International Journal of Multidisciplinary Research and Growth Evaluation.

Carbon Capture and Storage (CCS) in the U.S.: A Review of Market Challenges and Policy Recommendations

Omobolanle Omowunmi Dosumu [1], Olugbenga Adediwin [2], Emmanuella Onyinye Nwulu [3*], Ubamadu Bright Chibunna [4]
[1] C.T. Bauer College of Business, Department of Decision and Information Sciences, University of Houston, Houston, TX, USA
[2] Energyswitch Allied Oil Services Limited, Nigeria
[3] SNEPCo (Shell Nigeria Exploration and Production Company) Lagos. Nigeria
[4] Signal Alliance Technology Holding, Nigeria

* Corresponding Author: **Emmanuella Onyinye Nwulu**

Article Info

ISSN (online): 2582-7138
Volume: 05
Issue: 01
January-February 2024
Received: 18-12-2023
Accepted: 12-01-2024
Page No: 1515-1529

Abstract
Carbon Capture and Storage (CCS) is a critical technology in the U.S. strategy to achieve net-zero emissions and combat climate change. This review explores the market challenges and policy recommendations associated with CCS deployment, emphasizing its role in decarbonizing hard-to-abate sectors such as power generation, manufacturing, and industrial processes. Despite significant advancements in CCS technology, widespread adoption faces barriers, including high capital and operational costs, insufficient market incentives, and public acceptance challenges. Moreover, the lack of comprehensive infrastructure, such as CO_2 transport pipelines and storage facilities, poses a significant hurdle to scaling CCS operations. Policy frameworks like the 45Q tax credit and state-level initiatives have spurred CCS projects, but inconsistencies in regulatory standards and insufficient federal and state collaboration hinder broader adoption. This review highlights the importance of integrating CCS into broader climate policies, leveraging public-private partnerships, and fostering innovation to reduce costs and enhance efficiency. Stakeholder engagement is crucial to addressing community concerns and ensuring equitable implementation, particularly in regions with high CCS potential. The analysis identifies key strategies to overcome these challenges, including enhancing financial incentives, streamlining permitting processes, and investing in infrastructure development. Additionally, it underscores the need for robust monitoring, reporting, and verification (MRV) frameworks to ensure the long-term safety and effectiveness of CO_2 storage sites. Case studies of successful projects in the U.S. and other countries are examined to extract best practices and inform future initiatives. By addressing market and policy barriers, CCS can become a cornerstone of the U.S. decarbonization strategy, contributing to economic growth, job creation, and environmental sustainability. This review provides actionable policy recommendations to accelerate CCS deployment, supporting the U.S. in meeting its climate goals and maintaining global leadership in clean energy innovation.

DOI: https://doi.org/10.54660/.IJMRGE.2024.5.1.1515-1529

Keywords: Carbon Capture and Storage (CCS), U.S. Climate Policy, Decarbonization, CO_2 Infrastructure, 45Q Tax Credit, Public-Private Partnerships, Market Challenges, Policy Recommendations, Net-Zero Emissions, Clean Energy Innovation

1. Introduction

Carbon Capture and Storage (CCS) represents a critical technology for mitigating climate change by capturing carbon dioxide (CO_2) emissions from industrial and energy-related sources and storing them underground to prevent their release into the atmosphere. As global temperatures rise and climate-related challenges intensify, CCS has emerged as a key tool in the broader portfolio of strategies aimed at achieving net-zero emissions. In the United States, where energy production and heavy industries contribute significantly to greenhouse gas emissions, the adoption of CCS is crucial to meeting climate goals, including those outlined in the Paris Agreement and domestic net-zero targets by mid-century (Adebayo, Paul & Eyo-Udo, 2024, Okeke, *et al*, 2024, Oriekhoe, *et al*, 2024). By enabling emissions reductions from hard-to-abate sectors such as cement, steel, and chemicals, CCS complements the transition to renewable energy and enhances the feasibility of decarbonizing the U.S. economy.

Despite its promise, the deployment of CCS faces significant market challenges that hinder its widespread adoption. These include high capital costs, inadequate infrastructure for CO_2 transport and storage, regulatory uncertainties, and limited public acceptance. The absence of strong financial incentives and clear policy frameworks further complicates efforts to scale up CCS projects. Addressing these barriers is essential to unlocking the potential of CCS as a scalable climate solution and integrating it into the broader U.S. energy landscape (Adewusi, Chiekezie & Eyo-Udo, 2022, Pereira & Frazzon, 2021).

This study aims to identify the key market challenges impeding CCS adoption in the United States and to propose actionable policy recommendations to overcome these barriers. By examining the economic, technical, and regulatory aspects of CCS deployment, the study seeks to provide a comprehensive understanding of the obstacles facing this technology. Additionally, it explores the role of federal and state-level policies, public-private partnerships, and innovation in facilitating the development of a robust CCS industry (Eyieyien, *et al*, 2024, Okeke, *et al*, 2024, Oyewole, *et al*, 2024). The findings aim to inform stakeholders, including policymakers, industry leaders, and researchers, and to support the creation of a conducive environment for the growth of CCS as a viable and impactful climate mitigation strategy.

