Chapter 7

DOES RENEWABLE ENERGY CONSUMPTION SUPPORT GREEN GROWTH?

Ayhan KULOĞLU[1]

INTRODUCTION

The increasing population and consumption of the world, the acceleration of industrialization, the need for greater amounts of food and raw materials to meet increasing demands, and the fact that the majority of this raw material need is being met from non-renewable sources can lead to a decrease, or even depletion, of the limited resources on Earth. The increase in consumption and production has resulted in environmental problems becoming global in nature, losing their local nature due to their boundless character. Environmental problems affect societies directly, regardless of their categorization by race, language, religion, age, gender, or wealth. The concept of environmentally conscious consumption behavior was first used by Roberts in 1996 (Roberts, 1996, pp. 217-231). Green consumption is seen as an important element in achieving the goals of sustainable development and achieving sustainable consumption. Green consumption is the preference for products that have the least environmental impact and damage when it is not possible to satisfy the needs with existing products (Peattie, 2010, pp. 195-228).

Green consumption is an important component of sustainable consumption and one of the key elements of green growth, a development strategy that many countries are following. The phenomenon of green consumption draws attention to environmental factors while contributing to sustainable development based on awareness. Global warming, the depletion of natural resources, and population growth have begun to threaten the future of humanity, and this situation has resulted in a new trend of green consumption, where consumers are environmentally conscious, environmentally concerned, and therefore interested in green products. The excessive production and consumption

[1] Assist. Prof. Dr., Nevsehir Haci Bektas Veli University, akuloglu@nevsehir.edu.tr

brought about by industrialization and the consumer society, and the resulting environmental problems, played a significant role in the emergence of green consumption. The consumer society, which has its roots in the capitalist system, encourages individuals to consume, leading to further deepening of environmental problems. In addition to these developments, the depletion of Earth's resources, deforestation, and the gradual extinction of species, as well as the pollution of air, water, and soil, have led consumers to become aware of various problems that can affect them and all living beings (Mainieri et al., 1997, pp. 189-204).

Energy consumption is an important driving force for economic growth and is crucial for the development and expansion of economies (Khan et al., 2022, pp. 107-134). Global economic growth has increased by approximately 136% since 1990. Along with the increasing growth, total global energy consumption has increased by approximately 65% between 1990 and 2019 (IEA, 2022). Despite having advanced technology, fossil fuels still dominate global energy consumption, as they did in the past. In 1990, the share of total fossil fuels in all energy sources was approximately 81%, while in 2019, it was 80%. This indicates that there has been no significant decrease in the share of fossil fuel use over the past 30 years. Such a high level of fossil fuel use has negative effects on environmental quality. In 1990, per capita fossil fuel use was 1526.84 (koe), while in 2019, it increased by 13.31% due to population growth, with per capita fossil fuel use remaining at 1526.84 (koe) (IEA, 2022). Carbon emissions worldwide increased from 23.5 million kt in 2000 to 34.5 million kt in 2019, a rise of almost 50%. In 1990, per capita CO2 emissions were 3.9 tons, while in 2019, they increased by 12.82% to 4.4 tons (IEA, 2022). Increased fossil fuel use also leads to higher temperature changes. The increase in global temperature changes between 1990 and 2019 was approximately 127%. Therefore, the continued high level of fossil fuel use in achieving global economic growth exacerbates resource and environmental problems. Hence, global economies need to shift their focus from traditional economic growth to sustainable development (Danish & Ulucak, 2020).

The increasing levels of greenhouse gases continue to pose an increasingly significant threat to global climate change. Natural disasters resulting from global warming, such as floods, earthquakes, storms, and tsunamis, have reached alarming proportions for the world and humanity's future. Climate change is primarily caused by greenhouse gases, especially carbon dioxide

(CO2) emissions, which account for over 80% of these gases. Consequently, international organizations such as the United Nations, the World Bank, and the OECD have been heavily discussing concepts such as low-carbon economic growth and green growth in the context of political applications in recent years.

According to the Organization for Economic Cooperation and Development (OECD) in 2011, *"green growth"* denotes a paradigm wherein the prosperity and welfare of individuals are sustained through the continued provision of environmental amenities and natural resources, while simultaneously stimulating economic advancement through a conscientious consideration of said elements. Unlike sustainability, green growth aims to achieve long-term economic growth by taking into account environmental degradation (Popp, 2012). Sustainable economic development is based on three pillars: leaving the environment to future generations, meeting the needs of the poor, and maintaining the environment. Green growth, on the other hand, only considers economic and environmental aspects and does not examine social aspects. Ho & Wang (2014) posit that green growth can be regarded as a constituent element of sustainable development, which encompasses a multifaceted approach towards preserving ecological systems and enhancing societal well-being while promoting economic advancement. Countries are concerned that maintaining sustainable economies will lead to low growth rates due to high environmental costs.

The irrational use of natural resources and natural capital without considering future generations can cause irreparable damage and pose significant obstacles to economic growth and development. Therefore, growth strategies must be adjusted to protect the natural environment and leave a living environment for future generations. Renewable energy use is crucial to green growth. Meeting the energy demand, which is one of the most important requirements of growth and development, should be met by using renewable energy sources that do not harm the environment and are limitless in nature. Green growth is not just about using renewable energy sources, but also about using energy efficiently. In this context, our study aims to examine the impact of renewable energy use on green growth based on trends and empirical studies. The other sections of our study are stated below (Jacobs, 2013, pp. 197-214).

Conceptual and Theoretical Framework of Green Growth

The Rio+20 Sustainable Development Conference, held in 2012, was predominantly centered around the idea of green growth. This notion has

garnered the endorsement of various international institutions, including the Organization for Economic Cooperation and Development (OECD), the World Bank, and the United Nations Environment Programme (UNEP), which have advocated for the adoption of green growth policies. The World Bank defines green growth as *"resilient economic growth that is efficient in the use of natural resources, minimizes pollution and environmental degradation*" (World Bank, 2012). UNEP has defined a Green Economy as "*one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities"* (UNEP, 2011). OECD has provided an alternative definition of green growth, stipulating that it involves the facilitation of economic expansion and progress while simultaneously guaranteeing the perpetuation of the resources that underpin our welfare and the persistent provision of environmental services (OECD, 2015).

All of the above definitions include statements about the environmental, social, and economic goals of green growth. However, a precise definition and scale of green growth have not been given. As a result, in the studies conducted, a clear line between sustainable growth and green growth could not be drawn (Stoknes & Rockström, 2018, pp. 41-49). In addition, there is no specific measure of how much of the current economic growth is included in green growth. Stoknes & Rockström (2018) define green growth as an *"increase in economic output that reduces the total environmental footprint*." Another definition they propose is to describe the increase in output that increases the environmental footprint as *"gray growth."*

Sustainable development is a model that considers both environmental balance and economic growth, focuses on efficient use of natural resources, gives importance to environmental quality, and enables current generations to meet their needs without endangering future generations' ability to meet their own needs. To achieve sustainable development in a country, ecological sustainability, economic sustainability, and social sustainability must be ensured. In other words, sustainable development is economic development that has intergenerational resource-use efficiency, does not deplete natural capital, takes care of the needs of future generations, maintains a balance between the economy and ecosystem, and is ecologically sustainable. Social and economic policies, natural resource management, environmental protection, and the needs of future generations are all addressed in the sustainable development approach (Rogers, Jalal & Boyd, 2012).

