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Decarbonizing our Environment: Advancing Sustainable Development through Policies and Strategies

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ABSTRACT

Decarbonization is a pivotal strategy for combating climate change and achieving global sustainability objectives. This research paper explores the multifaceted approaches necessary to reduce carbon emissions across key sectors by harnessing cutting-edge technologies, maximizing energy efficiency, and driving the transition to renewable energy source. The study highlights the critical role of decarbonization in justifying the adverse impact of climate change, global warming and ecological degradation while advancing sustainable development goals. Through a comprehensively analysis of technological advancements and policies, the paper identifies effective strategies and actionable solutions for minimizing greenhouse gas emissions. It emphasizes the importance of integrating support for policy, technological advancements, and teamwork contributes to major decreases in carbon footprints. By examining best practices and recommending future research directions, this study seeks to add to the important global decarbonization conversation while promoting environmental stewardship. This paper serves as an important resource for policymakers, researchers, and stakeholders, providing insight into the attainment of a sustainable and resilient future through the implementation of comprehensive decarbonization policies and strategies.

Keywords: *Decarbonization, Climate Change, Sustainability, Reducing Carbon Emissions, Greenhouse Gas Emissions, Environmental Degradation, Global Warming, Policy, Strategy, SDG, Resilient, Built-environment, Energy Efficiency, Sustainable Transportation, Transport Planning, Sustainable Industrialization.*

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CHAPTER ONE
INTRODUCTION

A. Background of Study:

➢ *Context*

Decarbonization refers to the method of minimizing carbon dioxide emissions, is pivotal in the global effort to achieve environmental sustainability. The earth faces the dire consequences of climate change, nations and industries are adopting various strategies to conversion towards a low-carbon financial system. Key strategies involve the integration of renewable energy sources, for example: air, solar, and waterpower, which contribute to a reduction in dependence on fossil fuels. Additionally, enhancing energy efficiency across sectors, such as in transportation and manufacturing, helps to lower carbon footprints. Moreover, encouraging sustainable land use and reforestation efforts helps in carbon sequestration, thereby mitigating climate impacts. To achieve true sustainability, a holistic approach that includes behavioral changes, innovation, and international cooperation is essential, ensuring a transition to a carbon-neutral future.

➢ *Brief History of the study*

The study on decarbonizing has developed over decades, focusing on reducing carbon dioxide emissions to combat climate change. The concept gained worldwide attention in the late 20th century; scientists have identified the destructive impacts of greenhouse gas emissions on the environment. The 1992 Rio Earth Summit marked a pivotal moment, bringing countries together to address climate change, the adoption of the Kyoto Protocol in 1997 resulted in the establishment of necessary emission mitigating targets for developed nations. In the 2000s, research intensified on renewable energy technologies such as solar, air and waterpower as alternatives to fossil fuels. The concept of CCS (Carbon Capture and Storage) also emerged, aiming to prevent CO_2 from entering the atmosphere. The 2015 Paris Agreement further accelerated the global commitment to decarbonizations, establishing ambitious objectives to restrict global temperature increases to less than 2℃ above pre-industrial levels. Today, the study of decarbonizing incorporates a multidisciplinary approach, integrating technological innovation, policy frameworks and sustainable practices, reflecting a concerted effort to achieve environmental sustainability and diminish the possessions of climate change. **(UNFCCC, 2015)**

B. Rationalization of Study

Decarbonizations are crucial because it addresses an urgent necessity to decrease greenhouse gas emissions, with a particular emphasis on carbon dioxide (CO2), which serves as the primary catalyst for global warming. As global temperatures rise due to excessive CO_2 emissions from burning fossil fuels, the consequences are severe: more common and strong natural disasters, increasing sea levels, and disruptions to ecosystems. These changes threaten human health, food security, and global economies. Addressing decarbonizations is essential to mitigate these risks, promoting a sustainable future necessitates a transition to cleaner power sources, enhancement of energy efficiency, and the implementation of sustainable practices transversely various industries. This shift is vital for protecting the environment and securing long-term economic and social stability. The rationale for studying decarbonizations lies in its potential to address the root cause of global warming by transitioning to low-carbon or carbon-neutral systems. As nations worldwide strive to meet the goal set by the Paris Agreement, which aims to edge worldwide temperature rise to glowing below 2℃, decarbonizations efforts are crucial for achieving these goals. **(IPCC, 2018)** Understanding the process, challenges, and opportunities associated with decarbonizations is essential for policymakers, businesses, and communities to develop policies and strategies for decreasing carbon footprints and promoting sustainable development.

C. Problem Statement

The burning challenge of decarbonization lies in transitioning from a fossil fuel-dependent global nation to a sustainable, low-carbon future. Fossil fuels remain the leading energy source, releasing vast amounts of CO2 and other GHGs into the atmosphere. This addiction intensifies global warming, causing environmental degradation, more common and severe disasters, and significant socio-economic disruptions. In spite of increasing awareness and global commitments to mitigate climate change, progress remains slowed down by economic, technological, and political barriers. Efficient policies and strategies are essential to reduce carbon emissions while ensuring energy security, fostering economic growth, and promoting social equity. This research explores actionable pathways and policy frameworks to accelerate decarbonization and create a sustainable future.

D. Objectives

➢ *Broader Objective*

The broader objective of this study is "to investigate the concept of decarbonizations, its significance in a sustainable future, policy research, and the strategies necessary for policy implementation."

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➢ *Specific Objectives*

- To analyze the current state of carbon emissions across various sectors.
- To identify the key challenges and barriers to decarbonizations.
- To find-out the technological, policy, and strategies for achieving the goal.
- To provide recommendations for policymakers, businesses, and individuals to support decarbonizations efforts.

E. Limitation of Study

This research has been done mainly based on secondary data. Collection of primary data was not possible due to several important reasons. First, direct observation or data collection was not possible due to lack of time. Second, the overall political situation in the country made it difficult to conduct research at the field level. Thirdly, the lack of modern equipment for monitoring has hindered the quality of research. In the future, if one wants to re-research this topic using modern monitoring equipment, it will be possible to improve the quality of the research. I am hopeful that by collecting primary data using advanced technology and tools, the research results will provide more accurate and in-depth analysis.

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CHAPTER TWO
LITERATURE REVIEW

A. Literature Review

Human activities contribute to the emission of carbon dioxide and other greenhouse gases into the atmosphere. Research indicates that the presence of CO_2 in the atmosphere is primarily a result of anthropogenic activities (e.g. burning fossil fuels to produce electricity, transport, and industrial processes). The analysis of various isotopes of carbon in atmospheric carbon dioxide (CO_2) enables researchers to discern the origins of this greenhouse gas. Measurements of carbon-13, 14, and 12, confirm that the rise in CO_2 concentrations since the year 1800 primarily stems from emissions associated with fossil fuel combustion and land-clearing activities. Electricity generation that relies on the incineration of fossil fuels constitutes the principal source of carbon dioxide emissions in Australia. In the Global context, approximately 36.8 billion metric tons ($GtCO_2$) in 2022.

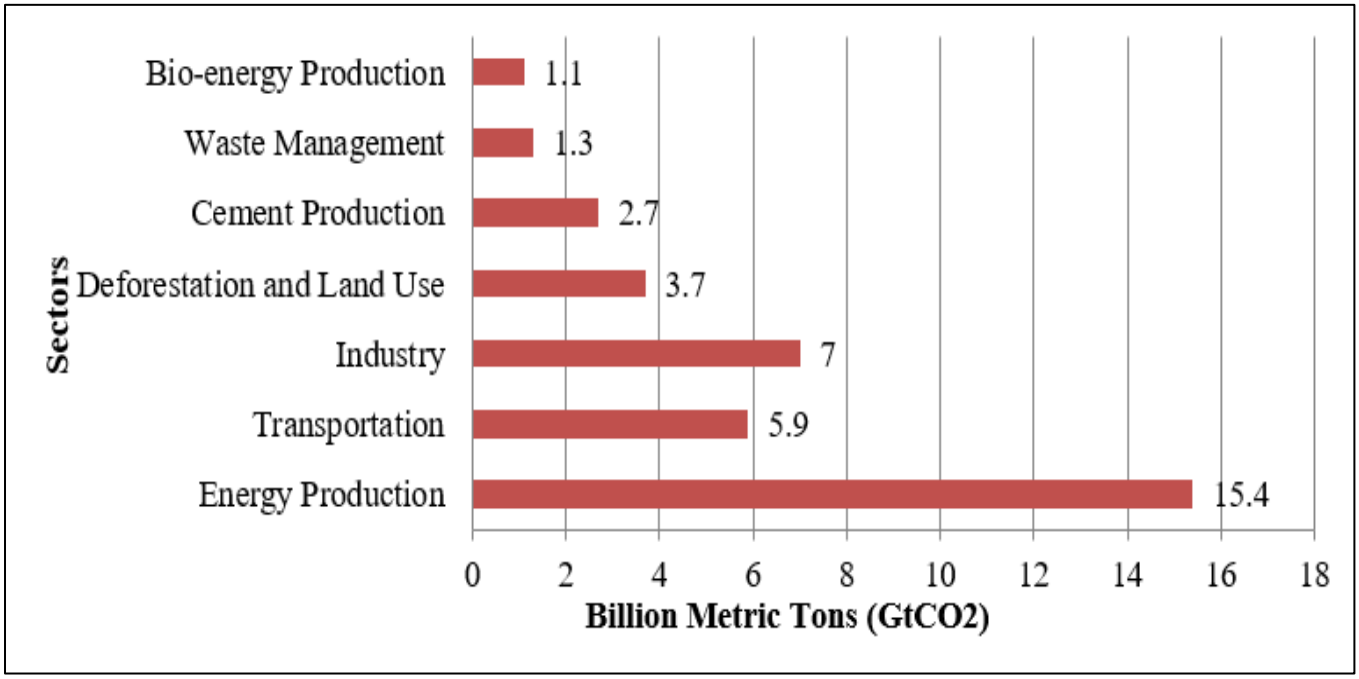

Chart 1: Sources of Global Carbon Emission 2022 **(IREA, 2023)**

The carbon cycle involves natural processes where carbon flows between the land, oceans, and living organisms. Land plants and ocean phytoplankton absorb CO_2 through photosynthesis, while soils also store and emit carbon. Oceans absorb about 30% of excess atmospheric CO_2, resulting in ocean acidification. Overall, Earth's systems absorb 190.2 billion tones of CO_2 annually. Flora and fauna, including humans, release CO_2 through respiration, and when organisms die, their stored carbon is released. Natural sources contribute an equal amount of 190.2 billion tones of CO_2 each year from processes like respiration, decay, forest fires, and volcanic eruptions. Human activities, particularly fossil fuel combustion, add 9.1 billion tones of CO_2 annually, with plants and soils absorbing 2.8 billion tones and oceans taking in 2.2 billion tones. Consequently, 4.1 billion tones of CO_2 remain in the atmosphere, increasing its concentration. **(ESSD 2022).**

The global carbon budget (GCB) delineated herein pertains to the mean values, variations, and trends associated with the perturbation of carbon dioxide (CO2) in the atmosphere, referencing the onset of the Industrial Era. This discussion outlines the components of the global carbon cycle throughout the historical period, with an emphasis on the most recent decade (2011–2021, and 2022). The need to quantify CO2 emissions from individual activities, the increase rate of atmospheric CO2, and changes in carbon storage in land and ocean reservoirs. It emphasizes the importance of understanding the perturbation budget over time and natural carbon cycle variability to assess the response of natural sinks to climate changes, CO_2 levels, and land-use changes. This understanding is crucial for quantifying emissions aligned with climate stabilization targets and presents a schematic representation of the global carbon cycle perturbation due to anthropogenic activities for the decade 2012-2021. **(ESSD 2022)**

