^2 = .463$). When the sub-dimensions of GOB are analyzed in relation to the sub-dimensions of OCB:

- Environmental sensitivity was found to have significant positive effects on all dimensions of OCB. It explained 20.5% of the variance in altruism ($\beta = 2.086$, $p < .001$), 21.5% in courtesy ($\beta = 2.507$, $p < .001$), 22.6% in sportsmanship ($\beta = 1.931$, $p < .001$), 22.5% in conscientiousness ($\beta = 2.108$, $p < .001$), and 20.3% in civic virtue ($\beta = 2.028$, $p < .001$).
- Environmental participation also demonstrated positive effects on all OCB dimensions. It accounted for 25.2% of the variance in altruism ($\beta = 2.482$, $p < .001$), 23.3% in courtesy ($\beta = 2.970$, $p < .001$), 20.2% in sportsmanship ($\beta = 2.676$, $p < .001$), 21.1% in conscientiousness ($\beta = 2.768$, $p < .001$), and 25.1% in civic virtue ($\beta = 2.433$, $p < .001$).
- Ecological sensitivity showed positive and significant effects as well: 20.9% of the variance in altruism ($\beta = 2.865$, $p < .001$), 17.2% in courtesy ($\beta = 3.366$, $p < .001$), 18.4% in sportsmanship ($\beta = 2.952$, $p < .001$), 17.4% in conscientiousness ($\beta = 3.110$, $p < .001$), and 19.8% in civic virtue ($\beta = 2.868$, $p < .001$) were explained by this dimension.
- Green purchasing significantly impacted OCB sub-dimensions: 26.1% in altruism ($\beta = 2.554$, $p < .001$), 23.3% in courtesy ($\beta = 3.059$, $p < .001$), 23.1% in sportsmanship ($\beta = 2.653$, $p < .001$), 23.8% in conscientiousness ($\beta = 2.754$, $p < .001$), and 28.1% in civic virtue ($\beta = 2.427$, $p < .001$).
- Technological sensitivity was also found to positively affect all OCB dimensions. It explained 26.7% of the variance in altruism ($\beta = 2.745$, $p < .001$), 21.2% in courtesy ($\beta = 3.296$, $p < .001$), 21.7% in sportsmanship ($\beta = 2.906$, $p < .001$), 18.5% in conscientiousness ($\beta = 3.139$, $p < .001$), and 19.7% in civic virtue ($\beta = 2.959$, $p < .001$).

These findings collectively indicate that each dimension of green organizational behavior significantly contributes to fostering various aspects of organizational citizenship behavior among employees.

The Independent Samples t-test was conducted to determine whether GOB differs according to the gender variable. The findings are presented in Table 2. Table 2 displays the results of the independent samples t-test conducted to examine whether GOB and its sub-dimensions differ significantly by gender. According to the findings, no statistically significant differences were observed between female and male participants in any of the GOB sub-dimensions or in overall GOB scores ($p > .05$). For example, while female personnel scored slightly lower ($M = 4.4350$) than males ($M = 4.4894$) in Environmental Sensitivity, this difference was not significant ($t = -0.528$, $p = .597$). Similarly, across other sub-dimensions such as Ecological Sensitivity ($t = -0.518$, $p = .604$) and Technological Sensitivity ($t = -0.963$, $p = .336$), the differences remained statistically insignificant. These results suggest that gender does not play a meaningful role in shaping green organizational behavior among the personnel included in the sample.

To determine whether OCB differs according to the gender variable, an Independent Samples t-test was conducted. The findings are presented in Table 3. According to the findings, no statistically significant differences were observed between male and female participants in the overall OCB score or most of its sub-dimensions ($p > .05$). However, a significant difference was found in the Altruism sub-dimension ($t = -1.989$; $p = .047$). Specifically, female participants ($M = 4.2667$) scored significantly lower than their male counterparts ($M = 4.5102$), suggesting that male personnel exhibit higher levels of helping and voluntary behaviors. For other sub-dimensions—Courtesy ($p = .895$), Sportsmanship ($p = .263$), Conscientiousness ($p = .189$), and Civic Virtue ($p = .387$)—no significant gender-based differences were detected. Overall, the level of OCB among personnel appears largely consistent across genders.

Tablo 2: t-Test Results of the GOB Scale According to the Gender Variable

Green Organizational Behavior	Sex	Sample Size	Mean	Standard Deviation	Standard Error	t	p
Environmental Sensitivity	Female	25	4,4350	,43916	,08783	-,528	,597
	Male	1110	4,4894	,51054	,01532		
Ecological Sensitivity	Female	25	4,0400	,50000	,10000	-,518	,604
	Male	1110	4,1128	,69803	,02095		
Environmental Participation	Female	25	4,1829	,50088	,10018	-,560	,576
	Male	1110	4,2553	,64298	,01930		
Green Purchasing	Female	25	4,3400	,58577	,11715	,235	,814
	Male	1110	4,3074	,68601	,02059		
Technological Sensitivity	Female	25	4,1200	,66583	,13317	-,963	,336
	Male	1110	4,2679	,76106	,02284		
Green Organizational Behavior	Female	25	4,2474	,39497	,07899	-,559	,577
	Male	1110	4,3074	,53370	,01602		

Tablo 3: t-Test Results of the OCB Scale According to the Gender Variable

Organizational Citizenship Behavior	Sex	Sample Size	Mean	Standard Deviation	Standard Error	t	p
Altruism	Female	25	4,2667	,63099	,12620	-1,989	,047
	Male	1110	4,5102	,60477	,01815		
Courtesy	Female	25	4,6400	,54365	,10873	-,132	,895
	Male	1110	4,6541	,52475	,01575		
Sportsmanship	Female	25	4,3867	,65744	,13149	-1,121	,263
	Male	1110	4,5267	,61690	,01852		
Conscientiousness	Female	25	4,4000	,71362	,14272	-1,314	,189
	Male	1110	4,5553	,58098	,01744		
Civic Virtue	Female	25	4,4133	,64031	,12806	-,865	,387
	Male	1110	4,5231	,62703	,01882		
Organizational Citizenship Behavior	Female	25	4,4213	,42978	,08596	-1,357	,175
	Male	1110	4,5539	,48406	,01453		