The concept of sustainability emphasizes intergenerational interaction in the long term. In environmental science, sustainability generally refers to the careful use of natural resources today while considering the needs of future generations for these resources. Sustainability means maintaining the total level of benefits that future generations derive from natural resources in the long term (Pezzey, 2017, pp. 263-281). According to Chichilnisky (1997), sustainability means leaving a legacy to future generations that ensures at least the same level of well-being as that of the present generation. Sustainability is a new approach, a new lifestyle that harmonizes social and economic activities with environmental protection (Jabareen, 2008, pp. 179-192).

Sustainable growth and green growth are two related but distinct concepts in the literature on environmental and economic sustainability. Sustainable growth refers to an economic growth model that can be sustained in the long term without significant harm to the natural environment or the depletion of natural resources. On the other hand, green growth emphasizes the potential to achieve economic growth while separating it from environmental degradation and promoting environmental sustainability (Lavrinenko et al., 2019, pp. 1113-1126). There is a significant amount of academic literature that investigates the relationship between sustainable growth and green growth and how these concepts can be achieved in practice (Lyytimäki et al., 2018, pp. 51-64). One of the key concepts in this literature is the idea of *"decoupling"* which refers to the process of separating economic growth from environmental impacts such as greenhouse gas emissions or resource consumption. Decoupling can be accomplished through a diverse range of tactics, including the enhancement of resource efficacy, the amplification of renewable energy utilization, and the advocacy of a circular economic framework.

There are studies that show that green growth strategies can contribute to sustainable growth by promoting economic development while reducing environmental impacts. For example, a study by Akram et al. (2020) found that investing in renewable energy and energy efficiency measures can reduce greenhouse gas emissions while promoting economic growth. Similarly, a study by the OECD (2011) found that promoting green growth can lead to job creation and economic development while reducing energy consumption and environmental impacts (Akram et al., 2020, p. 247).

However, there are challenges and trade-offs associated with pursuing both sustainable growth and green growth at the same time. For instance, some green

growth strategies may have negative social or economic impacts, such as job losses in fossil fuel-based industries. Additionally, achieving sustainable growth may require significant investments in new technologies and infrastructure, as well as fundamental changes in how economic growth is conceptualized and measured. Overall, the literature on sustainable and green growth suggests that these concepts are closely related, and that pursuing green growth strategies may contribute to achieving sustainable economic development in the long run. However, achieving both sustainable and green growth will require careful planning, coordination, and investment among numerous sectors and stakeholders (Bina, 2013, pp. 1023-1047).

The United Nations General Assembly has identified 17 sustainable development goals in their report, "*Transforming Our World: The 2030 Agenda for Sustainable Development,*" in which they express their commitment to achieving sustainable development in a balanced and integrated manner across three dimensions (economic, social, and environmental) (General Assembly, 2015). As seen in the report, "*Transforming Our World: The 2030 Agenda for Sustainable Development,*" the social dimension, which addresses concepts such as education, health, justice, and equality, is of great importance in the UN's approach to sustainable development. However, the focus of the OECD's Green Growth approach, which is the main topic of this study, is on the environment and economy. In this sense, Green Growth is focused on a narrower field.

History and Development of Green Growth

Environmental problems arising from increased technological advancements after World War II have become a major agenda item for all countries in the world. The threat of environmental problems to human life began to occupy the agenda in the 1970s and gradually began to manifest itself in the economic policies of countries. The failure of economic growth models to take into account environmental factors has led governments and economists to search for new economic models. As a result of these searches, the concepts of Sustainable Development and Green Growth have taken their place in the economics literatüre (Perez, 2017).

Social, economic, and environmental issues have led to both the questioning of society and the pressure to reconstruct Western culture. Along with the increase in environmental problems in the 20th century, the change in people's attitude towards nature and the formation of environmental awareness in society

have brought along efforts to solve the problem. Within this framework, the term *"development that does not exclude the environment*" was used for the first time by Conference Secretary Maurice Strong at the Stockholm Environmental Conference in 1972, and the principle of fair utilization of local resources was adopted. The chronological steps taken in the international arena from sustainable development to green growth can be listed as follows: preparation of the UN Environment Program (UNEP) with the Stockholm Conference (1972), preparation of the World Conservation Strategy (1980), establishment of the UN World Commission on Environment and Development (1983), Montreal Protocol (1989), Rio de Janeiro Conference on Environment and Development (1992), establishment of the Sustainable Development Commission (1993), Rio +5 (1997), Johannesburg Summit (Rio +10), Global Warming and Kyoto Protocol (2005), EU Environmental Program (2006), international platform for green growth with joint initiatives of UNEP, ILO and ITUC (2007), OECD green growth indicators (2011), Rio+20 (2012), and the United Nations Sustainable Development Summit in New York (2015) (Yılmaz, 2018, pp. 79-89).

The European Union (EU) has prepared the *"European Green Deal"* plan on December 11, 2019, with a focus on climate change and environmental sustainability. The proposed plan entails a novel growth strategy that seeks to transmute the European Union into a just and thriving community characterized by a modern, resource-efficient, and competitive economy that decouples economic advancement from resource consumption, culminating in the attainment of net-zero greenhouse gas emissions by 2050. The EU has begun to modernize and transform the economy towards climate neutrality. According to Claeys, Tagliapietra & Zachmann (2019), between 1990 and 2018, greenhouse gas emissions were reduced by 23%, while the economy grew by 61%. Notwithstanding, extant policies are projected to merely curtail greenhouse gas emissions by 60% by the year 2050.

Taking into account the current conditions and increasing environmental problems, sustainable development policies have been renewed and integrated into green growth. At this point, it can be argued that the green growth approach is a mosaic of economic and sustainable development policies. These strategies aim to combat two important problems, namely resource scarcity and climate change, as well as minimizing poverty and advancing the level of welfare needed by developing countries, through environmental management. Despite the fact that the scope of green growth is lower than sustainable development and it is

a subset of sustainable development, it has started to become more important than sustainable development in terms of environmental issues. In fact, it is clear that the social dimension of sustainable development is not taken into account at least as much as it should be. However, green growth has surpassed sustainable development (Gu, Renwick & Xue, 2018, pp. 675-683).