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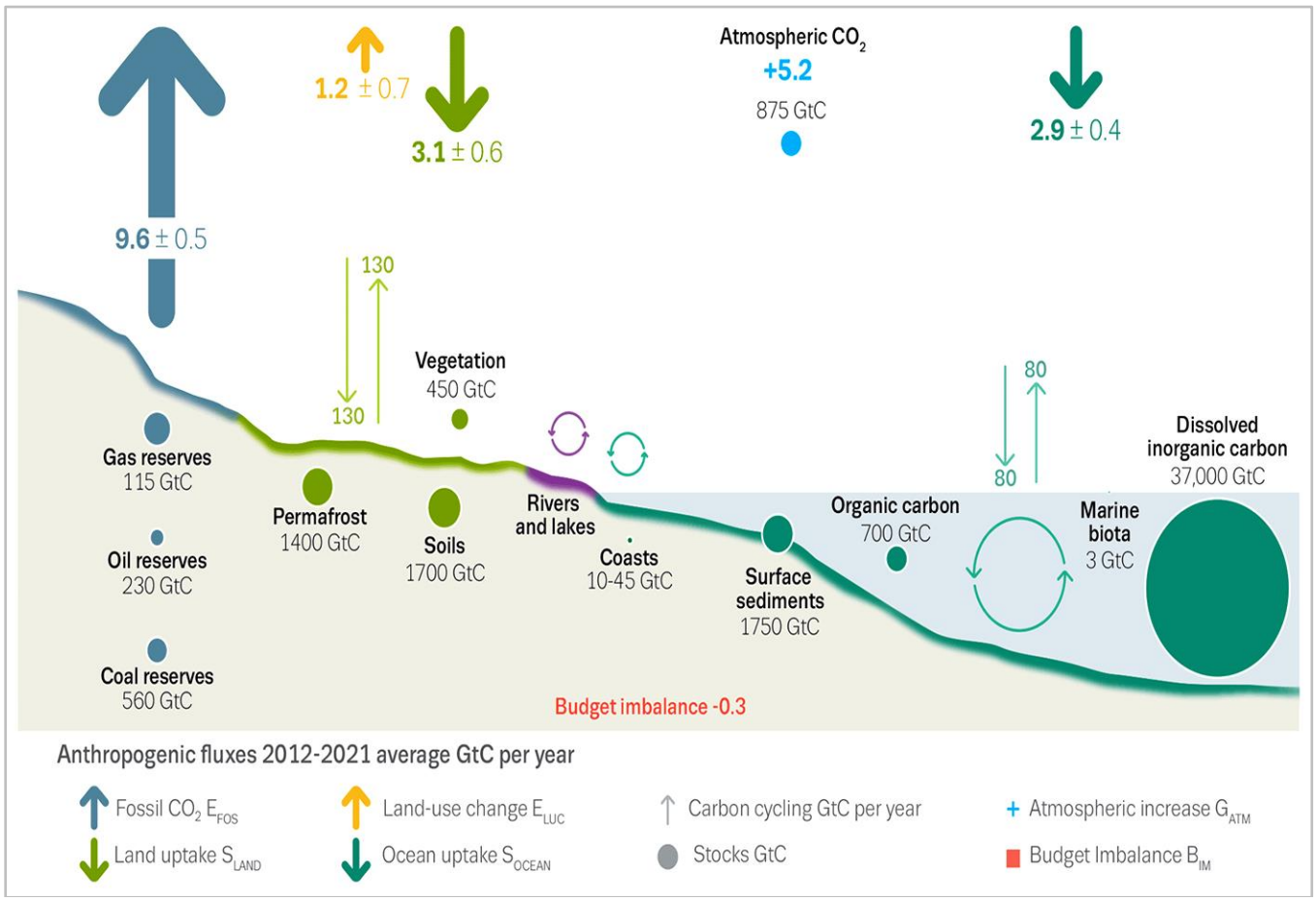

Fig 1: Global Carbon Budget 2022 **(ESSD, 2022)**

Emissions of CO_2 from fossil fuels create the major involvement to climate change. About 90% of the world's carbon emissions approach from the flaming of fossil fuels, mainly for electricity, heat and transport. Industrialized nations constitute merely 20% of the worldwide population, yet they are responsible for 80% of the increasing carbon dioxide emissions since the onset of the Industrial Revolution. A review of the per capita carbon emissions of Bangladesh and its neighboring countries reveals:

Table 1: Per Capita Carbon Emissions of Bangladesh and its Neighboring Countries (CO_2 Emission World Meter, 2022)

Country	CO2 Emissions (tons, 2022)	Population (2022)	Per Capita (tons, 2022)	Share of World (%)
Bangladesh	10,90,75,300	16,93,84,897	0.64	0.28
India	269,30,34,100	142,54,23,212	1.89	6.99
Pakistan	19,93,29,850	24,37,00,667	0.82	0.52
China	1266,74,28,430	142,51,79,569	8.89	32.88
Sri Lanka	1,85,35,920	2,28,34,965	0.81	0.05
Myanmar	3,73,94,010	53756787	0.7	0.10
Japan	108,26,45,430	124997578	8.66	2.81

The major sources of CO_2 emissions in the context of Bangladesh are power generation, transport, industry, agriculture, deforestation, etc. The use of natural gas, oil, and coal in power generation is the main cause of CO_2 emissions. The transport division also makes a major contribution due to the consumption of petrol and diesel from vehicles. The use of coal and other fuels in cement, brick kilns, and other heavy industries emits large amounts of CO_2. Chemical fertilizers and cultivation in the agricultural sector cause some CO_2 emissions. Besides, deforestation and land-use transform are also sources of CO_2 emissions. With the economic development of Bangladesh, emissions from these sectors are increasing, creating environmental challenges.

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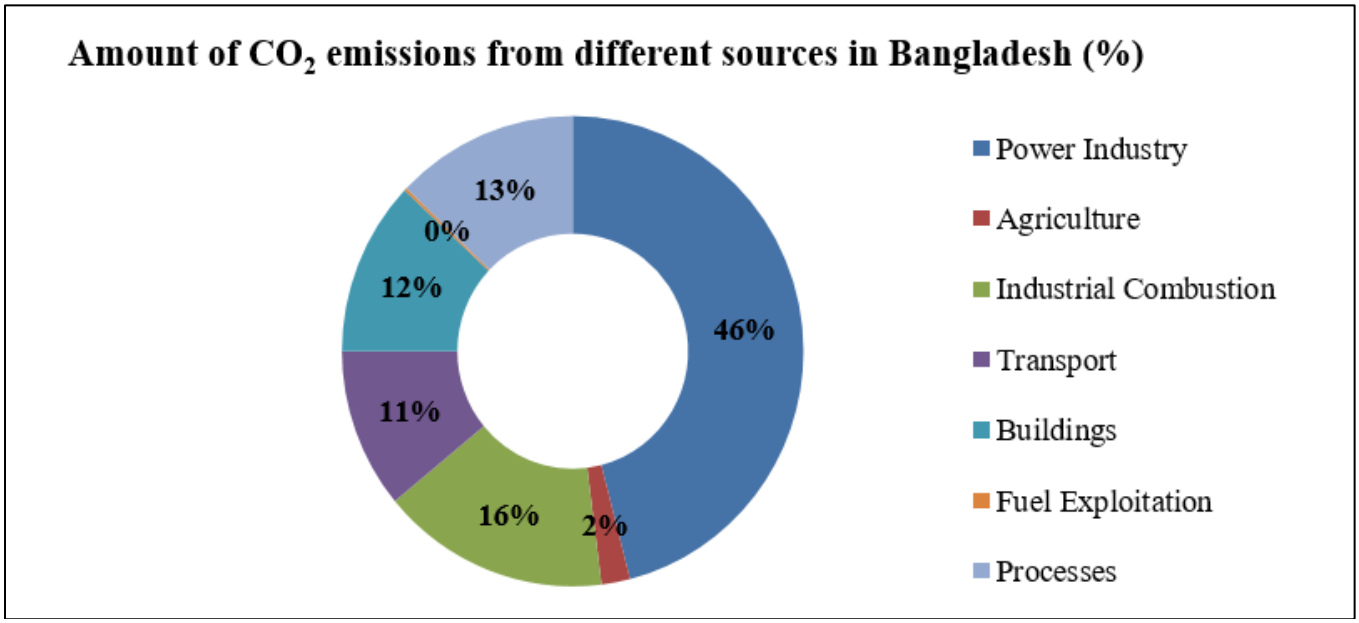

Chart 2: Amount of CO_2 Emissions from different Sources in Bangladesh 2011-2021 (Bangladesh CO_2 Emission, 2022)

In Bangladesh, like other industrialized countries, the industrial sector emits a significant amount of carbon every year. According to the study, about 62% of the country's total carbon emissions come up from Power Industry and Industrial Combustion in the industrial sector alone. The emissions result from the flaming of fuels like coal, natural gas, and oil for electricity production. Economic growth in Bangladesh is accompanied by industrial expansion, and carbon emissions are increasing in tandem with it. In particular, heavy industry, such as steel, cement, bricklaying and textile industries release large amount of carbon. Besides, the emission levels are also increasing due to the old and inefficient technology used in the production process of industrial plants. In this situation, it is important to emphasize the exercise of sustainable technologies and renewable energy source to protect the environment. If industrial carbon emissions are not brought under control, Bangladesh's environmental problems may deepen in the future.

If we look at the carbon emission levels of the past few years in the context of Bangladesh, we get the following chart:

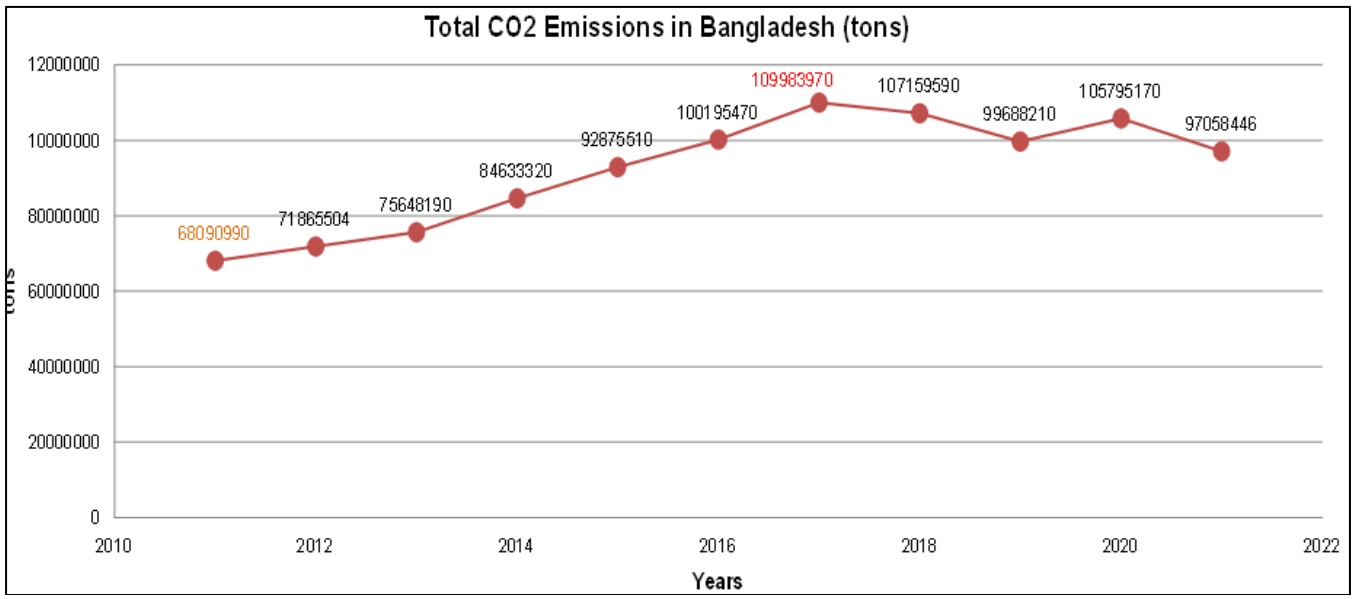

Chart 3: Total CO_2 Emission in Bangladesh from 2011 to 2021 (Bangladesh CO_2 Emission, 2022)

According to the above information, the highest carbon emission in 2017 was in Bangladesh. After that, it decreased slightly during the Covid period but its continuity could not be maintained. Later due to the socio-political reasons of Bangladesh and shortage of dollars in the bank, the industrial sector is expected to experience a slowdown, which may lead to a reduction in carbon emissions. Some of our country's initiatives in view of the SDG goals have also given us hope, if we proceed with the right strategy, it is possible to reduce this increase in carbon emissions.