The differences in participants' attitudes toward green organizational behavior based on age groups were analyzed using the ANOVA test. The findings of the analysis are presented in Table 4. Statistically significant differences were observed in the dimensions of Ecological Sensitivity ($F = 4.203$; $p = .002$) and Technological Sensitivity ($F = 3.188$; $p = .013$). Participants aged 24 and under reported the highest mean score for Ecological Sensitivity ($M = 4.3323$), which gradually decreased in older age groups. Similarly, for Technological Sensitivity, the youngest age group again reported the highest score ($M = 4.4704$), with a noticeable decline among participants aged 36–40. These findings suggest that younger personnel may be more sensitive to ecological concerns and more engaged with green technologies. For other sub-dimensions—Environmental

Sensitivity (p = .149), Environmental Participation (p = .550), and Green Purchasing (p = .319)—no statistically significant differences were found across age groups. Likewise, the overall GOB score did not significantly differ by age (F = 1.230; p = .296), indicating a generally uniform level of green behavior across age categories.

Tablo 4: ANOVA Test Results of GOB Scale by Age Groups

Green Organizational Behavior	Age	Sample	Mean	Standard	F	p
Environmental Sensitivity	24 and under	124	4,4919	,52424	1,695	,149
	25-30	635	4,4626	,53249		
	31-35	237	4,5000	,48207		
	36-40	68	4,5570	,42946		
	41 and above	71	4,6056	,40070		
Environmental Participation	24 and under	124	4,3203	,63061	,761	,550
	25-30	635	4,2587	,66498		
	31-35	237	4,2212	,60828		
	36-40	68	4,2773	,61896		
	41 and above	71	4,1791	,54943		
Ecological Sensitivity	24 and under	124	4,3323	,70717	4,203	**,002**
	25-30	635	4,1106	,70577		
	31-35	237	4,0354	,67303		
	36-40	68	4,0500	,69744		
	41 and above	71	4,0423	,55643		
Green Purchasing	24 and under	124	4,4093	,68397	1,178	,319
	25-30	635	4,3118	,69969		
	31-35	237	4,2911	,64984		
	36-40	68	4,2206	,69181		
	41 and above	71	4,2394	,63589		
Technological Sensitivity	24 and under	124	4,4704	,70616	3,188	**,013**
	25-30	635	4,2583	,76104		
	31-35	237	4,2166	,74344		
	36-40	68	4,1176	,93710		
	41 and above	71	4,2629	,63724		
Green Organizational Behavior	24 and under	124	4,4032	,54556	1,230	,296
	25-30	635	4,2995	,55645		
	31-35	237	4,2793	,49338		
	36-40	68	4,2919	,50213		
	41 and above	71	4,2984	,39767		

The differences in organizational citizenship behavior attitudes based on participants' age groups were analyzed using the ANOVA test. The findings of the analysis are presented in Table 5. The analysis revealed statistically significant differences in the dimensions of Altruism (F = 4.383; p = .002) and Sportsmanship (F = 2.539; p = .038). In the Altruism dimension, the highest mean score was observed in the 24 and under age group (M = 4.6183), while a noticeable decline was observed as age increased, with the lowest mean recorded in the 36–40 age group (M = 4.2647). This finding suggests that younger personnel tend to exhibit higher levels of helping behavior toward others. Similarly, in the Sportsmanship dimension, significant differences were identified, with the highest mean again in the 24 and under group (M = 4.6290) and the lowest mean in the 25–30 age group (M = 4.4803). Interestingly, the mean increased again in the 41 and above group (M = 4.6526), indicating that both younger and older personnel may be more tolerant of workplace challenges compared to middle-aged groups.

In contrast, no statistically significant differences were found across age groups for the dimensions of Courtesy (p = .320), Conscientiousness (p = .417), Civic Virtue (p = .362), and overall Organizational Citizenship Behavior (p = .353). These findings suggest that, except for specific sub-dimensions, OCB tends to remain relatively consistent across different age groups.

Tablo 5: ANOVA Test Results of OCB Scale by Age Groups

Organizational Citizenship Behavior	Age	Sample Size	Mean	Standard Deviation	F	p
Altruism	24 and under	124	4,6183	,55370	4,383	**,002**
	25-30	635	4,5270	,57622		
	31-35	237	4,4754	,63778		
	36-40	68	4,2647	,79292		
	41 and above	71	4,4366	,58443		
Courtesy	24 and under	124	4,6667	,56868	1,175	,320
	25-30	635	4,6294	,51800		
	31-35	237	4,6934	,52412		
	36-40	68	4,6324	,60714		
	41 and above	71	4,7371	,40986		
Sportsmanship	24 and under	124	4,6290	,57846	2,539	**,038**
	25-30	635	4,4803	,62719		
	31-35	237	4,5373	,65177		
	36-40	68	4,5539	,64030		
	41 and above	71	4,6526	,39213		
Conscientiousness	24 and under	124	4,5376	,59006	,981	,417
	25-30	635	4,5412	,57538		
	31-35	237	4,5626	,62621		
	36-40	68	4,5098	,64510		
	41 and above	71	4,6761	,42528		
Civic Virtue	24 and under	124	4,5349	,69430	1,087	,362
	25-30	635	4,5323	,60184		
	31-35	237	4,5260	,64140		

Tablo 5: ANOVA Test Results of OCB Scale by Age Groups

	36-40	68	4,3676	,77082		
	41 and above	71	4,5211	,51557		
Organizational Citizenship Behavior	24 and under	124	4,5973	,49768	1,105	,353
	25-30	635	4,5420	,46854		
	31-35	237	4,5589	,51145		
	36-40	68	4,4657	,59176		
	41 and above	71	4,6047	,35534		