2. Overview of carbon capture and storage (CCS)

Carbon Capture and Storage (CCS) is a critical climate mitigation technology designed to capture carbon dioxide (CO_2) emissions from industrial and energy sources, transport the captured CO_2 to storage sites, and securely store it underground to prevent its release into the atmosphere. The CCS process comprises three main stages: capture, transportation, and storage. The capture stage involves separating CO_2 from other gases produced during industrial processes or power generation (Adewale, *et al*, 2024, Okoye, *et al*, 2024, Oyewole, *et al*, 2024). This can be achieved using pre-combustion, post-combustion, or oxy-fuel combustion techniques, depending on the source and the desired application. Once captured, the CO_2 is compressed and transported, typically via pipelines, to designated storage locations. The final stage involves injecting the CO_2 into geological formations such as depleted oil and gas reservoirs, deep saline aquifers, or unmineable coal seams for long-term storage.

CCS is particularly valuable for its ability to reduce emissions from hard-to-abate sectors like cement, steel, and chemical production, which are critical for economic development but pose significant decarbonization challenges. In power generation, CCS can complement renewable energy sources by mitigating emissions from natural gas and coal-fired power plants, enabling a smoother transition to a low-carbon energy system. The technology also supports emerging applications, such as producing low-carbon hydrogen through natural gas reforming coupled with CCS, which is essential for decarbonizing sectors like transportation and heating (Okafor, *et al*, 2023, Okogwu, *et al*, 2023, Onukwulu, Agho & Eyo-Udo, 2023).

In the United States, the deployment of CCS has gained momentum in recent years, driven by increasing climate ambition and technological advancements. Existing CCS projects and initiatives reflect a mix of industrial applications and power generation efforts. Prominent projects include the Petra Nova facility in Texas, which applied post-combustion capture technology to a coal-fired power plant, and the Archer Daniels Midland (ADM) project in Illinois, which captures CO_2 from bioethanol production and stores it in deep saline formations. Additional projects like the Boundary Dam in North Dakota and the Summit Carbon Solutions pipeline demonstrate growing interest in integrating CCS into energy and industrial systems. Folger, 2017, presented the process of carbon capture as shown in figure 1.

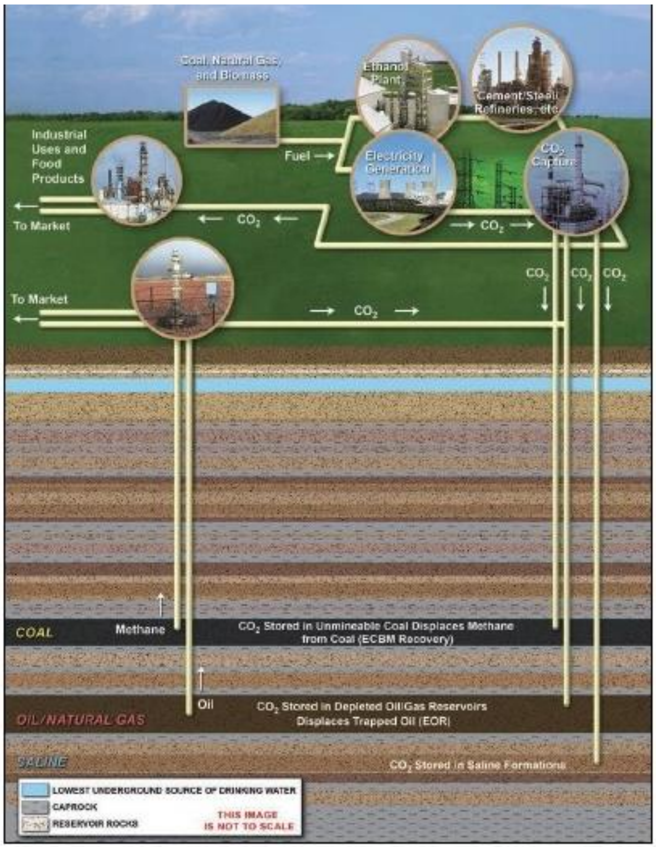

Fig 1: The CCS Process (Folger, 2017).

Despite these advancements, the current state of CCS deployment in the United States remains limited relative to its potential. A key factor in this slow pace of adoption is the high capital cost associated with developing and operating CCS infrastructure. Capturing CO_2 is energy-intensive and requires significant upfront investment in capture equipment, retrofitting existing facilities, and building new infrastructure. Transporting CO_2 to storage sites often necessitates constructing extensive pipeline networks, which face regulatory, land-use, and public acceptance challenges (Akter, *et al*, 2021, Okpeh & Ochefu, 2010, Shoetan, *et al*, 2024). Furthermore, ensuring safe and permanent CO_2 storage involves extensive geological assessments and monitoring systems, adding to the overall costs.

