Climate Change: Impacts on the Global Economy

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Abstract. Climate change significantly threatens the global economy by influencing various sectors through rising temperatures, extreme weather events, and shifting ecosystems. This paper explores economic consequences of climate change, which include reduced agricultural productivity, damage to infrastructure, supply chain disruptions, and increased costs related to disaster recovery and adaptation. Additionally, the transition to a low or zero-carbon economy presents both challenges and opportunities. Economic fields such as renewable energy and sustainable technology are experiencing growth, while fossil fuel-dependent sectors are in decline. The financial sectors of nations must also adapt to climate-related risks, including asset devaluation and insurance losses. This study highlights the need for proactive policies, investment in sustainable infrastructure, and international cooperation to mitigate economic vulnerabilities. By addressing climate change through innovation and policy reform, one can ensure long-term economic stability. These measures are essential to building a more resilient and sustainable global economy in the face of ongoing climate impacts.

Keywords: Climate Change, Economic Impact, Green Energy.

1. Introduction

Climate change is one of the most pressing global issues, affecting not only the environment but also economies worldwide. Human-induced greenhouse gas emissions primarily drove this phenomenon. As temperatures rise, extreme weather events become more frequent, and natural resources are strained, the global economy faces both challenges and opportunities. According to the Intergovernmental Panel on Climate Change (IICC), global average temperatures have risen by around 1.1 Celsius since the pre-industrial age, leading to a significant increase in the frequency of extreme weather events. While the adverse effects of climate change are well-documented, it is also important to recognize that these changes make create new opportunities for economic transformation and innovation. This paper employs a combination of quantitative analysis and studies to explore the impacts of climate change on the global economy. It explores how industries, governments, and individuals are adapting to these changes. It also discusses the different scenarios of climate change intensity that accelerate the development of green energy and transition toward renewable energy sources, potentially reshaping the global economic landscape. By examining multiple perspectives, this paper aims to provide a balanced view of climate change's economic effects, helping people around the world to have a better understanding of what climate change is and the impacts it could have.

2. The Science Behind Climate Change

Climate change refers to long-term shifts in global or regional climate patterns, particularly the rise in global temperatures caused by human activities. It's driven by an increase in greenhouse gases like carbon dioxide, methane, and many other gases that trap heat in the Earth's atmosphere. This is primarily a result of burning fossil fuels like coal, oil, and natural gas for energy, deforestation, and agricultural practices [1, 2].

2.1. History of Climate Change

The discovery of climate change began in the 19th century when the ice age and other natural changes in climate were first discovered, and the natural greenhouse effect was first found [3]. In the late 19th century, scientists first suggested that human-generated greenhouse gas emissions could alter the Earth's energy balance and climate. The concept of the greenhouse effect, though not referred to by that name at the time, was initially introduced in 1824 by Joseph Fourier. Claude Poulet further strengthened the argument and the evidence in 1827. In 1856, Eunice Newton Foote demonstrated that the warming effect of the sun is greater for humid air than for dry air, and the effect is even greater when carbon dioxide is in the mix [1, 2].

By the 1960s, scientific evidence increasingly supported the idea that carbon dioxide contributed to global warming. Researchers also found that human activities producing atmospheric aerosols, commonly known as air pollution, could have a cooling effect—later termed global dimming. Additionally, alternative explanations for global warming were explored, including factors such as volcanic activities and variations in solar radiation bases on orbits.

These changes in climate are not just theoretical—they have measurable effects on economies around the world.

One of the clearest ways climate changes affect the economy is through the increasing severity of natural disasters since there is usually no other reason why this would change. The Earth’s orbit shifts gradually over hundreds of thousands of years, so that wouldn’t be a factor and weather cycles or ocean current shifts cannot explain the increase of such events all around the world

2.2. Hurricanes and Storms

The first example that would come to mind is stronger hurricanes and storms. Climate change creates stronger storms because rising global temperatures increase ocean surface temperatures, which provide more energy for storm formation. Warmer oceans lead to higher evaporation rates, adding more moisture to the atmosphere. This fuels stronger winds, heavier rainfall, and more intense hurricanes, cyclones, and typhoons [3]. Additionally, climate change disrupts atmospheric circulation patterns, making extreme weather events more frequent and severe [4, 5].