Whether there is a difference in participants' green organizational behavior attitudes according to their statuses was analyzed using the ANOVA test. The findings of the analysis are presented in Table 6. Statistically significant differences were observed in the dimensions of Environmental Participation ($F = 2.535$; $p = .027$), Ecological Sensitivity ($F = 9.338$; $p = .027$), Green Purchasing ($F = 3.086$; $p = .009$), Technological Sensitivity ($F = 5.130$; $p < .001$), and overall Green Organizational Behavior ($F = 4.280$; $p < .001$). The mean scores for overall GOB indicate that Specialist NCOs exhibited the highest levels of green behavior (M = 4.3644), followed by Gendarmerie Specialists (M = 4.2797) and NCOs (M = 4.2535). In contrast, the lowest mean scores were recorded among Senior NCOs (M = 4.0111) and Civil Servants (M = 4.0222), suggesting that those not actively involved in field operations may be less engaged in environmentally conscious practices. In the Technological Sensitivity dimension, the Specialist NCO group again scored highest (M = 4.3556), whereas Senior NCOs reported the lowest mean (M = 3.7000). This finding indicates that mid-level technical personnel may be more responsive to green technological practices than their higher-ranking or administrative counterparts. The Ecological Sensitivity scores revealed a notable progression, with Specialist NCOs again leading (M = 4.2264), and Senior NCOs having the lowest mean (M = 3.5800), demonstrating a statistically significant difference across status groups. Although differences in Environmental Sensitivity did not reach statistical significance ($p = .076$), the highest mean was recorded among Gendarmerie Specialists (M = 4.6199), while Civil Servants had the lowest (M = 4.2500). These findings highlight meaningful variations in green behavior across different ranks and roles, particularly in the dimensions involving ecological awareness, green purchasing, and technological adaptability. The results suggest that duty status plays an influential role in shaping the adoption of green practices within the Gendarmerie organization.

Tablo 6: ANOVA Test Results of the GOB Scale According to Status

Green Organizational Behavior	**Status**	**Sample Size**	**Mean**	**Standard Deviation**	**F**	**p**
Environmental Sensitivity	Senior NCO	10	4,5625	,46491	2,002	,076
	Officer	198	4,4362	,50312		
	NCO	240	4,4542	,51948		
	Gendarmerie Specialist	49	4,6199	,39853		
	Specialist NCO	628	4,5100	,50821		
	Civil Servant	10	4,2500	,76830		
Environmental Participation	Senior NCO	10	3,8571	,54294	2,535	**,027**
	Officer	198	4,2157	,63133		
	NCO	240	4,2333	,61447		
	Gendarmerie Specialist	49	4,1370	,58609		

Tablo 6: ANOVA Test Results of the GOB Scale According to Status

	Specialist NCO	628	4,2950	,65264		
	Civil Servant	10	3,8714	,70775		
Ecological Sensitivity	Senior NCO	10	3,5800	,23944	9,338	**,027**
	Officer	198	3,9303	,68203		
	NCO	240	4,0008	,66760		
	Gendarmerie Specialist	49	4,0816	,56409		
	Specialist NCO	628	4,2264	,70015		
	Civil Servant	10	3,7800	,62147		
Green Purchasing	Senior NCO	10	3,9500	,64334	3,086	**,009**
	Officer	198	4,2336	,67969		
	NCO	240	4,2500	,70116		
	Gendarmerie Specialist	49	4,1633	,64459		
	Specialist NCO	628	4,3734	,67545		
	Civil Servant	10	4,1500	,72839		
Technological Sensitivity	Senior NCO	10	3,7000	1,10498	5,130	**<,001**
	Officer	198	4,1246	,76158		
	NCO	240	4,1917	,70551		
	Gendarmerie Specialist	49	4,1905	,80795		
	Specialist NCO	628	4,3556	,75811		
	Civil Servant	10	4,0000	,58794		
Green Organizational Behavior	Senior NCO	10	4,0111	,31526	4,280	**<,001**
	Officer	198	4,2207	,52515		
	NCO	240	4,2535	,50906		
	Gendarmerie Specialist	49	4,2797	,42821		
	Specialist NCO	628	4,3644	,54186		
	Civil Servant	10	4,0222	,64179		

Whether there is a difference in participants' organizational citizenship behavior attitudes according to their statuses was analyzed using the ANOVA test. The findings of the analysis are presented in Table 7. Among the five sub-dimensions, only Altruism showed a statistically significant difference ($F = 7.014$; $p < .001$). The other sub-dimensions—Courtesy ($p = .070$), Sportsmanship ($p = .055$), Conscientiousness ($p = .177$), and Civic Virtue ($p = .119$)—did not reach statistical significance. Similarly, the overall OCB score did not differ significantly across status groups ($F = 2.012$; $p = .074$). In terms of Altruism, Specialist NCOs reported the highest mean ($M = 4.5955$), followed by Gendarmerie Specialists ($M = 4.4626$) and NCOs ($M = 4.4111$). Conversely, Senior NCOs scored the lowest ($M =$

4.1667), indicating significantly less altruistic behavior compared to other groups. This suggests that personnel at the mid-level ranks may exhibit stronger tendencies to support and assist others in the organization. Although not statistically significant, the Courtesy dimension showed relatively high means across all groups, with Gendarmerie Specialists scoring the highest (M = 4.7823) and Civil Servants the lowest (M = 4.2333), implying potential practical differences worth further exploration. Similarly, Sportsmanship scores were highest among Gendarmerie Specialists (M = 4.6803), while Civil Servants had the lowest mean (M = 4.2667). These patterns, despite their lack of statistical significance, may reflect differences in job structure or motivation across duty roles. Overall, the total OCB mean scores indicate that Specialist NCOs (M = 4.5805) and Gendarmerie Specialists (M = 4.5878) display higher levels of citizenship behavior, while Civil Servants (M = 4.2800) and Senior NCOs (M = 4.3667) tend to report lower levels. While the difference in overall OCB was not statistically significant, the trend suggests that field-oriented and operational personnel might demonstrate stronger OCB characteristics than those in administrative or senior leadership roles.