The regulatory and financial support landscape for CCS in the United States has been evolving, with federal and state governments introducing policies to incentivize its deployment. The federal 45Q tax credit is a landmark initiative, offering financial incentives for capturing and storing CO_2. Under this program, facilities can receive tax credits of up to $85 per ton of CO_2 stored in secure geological formations and up to $60 per ton for CO_2 used in enhanced oil recovery (EOR) or other beneficial applications (Ajala, *et al*, 2024, Okoye, *et al*, 2024, Oyewole, *et al*, 2024). The Infrastructure Investment and Jobs Act of 2021 and the Inflation Reduction Act of 2022 have also allocated significant funding for CCS research, development, and demonstration projects, signaling strong federal support for advancing the technology.

However, the current level of financial incentives and regulatory clarity is insufficient to overcome the economic and logistical barriers faced by CCS projects. The deployment of CCS infrastructure requires substantial investment, long-term planning, and collaboration between multiple stakeholders, including governments, industry players, and local communities. The absence of a robust CO_2 transport and storage network further limits the scalability of CCS, as projects are often constrained by their proximity to suitable storage sites (Anjorin, *et al*, 2024, Olufemi-Phillips, *et al*, 2024, Oyewole, *et al*, 2024). Additionally, public perception of CCS remains mixed, with concerns about safety, environmental risks, and its role in perpetuating fossil fuel use contributing to resistance in some regions. Key incentives and project characteristics of realized-large-scale CCS projects globally presented by Beck, 2020, is shown in figure 2.

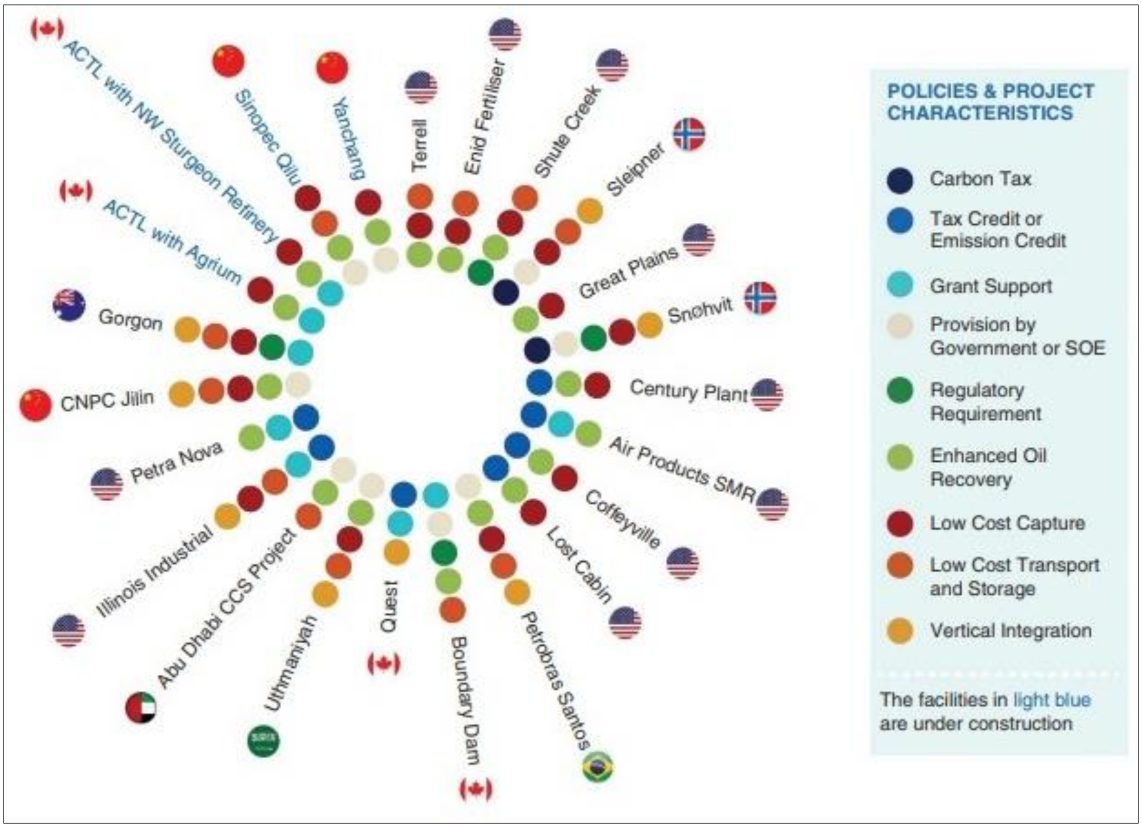

Fig 2: Key incentives and project characteristics of realized-large-scale CCS projects globally (Beck, 2020).

To address these challenges, a coordinated policy framework is essential to support the widespread adoption of CCS in the United States. Expanding the 45Q tax credit to offer higher financial incentives and making it accessible to smaller-scale projects could encourage broader participation. Policies that streamline permitting processes for CO_2 transport and storage infrastructure would also reduce delays and uncertainties associated with project development. Additionally, fostering public-private partnerships and leveraging federal funding to de-risk investments can stimulate innovation and reduce costs over time (Henke & Jacques Bughin, 2016, Onukwulu, *et al*, 2021).

An integrated approach that aligns CCS deployment with broader decarbonization goals is critical for maximizing its effectiveness. This includes coupling CCS with renewable energy expansion, energy efficiency measures, and strategies to phase out unabated fossil fuel use. Developing regional CCS hubs, where multiple emitters share infrastructure for CO_2 capture, transport, and storage, can enhance cost efficiency and enable economies of scale. Such hubs could be strategically located in regions with high concentrations of industrial emissions and suitable geological storage sites, such as the Gulf Coast and Midwest.