One can see the amplification of this effect through history. Climate change has significantly increased the frequency, intensity, and economic impact of hurricanes. Before the 1980s, major hurricanes (Category 3 and above) were less frequent, with Category 5 storms being rare. However, in recent decades, the proportion of Category 4 and 5 hurricanes have risen, with projections suggesting a 13% increase in such storms if global temperatures rise by 2°C, which has already happened [5,6]. Economic damages have also escalated, as seen with Hurricane Betsy in 1965, the first U.S. hurricane to cause over $1 billion in losses, compared to Cyclone Idai and Hurricane Harvey, which each exceeded $100 billion in damages and had massive death tolls [7, 8]. Additionally, hurricanes are now intensifying more rapidly, with the likelihood of such rapid intensification rising from 1% in the 1980s to 5% today [9, 10]. Warmer ocean temperatures and shifting atmospheric conditions contribute to this trend, making storms more dangerous and harder to predict. These changes highlight the urgent need for enhanced climate-resilience strategies.

In 2017, Hurricane Harvey made landfall in Texas as a Category 4 storm, causing unprecedented rainfall with over 60 inches in some areas. The storm resulted in USD 125 billion in damages, making it one of the costliest natural disasters in U.S. history [4, 5]. Over 100 lives were lost, and more than 300,000 structures were flooded. This case underscores the severe impacts of extreme weather events driven by climate change on infrastructure, the economy, and human life [5].

In 2019, Cyclone Idai struck Mozambique, Zimbabwe, and Malawi 2019, becoming one of the deadliest storms in the Southern Hemisphere. The cyclone caused extensive damage, with over USD 2.2 billion in economic losses and more than 400,000 people displaced [8]. The death toll exceeded 1,300, with millions more affected by flooding and food shortages. The cyclone's impact was exacerbated by the region's vulnerability to extreme weather events, highlighting the challenges faced by developing countries in adapting to climate change [9, 10]. The widespread destruction of infrastructure and agricultural lands underscored the need for improved disaster preparedness and climate resilience measures in the region [11, 12].

Hurricanes also have effects beyond the immediate damage caused by the storm. Hurricanes cause severe long-term economic damage by destroying infrastructure, businesses, and jobs, leading to prolonged financial instability. The destruction of roads, power grids, and manufacturing facilities can disrupt supply chains and raise production costs, as seen when Hurricane Helene caused a nationwide shortage of medical supplies [9]. Local economies struggle to recover as businesses close, property values decline, and job losses increase, with some communities never fully rebuilding. The cost of reconstruction can drain government resources, diverting funds from essential services. Additionally, hurricanes reduce tourism revenue in affected regions, further hindering economic recovery. These lasting financial burdens highlight the need for resilient infrastructure and economic planning to mitigate future losses [4, 5].

To deal with stronger storms caused by climate change, one can improve infrastructure to withstand extreme weather, strengthen flood defenses, and enhance early warning systems. One example of this already happening would be the United States. The United States has implemented various measures to reduce hurricane damage, focusing on infrastructure resilience, emergency preparedness, and legislation [13, 14]. Stricter building codes require storm shutters and elevated utilities to prevent flood damage. Evacuation plans and public awareness campaigns, such as those by OSHA and Ready.gov, help communities prepare [15, 16]. The Infrastructure Investment and Jobs Act allocated $7 billion to FEMA for climate resilience projects, with $3 billion designated for flood protection. Florida’s Hurricane Loss Mitigation Program funds property retrofits and hurricane research [16]. These efforts demonstrate the U.S.'s commitment to reducing hurricane impacts through proactive policies and preparedness.

Now, it should be evaluated whether if the efforts were worth it or not. Looking at the numbers, they certainly are. With damages of hurricanes often exceeding 100$ billion, causing death and destruction, a 10$ billion investment seems like a much smaller number considering the impact it could make.

However, hurricanes are not the only thing climate change can cause. Climate change could also cause the opposite of more humidity: long-lasting droughts that also happen to be amplified by climate change.

2.3. Droughts

Climate change creates longer and more severe droughts by increasing global temperatures, which lead to higher evaporation rates and reduced soil moisture. Warmer air holds more water, causing faster drying of land and vegetation. Additionally, shifting weather patterns can reduce rainfall in already dry regions, prolonging drought conditions and intensifying their severity [1, 2, 7, 10, 12].