Tablo 7: ANOVA Test Results of OCB Scale by Status

Organizational Citizenship Behavior	Status	Sample Size	Mean	Standard Deviation	F	p
Altruism	Senior NCO	10	4,1667	,86424	7,014	**<,001**
	Officer	198	4,3653	,57841		
	NCO	240	4,4111	,69297		
	Gendarmerie Specialist	49	4,4626	,57258		
	Specialist NCO	628	4,5955	,55774		
	Civil Servant	10	4,3667	,80814		
Courtesy	Senior NCO	10	4,7000	,33148	2,047	,070
	Officer	198	4,6801	,42462		
	NCO	240	4,6431	,57038		
	Gendarmerie Specialist	49	4,7823	,35060		
	Specialist NCO	628	4,6454	,54196		
	Civil Servant	10	4,2333	,77060		
Sportsmanship	Senior NCO	10	4,4667	,72350	2,177	,055
	Officer	198	4,5017	,56575		
	NCO	240	4,4431	,70694		
	Gendarmerie Specialist	49	4,6803	,41365		
	Specialist NCO	628	4,5541	,60367		
	Civil Servant	10	4,2667	,73367		
Conscientiousness	Senior NCO	10	4,4000	,64406	1,532	,177
	Officer	198	4,5269	,56710		
	NCO	240	4,5194	,62461		
	Gendarmerie Specialist	49	4,6054	,45984		

Tablo 7: ANOVA Test Results of OCB Scale by Status

	Specialist NCO	628	4,5764	,57719		
	Civil Servant	10	4,1667	,75768		
Civic Virtue	Senior NCO	10	4,1000	,73786	1,755	,119
	Officer	198	4,5758	,53384		
	NCO	240	4,4958	,65894		
	Gendarmerie Specialist	49	4,4082	,63925		
	Specialist NCO	628	4,5308	,63698		
	Civil Servant	10	4,3667	,65640		
Organizational Citizenship Behavior	Senior NCO	10	4,3667	,60553	2,012	,074
	Officer	198	4,5300	,41662		
	NCO	240	4,5025	,53113		
	Gendarmerie Specialist	49	4,5878	,34498		
	Specialist NCO	628	4,5805	,48542		
	Civil Servant	10	4,2800	,66726		

Whether there is a difference in participants' green organizational behavior attitudes according to their years of service was analyzed using the ANOVA test. The findings of the analysis are presented in Table 8. Among the five sub-dimensions, statistically significant differences were observed in Environmental Sensitivity ($F = 3.017$; $p = .017$) and Technological Sensitivity ($F = 2.599$; $p = .035$). No significant differences were found in Environmental Participation ($p = .875$), Ecological Sensitivity ($p = .069$), or Green Purchasing ($p = .739$). The overall GOB score also did not differ significantly by years of service ($F = 0.457$; $p = .767$). For Environmental Sensitivity, the mean scores increased with length of service. Personnel with more than 20 years of service reported the highest mean ($M = 4.6212$), followed by those with 16–20 years ($M = 4.5907$), while the lowest score was observed among those with 6–10 years ($M = 4.4084$). This suggests that longer-serving personnel may exhibit greater awareness of environmental responsibilities. In terms of Technological Sensitivity, those with 1–5 years of service had the highest average score ($M = 4.3121$), indicating a stronger inclination toward adopting and using environmentally friendly technologies. Conversely, personnel with 16–20 years of service showed the lowest mean ($M = 4.0980$), possibly reflecting generational differences in technology usage or comfort levels with green innovations. Although the other sub-dimensions did not reach statistical significance, it is noteworthy that Environmental Participation showed relatively stable means across all service groups, indicating a generally consistent level of behavioral engagement in environmental initiatives regardless of tenure.

Tablo 8: ANOVA Test Results of the GOB Scale According to Years of Service

Green Organizational Behavior	**Years of Service**	**Sample Size**	**Mean**	**Standard Deviation**	**F**	**p**
Environmental Sensitivity	1-5 Years	722	4,4841	,52210	3,017	**,017**
	6-10 Years	191	4,4084	,54813		
	11-15 Years	105	4,5286	,40588		
	16-20 Years	51	4,5907	,43595		
	20 Years above	66	4,6212	,40010		

Tablo 8: ANOVA Test Results of the GOB Scale According to Years of Service

Environmental Participation	1-5 Years	722	4,2671	,65177	,305	,875
	6-10 Years	191	4,2506	,65082		
	11-15 Years	105	4,2150	,62274		
	16-20 Years	51	4,2129	,58020		
	20 Years above	66	4,2100	,55765		
Ecological Sensitivity	1-5 Years	722	4,1396	,71738	2,178	,069
	6-10 Years	191	4,1372	,65037		
	11-15 Years	105	3,9448	,72031		
	16-20 Years	51	4,0314	,58566		
	20 Years above	66	4,0515	,55171		
Green Purchasing	1-5 Years	722	4,3186	,69397	,496	,739
	6-10 Years	191	4,3272	,66757		
	11-15 Years	105	4,2857	,69978		
	16-20 Years	51	4,2059	,61989		
	20 Years above	66	4,2538	,64673		
Technological Sensitivity	1-5 Years	722	4,3121	,73809	2,599	**,035**
	6-10 Years	191	4,1466	,81688		
	11-15 Years	105	4,2190	,77326		
	16-20 Years	51	4,0980	,89267		
	20 Years above	66	4,2879	,63215		
Green Organizational Behavior	1-5 Years	722	4,3204	,55127	,457	,767
	6-10 Years	191	4,2761	,53345		
	11-15 Years	105	4,2688	,49892		
	16-20 Years	51	4,2774	,44619		
	20 Years above	66	4,3176	,39566		

Whether there is a difference in participants' attitudes toward organizational citizenship behavior according to their years of service was analyzed using ANOVA. The findings of the analysis are presented in Table 9. Among the five OCB sub-dimensions, only Altruism showed a statistically significant difference across service groups ($F = 4.964$; $p < .001$). No significant differences were found in the sub-dimensions of Courtesy ($p = .542$), Sportsmanship ($p = .420$), Conscientiousness ($p = .404$), or Civic Virtue ($p = .271$). Similarly, overall OCB scores did not differ significantly based on years of service ($F = 1.068$; $p = .371$). For the Altruism dimension, personnel with 1–5 years of service had the highest mean score ($M = 4.5397$), followed closely by those with 6–10 years ($M = 4.5026$), while personnel with 16–20 years of service reported the lowest mean score ($M = 4.1634$). This may suggest that newer or mid-career personnel are more inclined to engage in voluntary and helpful behaviors beyond their formal duties. The absence of significant differences in the other OCB dimensions implies a general consistency in courtesy, sportsmanship, conscientiousness, and civic virtue behaviors regardless of tenure. Notably, even though the overall OCB score was slightly higher for personnel with

more than 20 years of service (M = 4.6212), this difference was not statistically significant.