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B. Conceptualization and Operationalization of Decarbonizations

➢ *Conceptualization*

Decarbonizations refer to the process of reducing CO_2 emission across different sectors, mainly those that are seriously dependent on fossil fuels. The concept is basically aligned with the overarching objective of addressing climate change through the evolution to a low-carbon economy. **(IEA, 2020)** The primary focus of decarbonization is on minimizing the CO_2 footprint of human activity to curb the adverse effects of global warming. Decarbonization is conceptualized as a multifaceted approach that involves a combination of technological innovation, policy intervention, and behavioral change. At its core, it seeks to shift the global economy from one that is heavily dependent on carbon-intensive energy sources like oil, coal, and natural gas, to one that relies on renewable energy sources. This transition also includes civilizing energy efficiency, attractive carbon storage technologies, and promotes sustainable practices in different field. **(IEA, 2020)** The concept of decarbonization is connected to the circular economy, which focuses on reusing and recycling resources to minimize waste and reduce the need for new materials. This approach lowers carbon emissions and supports economic sustainability by fostering new jobs and industries in green technologies.

➢ *Operationalization*

Operationalization of decarbonizations involves translating the concept into concrete actions, policies, and strategies, which can implemented across various sectors and levels of society. This process requires a coordinated effort among individuals, governments, and businesses to achieve measurable reduction in carbon emissions.

➢ *Policy and Regulation*

Governments play an important role in Operationalization of decarbonizations by enacting policies and regulations that set targets for carbon reduction. Carbon-pricing mechanisms, like carbon duties and cap-and-trade systems, propose fiscal incentives for businesses to cut their emissions. These strategies are designed to encourage more sustainable practices and promote environmental responsibility. Governments can also establish renewable energy targets, promote energy efficiency standards, and invest in research, analysis, and development for eco-friendly technologies.

➢ *Technological Innovation*

The advancement and implementation of new technologies play a key role in the efforts toward decarbonization. This encompasses improvements in renewable energy technologies, including the expansion of more efficient solar panels and wind turbines. Additionally, innovations in energy storage are essential for effectively managing the variable nature of alternative energy sources. Carbon storage technology, which aim to capture CO_2 emission from industrial processes and securely store them underground, are also significant in mitigating emissions from sectors that present challenges for decarbonization, such as cement and steel production.

➢ *Infrastructure Development*

The development and enhancement of infrastructure play a major role in the decarbonization process. This entails the expansion of the electric grid to facilitate an improved integration of renewable energy sources, the advancement of public transportation systems to decrease the dependency on personal vehicles, and the establishment of supportive infrastructure for electric vehicles (EVs), including the installation of charging stations. Additionally, the incorporation of smart grids and digital technologies can be leveraged to optimize energy consumption and reduce waste.

➢ *Corporate Responsibility*

Organizations play a vital role in the operationalization of decarbonization through the implementation of sustainable practices aimed at reducing their carbon emissions. This may encompass a transition to renewable energy sources, enhancements in energy efficiency across operations, and investments in carbon offset initiatives. Furthermore, companies are encouraged to establish science-based targets for carbon reduction and to transparently communicate their progress to stakeholders.

➢ *Public Engagement and Education*

Engaging the public and fostering awareness regarding the significance of decarbonization is essential for its effective implementation. This process includes educating individuals about the ramifications of their choices on carbon emissions and promoting behavioral changes, such as decreasing energy consumption, embracing sustainable transportation alternatives, and endorsing environmentally friendly products and services.

➢ *International Collaboration*

Decarbonization constitutes a formidable global challenge that necessitates international collaboration. Nations need to engage in cooperative efforts to exchange knowledge, technologies, and best practices, as well as to assist developing countries in their transition to low-carbon economies. Global frameworks, such as the Paris Agreement, are instrumental in establishing international targets and guidelines for effective decarbonization initiatives.

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CHAPTER THREE
METHODOLOGY

The methodology of this study "Decarbonizing our Environment: Advancing Sustainable Development through Policies and Strategies" will systematically analyze the challenges associated with promoting environmental sustainability in our future and try to find some strategies for moving towards a sustainable future.

Fig 2: Methodology of the Study

A. Study Types

In this study, I will collect data from Secondary sources and analyze that data through various tools to fulfill the objectives of my study.

B. Data Collection

Data will gather information from various Secondary sources like books, articles, and websites.

C. Data Shorting

After completing the data collection phase of this study, the gathered data will be carefully organized and short in the specified location to facilitate efficient data analysis to get the objectives.

D. Data Analysis

In this study, data will be analyzed by applying different tools (SWOT, PESTEL, Causes and Effect, etc.) of data analysis after getting data from Secondary Data sources to finalized the objectives of the study.

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CHAPTER FOUR
CONTEXT ANALYSIS

A. SWOT Analysis of Decarbonization

Fig 3: SWOT Analysis of Decarbonizations

➢ *Strength:*

- Rapid advancements in renewable energy technologies make decarbonization increasingly feasible and cost-effective.
- Many companies are adopting sustainability practices and setting ambitious net-zero goals, helping drive decarbonization across industries.
- Governments worldwide are implementing stricter environmental regulations and incentives (carbon taxes, subsidies for green tech, etc.) to push industries toward decarbonization.
- Investments in sustainable infrastructure (smart grids, EV charging networks, etc.) support the shift to low-carbon energy and transportation systems.
- Global agreement like the "Paris Climate Accord" present frameworks for countries to team up on reducing emissions, sharing knowledge, and funding.
- Growing awareness and concern about climate change are increasing public support for decarbonization initiatives, driving policy changes and sustainable consumption patterns.

➢ *Weakness:*

- The transition to decarbonize energy systems repeatedly requires significant truthful investment in technology, development, and education.
- Some sectors (e.g., heavy industry, aviation, etc.) lack matures technologies for full decarbonization, which slows down the transition.
- Insufficient infrastructure for renewable energy production and distribution (e.g., outdated grids, limited EV charging stations, etc.) hampers widespread adoption.
- Fragmented or inconsistent policies across regions, countries, and industries can create barriers to cohesive decarbonization efforts.
- Some companies may engage in "green washing," misleading the public about their sustainability efforts, which can undermine true progress.
- In some areas, there is public resistance to decarbonization efforts, particularly if they are perceived as threatening jobs or economic growth in carbon-intensive industries.

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➢ *Opportunities:*

- Opportunities for breakthroughs in renewable energy generation, storage, and transmission (e.g., hydrogen power, nuclear fusion, etc.) can accelerate decarbonization.
- The development of green industries can create millions of new jobs in renewable energy, infrastructure, and sustainable transportation sectors.
- Increased opportunities for international collaboration and funding through global climate funds and initiatives can help developing nations decarbonizes.
- Expanding electric vehicle (EV) adoption and developing carbon-neutral transportation infrastructure offer significant opportunities for reducing emissions.
- Companies leading in decarbonization efforts can enhance their reputations, attract investors, and tap into growing markets for green products and services.
- Collaborations between governments, NGOs, and private firms can drive large-scale decarbonization projects, especially in urban development and energy sectors.

➢ *Threats:*

- Decarbonization can lead to short-term economic disruption, particularly in carbon-intensive industries, leading to job losses and resistance from affected sectors.
- Governments heavily reliant on fossil fuel industries may resist decarbonization policies or prioritize economic growth over climate action.
- Over-reliance on emerging technologies (like carbon capture or nuclear) that are not yet fully viable may delay the transition to proven low-carbon solutions.
- Developing countries may struggle to afford decarbonization efforts, creating inequalities between nations and potentially slowing global progress.
- Slow progress in replacing fossil fuel-based infrastructure with renewable alternatives, especially in regions dependent on coal, oil, and natural gas, threatens decarbonization goals.
- If decarbonization efforts do not keep pace with climate change, the effects of Global Warming could make mitigation efforts harder and more costly.

B. PESTEL Analysis of Decarbonization

The PESTEL analysis in this study highlighted a wide range of external factors influencing the decarbonization movement. It provides a comprehensive structure for analyzing the global conversion towards a low-carbon economy.

Table 2: PESTEL Analysis

Factors	Issues
Political Impacts	• Shift in Global Power Dynamics • Green Energy Diplomacy • Economic Policy Shifts • Energy Security • Climate Change Legislation
Economical Impacts	• Transition Costs • Job Creation and Loss • Energy Price Instability • Innovation and Economic Growth • Global Trade Shifts
Social Impacts	• Job Displacement • Energy Equity • Public Health Improvements • Climate Migration • Behavioral Shifts
Technological Impacts	• Innovation in Clean Technologies • Competition in Green Tech Markets • Digitalization of Energy Systems • Technology Transfer and Diplomacy • R&D Policy Shifts
Environmental Impacts	• Climate Policy Reform • Biodiversity Protection

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	• Land Use Conflicts • Carbon Taxation • Global Climate Leadership
Legal Impacts	• Climate Law Enforcement • Corporate Liability • Energy Sector Reforms • Intellectual Property (IP) in Green Tech • International Compliance

➢ *Political Impacts:*

- Decarbonization reduces dependence on fossil fuels, diminishing the geopolitical influence of oil-rich nations and empowering countries leading in renewable energy technologies.
- Nations investing in clean energy infrastructure may leverage their advancements for diplomatic influence, fostering new alliances and collaborations.
- Governments must create policies to manage the transition to green energy, balancing job losses in traditional energy sectors with the growth of green jobs.
- Countries can enhance energy independence through local renewable energy sources, reducing vulnerability to global oil market fluctuations.
- Decarbonization pressures political systems to enact stricter climate policies, which can lead to political debates, regulatory changes, and potential conflicts between pro-environment and business-as-usual lobbies.

➢ *Economical Impacts:*

- Decarbonization requires substantial speculation in renewable energy development, leading to short-term economic challenges, especially for developing nations dependent on fossil fuels.
- While decarbonization generates new jobs in the renewable energy division, it also causes job-losses in traditional energy industries like coal, oil, and gas, leading to regional economic disparities.
- Primary costs of transitioning to renewable energy might cause fluctuations in energy prices, affecting both consumers and industries that rely on stable energy costs.
- Investment in green technologies can spur innovation, creating new industries and dynamic economic growth, particularly in the fields of energy storage, electric vehicles, and sustainable infrastructure.
- Countries leading in clean energy technologies may dominate global trade, while those lagging behind face economic decline as demand for fossil fuels decreases.

➢ *Social Impacts:*

- Decarbonization can lead to job losses in fossil fuel industries, affecting communities dependent on coal, oil, and gas, causing social unrest and the need for retraining programs.
- Access to renewable energy may widen the gap between wealthy and low-income communities, as the transition could be costly, leading to unequal energy access and affordability issues.
- Reduced air pollution from fossil fuel combustion can lead to significant improvements in public health, decreasing respiratory illnesses and reducing healthcare costs.
- As decarbonization, efforts aim to mitigate climate change, communities already affected by rising sea levels and extreme weather may still face displacement, leading to social tensions and migration crises.
- Public attitudes towards consumption, transportation, and energy use will likely evolve, as societies adopt more sustainable lifestyles, driven by policies and awareness of environmental impacts.

➢ *Technological Impacts:*

- Decarbonization drives rapid advancement in renewable energy technologies like solar, air, and battery storage, reshaping political agendas around research funding and energy independence.
- Countries competing to lead in green technologies may experience shifts in political priorities, with increased focus on investing in tech sectors to gain global dominance.
- The integration of smart grids, AI, and IoT in managing energy efficiency requires political frameworks for data security, privacy, and infrastructure modernization.
- Decarbonization pressures wealthier nations to share clean energy technologies with developing countries, influencing global diplomatic relations and trade agreements.