The potential for CCS to contribute to achieving U.S. net-zero emissions targets is significant, but its success depends on overcoming technical, economic, and social barriers. By investing in research and development, creating favorable market conditions, and addressing public concerns through transparent communication and community engagement, the United States can position CCS as a cornerstone of its climate strategy (Adeoye, *et al*, 2024, Olufemi-Phillips, *et al*, 2024, Sam-Bulya, *et al*, 2024). Ultimately, the effective implementation of CCS will require a collaborative effort that balances economic development, environmental sustainability, and energy security, ensuring that this technology plays a meaningful role in the transition to a low-carbon future.

2.1 Methodology

The methodology for this study involves a comprehensive and structured approach to analyzing the state of Carbon Capture and Storage (CCS) in the United States, focusing on market challenges and policy recommendations. This includes a qualitative review of relevant literature, comparative analysis of case studies, and the use of an analytical framework to identify challenges and assess policy gaps. The research design prioritizes a multidisciplinary perspective, integrating insights from environmental science, policy studies, and industrial practices.

The research design begins with a qualitative review of academic literature, policy documents, and industry reports to develop an in-depth understanding of CCS technologies and their adoption in the United States. Scholarly articles from peer-reviewed journals provide insights into the technical, economic, and environmental dimensions of CCS. Policy documents from federal and state agencies, such as the Department of Energy (DOE) and Environmental Protection Agency (EPA), are analyzed to evaluate the regulatory and financial frameworks supporting CCS deployment (Eyo-Udo, Odimarha & Ejairu, 2024, Orieno, *et al*, 2024, Oyewole, *et al*, 2024). Industry reports, including white papers from organizations like the Global CCS Institute and the International Energy Agency (IEA), offer practical perspectives on challenges and opportunities for CCS implementation. Folger, 2017**,** presented CO2 Utilization Focus Area in the United State Department of energy as shown in figure 3.

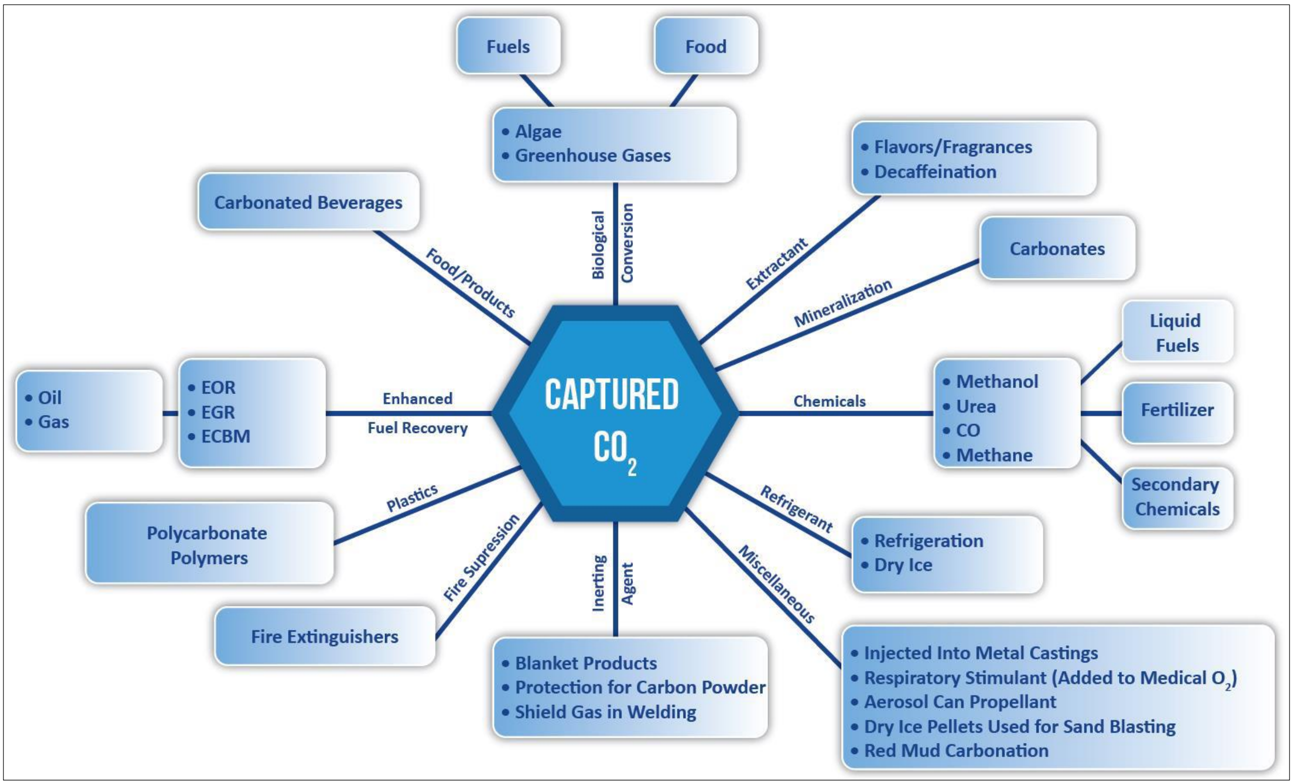

Fig 3: U.S. DOE, National Energy Technology Laboratory, CO2 Utilization Focus Area **(**Folger, 2017**).**