Tablo 9: ANOVA Test Results of the OCB Scale According to Years of Service

Organizational Citizenship Behavior	Years of Service	Sample	Mean	Standard	F	p
Altruism	1-5 Years	722	4,5397	,56891	4,964	**<,001**
	6-10 Years	191	4,5026	,64967		
	11-15 Years	105	4,4476	,70078		
	16-20 Years	51	4,1634	,69080		
	20 Years above	66	4,4848	,56744		
Courtesy	1-5 Years	722	4,6353	,53215	,774	,542
	6-10 Years	191	4,6806	,53512		
	11-15 Years	105	4,6698	,55949		
	16-20 Years	51	4,6797	,37689		
	20 Years above	66	4,7323	,45374		
Sportsmanship	1-5 Years	722	4,5069	,61799	,975	,420
	6-10 Years	191	4,5340	,62770		
	11-15 Years	105	4,5333	,70499		
	16-20 Years	51	4,5229	,60829		
	20 Years above	66	4,6616	,41135		
Conscientiousness	1-5 Years	722	4,5425	,58448	1,004	,404
	6-10 Years	191	4,5515	,62557		
	11-15 Years	105	4,5714	,60397		
	16-20 Years	51	4,4837	,53878		
	20 Years above	66	4,6768	,44133		
Civic Virtue	1-5 Years	722	4,5346	,60418	1,292	,271
	6-10 Years	191	4,5061	,67438		
	11-15 Years	105	4,5238	,72036		
	16-20 Years	51	4,3333	,66999		
	20 Years above	66	4,5505	,52783		
Organizational Citizenship Behavior	1-5 Years	722	4,5518	,46986	1,068	,371
	6-10 Years	191	4,5550	,51685		
	11-15 Years	105	4,5492	,56851		
	16-20 Years	51	4,4366	,46444		
	20 Years above	66	4,6212	,38004		

Whether there is a difference in participants' green organizational behavior attitudes based on their education level was analyzed using the ANOVA test. The findings of the analysis are presented in Table 10. The results reveal that

significant differences exist across education levels for the sub-dimensions of Ecological Sensitivity ($F = 6.924$; $p < .001$), Green Purchasing ($F = 3.279$; $p = .006$), and Technological Sensitivity ($F = 4.702$; $p < .001$). Additionally, a statistically significant difference was found in the overall GOB scores ($F = 4.060$; $p = .001$). Participants with a middle school education demonstrated the highest mean scores in several sub-dimensions, including Green Purchasing ($M = 4.6071$), Technological Sensitivity ($M = 4.5476$), and overall GOB ($M = 4.4868$), suggesting a strong engagement in green behaviors despite lower formal education. Doctorate holders also reported high mean scores; however, the sample size for this group was very small ($n = 2$), which limits the generalizability of these findings. Conversely, personnel holding bachelor's degrees reported comparatively lower mean scores, particularly in Ecological Sensitivity ($M = 3.9586$) and Green Purchasing ($M = 4.2127$), indicating a potential decline in green behavioral tendencies at this educational level. This trend may reflect increased role demands, bureaucratic constraints, or differences in environmental engagement linked to job responsibilities. No statistically significant differences were observed in the sub-dimensions of Environmental Sensitivity ($p = .241$) and Environmental Participation ($p = .073$), suggesting these behaviors may be more uniformly distributed across education levels.

Tablo 10: ANOVA Test Results of the GOB Scale by Education Level

Green Organizational Behavior	Education Level	Sample Size	Mean	Standard Deviation	F	p
Environmental Sensitivity	Middle School	14	4,5893	,37477	1,348	,241
	High School	368	4,4966	,51467		
	Associate Degree	283	4,5212	,51645		
	Bachelor's Degree	415	4,4452	,51143		
	Master's Degree	53	4,5495	,42626		
	Doctorate (Ph.D.)	2	4,8750	,17678		
Environmental Participation	Middle School	14	4,3980	,75630	2,022	,073
	High School	368	4,2908	,63655		
	Associate Degree	283	4,2918	,65848		
	Bachelor's Degree	415	4,1797	,62173		
	Master's Degree	53	4,3181	,64902		
	Doctorate (Ph.D.)	2	4,7143	,40406		
Ecological Sensitivity	Middle School	14	4,3143	,85111	6,924	**<,001**
	High School	368	4,2179	,69643		
	Associate Degree	283	4,1873	,70105		
	Bachelor's Degree	415	3,9586	,66508		
	Master's Degree	53	4,0943	,63561		
	Doctorate (Ph.D.)	2	4,4000	,28284		
Green Purchasing	Middle School	14	4,6071	,64833	3,279	**,006**
	High School	368	4,3811	,65663		
	Associate Degree	283	4,3348	,69850		
	Bachelor's Degree	415	4,2127	,68396		
	Master's Degree	53	4,3113	,72706		

Tablo 10: ANOVA Test Results of the GOB Scale by Education Level

	Doctorate (Ph.D.)	2	4,7500	,35355		
Technological Sensitivity	Middle School	14	4,5476	,80178	4,702	**<,001**
	High School	368	4,3605	,76511		
	Associate Degree	283	4,3333	,73310		
	Bachelor's Degree	415	4,1341	,74963		
	Master's Degree	53	4,1761	,78338		
	Doctorate (Ph.D.)	2	4,3333	,94281		
Green Organizational Behavior	Middle School	14	4,4868	,50278	4,060	**,001**
	High School	368	4,3594	,53369		
	Associate Degree	283	4,3514	,55342		
	Bachelor's Degree	415	4,2172	,50840		
	Master's Degree	53	4,3284	,49712		
	Doctorate (Ph.D.)	2	4,6667	,15713		