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- Governments will prioritize research and development policies to foster breakthroughs in carbon capture, green hydrogen, and nuclear fusion, affecting national strategies for long-term economic competitiveness.

➢ *Environmental Impacts:*

- Decarbonization pushes governments to enact stricter environmental regulations and policies, aiming to reduce carbon emissions and meet international climate commitment.
- The transfer from fossil fuels helps reduce habitat destruction and pollution, leading to political initiatives focused on conserving ecosystems and endangered species.
- Expanding renewable energy projects like those that wind farms and solar plants can lead to political disputes over land use, balancing development with the preservation of natural areas.
- Governments may implement carbon taxes or cap-and-trade systems, creating political debate over the economic burden on industries versus the environmental benefits.
- Nations excelling in decarbonization can assert themselves as global leaders in environmental governance, influencing international negotiations on climate action and sustainability.

➢ *Legal Impacts:*

- Decarbonization leads to the creation and enforcement of more stringent environmental regulations, requiring businesses and industries to meet carbon reduction targets or face penalties.
- Companies may face increased legal scrutiny for their carbon emissions, with growing accountability for environmental harm, leading to more lawsuits and pressure for sustainable practices.
- Legal frameworks governing energy production will evolve, with new regulations promoting renewable energy development and phasing out fossil fuel dependence, affecting utilities and energy companies.
- Legal disputes over patents and IP rights may arise as companies compete to develop cutting-edge clean technologies, influencing international trade and innovation.
- Countries will be required to align national laws with global climate agreements leading to legal reforms aimed at reducing emissions and enhancing sustainability efforts.

C. Causes and Affect of Carbon Emission:

➢ *Causes of Carbon Emission:*

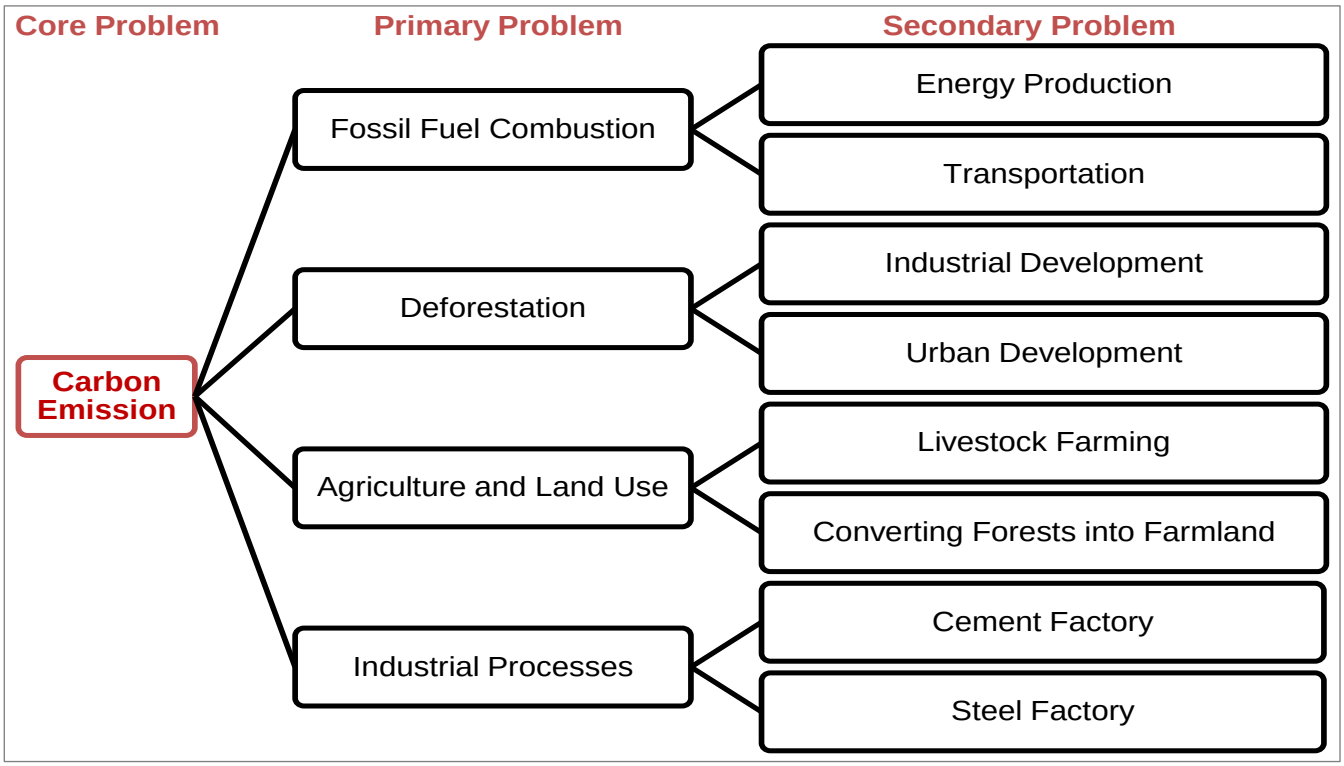

Fig 4: Problem Tree of Carbon Emission

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To effectively reduce carbon pollution in the atmosphere, it is crucial to conduct a thorough analysis of its sources and understand its impact on the environment. This study aims to identify the root causes and consequences of carbon pollution.

- **Fossil Fuel Ignition:** The burning of fossil fuels, including natural gas, coal, and oil, serves as the primary contributor to carbon emissions. This process encompasses various activities, such as electricity generation, heating, and the operation of vehicles, which are integral to energy production, transportation, and industrial processes.
- **Deforestation:** Plants absorb CO_2, so deforestation reduces the planet's capability to capture and store carbon. The clearing of forests for agricultural purposes or urban development results not only in the loss of their capacity to sequester carbon but also in the release of the carbon that has been stored within the trees.
- **Agriculture and Land Use:** Agricultural activities, especially livestock farming, contribute considerably to greenhouse gas emissions during the release of methane and nitrous oxide (from fertilizers). Land-use changes, like converting forests into farmland, or urban development also contribute to increased carbon emissions.
- **Industrial Processes:** The production of materials such as cement, steel, and chemicals generates huge amount of CO_2 and other greenhouse gases. These processes are energy-intensive and often rely on fossil fuels, adding to the overall emissions.

➢ *Affect of Carbon Emission:*

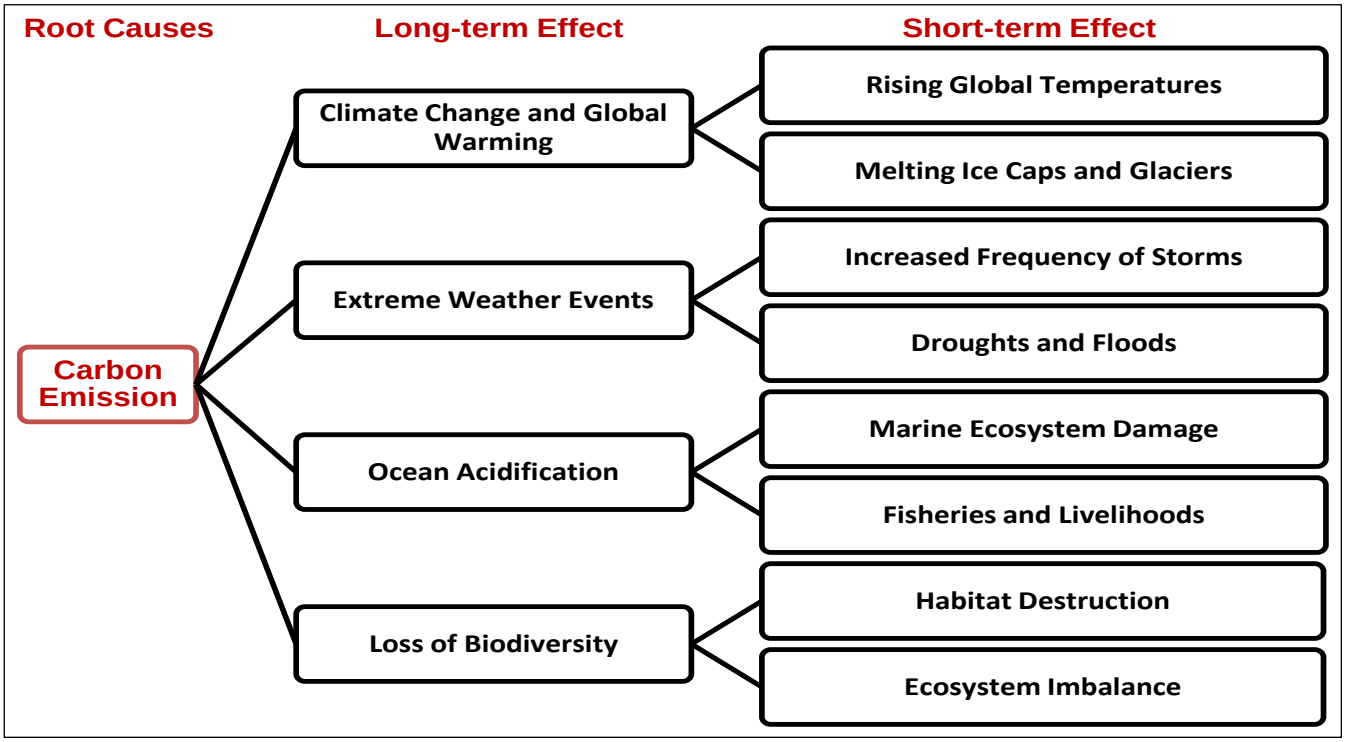

Fig 5: Effects of Carbon Emission

- *Climate Change and Global Warming*

✓ **Increasing Global Temperatures:** The increase in carbon emissions is resulting in the entrapment of heat within the Earth's atmosphere, consequently leading to a rise in average global temperatures. This phenomenon is producing frequent and rigorous heat waves, altering existing weather patterns, and extending summer seasons.
✓ **Melting Ice Caps and Glaciers:** The rising temperatures have been instrumental in the melting of polar-ice caps and glaciers, which contributes to the elevation of sea levels and the degradation of habitats for polar species.

- *Extreme Weather Events*

✓ **Increased Frequency of Storms:** Higher carbon emissions contribute to more intense and frequent storms, hurricanes, and typhoons. Warmer oceans feed these storms, increasing their destructive power.
✓ **Droughts and Floods:** Shifting weather patterns due to carbon emissions cause more strong droughts in several regions and severe flooding in others, disrupting agriculture and leading to water shortages.

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- *Ocean Acidification*

- **Marine Ecosystem Damage:** The oceans take in a considerable amount of CO_2 emissions, which results in acidification. This harms marine organisms, particularly coral reefs, shellfish, and plankton, which are vital parts of the marine food web.
- **Fisheries and Livelihoods:** Ocean acidification negatively affects fisheries, affecting food security and the livelihood of millions of citizens who depend on marine resources.

- *Loss of Biodiversity*

✓ **Habitat Destruction:** Climate change, determined by carbon emissions, leads to habitat loss for many species. Shifts in temperature and modifications to ecosystems compel both flora and fauna to either migrate or adapt; however, numerous species are unable to cope with the rapidity of these changes, ultimately leading to their extinction.
✓ **Ecosystem Imbalance:** As species are lost or displaced, ecosystems become imbalanced. This can lead to the collapse of food chains, affecting not just wildlife, but also human agricultural systems that rely on pollinators and healthy ecosystems.

D. Challenges of Decarbonizations:

Despite the growing need for decarbonization, major challenges persist. Dependence on fossil fuels, high-costs of transitioning to renewable energy, and insufficient infrastructure for low-carbon technologies hinder progress. Global disparities in resources make it difficult for developing nations to implement decarbonization strategies, as economic constraints limit their ability to invest in clean energy. Some problems, challenges and barriers in decarbonizations across various sectors are given below:

➢ *Power & Energy Sector:*

The energy sector continues to be the predominant source of global carbon dioxide emissions, primarily due to the persistent dependence on fossil fuels, including oil, coal, and natural gas. Although there has been a notable increase in the adoption of renewable energy sources, fossil fuels still represent a substantial portion of global energy production, resulting in elevated carbon emissions. In developing countries like Bangladesh, this sector has the highest carbon emissions every year.