A comparative analysis of CCS case studies is conducted to explore the factors influencing the success and limitations of existing projects. U.S.-based CCS initiatives, such as the Petra Nova project in Texas and the ADM project in Illinois, are examined alongside international examples like the Sleipner CO_2 storage project in Norway. This comparison helps identify best practices, innovative approaches, and contextual differences that affect project outcomes. By understanding these variables, the study can draw actionable insights relevant to the U.S. market.

Data for the analysis are sourced from government publications, peer-reviewed journals, and industry white papers. Federal reports from the DOE and EPA provide authoritative information on the technical specifications, regulatory frameworks, and funding mechanisms for CCS. Peer-reviewed journals offer scientifically validated findings on the efficacy of CCS technologies and their environmental impacts (Adegoke, *et al*, 2024, Olufemi-Phillips, *et al*, 2024, Oyewole, *et al*, 2024). Reports from organizations like the IEA and Global CCS Institute are instrumental in benchmarking U.S. efforts against global trends and best practices, ensuring a holistic perspective.

The study employs a robust analytical framework to examine the identified market challenges and evaluate policy gaps. Thematic analysis is used to categorize challenges into key areas such as economic barriers, regulatory complexities, and public acceptance issues. This involves coding qualitative data from the reviewed literature and case studies to identify recurring themes and patterns. For instance, high capital costs and limited CO_2 transport infrastructure are consistently highlighted as critical economic challenges (Abuza, 2017, Ojebode & Onekutu, 2021). The findings from this thematic analysis inform the development of targeted policy recommendations. An overview of an approach to the design of solvents and processes for CO2 capture, highlighting the role of different modelling and experimental activities presented by Bui, *et al*, 2018, is shown in figure 4.

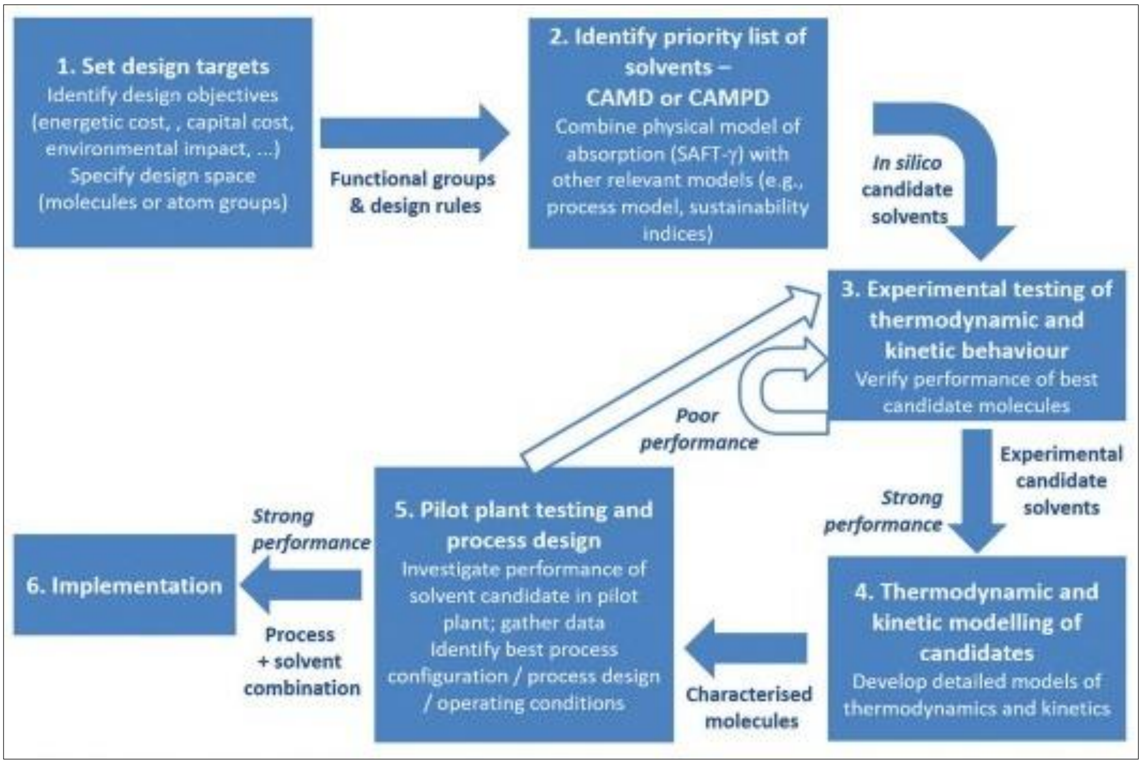

Fig 4: An overview of an approach to the design of solvents and processes for CO2 capture, highlighting the role of different modelling and experimental activities (Bui, *et al*, 2018).