The difference in participants' organizational citizenship behavior attitudes based on their educational level was analyzed using ANOVA. The findings of the analysis are presented in Table 11. Among the five OCB sub-dimensions, a statistically significant difference was observed only in Altruism ($F = 6.048$; $p < .001$). The remaining dimensions — Courtesy ($p = .934$), Sportsmanship ($p = .881$), Conscientiousness ($p = .688$), and Civic Virtue ($p = .405$) — did not show statistically significant differences across educational groups. Similarly, the total OCB scores did not differ significantly by education level ($F = 0.754$; $p = .583$). In the Altruism dimension, personnel with a middle school education reported the highest mean score ($M = 4.7143$), followed by high school graduates ($M = 4.6060$). Conversely, bachelor's degree holders exhibited the lowest mean altruism score ($M = 4.3871$). Although doctorate holders scored relatively high ($M = 4.5000$), the very limited sample size ($n = 2$) restricts the generalizability of this finding. These results suggest that lower education levels may be associated with higher levels of altruistic behavior in the workplace, possibly reflecting a stronger orientation toward communal or collectivist values. No significant variations in the overall OCB scores by education level suggest a general consistency in organizational citizenship behaviors among personnel, regardless of formal education. This finding may point to the institutional culture of the Gendarmerie, which promotes uniformity in work ethic and behavior irrespective of educational attainment.

Tablo 11: ANOVA Test Results of OCB Scale by Education Level

Organizational Citizenship Behavior	**Education Level**	**Sample Size**	**Mean**	**Standard Deviation**	**F**	**p**
Altruism	Middle School	14	4,7143	,58261	6,048	**<,001**
	High School	368	4,6060	,55918		
	Associate Degree	283	4,5477	,57563		
	Bachelor's Degree	415	4,3871	,64916		
	Master's Degree	53	4,4403	,59115		
	Doctorate (Ph.D.)	2	4,5000	,70711		
Courtesy	Middle School	14	4,5238	,68829	,261	,934

Tablo 11: ANOVA Test Results of OCB Scale by Education Level

	High School	368	4,6603	,54383		
	Associate Degree	283	4,6384	,52591		
	Bachelor's Degree	415	4,6635	,51441		
	Master's Degree	53	4,6478	,43074		
	Doctorate (Ph.D.)	2	4,6667	,47140		
Sportsmanship	Middle School	14	4,5714	,74454	,352	,881
	High School	368	4,5480	,62163		
	Associate Degree	283	4,5006	,63169		
	Bachelor's Degree	415	4,5197	,61260		
	Master's Degree	53	4,5094	,54146		
	Doctorate (Ph.D.)	2	4,1667	,23570		
Conscientiousness	Middle School	14	4,5476	,56398	,616	,688
	High School	368	4,5688	,59065		
	Associate Degree	283	4,5583	,56844		
	Bachelor's Degree	415	4,5205	,60420		
	Master's Degree	53	4,6352	,47260		
	Doctorate (Ph.D.)	2	4,8333	,23570		
Civic Virtue	Middle School	14	4,6667	,43363	1,020	,405
	High School	368	4,5299	,64662		
	Associate Degree	283	4,4959	,66213		
	Bachelor's Degree	415	4,5052	,60408		
	Master's Degree	53	4,6541	,51041		
	Doctorate (Ph.D.)	2	5,0000	,00000		
Organizational Citizenship Behavior	Middle School	14	4,6048	,52783	,754	,583
	High School	368	4,5826	,50236		
	Associate Degree	283	4,5482	,47542		
	Bachelor's Degree	415	4,5192	,48129		
	Master's Degree	53	4,5774	,38850		
	Doctorate (Ph.D.)	2	4,6333	,32998		

Based on the findings from the study:

- Green organizational behavior has a significant positive effect on organizational citizenship behavior ($p<.001$). The variance in employees 'perception of green organizational behavior and their demonstration of organizational citizenship behavior is 46,3% ($R^2=.463$). **Therefore, the alternative hypothesis (H_A) is supported.** These findings align with recent studies that demonstrate how environmentally proactive behaviors reinforce broader prosocial tendencies at work

(Chaudhary & Akhouri, 2023; Wu & Wang, 2022).