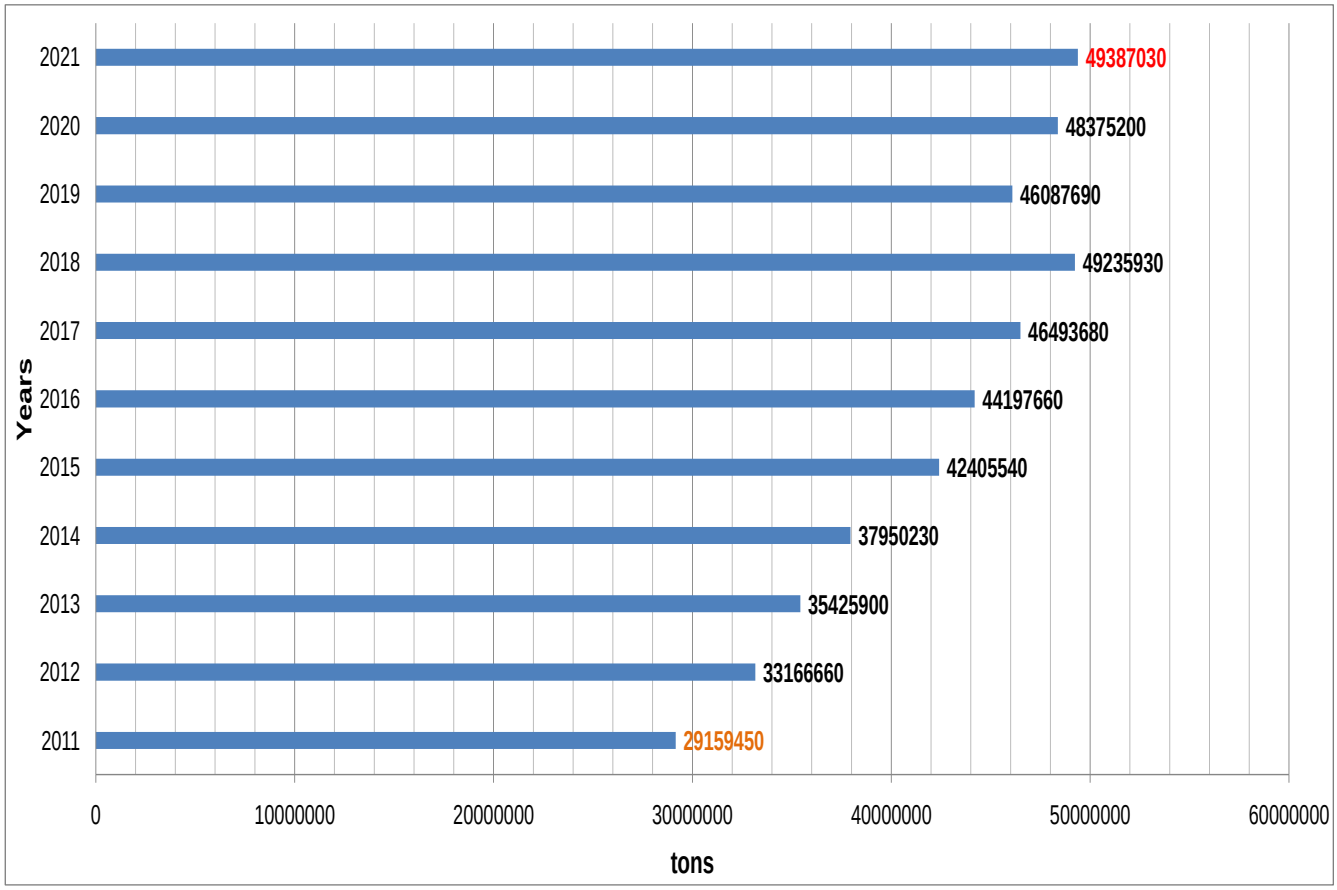

Chart 4: CO_2 Emissions Due to Power Industry in BD (Bangladesh CO_2 Emission, 2022)

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From the study, we get a picture of CO_2 emission due to the power industry in Bangladesh from the year 2011 to 2021, where it is seen that in 2011 there were 29159450 tons of carbon emission in this sector alone which increased to 49387030 tons in 2021. In the last 10 years, there has been a total of 461884970 tons of carbon emissions in Bangladesh, which is 46%, compared to other sectors. **(Bangladesh CO_2 Emission, 2022)** The conversion to low-carbon technology and practices repeatedly requires significant truthful investment, which can be prohibitive for many businesses and rising nations. The expense associated with building renewable energy infrastructure, energy-efficient technologies, and research and development (R&D) poses a challenge.

➢ *Transportation Sector:*

The transportation sector is heavily dependent on oil, with internal combustion engines dominating the global vehicle fleet. This leads to substantial CO_2 emissions, particularly from road transport, aviation, and shipping. Between 2011 and 2021, the number of private cars in Bangladesh saw a significant increase, driven by factors such as rising incomes, urbanization, and an expanding middle class. As per the BRTA (Bangladesh Road Transport Authority), the number of registered private cars grew from approximately 2, 21,000 in 2011 to over 5, 00,000 by 2021, marking a substantial rise in private vehicle ownership **(BRTA, 2021)**. This growth was concentrated primarily in Dhaka, where increasing economic opportunities and a lack of reliable public transportation spurred higher demand for private cars **(Rahman & Salim, 2020).** This rapid increase has raised concerns about worsening traffic congestion, air pollution, and urban infrastructure strain **(World Bank, 2020).**

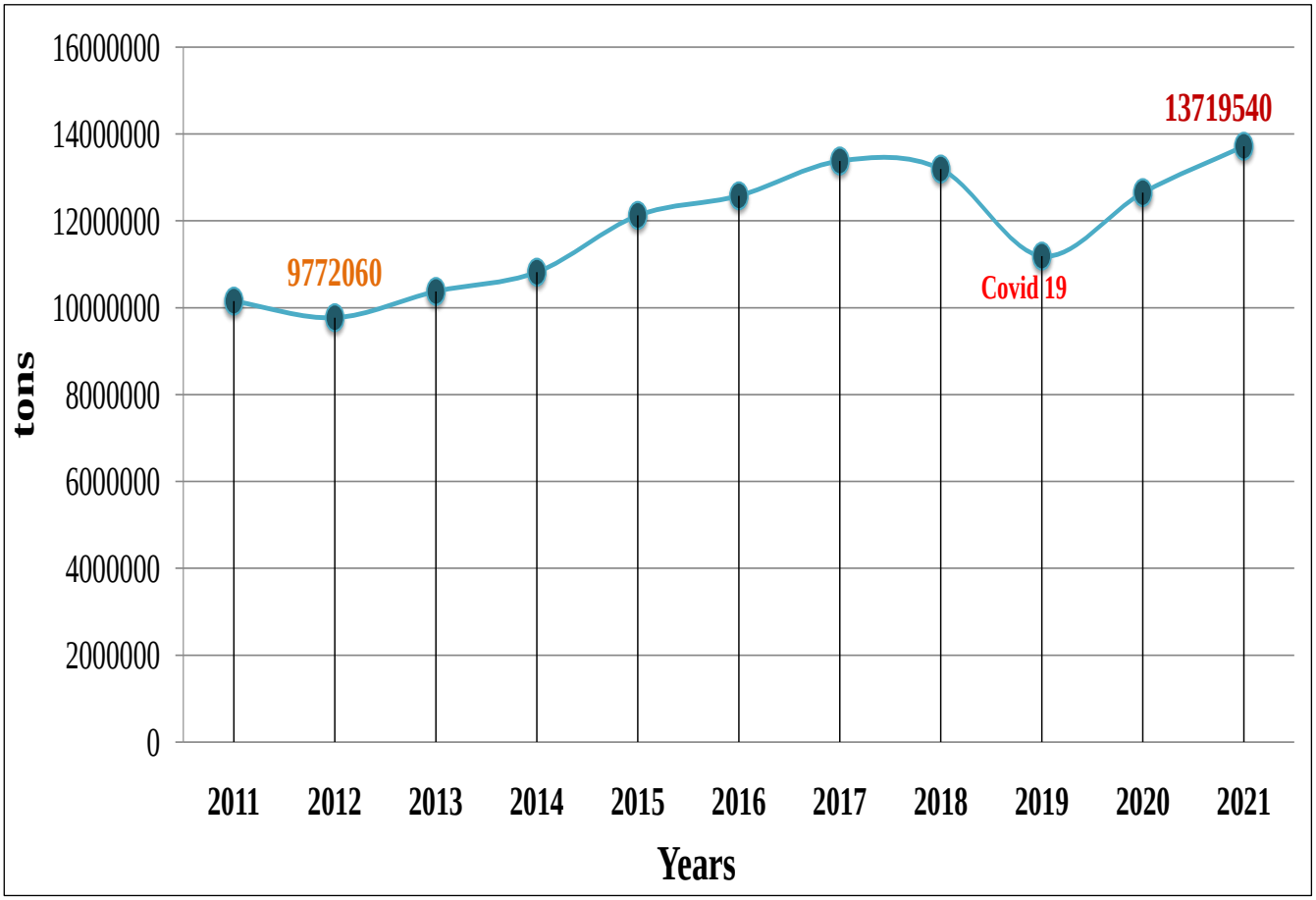

Chart 5: CO_2 Emissions from Transport Sector in BD **(Bangladesh CO_2 Emission, 2022)**

➢ *Industrial Sector:*

Decarbonization in the industrial sector faces challenges like high-energy demand, dependence on fossil fuels, and the high cost of clean technologies. Industries such as cement, steel, and chemicals have complex processes that are difficult to electrify or decarbonizes.

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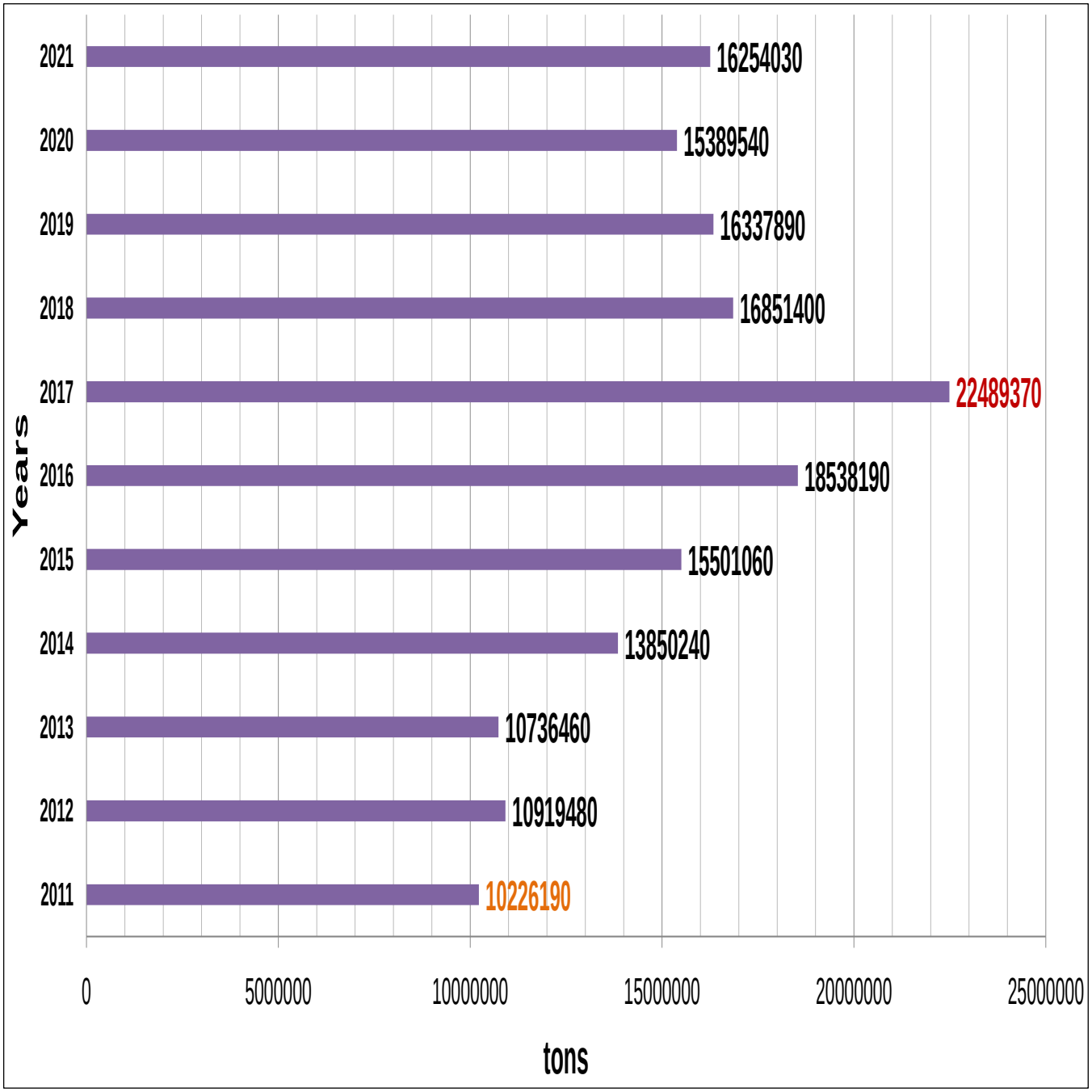