Theoretical and Empirical Framework of Renewable Energy and Green Growth Relationship

Elaborate literature exists on renewable energy and its impact on growth. Empirical studies have investigated the long and short-term effects of renewable energy usage on the economic growth of different countries or groups of countries (Apergis et al., 2010, pp. 2255-2260; Inglesi-Lotz, 2016, pp. 58-63; Pao & Fu, 2013, pp. 381-392). However, there is not enough deep empirical research in the literature on green growth and renewable energy. The concept of green growth emerged after the global financial crises of 2008. Sohag et al. (2021) assert that a potential cause for the dearth of comprehensive empirical analysis in the field of green growth is the ambiguous differentiation between the concept of green growth and that of sustainability. The concept of green development was first introduced in the strategies of the United Nations Environment Programme (UNEP) and in the report titled *"The Future We Want"* from the Rio+20 Sustainable Development Conference in 2012. Our main motivation in this study is to examine the concept of green growth in a way that contributes to the literature.

The concept of green growth is one of the 17 Sustainable Development Goals put forth by the United Nations under the umbrella of sustainable development (UN, 2012). Therefore, green growth, which is pursued without harming the environment, is evaluated within the framework of sustainable growth (Bartelmus, 2013, pp. 165-170). Accordingly, sustainable growth and renewable energy studies occupy a significant place in the literature. Zaman et al. (2016) evaluate green growth as a feasible solution to promote sustainable economic growth that will help preserve the world's natural vegetation. There are studies that empirically demonstrate the impact of renewable energy consumption levels on countries' sustainable economic development, such as those conducted on OECD 28 countries (Soukiazis, Proenca & Cerqueira, 2019), BRICS countries (Baloch et al., 2019, pp. 632-638; Zaman et al., 2016, pp. 1263-1271), and G20 countries (Paramati, Apergis & Ummalla, 2018, pp. 1375-1387).

There are many empirical studies examining the effects of economic growth and environmental degradation on emissions. Socio-economic variables that have an impact on emissions (Mardani et al., 2019), green technologies (Dauda et al., 2021), carbon taxes (Andersson, 2019, pp. 1-30), financial development (Jiang & Ma, 2019, p. 5241), human capital (Yao et al. al., 2020) and energy efficiency (Akram et al., 2020) have been studied on many variables. Environmental technologies or innovations are seen as an important tool that supports sustainable development in order to reduce the effects of environmental disasters and achieve green transformation (Abid, Ceci & Ikram, 2022, pp. 25428-25447). There are studies proving that environmental technologies or innovations have a reducing effect on emissions (Balsalobre, Álvarez & Cantos, 2015, pp. 4881-4892; Lin & Zhu, 2019, pp. 1505-1512; Mensah et. al., 2018, pp. 29678-29698). On the other hand, Hickel & Kallis (2020) argued theoretically that green growth cannot be achieved. They expressed that historical data and empirical studies do not show an absolute decoupling of resource use and carbon emission rates, and there is no decoupling of carbon emissions to prevent global warming. Therefore, they stated that the green growth strategy is wrong, and alternative methods need to be explored. Similarly, Barua (2022) expressed that there are serious obstacles in the way of green growth and that countries are increasing their dependence on fossil fuels rather than pursuing green growth. Hence, they stated that sustainable energy-supported green growth is a necessity due to reasons such as the lack of financial and economic capacity, market failures and failures, weak governance and a fragile economic system, innovation shortcomings, inadequate regulatory and policy frameworks, and education deficiencies.

Numerous empirical investigations have been conducted on various groups of developed and developing nations, revealing that the escalation of renewable energy consumption yields favorable effects on gross domestic product (GDP) (Apergis et al., 2010, pp. 2255-2260; Apergis & Payne, 2010, pp. 656-660; Luqman, Ahmad & Bakhsh, 2019, pp. 1299-1309; Bao & Xu, 2019, pp. 483-493; Rahman & Velayutham, 2020, pp. 399-408). Conversely, studies have also been found that demonstrate the negative impact of renewable energy usage on GDP in underdeveloped country groups (Maji, Sulaiman & Abdul-Rahim, 2019, pp. 384-392).

Sohag et al. (2021) examined the role of innovation and renewable energy in green growth across 21 OECD countries in their study. Their findings suggest

a positive long-term relationship between renewable energy development, technological innovation, and green growth. In addition, they document an inverse association between genuine interest rates and green growth. In their study, the Green Gross Domestic Products measured in constant 2010 USD was used as the green growth variable. They added long-term education and health expenditures to the growth variable (GDP) in their model and identified the impact of greenhouse gas emissions, natural resource depletion, and other negative effects. As an additional conclusion, they stated that military expenditures have a negative impact on green growth and increasing military expenditures have a detrimental effect on green growth.

Hao et al. (2021) examined the impact of green growth on carbon emissions in G7 countries in their study. They indicated that green growth has a reducing effect on emissions. In addition, they stated that innovative technologies, taxes, and turning towards renewable resources will support green growth by reducing emissions. Xie et al. (2020) investigated the relationship between renewable energy consumption and green economic development from the perspective of technological progress for OECD countries, and concluded that only renewable energy consumption can promote green growth. Taşkın, Vardar & Okan (2020) examined the relationship between green growth and renewable energy consumption in OECD countries during the period of 1990-2015. They stated that renewable energy consumption has a positive long-term effect on green growth, but is limited by commercial openness. They also noted that the limited effect is due to the installation costs of renewable energy infrastructure. Danish & Ulucak (2020) attempted to reveal the impact of environmental technologies on green growth in BRICS countries by keeping renewable and non-renewable energy variables constant in their study. They concluded that environmental technologies reduce production-related emissions.

In their study, Hussain et al. (2022) examined the impact of green technology and environmental factors on green growth in high-income country groups during the period of 2000-2020. The results indicate that green technologies support green growth and reduce emissions. Dai et al. (2016) analyzed the economic impacts of renewable energy development in China until 2050. They found that this transformation would not have significant macroeconomic costs and would contribute significantly to green growth. According Razzaq et al. (2023), using data from the period of 2007-2019, they suggested that digital finance and renewable energy technologies promote green growth in China.

Another study conducted in China shows that green energy sources accelerate green growth, and medium-high technology green trade contributes to improving green growth (Li, Dong & Dong, 2022, pp. 1-25).

In their studies on the Economic Community of West African States (ECOWAS) from 1990 to 2018, Mohsin et al. (2022) have indicated that renewable energy and technological innovation support green growth, and that a 1% increase in renewable energy contributes to sustainable growth by 3.2%. Vivek et al. (2021) have highlighted the importance of environmental technologies on green and sustainable growth, while pointing out that the cost of technological innovation is a serious obstacle for developing or less developed countries. Suki et al. (2022) have conducted research on the ASEAN-6 countries, which are among the largest greenhouse gas emitters, from 1992 to 2018, and have expressed that innovations and renewable sources have a positive impact on green growth.

The empirical studies mentioned above generally indicate that green transformation will contribute to countries' sustainable growth by reducing greenhouse gas emissions. Van Vuuren et al. (2017), whose study supports the outcome of this transformation, have indicated that, as a result of resource efficiency, preference for sustainable production methods, and investments in human development, a lower emission value than that of 2010 will be reached by 2100.