Climate change has led to a severe drought in the American West, marking the driest 22-year period in at least 1,200 years. This prolonged drought has diminished drinking water supplies, harmed crops, and increased forest susceptibility to insect infestations. Additionally, it can trigger a positive feedback loop, where reduced soil moisture and plant cover accelerate evaporation, further worsening dry conditions [1, 2, 4, 12, 13]. Examples of these would be:

The Horn of Africa experienced a severe multi-year drought from 2011 to 2022, which is considered one of the most devastating climatic disasters in decades. This drought affected over 20 million people across Somalia, Kenya, and Ethiopia, leading to widespread crop failures and livestock deaths that triggered severe famines. The economic losses from this prolonged drought are estimated at USD 12 billion [14, 15]. In Somalia alone, over 260,000 people died during the 2011 famine. This case highlights how extreme droughts caused by climate change can directly impact agricultural economies and trigger humanitarian crises, further exacerbating regional economic vulnerabilities [16, 17].

California faced a severe drought from 2012 to 2016, which had profound impacts on the state's economy and society. The drought caused annual agricultural losses exceeding USD 5 billion and led to the significant depletion of groundwater reserves. Additionally, over 100 million trees died during this period, which not only damaged the ecosystem but also increased the risk of wildfires. This case illustrates that droughts driven by climate change can have cascading effects, directly impacting agricultural economies and threatening water supply and ecosystem stability [8, 16, 17].

To deal with longer and more severe droughts caused by climate change, one can improve water conservation, enhance irrigation efficiency, and promote drought-resistant crops. Investing in water storage and restoring ecosystems helps manage water supply. Reducing greenhouse gas emissions through renewable and sustainable energy can also mitigate future drought risks.

Australia has faced severe droughts, particularly in the Murray-Darling Basin, exacerbated by climate change. To address this, the country has implemented the Murray-Darling Basin Plan, which ensures sustainable water use and promotes efficient irrigation methods. Desalination plants, such as the Sydney Desalination Plant, provide backup water sources. Drought relief programs offer financial assistance to farmers and communities affected by water scarcity [18]. The government also encourages climate adaptation through drought-resistant crops, improved water storage, and sustainable farming practices. Additionally, reforestation and land restoration efforts help mitigate desertification and improve water retention (Murray-Darling Basin Authority; Australian Government Department of Agriculture, Water, and the Environment) [19, 20].

And were these efforts worth it? Considering the extreme amount of economic and ecological damage droughts can cause, these relatively small numbers spent on preventing the worse effects are most definitely a wise choice.

The dryness causing droughts is itself a large issue, but another possibility is that the lack of humidity can cause more and more intense wildfire [21, 22].

2.4. Wildfires

Drier, hotter climates caused by climate change and global warming create conditions that induce more vicious wildfire seasons—with fires that spread faster and burn longer, which puts millions of lives and homes at risk. Climate change has significantly intensified wildfires globally [23, 24, 25]. In the United States, the average annual area burned has more than doubled since the 1980s, increasing from approximately 2 million acres per year to over 4 million. Similarly, California's 2020 wildfire season saw over 4 million acres burned, marking the state's largest wildfire season on record [17, 18]. These trends highlight the escalating threat of wildfires due to climate change, emphasizing the need for enhanced mitigation and adaptation strategies [7, 22]. Some specific cases and numbers would be:

Australia experienced a series of severe bushfires from 2019 to 2020, commonly referred to as the "Black Summer." These fires burned over 46 million acres of land, destroyed 5,900 buildings, and resulted in the death or displacement of an estimated 3 billion animals. The economic cost of these fires exceeded USD 4.4 billion, and 34 people lost their lives. This case demonstrates how extreme heat and drought conditions, exacerbated by climate change, can increase the frequency and intensity of wildfires, posing significant threats to ecosystems, infrastructure, and human safety [7, 15, 23].

The 2020 California wildfire season was one of the most severe on record, with over 4.2 million acres burned across the state. This unprecedented fire season included five of the seven largest wildfires in California's history. The fires resulted in significant economic and social impacts, with over 10,000 structures destroyed and total damages exceeding USD 19 billion. Additionally, 33 lives were lost as a direct result of the fires. The intensity of the wildfire season was attributed to a combination of factors, including poor forest management practices over the past century and rising temperatures due to climate change. The fires also had severe health impacts, with significant increases in fine particulate matter (PM2.5) and ozone levels, leading to an estimated 539 premature deaths and 1,886 additional hospitalizations. These impacts highlight the far-reaching consequences of climate change on infrastructure, public health, and economic stability in California [7, 8].

To deal with wildfires caused by climate change, one can improve forest management, use controlled burns, and strengthen building codes in fire-prone areas. Early warning systems and community preparedness are essential [7, 8]. Reducing greenhouse gas emissions through renewable energy and sustainable practices can help mitigate future wildfire risks [15-18].