Chart 6: CO_2 Emissions from Industrial Combustion in BD **(BD CO_2 Emission, 2022)**

Additionally, there are barriers like limited access to renewable energy, lack of infrastructure, and regulatory challenges. Transitioning to low-carbon solutions requires significant investment, technological innovation, and collaboration across sectors, making the process slow and complex.

- *Agriculture and Land Use:*

Deforestation, land degradation, and unsustainable agricultural practices significantly contribute to carbon emissions. Decarbonizing agriculture and land use is challenging due to the sector's reliance on natural processes that are hard to control. Agriculture plays a substantial role in the generation of greenhouse gas emission, mainly through the discharge of methane from livestock and nitrous oxide from the appliance of fertilizers, and deforestation for land use. Reducing emissions requires changes in farming practices, such as adopting sustainable agriculture, reducing livestock production, and restoring forests. However, the lack of clear policies, financial incentives, and technological solutions further complicate efforts to decarbonizes this sector.

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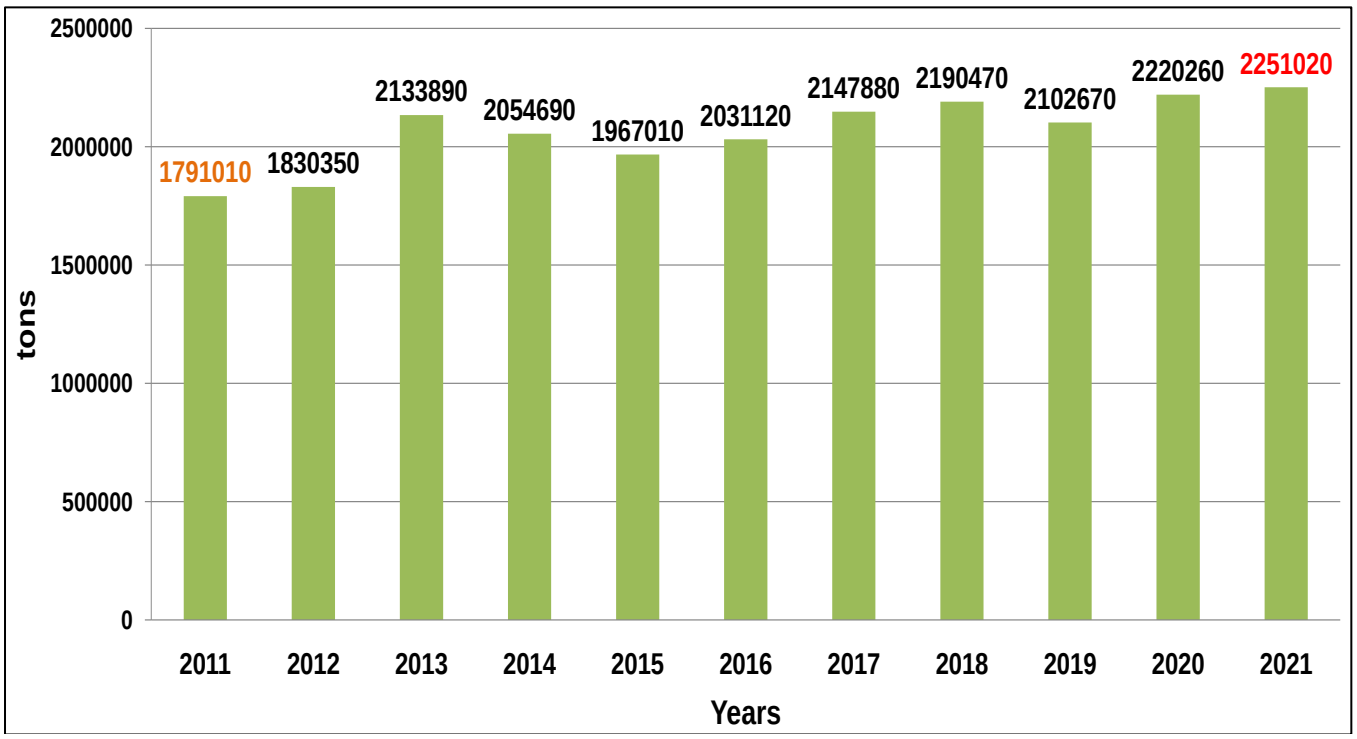

Chart 7: CO_2 Emissions from Agricultural Activities in BD **(BD CO_2 Emission, 2022)**

➢ *Technological Challenges:*

Decarbonizations face significant technological challenges, particularly in scaling up and deploying clean technologies. Many industries, such as heavy manufacturing, rely on processes that are difficult to electrify or decarbonizes, like high-temperature operations.

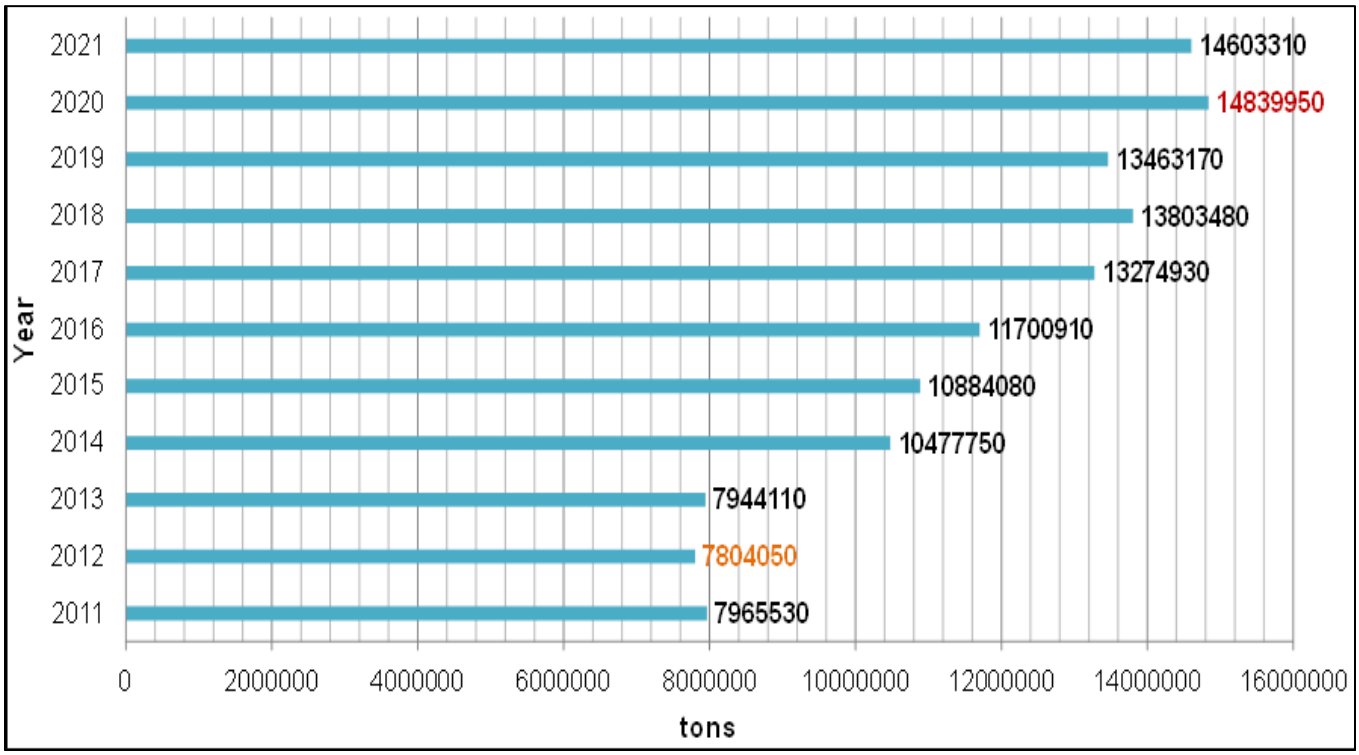

Chart 8: CO_2 Emissions from Industrial Processes in BD **(BD CO_2 Emission, 2022)**

Current renewable energy sources, while advancing, still struggle with issues like intermittency and storage capability. Carbon capture and storage technology are in their infancy and are costly. Innovations like green hydrogen and advanced batteries are promising but require substantial research, development, and investment to become commercially viable on a large scale.

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➢ *Challenges of Building & Construction Sector*

The building sector in Bangladesh is experiencing a concerning rise in CO_2 emissions. This increase can be attributed to urbanization, population growth, and the resulting heightened demand for residential, office, and commercial buildings. Research indicates that almost 12% of Bangladesh's total CO_2 emissions stems from the construction and building sector, particularly due to the substantial CO_2 emissions generated by cement and brick factories.