Current Outlook on Renewable Energy and Carbon Emissions in the World

According to the World Energy Outlook (2022) report, while economic growth increased by approximately 136% between 1990 and 2019, total global energy consumption increased by around 65% (IEA, 2022). Despite having advanced technologies, fossil fuels continue to dominate the global energy mix as they did in the past. In 1990, the share of total fossil fuels in all energy sources was approximately 81%, while in 2019, this share decreased only slightly to 80%. This indicates that there has not been a significant decrease in the share of fossil fuel use over the past 30 years. However, while per capita fossil fuel consumption was 1526.84 (koe) in 1990, this amount increased by 13.31% in 2019, reaching 1731.25 (koe) due to the growing population. The lower increase in per capita carbon emissions compared to the increase in the world

population over the last 30 years is attributed to investments made in green technology and innovation.

Looking at Figure 1, it can be observed that while there were a total of 5 million tons of carbon emissions in the world in the 1950s, this number increased to 25 million tons in the 2000s and exceeded 35 million tons in 2021. Approximately, carbon emissions in the world have increased by 7 times from 5 million tons to 35 million tons over the past 30 years. When we look at the year 2020, we see that the emission rates hit a downward peak due to Covid-19.

Figure 1. World Carbon Emission Rates (1990-2019) (World Bank, 2022)

When looking at Figure 2, it can be seen that per capita emission rates in the world follow a stagnant trend during certain periods and an increasing trend during others. Between 1990 and 2000, it follows a stagnant trend, while between 2003-2007 and 2009-2014, it follows an increasing trend. The low trend in the increase of per capita emissions is seen to be due to energy efficiency and green transformation. Decreases due to crises that occurred in 2008 and 2020 are also observed.

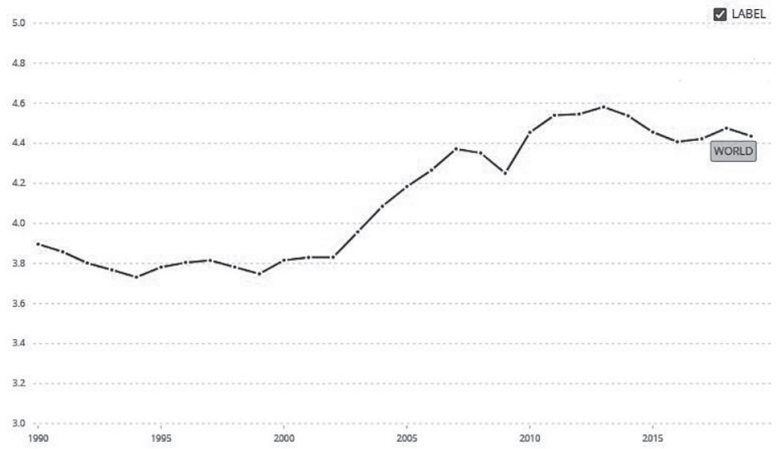

Figure 2. World Carbon Emission Rates (Mt per capita) (1990-2019) (World Bank, 2022)

Looking at Figure 3, the distribution of emission rates per capita as of 2021 is seen at the regional level. It is seen that the countries with the highest per capita emission rates are China, Russia, Canada, Australia and the USA. It is seen that the countries with the lowest emission rates are South African countries.

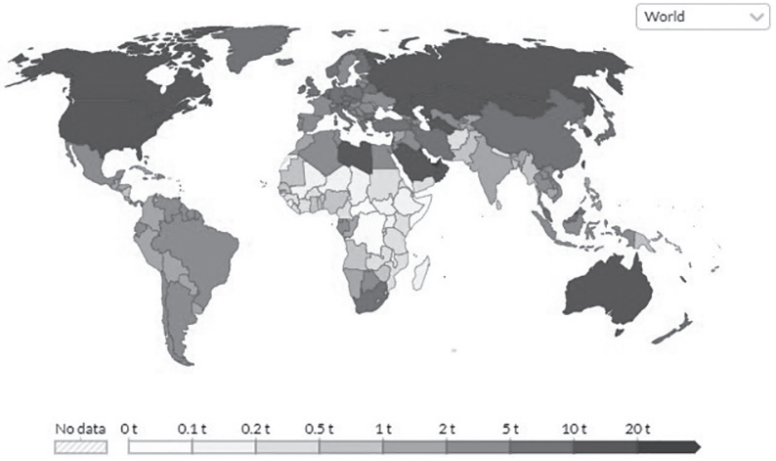

Figure 3. Regional Per Capita Emission Rates (2021)[2]

[2] Figure 3-4-5-6-7 retrieved from Our World in Data based on the Global Carbon Project (2022)

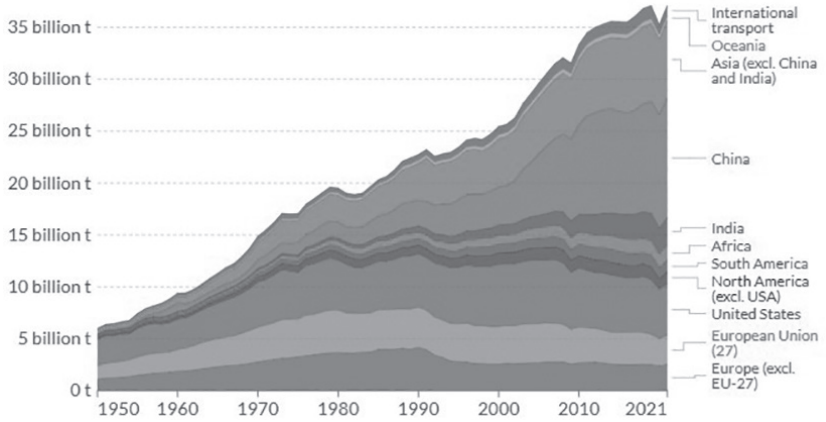

Figure 4. World Carbon Emission Rates (By Regions) (1950-2021)

Upon examining Figure 4 and Figure 5, it can be observed that regionally, China is followed by the United States and then other Asian countries (excluding China and India) in terms of the distribution of emission rates. The share of the European Union (EU-27) and European countries (excluding EU-27) in global emissions is relatively low. As of 2021, China has the highest share of emissions at around 30%, followed by the United States at around 14%, and the emissions share of the European Union (27) and India is around 7%. The United States and European Union countries are the ones that have reduced their emission rates the most. While the United States' emission share was around 24% in the 2000s, it dropped to around 14% in 2021.