Policy gap assessment is conducted using a benchmarking approach, comparing U.S. policies with global best practices. This involves evaluating the comprehensiveness, clarity, and effectiveness of existing U.S. CCS policies against those of countries with advanced CCS frameworks, such as Norway, Canada, and Australia. For example, Norway's carbon tax and financial incentives for CCS are analyzed to determine how similar measures could be adapted for the U.S. context. The assessment identifies areas where U.S. policies fall short, such as the need for streamlined permitting processes and enhanced financial support for CCS projects (Gidiagba, *et al*, 2023, Ihemereze, *et al*, 2023, Onukwulu, Agho & Eyo-Udo, 2023).

The methodology also incorporates stakeholder perspectives to ensure practical relevance and inclusivity. This includes reviewing input from industry leaders, policymakers, and community representatives through public consultation documents and industry surveys. By considering the viewpoints of diverse stakeholders, the study aims to address both technical and social dimensions of CCS adoption. For instance, understanding community concerns about safety and environmental risks helps shape recommendations for public engagement and risk communication strategies (Eyo-Udo, *et al*, 2024, Olutimehin, *et al*, 2024, Oyewole, *et al*, 2024). The integration of qualitative review, comparative analysis, and thematic and benchmarking frameworks ensures that the methodology is comprehensive and multidisciplinary. By systematically examining the interplay between market challenges, policy frameworks, and stakeholder perspectives, the study provides a well-rounded understanding of the factors shaping CCS adoption in the United States (Adegoke, Ofodile & Ochuba, 2024, Kaggwa, *et al*, 2024, Omowole, *et al*, 2024).

The findings from this methodology are intended to inform actionable policy recommendations that address the identified challenges and leverage opportunities for CCS development. This includes strategies for enhancing financial incentives, streamlining regulatory processes, and fostering public-private partnerships. Additionally, the study emphasizes the importance of aligning CCS policies with broader climate and energy goals to maximize their impact and feasibility. By adopting this structured approach, the research contributes to advancing the understanding and implementation of CCS as a critical tool for achieving the United States' climate objectives (Eyieyien, *et al*, 2024, Olutimehin, *et al*, 2024, Oyewole, *et al*, 2024).

2.2 Market challenges in CCS deployment

The deployment of Carbon Capture and Storage (CCS) in the United States faces a range of market challenges that impede its widespread adoption and integration into the energy and industrial sectors. These challenges are multifaceted and include economic and financial barriers, infrastructure limitations, regulatory and legal issues, and social and public perception challenges. Together, these barriers hinder the ability to scale CCS technologies and limit their contribution to meeting the U.S. net-zero emissions goals.

One of the primary challenges facing CCS deployment is the high capital and operational costs associated with its implementation. The capture process itself requires substantial investment in technology, infrastructure, and operational expenses. The need to retrofit existing facilities with CCS equipment is particularly costly, as it often involves significant modifications to power plants or industrial facilities (Adewusi, Chiekezie & Eyo-Udo, 2023, Ogbu, *et al*, 2023, Uwaoma, *et al*, 2023). The financial burden of establishing CCS infrastructure is compounded by the ongoing operational costs related to energy use, maintenance, and monitoring. While the technical aspects of CCS are advancing, the cost per ton of captured CO_2 remains high, making it economically unfeasible for many potential projects without substantial financial support. This financial strain is exacerbated by limited market incentives. Although there are some incentives, such as the 45Q tax credit, they are often insufficient to offset the high upfront costs of CCS projects. Furthermore, the long payback periods associated with CCS investments make it difficult to attract private sector capital. Investors remain hesitant due to the uncertainty surrounding the viability of CCS as a mainstream climate solution, especially when competing with other technologies like renewable energy, which may offer quicker returns on investment (Adewusi, Chiekezie & Eyo-Udo, 2022, Onukwulu, Agho & Eyo-Udo, 2022). The lack of consistent, long-term incentives for CCS projects contributes to the market's hesitation to adopt the technology at scale.

Another significant barrier is the lack of adequate CO_2 transport and storage infrastructure. While CCS technology for capturing CO_2 has advanced, transporting and storing the captured CO_2 is a complex and costly process. The U.S. currently lacks a nationwide or even regional network of pipelines capable of transporting large quantities of CO_2 from industrial and energy sources to designated storage sites (Addy, *et al*, 2024, Olutimehin, *et al*, 2024, Paul & Iyelolu, 2024). This lack of infrastructure limits the feasibility of large-scale CCS deployment and often necessitates expensive, project-specific pipeline construction, further increasing costs. In addition, the availability of suitable geological storage sites is geographically limited. Identifying and securing appropriate locations for long-term CO_2 storage is a critical aspect of CCS deployment, but the current infrastructure is not developed to the scale needed for widespread adoption (Akinrinola, *et al*, 2024, Igwe, *et al*, 2024, Omowole, *et al*, 2024). While some regions, such as the Gulf Coast and the Midwest, have favorable geology for CO_2 storage, most of the country lacks the necessary infrastructure and geological conditions to support CCS deployment. Moreover, scaling regional CCS hubs to share infrastructure among multiple industries and sources of CO_2 remains a challenge due to logistical, financial, and regulatory constraints. The creation of large, integrated CCS hubs that combine capture, transport, and storage could offer economies of scale, but regulatory hurdles, such as permitting processes and public opposition, present significant obstacles.