One example of a country both very vulnerable and very active when dealing with the issue is, yet again, Australia. Australia has implemented several strategies to address the increasing severity of bushfires exacerbated by climate change. In the aftermath of the catastrophic 2019–2020 Black Summer fires, which burned over 17 million hectares, resulted in 33 fatalities, destroyed thousands of homes and caused millions of deaths in animal populations, the Australian Government allocated $50 million for immediate wildlife protection and long-term restoration efforts [18, 24]. State agencies have also focused on fuel management techniques, including controlled burns and vegetation clearing, to reduce fire intensity and spread [25, 26]. Additionally, the Australian Bushfire & Climate Plan provides a comprehensive framework for governments, fire agencies, and communities to enhance preparedness and resilience against future bushfires [10, 19].

But should Australia have allocated these resources to prevent these fires? Looking at the irreversible effect they could have, the money used in preventing wildfires is very well-spent.

However, there are other effects that do not happen in an instant then go away, instead steadily growing worse [27]. The best example of this also happens to be quite unknown. It refers to the process of ocean acidification.

2.5. Ocean Acidification

Climate change and ocean acidification are both driven by increased atmospheric carbon dioxide levels resulting from human activities such as fossil fuel usage, deforestation, and certain agricultural practices [28, 29]. As atmospheric carbon dioxide concentrations rise, more carbon dioxide dissolves into the ocean, which reacts with seawater to form carbonic acid [30, 31]. This process lowers the pH of the ocean, making it more acidic. The increased temperature also increases the solubility of water, allowing more carbon dioxide to dissolve in water, further lowering the pH of oceans. Ocean acidification has led to significant ecological and economic challenges, notably impacting coral reefs and shellfish industries. Examples include:

Studies have documented a global decline in coral reef calcification, with an average reduction rate of 4.3% per year. Specifically, research on the Great Barrier Reef indicates a 14.2% decrease in calcification since 1990, primarily due to a 13.3% reduction in linear extension rates. This decline compromises the structural integrity of coral reefs, making them more susceptible to erosion and less capable of providing essential habitats for marine species [29].

Beginning in 2005, oyster hatcheries in the Pacific Northwest experienced significant production declines due to increased ocean acidity, threatening the $111 million West Coast shellfish industry. This decline jeopardized over 3,000 jobs associated with the industry. The increased acidity hindered the ability of oyster larvae to form shells, leading to high mortality rates and substantial economic losses for shellfish growers [14].

A variety of actions are necessary to combat ocean acidification and address its significant ecological and economic impacts. Solving ocean acidification requires reducing CO_2 emissions by transitioning to renewable energy and adopting sustainable practices. Carbon dioxide removal (CDR) methods, like direct air capture and afforestation, help lower atmospheric CO_2 levels. Restoring marine vegetation, such as kelp and eelgrass, can locally reduce acidity, while protecting forests aids carbon sequestration. Combining these strategies can mitigate ocean acidification and protect marine ecosystems.

To implement these solutions effectively, coordinated efforts from multiple stakeholders are essential. As one can imagine, accomplishing these isn't a light task. However, there are still organizations trying to achieve this. One example of an organization trying to do this is the EU. The European Union (EU) has taken significant steps to combat ocean acidification through a variety of initiatives. A great example of this is the European Green Deal, which aims to make Europe climate-neutral by 2050 through significant CO_2 emission reductions, a shift to renewable energy, and the promotion of sustainable industry practices. Another important initiative is the Marine Strategy Framework Directive (MSFD), designed to protect Europe's marine environment. It sets specific targets to cut CO_2 emissions and enhance marine ecosystem health, tackling the root causes of ocean acidification. Additionally, the EU Biodiversity Strategy for 2030 emphasizes the restoration of ecosystems, including marine vegetation like seagrasses and kelp, which help mitigate acidification by absorbing CO_2. Through these coordinated efforts, the EU is working to reduce the impact of ocean acidification and promote healthier marine environments [17].

Despite the work put into the cause, it isn't that effective. Solving this issue takes the collaboration of many parties and is a global effort. The impact of one organization can be recognized, but not enough.

3. Green energy

However, there is a "cure all solution" to these problems: To stop using fossil fuels. Since halting all forms of energy production is impossible, one should look towards the alternative to fossil fuels, which is clean or "green" energy, energy made using methods that don't release carbon dioxide.