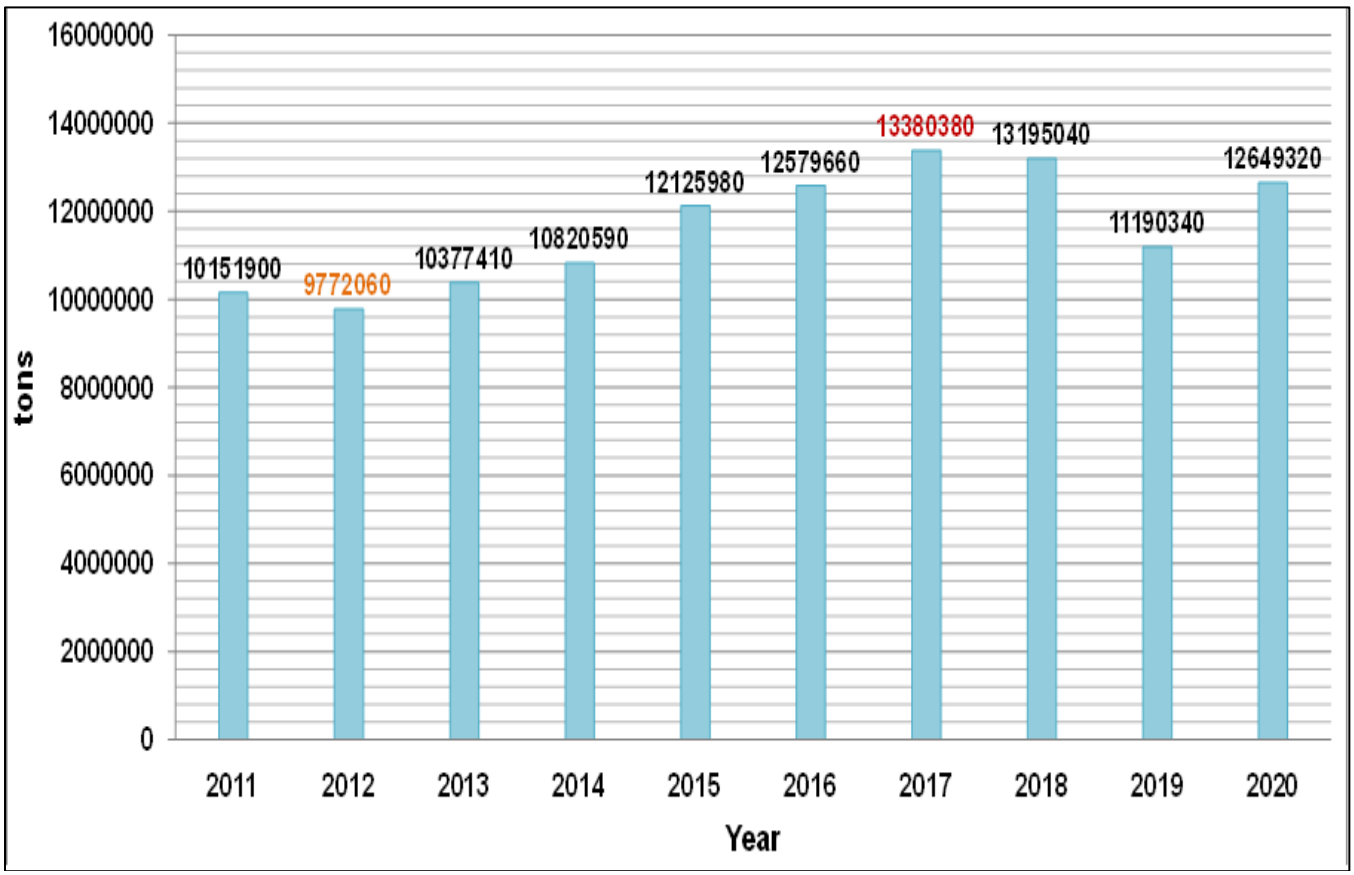

Chart 9: CO_2 Emissions from Building & Construction Sector **(BD CO_2 Emission, 2022)**

Unregulated construction practices and energy wastage are further contributing to the deteriorating air quality in the city. Prioritizing sustainable construction and green buildings offers a potential solution to mitigate future CO_2 emissions. The incorporation of energy-efficient building materials and technologies, such as advanced ventilation systems, holds considerable promise for the reduction of carbon dioxide emissions in the construction sector.

➢ *Policy and Regulatory Challenges:*

Decarbonizations efforts are hindered by significant policy and regulatory challenges. A key issue is the lack of consistent, long-term policies that provide clear guidance and incentives for reducing emissions. In many regions, there is insufficient regulatory support for renewable energy adoption and carbon pricing mechanisms, which are essential for driving change. Additionally, conflicting regulations across jurisdictions create uncertainty for businesses, slowing investment in low-carbon technologies. The complexity of integrating decarbonizations into existing regulatory frameworks, especially in sectors like agriculture and heavy industry, further complicates the process.

➢ *Social and Behavioral Challenges:*

Decarbonizations face social and behavioral challenges that are often overlooked but crucial. Public resistance to change is a significant hurdle, as many people are hesitant to alter their lifestyles, such as dropping meat consumption, embracing community transportation, or adopting energy-efficient practices. Cultural norms and habits deeply ingrained in society can make it difficult to shift towards more sustainable behaviors. Additionally, there is a knowledge gap; many individuals lack awareness or understanding of the importance of decarbonizations and how their actions contribute to climate change.

➢ *Businesses Sector:*

Businesses encounter challenges in decarbonization, including high upfront costs, difficulty in decarbonizing certain processes, lack of standardized metrics for emissions, supply chain disruptions, increased operational costs, regulatory uncertainties, and aligning immediate economic challenges with long-term sustainability objectives.

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CHAPTER FIVE
FINDINGS THE STRATEGIES OF DECARBONIZATION

Decarbonization is a significant strategy for justifying climate change by dropping carbon emissions across various sectors. Here are some probable solutions for achieving decarbonization:

A. Transition to Renewable Energy

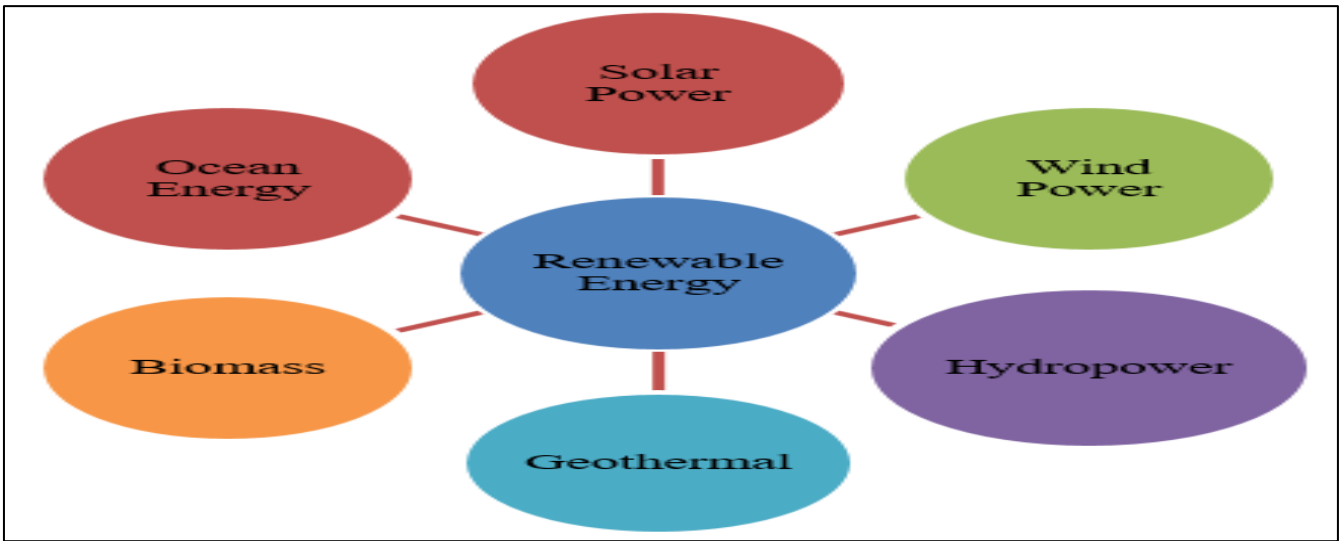

Fig 6: Sources of Renewable Energy

The transition to renewable energy is imperative for achieving decarbonization. By moving, away from fossil fuels and embracing clean energy sources, such as solar, air, waterpower, and geothermal, it is possible to significantly diminish carbon emissions. Renewable energy not only provides a sustainable alternative to coal, oil, and gas but also helps moderate climate change, recover air quality, and generate green jobs. Investing in renewable infrastructure, advancing technology, and implementing supportive policies are key to accelerating this transition. This shift is vital for achieve a low-carbon future and ensuring energy security while preserving the environment for upcoming generations.

B. Electrification of Transportation

Electrification of transportation is a vital strategy for decarbonization. By replacing gasoline and diesel vehicles with electric vehicles (EVs), we can drastically cut GHGs emissions from the transport sector. Electric Power by renewable energy sources recommends a cleaner alternative, reducing dependence on fossil fuels and lowering air pollution. Expanding charging infrastructure, advancing battery technology, and promoting public transport electrification are crucial steps in this transition. Additionally, supporting policy and incentive can accelerate the implementation of EVs, contributing to a more sustainable and low-carbon opportunity while enhancing energy efficiency and reducing overall environmental impact.

C. Energy Efficiency

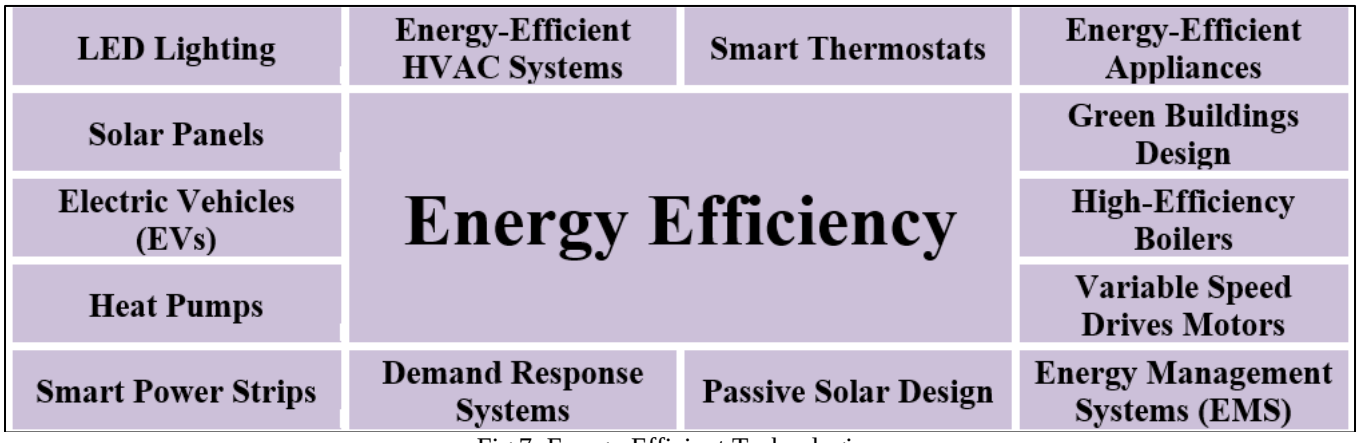

Fig 7: Energy-Efficient Technologies

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Energy efficiency is a key component of decarbonization, focusing on reducing energy consumption while maintaining the same level of service. By optimizing energy use in industries, buildings, and transportation, we can considerably lower carbon emissions. This involves adopting energy-efficient technologies as well as improving insulation and ventilation in buildings. In industries, upgrading machinery and refining processes can reduce energy waste. Enhancing energy efficiency not only reduces greenhouse gas emissions but also decreases operational costs, conserves essential resources, and facilitates a sustainable transition to a low-carbon economy. This makes energy efficiency a vital component in the effort to address climate change.

D. Carbon Capture and Storage (CCS)

Carbon Capture and Storage (CCS) represents a crucial technological advancement in the effort to achieve decarbonization. This technology effectively captures carbon dioxide emissions produced by industrial activities and power generation before they are released into the atmosphere. The captured CO_2 is subsequently transported and securely stored in deep geological formations, including depleted oil and gas reservoirs. CCS has the potential to substantially reduce emissions from sectors that present significant challenges in terms of decarbonization, such as cement, steel, and chemical manufacturing. By preventing CO_2 from contributing to global warming, CCS complements renewable energy efforts, helping to achieve net-zero emissions. Scaling up CCS deployment, supported by investment and policy incentives, is essential for meeting climate goals and justifying climate change.