Regulatory and legal issues also pose substantial challenges to the widespread deployment of CCS. One of the most significant regulatory barriers is the complexity and inconsistency of permitting processes. CCS projects often require permits for multiple stages of the process, including capture, transportation, and storage. These permits vary by state and locality, creating a patchwork regulatory environment that complicates project planning and increases delays (Calfa, *et al*, 2015, Olufemi-Phillips, *et al*, 2020). Additionally, the federal government and individual states may have different standards for environmental protection and CO_2 monitoring, further complicating regulatory compliance. The permitting process is time-consuming and can be unpredictable, adding to the uncertainty faced by project developers and investors. Beyond permitting, there are also legal concerns related to the long-term liability associated with CO_2 storage. Once CO_2 is injected into geological formations, it is critical to ensure that it remains safely stored and does not leak into the atmosphere. However, the legal liability for potential leaks and environmental damage is not clearly defined (Adebayo, Paul & Eyo-Udo, 2024, Ijomah, *et al*, 2024, Omowole, *et al*, 2024). Operators may be held accountable for monitoring and managing storage sites for decades or even centuries, raising concerns about the long-term viability and insurance requirements for CCS projects. These uncertainties increase the perceived risk of investing in CCS and may deter both public and private sector involvement.

In addition to economic, infrastructural, and regulatory challenges, social and public perception issues play a crucial role in hindering CCS deployment. Community opposition to CCS projects is a significant challenge, particularly when it comes to the siting of CO_2 storage facilities. Many communities' express concerns about the safety and environmental risks associated with storing large volumes of CO_2 underground. Fears of potential leaks or seismic activity caused by the injection process contribute to public skepticism (Daraojimba, *et al*, 2023, Ihemereze, *et al*, 2023, Tula, *et al*, 2023). Additionally, CCS projects are often associated with continued reliance on fossil fuels, which can lead to opposition from environmental groups and communities advocating for a rapid transition to renewable energy sources. This public resistance is compounded by the lack of clear communication and transparency surrounding CCS projects. Misunderstandings about the safety, efficacy, and role of CCS in addressing climate change can exacerbate public fears. Therefore, transparent communication and effective stakeholder engagement are essential for gaining public acceptance. Governments and project developers must engage with local communities early in the planning process, providing clear and accessible information about the safety measures, benefits, and long-term goals of CCS projects (Adeoye, *et al*, 2024, Igwe, *et al*, 2024, Omowole, *et al*, 2024). Establishing trust with local communities through open dialogue can help address concerns and build broader support for CCS as a climate mitigation tool.

The market challenges facing CCS deployment in the United States are significant and multifaceted. Economic and financial barriers, such as high costs and limited incentives, need to be addressed to make CCS more attractive to investors. Developing a nationwide CO_2 transport and storage infrastructure is essential to scaling CCS projects and enabling cost-effective solutions. Regulatory and legal challenges, including permitting complexities and liability concerns, must be streamlined to facilitate project approval and long-term operational stability (Adesina, Iyelolu & Paul, 2024, Olutimehin, *et al*, 2024, Paul, *et al*, 2024). Finally, overcoming social and public perception challenges requires effective communication, community engagement, and transparency about the benefits and risks of CCS. Addressing these barriers will require a coordinated effort from governments, industry stakeholders, and local communities. By creating a more favorable market environment, the U.S. can unlock the potential of CCS to significantly reduce emissions and contribute to achieving net-zero emissions targets.

2.3 Policy Recommendations

Policy recommendations for advancing Carbon Capture and Storage (CCS) in the United States are essential to overcoming the market challenges that hinder its widespread adoption. Given the importance of CCS in reducing greenhouse gas emissions and meeting U.S. climate goals, effective policy interventions are crucial. The key recommendations focus on enhancing financial incentives, streamlining regulatory processes, investing in infrastructure development, promoting public-private partnerships, and addressing public concerns (Ajala, *et al*, 2024, Olutimehin, *et al*, 2024, Sam-Bulya, *et al*, 2024). By addressing these areas, the U.S. can create a favorable environment for the expansion of CCS and accelerate the transition to a low-carbon economy.

One of the most significant policy recommendations is to enhance financial incentives for CCS adoption. The 45Q tax credit, which provides a financial incentive for CO_2 capture, has been an important driver for CCS projects in the U.S. However, to accelerate the development of CCS technology, it is necessary to strengthen and expand this tax credit. This could include increasing the value of the credit, extending its duration, and offering additional incentives for projects that store CO_2 permanently rather than for short-term storage (Eyieyien, *et al*, 2024, Olurin, *et al*, 2024, Sam-Bulya, *et al*, 2024). Strengthening 45Q would provide a more robust financial framework for businesses to invest in CCS, making the technology more attractive and competitive in the market. Additionally, promoting direct subsidies and carbon pricing mechanisms would help reduce the upfront costs of CCS projects. Direct subsidies could provide initial funding to offset the high capital costs associated with CCS technology, enabling companies to begin projects with less financial risk. Carbon pricing mechanisms, such as a national carbon tax or cap-and-trade system, could provide a long-term price signal for the cost of carbon emissions, making CCS more economically viable by incentivizing industries to adopt the technology (Eyo-Udo, *et al*, 2024, Hosen, *et al*, 2024, Olutimehin, *et al*, 2024).