3.1. Explanation of Green energy

Examples of green energy include solar power, captured through solar panels; wind energy, generated by wind turbines; hydropower, produced by harnessing flowing water in dams; geothermal energy, which uses heat from beneath the Earth's surface; and biomass, derived from organic materials such as wood, agricultural waste, or other renewable sources. These sources provide clean, renewable energy that also doesn't release a lot of carbon dioxide. Now, these forms of energy do have downsides. For example, wind, water and solar energy only work during certain periods of time, like if it is windy or if the sun is out. However, these issues have solutions, like storage for excess energy made by these forms of energy to fill the gap if the production of the energy isn't active.

The global transition to green energy is shaped by specific policies, financial incentives, and international agreements with the goal of reducing emissions and promoting renewable energy sources.

3.2. Policies

In terms of financial incentives, the U.S. government offers the Investment Tax Credit, which provides a 26% tax credit for solar installations. This has helped solar power grow by over 40% annually in recent years, with the solar industry now employing over 250,000 people in the U.S. alone. Similarly, the European Union has invested €30 billion in renewable energy research under its Horizon 2020 program, supporting advancements in technologies like offshore wind and solar power [19, 29].

Regulatory frameworks also play a substantial role. The Renewable Energy Directive (RED II), which came into effect in 2021, mandates that at least 32% of energy generated in the EU must come from renewable sources by 2030. This has led to an increase in the share of renewables in the EU's energy mix, with wind and solar accounting for 22% of electricity generation in 2020 [28, 29]. In China, the government's 14th Five-Year Plan for 2021-2025 sets ambitious goals, aiming to increase its renewable energy production by 1,200 gigawatts, including 450 gigawatts of wind power and 350 gigawatts of solar power [17].

International agreements, especially the Paris Agreement, have further propelled national policies. Under the agreement, nations pledged to keep global temperature increases well below 2 degrees celcius above pre-industrial levels. As a result, many countries have updated their national energy plans. For example, the U.S. rejoined the Paris Agreement in 2021, and President Biden's administration has since set a target of reducing U.S. greenhouse gas emissions by 50 to 52% by 2030, with a major focus on expanding clean energy [29].

Investments in renewable energy continue to surge, with global spending on clean energy technologies set to exceed USD 3 trillion by 2025, according to the International Energy Agency. This is more than double the investment in fossil fuel infrastructure, highlighting the increasing prioritization of green energy [31]. However, challenges remain, such as the global competitiveness of clean energy technologies. The European Commission's 2025 Progress Report notes that while renewable technologies are becoming cost-competitive, issues such as high energy prices and supply chain disruptions continue to affect the pace of transition [30].

In summary, the growth of green energy is driven by concrete policies, financial incentives, and international commitments, with specific examples showing substantial progress in countries like the U.S., EU member states, and China [31]. As investments continue to increase, overcoming remaining challenges will be key to accelerating the global shift toward sustainable energy.

3.3. Benefits of Transitioning

The benefits of green energy stems beyond climate change as well. Green energy offers benefits to the global economy by driving innovation, creating jobs, and fostering energy security. The transition to renewable energy technologies, such as wind, solar, and geothermal, has spurred the increase of new industries and job opportunities. For example, the global renewable energy sector employed over 11 million people in 2020, and the solar energy industry alone accounted for around 3.8 million jobs worldwide. As more countries invest in clean energy infrastructure, these industries continue to expand, contributing to economic growth. Moreover, green energy reduces reliance on fossil fuels, improving energy security and stabilizing economies by mitigating the volatility of oil and gas prices. It also attracts significant investments: global spending on renewable energy is expected to exceed USD 3 trillion by 2025, further boosting economic development. Ultimately, green energy is not only an environmentally responsible choice but also a crucial driver of long-term economic resilience and sustainability [13, 19, 23, 25, 30].

4. Conclusion

In conclusion, climate change has significant and far-reaching effects on the global economy, influencing industries, governments, and communities in both positive and negative ways. This paper found that while climate change poses major threats, such as economic instability, damage to infrastructure, and increased costs for disaster recovery, it also presents opportunities for innovation, growth in renewable energy, and advancements in sustainable technology. Overall, the impacts of climate change on the global economy are mostly negative, with some potential of gains within.

One limitation of this paper is that it relies on existing research, which may not capture the most recent developments in climate policy and economic adaptation. Additionally, the analysis is broad, lacking in-depth regional case studies. The next steps for this paper would involve conducting deeper regional analyses to understand how climate change impacts different economies uniquely. Future research could also incorporate real-time data, expert interviews, and case studies to provide a more comprehensive perspective.

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