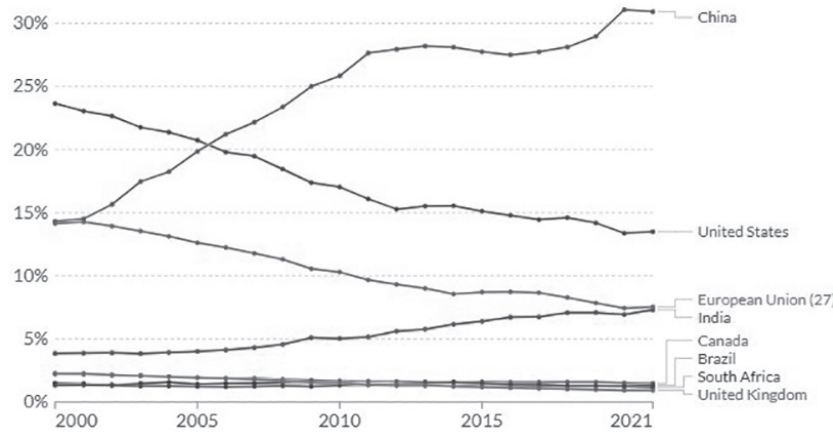

Figure 5. World Emission Shares (2000-2021)

When looking at Table 1, it can be observed that high-income countries have a population share of 16% and a share of 39% in emissions production. The group with the highest population share is low-income countries, whose share is 40%, while their share in emissions production is 13%. While high-income countries have high shares in emissions production and consumption, the opposite is true for low-income countries, whose shares are low. Regionally, the highest population share is in Asian countries, and similarly, their emissions shares are also very high. Proportionally, the share of high-income country groups in emissions production is almost 2.5 times their population share.

Table 1. Emission Rates by Income Groups and Regions (2021)

Income or regional group	Share of population (%)	Share of production-based CO_2 emissions (%)	Share of consumption-based CO_2 emissions (%)
High income	16%	39%	46%
Upper-middle income	35%	48%	41%
Lower-middle income	40%	13%	13%
Low income	9%	0.4%	0.4%
North America	5%	17%	19%
Europe	10%	16%	18%
Latin America & the Caribbean	9%	6%	6%
Asia	60%	56%	52%
Africa	16%	4%	3%
Oceania	0.5%	1.3%	1.3%

Source: Our World in Data based on the Global Carbon Project (2022)

According to the World Energy Outlook (2022) report, the crisis caused by Covid-19 and Russia's intervention in Ukraine has exposed the vulnerability of energy markets and highlighted the necessity for countries to invest in clean energy policies after the energy crisis. The report predicts that clean energy investments worldwide will increase by 50% to reach 2 trillion US dollars by

2030. High energy prices resulting from the crisis are leading countries to focus more on energy efficiency and innovation to reduce energy use. Additionally, it is expected that investments in low-emission vehicles will sharply increase as countries implement stronger policies. Energy crises are expected to accelerate the clean energy transformation towards a cleaner and safer energy system, marking a historic turning point (IEA, 2022).

In 2019, the share of renewable energy in primary energy sources reached around 11% worldwide. When looking at Figure 6, it can be seen that Iceland is the country that uses renewable energy sources the most, with approximately 87% share. Following Iceland are Norway (71%), Sweden (51%), Brazil (47%), and Canada (30%). When examining Figure 7, it is observed that hydro energy (approximately 4000 TWh) is in the first place among renewable energy sources, followed by wind energy (approximately 2000 TWh) in second place and solar energy (approximately 1000 TWh) in third place.

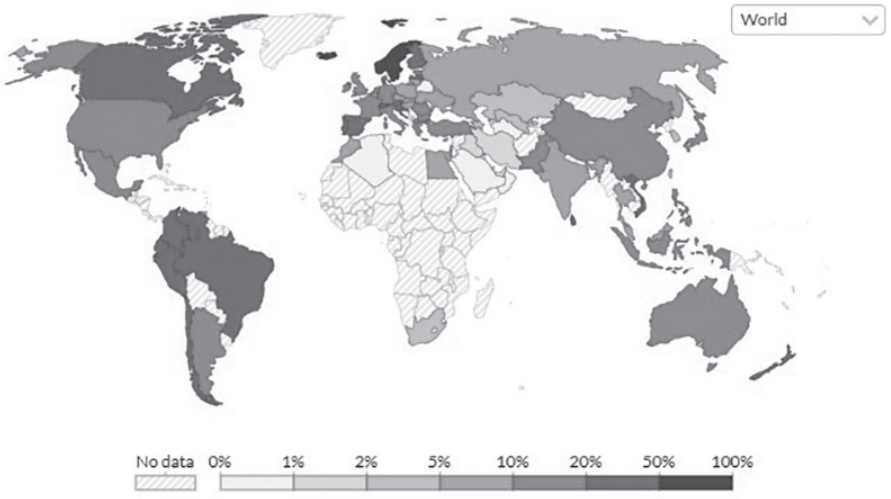

Figure 6. Share of Renewable Energy in Primary Energy Sources (2021)

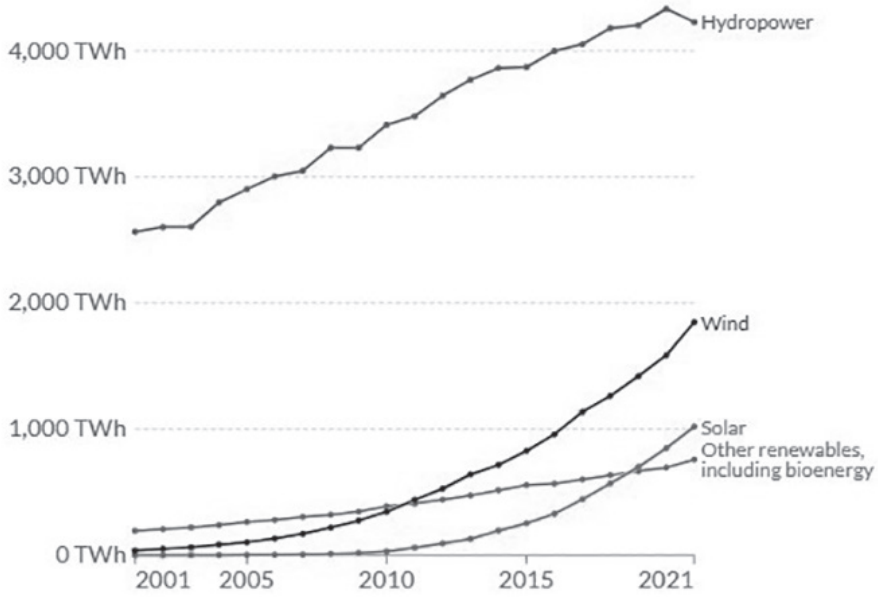

Figure 7. Shares of Renewable Energy Resources (2001-2021)

CONCLUSION AND DISCUSSIONS

The levels of production and consumption have been steadily increasing year by year as a result of the impact of the Industrial Revolution and advancements in technology. As the world economies have developed, human welfare has progressed in many areas. However, intense carbon emissions and environmental pollution caused by high production levels have brought about the climate crisis. In today's world, where it is difficult to achieve sustainable growth goals with traditional growth models, it is important to effectively use existing resources and turn to alternative sources. Additionally, preventing environmental pollution, preventing the decrease in biodiversity, and stopping climate change have become mandatory. All of these necessities require the implementation of a series of green policies in the economy and the realization of green transformation.