- Environmental sensitivity has a significant positive effect on altruism (p<.001). The variance in employees ' perception of environmental sensitivity and their demonstration of altruistic behavior is 20,5% (R^2=.205). **Therefore, hypothesis H_{1a} is supported.**
- Environmental sensitivity has a significant positive effect on courtesy (p<.001). The variance in employees ' perception of environmental sensitivity and their demonstration of courteous behavior is 21,5% (R^2=.215). **Therefore, hypothesis H_{1b} is supported.**
- Environmental sensitivity has a significant positive effect on sportsmanship (p<.001). The variance in employees 'perception of environmental sensitivity and their demonstration of sportsmanship behavior is 22,6% (R^2=.226). **Therefore, hypothesis H_{1c} is supported.**
- Environmental sensitivity has a significant positive effect on conscientiousness (p<.001). The variance in employees 'perception of environmental sensitivity and their demonstration of conscientious behavior is 22,5% (R^2=.225). **Therefore, hypothesis H_{1d} is supported.**
- Environmental sensitivity has a significant positive effect on civic virtue (p<.001). The variance in employees 'perception of environmental sensitivity and their demonstration of civic virtue behavior is 20,3% (R^2=.203). **Therefore, hypothesis H_{1e} is supported.**
- Environmental participation has a significant positive effect on altruism (p<.001). The variance in employees ' perception of environmental participation and their demonstration of altruistic behavior is 25,2% (R^2=.252). **Therefore, hypothesis H_{2a} is supported.**
- Environmental participation has a significant positive effect on courtesy (p<.001). The variance in employees ' perception of environmental participation and their demonstration of courteous behavior is 23,3% (R^2=.233). **Therefore, hypothesis H_{2b} is supported.**
- Environmental participation has a significant positive effect on sportsmanship (p<.001). The variance in employees 'perception of environmental participation and their demonstration of sportsmanship behavior is 20,2% (R^2=.202). **Therefore, hypothesis H_{2c} is supported.**
- Environmental participation has a significant positive effect on conscientiousness (p<.001). The variance in employees 'perception of environmental participation and their demonstration of conscientious behavior 21,1% (R^2=.211). **Therefore, hypothesis H_{2d} is supported.**
- Environmental participation has a significant positive effect on civic virtue (p<.001). The variance in employees 'perception of environmental participation and their demonstration of civic virtue behavior is 25,1% (R^2=.251). **Therefore, hypothesis H_{2e} is supported.**
- Ecological sensitivity has a significant positive effect on altruism (p<.001). The variance in employees ' perception of ecological sensitivity and their demonstration of altruistic behavior is 20,9% (R^2=.209). **Therefore, hypothesis H_{3a} is supported.**
- Ecological sensitivity has a significant positive effect on courtesy (p<.001). The variance in employees ' perception of ecological sensitivity and their demonstration of courteous behavior is 17,2% (R^2=.172). **Therefore, hypothesis H_{3b} is supported.**
- Ecological sensitivity has been found to have a positive and significant effect on sportsmanship (p<.001). The variance explained by employees 'perception of ecological sensitivity and their demonstration of sportsmanship behavior is 18,4% (R^2=.184). **Therefore, hypothesis H_{3c} is supported.**
- Ecological sensitivity has a significant positive effect on sportsmanship (p<.001). The variance in employees ' perception of ecological sensitivity and their demonstration of sportsmanship behavior is 17,4% (R^2=.174). **Therefore, hypothesis H_{3d} is supported.**
- Ecological sensitivity has a significant positive effect on civic virtue (p<.001). The variance in employees ' perception of ecological sensitivity and their demonstration of civic virtue behavior is 19,8% (R^2=.198). **Therefore, hypothesis H_{3e} is supported.**
- Green purchasing has a significant positive effect on altruism (p<.001). The variance in employees ' perception of green purchasing and their demonstration of altruistic behavior is 26,1% (R^2=.261). **Therefore, hypothesis H_{4a} is supported.**
- Green purchasing has a significant positive effect on courtesy (p<.001). The variance in employees ' perception of green purchasing and their demonstration of courteous behavior is 23,3% (R^2=.233). **Therefore, hypothesis H_{4b} is supported.**
- Green purchasing has a significant positive effect on sportsmanship (p<.001). The variance in employees ' perception of green purchasing and their demonstration of sportsmanship behavior is 23,1% (R^2=.231). **Therefore, hypothesis H_{4c} is supported.**
- Green purchasing has a significant positive effect on conscientiousness (p<.001). The variance in employees ' perception of green purchasing and their demonstration of conscientiousness behavior is 23,8% (R^2=.238). **Therefore, hypothesis H_{4d} is supported.**
- Green purchasing has a significant positive effect on civic virtue (p<.001). The variance in employees ' perception of green purchasing and their demonstration of civic virtue behavior is 28,1% (R^2=..281). **Therefore, hypothesis H_{4e} is supported.**
- Technological sensitivity has a significant positive effect on altruism (p<.001). The variance in employees '

perception of technological sensitivity and their demonstration of altruistic behavior is 26,7% (R^2=.267). **Therefore, hypothesis H_{5a} is supported.**

- Technological sensitivity has a significant positive effect on courtesy (p<.001). The variance in employees ' perception of technological sensitivity and their demonstration of courteous behavior is 21,2% (R^2=.212). **Therefore, hypothesis H_{5b} is supported.**
- Technological sensitivity has a significant positive effect on sportsmanship (p<.001). The variance in employees ' perception of technological sensitivity and their demonstration of gentlemanly behavior is 21,7% (R^2=.217). **Therefore, hypothesis H_{5c} is supported.**
- Technological sensitivity has a significant positive effect on conscientiousness (p<.001). The variance in employees 'perception of technological sensitivity and their demonstration of conscientious behavior is 18,5% (R^2=.185). **Therefore, hypothesis H_{5d} is supported.**
- Technological sensitivity has a significant positive effect on civic virtue (p<.001). The variance in employees ' perception of technological sensitivity and their demonstration of civic virtue behavior is 19,7% (R^2=.197). **Therefore, hypothesis H_{5e} is supported.**
- Based on the independent sample t-test results, there is no significant difference between women and men in terms of green behaviors (p>.05). **Therefore, hypothesis H_{6a} is supported.**
- Based on the Mann-Whitney U test results, there is a significant difference between women and men in terms of organizational citizenship behaviors (p<.05). **Therefore, the results did not provide sufficient evidence to support the hypothesis H_{6b}.**
- There is no significant difference between participants ' age groups and green organizational behavior (p>.05). In other words, changes in participants 'age groups do not affect green organizational behavior. **Therefore, hypothesis H_{7a} is supported.**
- There is no significant difference between participants ' age groups and organizational citizenship behavior (p>.05). In other words, changes in participants 'age groups do not affect organizational citizenship behavior. **Therefore, hypothesis H_{7b} is supported.**
- There is a significant difference between participants ' statuses and green organizational behavior (p<.05). In other words, changes in participants 'statuses affect green organizational behavior. **Therefore, the results did not provide sufficient evidence to support the hypothesis H_{8a}.**
- There is no significant difference between participants ' statuses and organizational citizenship behavior (p>.05). In other words, changes in participants 'statuses do not affect organizational citizenship behavior. **Therefore, hypothesis H_{8b} is supported.**
- There is no significant difference between participants ' years of service and green organizational behavior (p>.05). In other words, changes in participants 'years of service do not affect green organizational behavior. **Therefore, hypothesis H_{9a} is supported.**
- There is no significant difference between participants ' years of service distribution and organizational citizenship behavior (p>.05). In other words, changes in participants 'years of service do not affect organizational citizenship behavior. **Therefore, hypothesis H_{9b} is supported.**
- There is a significant difference between participants ' education levels and green organizational behavior (p<.05). In other words, changes in participants ' education levels affect green organizational behavior. **Therefore, the results did not provide sufficient evidence to support the hypothesis H_{10a}.**
- There is no significant difference between participants ' education levels and organizational citizenship behavior (p>.05). In other words, changes in participants ' education levels do not affect organizational citizenship behavior. **Therefore, hypothesis H_{10b} is supported.**