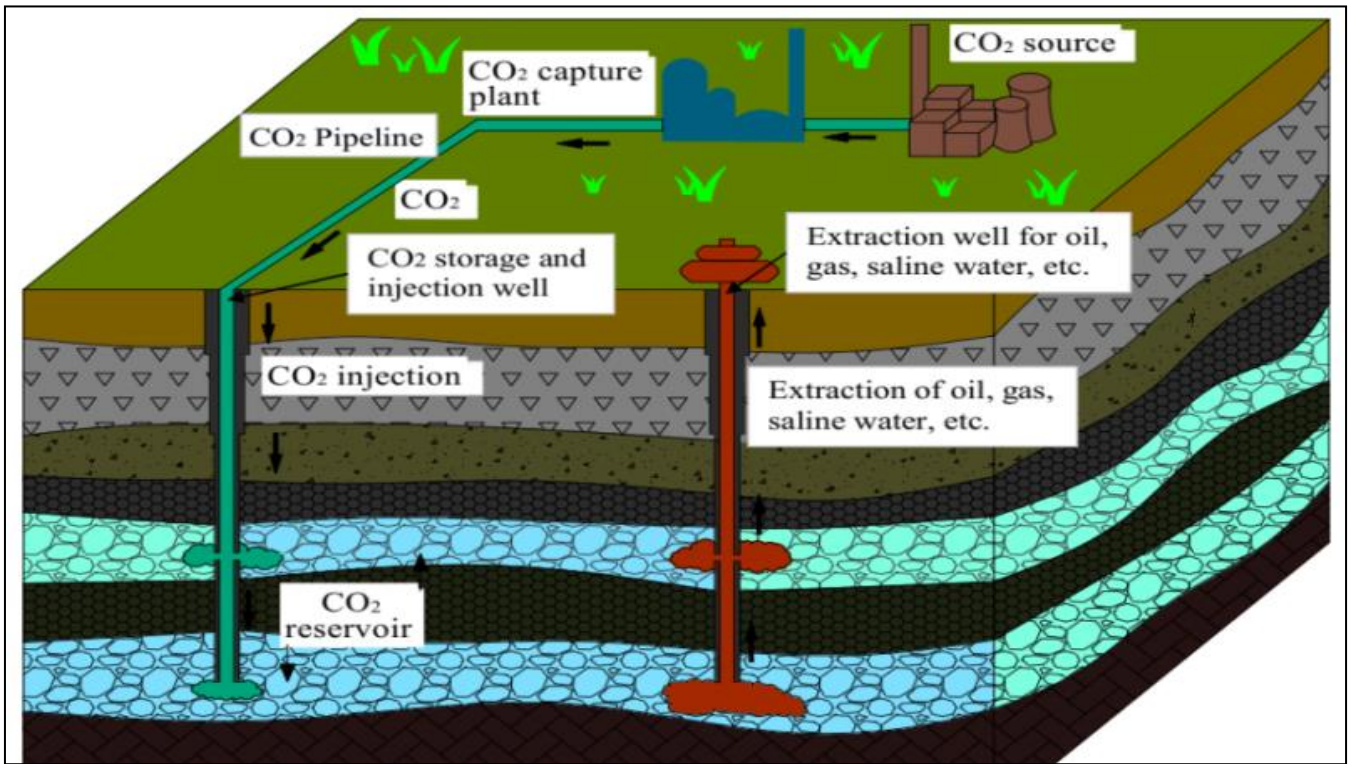

Fig 8: Carbon Capture and Storage Idea (**Jiaquan Li at al., 2018)**

E. Sustainable Agriculture

Sustainable agriculture plays a key role in decarbonization by dipping greenhouse gas emissions and enhancing carbon sequestration. Practices like regenerative farming, agro forestry, and organic farming improve soil health, increase biodiversity, and capture CO_2 in vegetation and soil. Dropping reliance on synthetic fertilizers and pesticides further lowers emissions. Sustainable agriculture not only mitigates climate change except also ensures long-term food security, promoting a healthier environment and supporting rural livelihoods while contributing to worldwide efforts to achieve low-carbon future.

Regenerative Farming	Agro Forestry	Organic Farming
Improve Soil Health	Increase Biodiversity	Reducing Synthetic Fertilizers & Pesticides

Fig 9: Activities Demanded for Sustainable Agriculture in Bangladesh

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F. Green Hydrogen

Green hydrogen is a key solution for decarbonization, utilizes renewable energy sources to facilitate the electrolysis of water, resulting in the separation of hydrogen and oxygen. As a clean fuel, Green Hydrogen emits no carbon when used, creation it ideal for sectors like heavy industry, transportation, and power generation. It can replace fossil fuels in hard-to-decarbonizes areas, offering a sustainable alternative that supports global climate goals. The expansion of green hydrogen production and the development of related infrastructure are critical components in the pursuit of a low-carbon economy and the mitigation of global greenhouse gas emissions.

G. Circular Economy

A circular economy is vital for decarbonization, focus on reducing waste, reuse materials, and recycle products to decrease carbon emissions. In contrast to the conventional "linear economy," which operates on a model characterized by the phases of "manufacture, consumption, disposes", a circular economy prioritizes resource efficiency and sustainability. This approach seeks to minimize waste and promote the continual use of resources, thereby fostering a more sustainable economic framework.

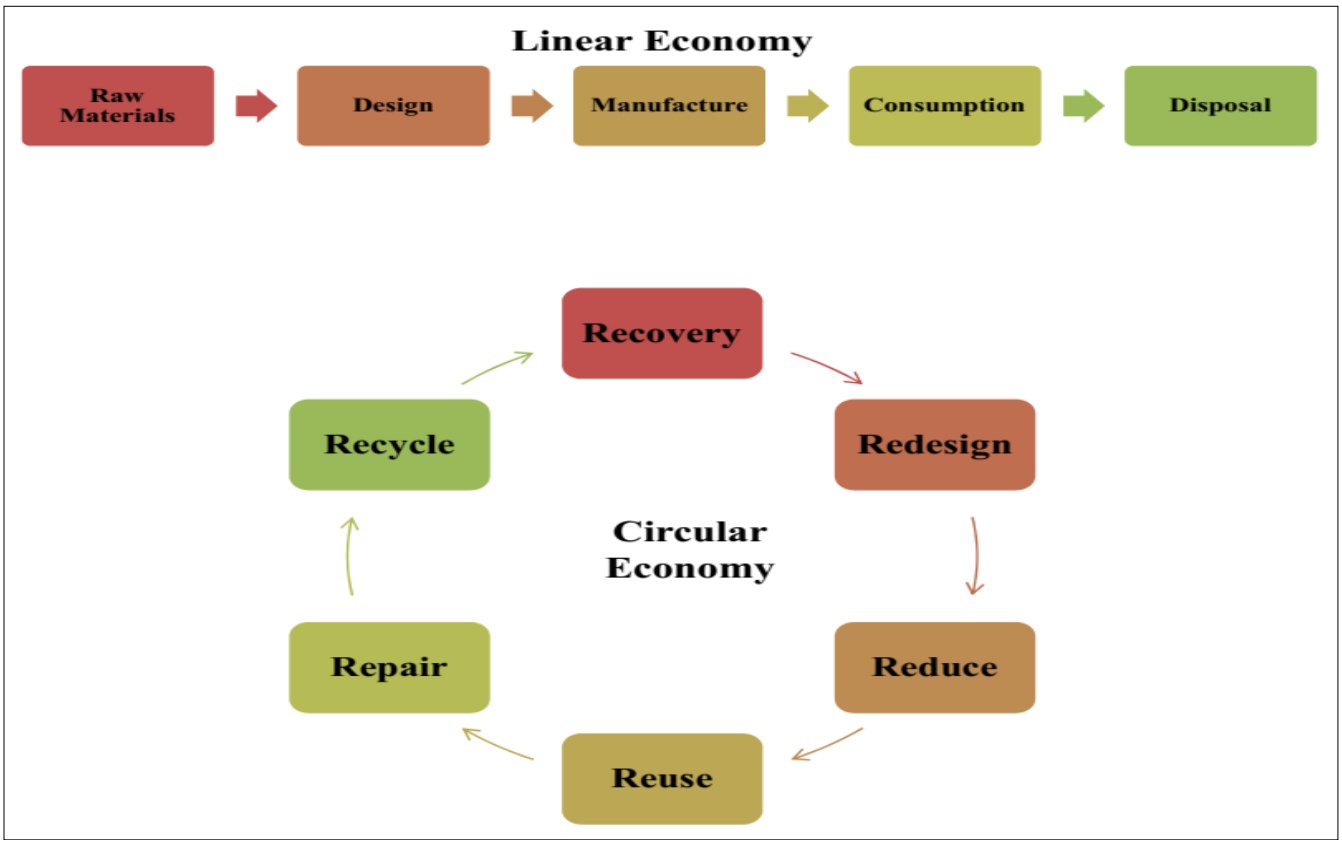

Fig 10: Process of Linear and Circular Economy

By designing products for durability, reparability, and recyclability, and by encouraging sharing, leasing, and refurbishing, we can significantly reduce the demand for raw materials and energy. This activity not only lowering the emission but also conserves natural resources, reduces environmental impact, and fosters economic resilience. Implementing circular economy principles is necessary for achieving a sustainable, low-carbon future.

H. Policies and Regulatory Measures

Policies and regulatory measures are crucial for decarbonization, providing the framework to drive emissions reductions. Carbon pricing mechanisms, including carbon taxes and cap-and-trade systems, serve to incentivize businesses to reduce their carbon footprints effectively. Governments have the capacity to establish subsidies and incentives aimed at promoting renewable energy, enhancing energy efficiency, and supporting the development of low-carbon technologies. Setting stringent emissions standards, promoting green building codes, and mandating clean energy targets further accelerates decarbonization efforts. These policies create a supportive environment for innovation and investment in sustainable practices, essential for achieving global climate goals.

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I. Behavioral Changes

Behavioral changes are necessary for decarbonization, involving shifts in consumption patterns, energy use, and lifestyle choices. Simple actions like reducing energy consumption, choosing sustainable products, embracing public transportation, and supporting renewable energy can collectively lower carbon footprints. Public awareness and commitment to sustainable living are key to achieving climate goals.

J. Innovation and Technology

Innovation and technology drive decarbonization by developing cleaner energy solutions, enhancing energy efficiency, and creating low-carbon alternatives. Breakthroughs in smart grids, renewable energy, electric vehicles, and carbon capture technologies are crucial. Investing in research and development accelerates these advancements, making decarbonization more achievable and supporting a sustainable, low-carbon future.

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CHAPTER SIX
RECOMMENDATIONS

➢ *To Accelerate Decarbonization Efforts, the Following Recommendations are Proposed:*

- **Policy Alignment**: Governments should align national policies with international climate goals, providing clear guidelines and support for decarbonization initiatives.
- **Investment in Research, Analysis and Development**: Enhancing financial support for research, analysis, and development of low-carbon technologies, carbon capture and storage (CCS), circular economy initiatives, and innovative solutions is essential for addressing both technical and economic challenges.
- **Urban Design and Planning:** Design cities with more green spaces, sustainable urban planning, and low-carbon transportation systems enhance investment in energy-efficient public transportation and promote non-motorized transport options like cycling and walking.
- **Public-Private Partnerships**: Collaboration between the public and private sectors is essential for facilitating the large-scale implementation of renewable energy solutions and various decarbonization technologies. This partnership is pivotal in driving advancements and achieving sustainability objectives within the energy landscape.
- **Education and Awareness**: Enhancing awareness regarding the significance of decarbonization, along with fostering education on sustainable practices, has the potential to empower individuals and communities to actively engage in these initiatives.
- **Legislate for a Green Economy:** Legislate to gradually eliminate subsidies for fossil fuels and reallocate financial resources towards renewable energy initiatives and sustainable infrastructure development.
- **Global Cooperation**: Global collaboration is essential to concentrate on the global scenery of climate change and guarantee that all nations have the resources and support needed to decarbonizes their economies.

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CHAPTER SEVEN
CONCLUSION

Decarbonization represents a vital policy and strategic framework aimed at tackling the pressing climate crisis and fostering a sustainable future for generations to come. While it is true that numerous challenges lie ahead, the transition to a low-carbon economy offers a multitude of benefits that encompass environmental, financial, and social dimensions. By wholeheartedly adopting renewable energy sources such as solar, wind, and hydroelectric power, enhancing energy efficiency across industries, and driving forward innovation in technology and practices, the global community can significantly curtail carbon emissions. This, in turn, will help achieve the ambitious environmental targets laid out in international agreements aimed at mitigating climate change. The success of decarbonization efforts hinges on our ability to unite in collective action, the development of strong and effective policies, and a steadfast dedication to sustainability that permeates every sector of society. This cohesive approach will empower nations, businesses, and individuals alike to work together towards a common goal: a cleaner, healthier planet that prioritizes the well-being of both its inhabitants and the environment.

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