There have been various discussions about green growth, particularly around the potential benefits, challenges, and policy implications of promoting sustainable economic development. One of the key debates around green growth centers on the trade-off between economic growth and environmental

sustainability. Some argue that economic growth is necessary to address poverty and promote social well-being, and that environmental concerns should be addressed separately. Others argue that economic growth and environmental sustainability can be pursued together, through investments in clean technologies, resource efficiency, and sustainable practices. Another discussion around green growth relates to the role of public policies and international cooperation in promoting sustainable economic development. Governments and international organizations have implemented various policies to incentivize green investments and promote sustainable practices, such as renewable energy subsidies, carbon pricing mechanisms, and green public procurement. However, there are also challenges in implementing and coordinating these policies, particularly given the diverse economic, social, and environmental contexts across different countries and regions. Furthermore, there is also debate around the distributional implications of green growth, particularly around the potential impacts on different social groups and regions. For example, some argue that green investments and policies may disproportionately benefit certain groups, such as urban populations, while others may face negative impacts, such as rural communities dependent on fossil fuel industries.

Overall, while there are diverse views and debates around green growth, there is a growing recognition of the importance of promoting sustainable economic development that supports both economic growth and environmental sustainability. The implementation of effective policies and investments in clean technologies and sustainable practices can play a crucial role in achieving these goals.

According to the International Energy Agency (IEA), renewables accounted for almost 72% of new power capacity additions worldwide in 2019. The total renewable power capacity reached 2,537 GW in 2019, representing around 34% of the world's total installed electricity capacity. In terms of carbon emissions, the energy sector is the largest source of greenhouse gas emissions worldwide, accounting for approximately 73% of total emissions in 2019. Fossil fuels such as coal, oil, and natural gas are the primary sources of energy, and their combustion releases carbon dioxide and other greenhouse gases into the atmosphere. The use of renewable energy sources can help to reduce carbon emissions from the energy sector. According to the IEA, renewable energy sources avoided approximately 2.5 gigatons of carbon dioxide emissions in 2019, which is equivalent to the total emissions of the United States. However, despite

the growth of renewable energy, the world's carbon emissions continue to rise, driven by increasing energy demand and the continued use of fossil fuels. In 2019, global carbon dioxide emissions from energy use reached a record high of 33.1 gigatons. This highlights the need for further action to accelerate the transition to renewable energy sources and reduce carbon emissions in the energy sector and other sectors of the economy. Overall, the use of renewable energy sources has been growing rapidly in recent years and can play a crucial role in reducing carbon emissions and promoting environmental sustainability. However, further efforts are needed to accelerate the transition to renewable energy sources and reduce the world's carbon footprint.

As a theoretical and empirical outcome of our study, the utilization of renewable energy sources supports green growth through a multitude of transmission mechanisms and contributes to environmental sustainability. Renewable energy is environmentally sustainable. Renewable energy sources such as solar, wind, hydro, geothermal, and biomass do not produce greenhouse gas emissions that contribute to climate change. This means that renewable energy consumption can help mitigate the negative impacts of climate change and promote a more sustainable environment. By reducing the use of fossil fuels, renewable energy can also help to reduce air pollution and improve public health. Renewable energy promotes energy security. Renewable energy can help reduce dependence on fossil fuels, which are a finite resource and subject to price fluctuations and geopolitical risks. By diversifying the energy mix, countries can become more resilient to supply disruptions and price volatility, which can promote economic stability and development. Renewable energy creates new economic opportunities. The renewable energy industry is a rapidly growing sector that has the potential to create new economic opportunities and jobs. Renewable energy projects require skilled workers in areas such as manufacturing, installation, and maintenance, which can create new employment opportunities in both urban and rural areas. Renewable energy investments can also stimulate economic activity and promote local development. Renewable energy supports social inclusion. Renewable energy projects can be designed to promote social inclusion and provide benefits to local communities. For example, community-owned renewable energy projects can provide a source of income for local residents and promote community engagement and participation. In summary, renewable energy consumption can support green growth by promoting environmental sustainability, energy

security, economic development, and social inclusion. However, the transition to renewable energy requires policy support and investment in research, development, and deployment of renewable energy technologies.

Green growth refers to economic growth that is environmentally sustainable and promotes social development and inclusiveness. To promote green growth, countries should consider implementing policies for several important areas:

1. Renewable Energy: Governments can promote the use of renewable energy sources by providing incentives or tax breaks to invest in renewable infrastructure, setting targets for the percentage of energy from renewable sources.
2. Energy Efficiency: Governments can promote energy efficiency by setting standards for devices, buildings, and vehicles, and by offering incentives for businesses and individuals to adopt energy-efficient technologies.
3. Sustainable Transportation: Policies that promote sustainable transportation can reduce greenhouse gas emissions and improve air quality by encouraging public transportation and active transportation modes such as cycling and walking.
4. Circular Economy: Countries can promote a circular economy in which waste is reduced, resources are conserved, and materials are reused or recycled. This can be achieved through policies such as extended producer responsibility regulations, which require producers to take back their products at the end of their useful life and recycle them.
5. Green Finance: Governments can promote the flow of green investments by creating incentives for investors to finance green infrastructure and technologies.
6. Nature-based Solutions: Finally, countries can promote nature-based solutions that can help mitigate climate change and provide other social and economic benefits. These may include activities such as preserving and restoring natural ecosystems.

Overall, to achieve green growth, countries should implement a set of policies that support sustainable economic development while also protecting the environment and promoting social inclusiveness.

REFERENCES

Abid, N., Ceci, F., & Ikram, M. (2022). Green growth and sustainable development: dynamic linkage between technological innovation, ISO 14001, and environmental challenges. *Environmental Science and Pollution Research,* 29(17), 25428-25447. https://doi.org/10.1007/s11356-021-17518-y

Akram, R., Chen, F., Khalid, F., Ye, Z., & Majeed, M. T. (2020). Heterogeneous effects of energy efficiency and renewable energy on carbon emissions: Evidence from developing countries. *Journal of Cleaner Production,* 247, 119122. https://doi.org/10.1016/j.jclepro.2019.119122

Andersson, J. J. (2019). Carbon taxes and CO 2 emissions: Sweden as a case study. *American Economic Journal: Economic Policy,* 11(4), 1-30. doi: 10.1257/pol.20170144

Apergis, N., Payne, J., Menyah, K. & Wolde-Rufael, Y. (2010). On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. *Ecological Economics,* 69, 2255-2260. https://doi.org/10.1016/j.ecolecon.2010.06.014

Apergis, N. & Payne, J. E. (2010). Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. *Energy Policy,* 38, 656-660. https://doi.org/10.1016/j.enpol.2009.09.002

Apergis, N., Payne, J. E., Menyah, K., & Wolde-Rufael, Y. (2010). On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. *Ecological Economics*, 69(11), 2255-2260.