5. Conclusion And Recommendations

This study examines the effect of GOB on OCB, grounded in the Theory of Planned Behavior and Social Exchange Theory. These theories support the assumption that pro-environmental behaviors within an organization can enhance voluntary and supportive behaviors among employees. This research fills an important gap in the literature by focusing on military personnel—a group rarely studied in relation to green behaviors—thus expanding the contextual scope of GOB–OCB research. The findings from the Gendarmerie General Command provide insights into how formal structure and discipline intersect with environmentally responsible behavior.

The analysis of demographic variables (H_6a–$H_{10}b$) revealed that while age and years of service did not significantly affect GOB or OCB, variables such as gender, status, and education level showed meaningful differences. These findings are valuable for developing targeted environmental training programs and promoting OCB in specific demographic groups. According to these results, it can be said that gender, age groups, and years of service do not affect the display of green organizational behavior. However, status groups and educational levels do lead to differences in the display of green organizational behavior. Based on these results, it can be suggested that those in the specialist non-commissioned officer status and those with a doctoral education level may exhibit more green organizational behavior. This highlights how hierarchical dynamics in military institutions can unintentionally promote or inhibit green behavior. This aspect could be further examined in future research. As for the educational level, it is believed that the higher awareness level of

doctoral graduates may lead to more green organizational behavior. According to Özalp's (2019) master's thesis, conducted on university administrative personnel, while no differentiation was found according to age, education level, and work experience, differences were detected based on gender and position. These findings are in line with the current study conducted on military personnel, as significant differences were also observed based on gender and status. The findings of this study, where there is no differentiation based on age and years of service but differences are observed based on gender and status, align with this previous research.

H_{7b} – H_{8b} –H_{9b}– H_{10b} indicate that there is no significant difference between organizational citizenship behavior and age groups, years of service, status, and education level; however, according to H_{6a}, there is a significant relationship between gender and green organizational behavior. Based on these results, it can be said that demographic variables such as age groups, years of service, status, and education level do not affect the display of organizational citizenship behavior. However, organizational citizenship behavior is influenced by changes in gender. Men display higher levels of organizational citizenship behavior compared to women. This may be attributed to the higher number of male personnel in the Gendarmerie General Command compared to female personnel. According to Gökdere's (2021) master's thesis, which focused on public school teachers, no differentiation was found based on age, gender, education level, seniority at the workplace, or work experience. This aligns with our findings, where no significant differences were observed in OCB based on age, years of service, status, or education level. The findings of this study align with these results, as no differentiation was observed based on age groups, years of service, status, or education level. According to Et Oltulu's (2021) doctoral thesis, conducted with civil servants in public institutions, while no differentiation was found based on age, gender, education level, or work experience, the level of organizational citizenship behavior differed based on work position. This partially aligns with our study, where differences were also found by status; however, unlike Et Oltulu's findings, our results indicated that gender also had a significant impact. The findings of this doctoral study show alignment with this study in terms of age groups, years of service, and education level analysis, but not with gender and status. This is also supported by the doctoral theses of Tecimen (2020), Öztürk (2020), and Kantarcıoğlu (2019), which found differentiation based on gender.

The positive and moderate relationship found between GOB and OCB ($\beta = .463$) aligns with prior findings (Pham et al., 2018; 2019) and confirms that employees' pro-environmental behaviors are strongly associated with their citizenship behaviors, especially in a structured and disciplined organization like the Gendarmerie. Accordingly, it was found that there is a positive relationship of 46.3% between employees 'perception of green organizational behavior and their display of organizational citizenship behavior. In other words, for each unit increase in green organizational behavior, there is a 0.463 unit increase in organizational citizenship behavior. This highlights the willingness and voluntariness of Gendarmerie General Command employees to participate in environmental activities. Given that activities within the institution are rewarded and monitored, it is expected that such a positive relationship would emerge. Pham et al. (2018), in their study conducted in the manufacturing sector, showed that when environmental concerns are supported by managers, they lead to positive outcomes and increase willingness. This supports our finding that environmental behavior in structured organizations like the Gendarmerie can be enhanced through managerial support and institutional rewards. According to Pham et al. (2019), in their research focused on the public sector in Asian countries, participation in green practices and activities contributed to problem-solving and individual development. Similarly, our study found a positive and moderate relationship between employees' green organizational behavior and their organizational citizenship behavior in a military context.

These results reinforce the theoretical premise that values, awareness, and perceived behavioral control (as per the Theory of Planned Behavior) contribute to voluntary citizenship behaviors in green contexts. Thus, this study contributes to both theory and practice by showing that green values can thrive in formal and hierarchical organizations. It is evaluated that there is a relationship between green organizational behavior and organizational citizenship behavior among Gendarmerie General Command employees, and this relationship is considered to be moderately significant. Given recent scholarly calls for integrating green values into organizational citizenship frameworks (Kalyar et al., 2023; Naeem et al., 2023), our findings underscore the need for institutional policies that support and reward GOB.

Recommendations:

1. Increase green awareness among higher-ranking officers and ensure environmental participation is not limited to lower-ranking roles.

2. Expand environmental education initiatives, especially among bachelor-level personnel.

3. Institutionalize environmental responsibility by integrating it into promotion and reward systems.

4. Improve OCB by fostering fairness, recognition, and inclusion across all ranks and departments.

5. Promote a culture where voluntary, environmentally friendly actions are publicly recognized.

Limitations: This study is limited to the personnel of the Gendarmerie General Command and uses a cross-sectional design. Future studies could employ longitudinal data and include other military or public institutions to enhance generalizability. Self-reported data may also carry bias, and

future work might benefit from triangulation or observational methods.

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