Baloch, M. A., Mahmood, N., & Zhang, J. W. (2019). Effect of natural resources, renewable energy and economic development on CO2 emissions in BRICS countries. *Science of the Total Environment*, 678, 632-638. https://doi.org/10.1016/j.scitotenv.2019.05.028

Balsalobre, D., Álvarez, A., & Cantos, J. M. (2015). Public budgets for energy RD&D and the effects on energy intensity and pollution levels. *Environmental Science and Pollution Research,* 22(7), 4881-4892. https://doi.org/10.1007/s11356-014-3121-3

Bao, C. & Xu, M. (2019). Cause and effect of renewable energy consumption on urbanization and economic growth in China's provinces and regions. *Journal of Cleaner Production*, 231, 483-493. https://doi.org/10.1016/j.jclepro.2019.05.191

Bartelmus, P. (2013). The future we want: Green growth or sustainable development? *Environmental Development*, 7, 165-170. https://doi.org/10.1016/j.envdev.2013.04.001

Barua, S. (2022). Green growth and energy transition: An assessment of selected emerging economies. *In Energy-Growth Nexus in an Era of Globalization*. Elsevier. https://doi.org/10.1016/B978-0-12-824440-1.00003-5

Bina, O. (2013). The green economy and sustainable development: an uneasy balance? *Environment and Planning C: Government and Policy,* 31(6), 1023-1047. doi:10.1068/c1310j

Chichilnisky, G. (1997). What is sustainable development?.*Land Economics,* 467-491. https://doi.org/10.2307/3147240

Claeys, G., Tagliapietra, S., & Zachmann, G. (2019). *How to make the European Green Deal work (Vol. 5).* Brussels, Belgium: Bruegel.

Dai, H., Xie, X., Xie, Y., Liu, J., & Masui, T. (2016). Green growth: The economic impacts of large-scale renewable energy development in China. *Applied energy,* 162, 435-449. https://doi.org/10.1016/j.apenergy.2015.10.049

Dauda, L., Long, X., Mensah, C. N., Salman, M., Boamah, K. B., Ampon-Wireko, S., & Dogbe, C. S. K. (2021). Innovation, trade openness and CO2 emissions in selected countries in Africa. *Journal of Cleaner Production,* 281, 125143. https://doi.org/10.1016/j.jclepro.2020.125143

General Assembly, (2015). *Resolution adopted by the General Assembly on 11 September 2015.* New York: United Nations.

Gu, J., Renwick, N., & Xue, L. (2018). The BRICS and Africa's search for green growth, clean energy and sustainable development. *Energy Policy*, 120, 675-683. https://doi.org/10.1016/j.enpol.2018.05.028

Hao, L. N., Umar, M., Khan, Z., & Ali, W. (2021). Green growth and low carbon emission in G7 countries: how critical the network of environmental taxes, renewable energy and human capital is?. *Science of The Total Environment,* 752, 141853. https://doi.org/10.1016/j.scitotenv.2020.141853

Hickel, J., & Kallis, G. (2020). Is green growth possible?. *New political economy,* 25(4), 469-486. https://doi.org/10.1080/13563467.2019.1598964

Ho, M. S., & Wang, Z. (2014). Green growth (for China): A literature review. *Resources for the Future Discussion Paper*, 14-22. http://dx.doi.org/10.2139/ssrn.2537838

Hussain, Z., Mehmood, B., Khan, M. K., & Tsimisaraka, R. S. M. (2022). Green growth, green technology, and environmental health: evidence from high-GDP countries. *Frontiers in Public Health*, 9, 816697. https://doi.org/10.3389/fpubh.2021.816697

IEA. 2022. *World Energy Outlook 2022.* Data Retrieved March 4, 2023, https://www.iea.org/reports/world-energy-outlook-2022

Inglesi-Lotz, R. (2016). The impact of renewable energy consumption to economic growth: A panel data application. *Energy economics,* 53, 58-63. https://doi.org/10.1016/j.eneco.2015.01.003

Internatıonal Energy Agency (IEA). (2022) *"Data and Statistics".* Data Retrieved March 4, 2023, https://www.iea.org/data-and-statistics/data-tools/greenhouse-gas-emissions-from-energy-data-explorer

Jabareen, Y. (2008). A new conceptual framework for sustainable development. *Environment, development and sustainability*, 10, 179-192. https://doi.org/10.1007/s10668-006-9058-z

Jacobs, M. (2013). *Green growth. The handbook of global climate and environment policy*, 197-214. https://doi.org/10.1002/9781118326213.ch12

Jiang, C., & Ma, X. (2019). The impact of financial development on carbon emissions: a global perspective. *Sustainability*, 11(19), 5241. https://doi.org/10.3390/su11195241

Khan, M. B., Saleem, H., Shabbir, M. S., & Huobao, X. (2022). The effects of globalization, energy consumption and economic growth on carbon dioxide emissions in South Asian countries. *Energy & Environment,* 33(1), 107-134. https://doi.org/10.1177/0958305X2098696

Lavrinenko, O., Ignatjeva, S., Ohotina, A., Rybalkin, O., & Lazdans, D. (2019). The role of green economy in sustainable development (case study: the EU states). *Entrepreneurship and sustainability issues*, 6, 1113-1126. doi: 10.9770/jesi.2019.6.3(4)

Li, J., Dong, X., & Dong, K. (2022). Is China's green growth possible? The roles of green trade and green energy. *Economic Research-Ekonomska Istraživanja,* 1-25. https://doi.org/10.1080/1331677X.2022.2058978

Lin, B., & Zhu, J. (2019). The role of renewable energy technological innovation on climate change: Empirical evidence from China. *Science of the Total Environment,* 659, 1505-1512. https://doi.org/10.1016/j.scitotenv.2018.12.449

Luqman, M., Ahmad, N. & Bakhsh, K. (2019). Nuclear energy, renewable energy and economic growth in Pakistan: Evidence from non-linear autoregressive distributed lag model. *Renewable Energy*, 139, 1299-1309. https://doi.org/10.1016/j.renene.2019.03.008

Lyytimäki, J., Antikainen, R., Hokkanen, J., Koskela, S., Kurppa, S., Känkänen, R., & Seppälä, J. (2018). Developing key indicators of green growth. *Sustainable Development,* 26(1), 51-64. https://doi.org/10.1002/sd.1690

Mainieri, T., Barnett, E. G., Valdero, T. R., Unipan, J. B., & Oskamp, S. (1997). Green buying: The influence of environmental concern on consumer behavior. *The Journal of social psychology,* 137(2), 189-204. https://doi.org/10.1080/00224549709595430

Maji, I. K., Sulaiman, C. & Abdul-Rahim, A. S. (2019). Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. *Energy Report,* 5, 384-392. https://doi.org/10.1016/j.egyr.2019.03.005

Mardani, A., Streimikiene, D., Cavallaro, F., Loganathan, N., & Khoshnoudi, M. (2019). Carbon dioxide (CO2) emissions and economic growth: A systematic review of two decades of research from 1995 to 2017. *Science of the total environment,* 649, 31-49. https://doi.org/10.1016/j.scitotenv.2018.08.229

Mensah, C. N., Long, X., Boamah, K. B., Bediako, I. A., Dauda, L., & Salman, M. (2018). The effect of innovation on CO2 emissions of OCED countries from 1990 to 2014. *Environmental Science and Pollution Research*, 25(29), 29678-29698. https://doi.org/10.1016/j.scitotenv.2018.08.229

Mohsin, M., Taghizadeh-Hesary, F., Iqbal, N., & Saydaliev, H. B. (2022). The role of technological progress and renewable energy deployment in green economic growth. *Renewable Energy,* 190, 777-787. https://doi.org/10.1016/j.renene.2022.03.076

United Nations, (2012). *The future we want: outcome document adopted at Rio+ 20*. United Nations: Rio de Janeiro, Brazil.

OECD. (2015). *Towards green growth? Tracking progress.* OECD Green Growth Studies.

Pao, H. T., & Fu, H. C. (2013). Renewable energy, non-renewable energy and economic growth in Brazil. *Renewable and Sustainable Energy Reviews,* 25, 381-392. https://doi.org/10.1016/j.rser.2013.05.004

Paramati, S. R., Apergis, N., & Ummalla, M. (2018). Dynamics of renewable energy consumption and economic activities across the agriculture, industry, and service sectors: evidence in the perspective of sustainable development. *Environmental Science and Pollution Research,* 25(2), 1375-1387. https://doi.org/10.1007/s11356-017-0552-7

Peattie, K. (2010). Green consumption: behavior and norms. *Annual review of environment and resources*, 35(1), 195-228. https://doi.org/10.1146/annurev-environ-032609-094328

Perez, C. (2017). Is smart green growth the solution? Lessons from history. *In Beyond the Technological Revolution Working Paper Series* WP2017-01.

Pezzey, J. C. (2017). Sustainability constraints versus "optimality" versus intertemporal concern, and axioms versus data. *In The Economics of Sustainability*, 263-281. Routledge. https://doi.org/10.2307/3147239

Popp, D. (2012), *The Role of Technological Change in Green Growth,* The World Bank.

Rahman, M. M. & Velayutham, E. (2020). Renewable and non-renewable energy consumption-economic growth nexus: New evidence from South Asia. *Renewable Energy,* 147, 399-408. https://doi.org/10.1016/j.renene.2019.09.007

Razzaq, A., Sharif, A., Ozturk, I., & Skare, M. (2023). Asymmetric influence of digital finance, and renewable energy technology innovation on green growth in China. *Renewable Energy*, 202, 310-319. https://doi.org/10.1016/j.renene.2022.11.082

Roberts, J. A. (1996). Green consumers in the 1990s: profile and implications for advertising. *Journal of business research,* 36(3), 217-231. https://doi.org/10.1016/0148-2963(95)00150-6

Rogers, P. P., Jalal, K. F., & Boyd, J. A. (2012). *An introduction to sustainable development.* Routledge. https://doi.org/10.4324/9781849770477

Sohag, K., Husain, S., Hammoudeh, S., & Omar, N. (2021). Innovation, militarization, and renewable energy and green growth in OECD countries. *Environmental Science and Pollution Research,* 28(27), 36004-36017. https://doi.org/10.1007/s11356-021-13326-6

Soukiazis, E., Proenca, S., & Cerqueira, P. A. (2019). The interconnections between renewable energy, economic development and environmental pollution: A simultaneous equation system approach. *The Energy Journal,* 40(4). doi: 10.5547/01956574.40.4.esou

Stoknes, P. E., & Rockström, J. (2018). Redefining green growth within planetary boundaries. *Energy Research & Social Science,* 44, 41-49. https://doi.org/10.1016/j.erss.2018.04.030

Suki, N. M., Suki, N. M., Afshan, S., Sharif, A., Kasim, M. A., & Hanafi, S. R. M. (2022). How does green technology innovation affect green growth in ASEAN-6 countries? Evidence from advance panel estimations. *Gondwana Research,* 111, 165-173. https://doi.org/10.1016/j.gr.2022.06.019

Taşkın, D., Vardar, G., & Okan, B. (2020). Does renewable energy promote green economic growth in OECD countries?. *Sustainability Accounting, Management and Policy Journal*, 11(4), 771-798. https://doi.org/10.1108/SAMPJ-04-2019-0192

Danish & Ulucak, R. (2020). How do environmental technologies affect green growth? Evidence from BRICS economies. *Science of the Total Environment,* 712, 136504. https://doi.org/10.1016/j.scitotenv.2020.136504

UNEP. (2011). *Towards a green economy: Pathways to sustainable development and poverty eradication*. Nairobi, Kenya: UNEP.

Van Vuuren, D. P., Stehfest, E., Gernaat, D. E., Doelman, J. C., Van den Berg, M., Harmsen, M & Tabeau, A. (2017). Energy, land-use and greenhouse gas emissions trajectories under a green growth paradigm. *Global Environmental Change,* 42, 237-250. https://doi.org/10.1016/j.gloenvcha.2016.05.008

Vivek, C. M., Ramkumar, P., Srividhya, P. K., & Sivasubramanian, M. (2021). Recent strategies and trends in implanting of renewable energy sources for sustainability–A review. *Materials Today: Proceedings,* 46, 8204-8208. https://doi.org/10.1016/j.matpr.2021.03.208

World Bank, *CO2 Emissions (KT).* Data Retrieved March 4, 2023, from https://data.worldbank.org/indicator/EN.ATM.CO2E.KT.

World Bank. (2012). *Inclusive green growth: The pathway to sustainable development*. The World Bank.

Xie, F., Liu, Y., Guan, F., & Wang, N. (2020). How to coordinate the relationship between renewable energy consumption and green economic development: from the perspective of technological advancement. *Environmental Sciences Europe,* 32(1), 1-15. https://doi.org/10.1186/s12302-020-00350-5

Yao, Y., Ivanovski, K., Inekwe, J., & Smyth, R. (2020). Human capital and CO2 emissions in the long run. *Energy economics,* 91, 104907. https://doi.org/10.1016/j.eneco.2020.104907

Yılmaz, V. (2018). Sürdürülebilir Kalkınma ve Yeşil Büyüme Arasındaki İlişki. *Journal of International Management Educational and Economics Perspectives,* 6(2), 79-89.

Zaman, K., bin Abdullah, A., Khan, A., bin Mohd Nasir, M. R., Hamzah, T. A. A. T., & Hussain, S. (2016). Dynamic linkages among energy consumption, environment, health, and wealth in BRICS countries: green growth key to sustainable development. *Renewable and Sustainable Energy Reviews,* 56, 1263-1271. https://doi.org/10.1016/j.rser.2015.12.010