Streamlining regulatory processes is another critical policy recommendation. The current regulatory environment for CCS is complex and varies significantly across states. Permitting processes are often time-consuming, with multiple regulatory bodies involved in approving projects. Simplifying permitting procedures could reduce the administrative burden on project developers and help accelerate the timeline for CCS deployment. A more efficient permitting process would allow projects to move forward faster and more predictably, which is essential for meeting ambitious emissions reduction targets (Ogunjobi, *et al*, 2023, Onukwulu, Agho & Eyo-Udo, 2023, Uwaoma, *et al*, 2023). Moreover, harmonizing federal and state-level policies would help create a consistent regulatory framework for CCS. By aligning policies and ensuring that federal regulations provide clear guidelines for CCS deployment, the U.S. government can reduce uncertainties for businesses and promote a more cohesive approach to CCS development.

Investing in infrastructure development is essential for the success of CCS. The lack of adequate CO_2 transport and storage infrastructure remains a significant barrier to widespread CCS deployment. Expanding CO_2 transport networks, such as pipelines, would enable industries to more easily capture and transport CO_2 to suitable storage sites. Federal and state governments should incentivize the construction of these networks through grants, loans, and tax incentives (Adeoye, *et al*, 2024, Olutimehin, *et al*, 2024, Raji, *et al*, 2024). Additionally, the establishment of regional CCS hubs could provide cost-sharing opportunities for industries and reduce the overall infrastructure investment burden. Regional hubs would allow multiple industries to utilize shared transport and storage facilities, increasing the overall efficiency and cost-effectiveness of CCS deployment. By investing in infrastructure, the U.S. government can help create the necessary foundation for large-scale CCS deployment and support the integration of CCS into the broader energy and industrial systems.

Promoting public-private partnerships (PPPs) is another important strategy to accelerate the adoption of CCS. The development of CCS technology involves significant costs and risks, which can be difficult for individual companies to shoulder alone. By leveraging collaborations between the public and private sectors, the financial and technical risks associated with CCS projects can be shared. Public-private partnerships can take various forms, such as co-investment in infrastructure, joint research and development efforts, or collaborative regulatory advocacy (Grandhi, Patwa & Saleem, 2021, Onukwulu, Agho & Eyo-Udo, 2022). These partnerships can help create economies of scale, reduce project costs, and drive innovation in CCS technology. Moreover, PPPs can provide stability and assurance for investors, who may be more likely to fund CCS projects when they know that government support is available. Governments can play a pivotal role by providing the regulatory framework, incentives, and funding necessary to attract private sector participation and investment in CCS.

Addressing public concerns is another critical component of advancing CCS in the U.S. Public opposition to CCS projects, especially those involving CO_2 storage, has been a significant obstacle. To address this challenge, the implementation of transparent monitoring, reporting, and verification (MRV) systems is essential. These systems can provide independent verification of CO_2 storage activities, ensuring that CO_2 is stored safely and effectively and that potential risks are mitigated (Eyo-Udo, Odimarha & Kolade, 2024, Ofodile, *et al*, 2024, Raji, *et al*, 2024). Transparent MRV systems would help build trust with local communities and the public, demonstrating that CCS projects are being managed responsibly and that their environmental impact is being closely monitored. Additionally, community engagement and equitable deployment strategies should be implemented to involve local communities in the planning and decision-making processes. Engaging communities early in the development of CCS projects and addressing their concerns about safety, environmental impact, and economic benefits can help gain public support and reduce opposition to CCS projects. Equitable deployment strategies should ensure that the benefits of CCS, such as job creation and economic development, are distributed fairly among local communities, especially those that may be disproportionately affected by climate change or industrial pollution.

Finally, it is crucial to align CCS policy recommendations with broader climate and energy goals. CCS is not a standalone solution but should be integrated into a comprehensive climate strategy that includes renewable energy development, energy efficiency measures, and other carbon mitigation technologies. Policymakers should ensure that CCS is seen as a complementary tool to decarbonize hard-to-abate sectors such as heavy industry, cement production, and power generation, rather than as a substitute for direct emissions reductions (Adebayo, Paul & Eyo-Udo, 2024, Ofodile, *et al*, 2024, Raji, *et al*, 2024). By framing CCS within a broader climate context and aligning it with other decarbonization efforts, the U.S. can maximize the potential of CCS while also addressing the root causes of climate change.

In conclusion, implementing these policy recommendations can significantly enhance the deployment of CCS in the U.S. Strengthening financial incentives, streamlining regulatory processes, investing in infrastructure, promoting public-private partnerships, and addressing public concerns are critical steps in overcoming the market challenges facing CCS (Adewusi, Chiekezie & Eyo-Udo, 2022, Oyeniyi, *et al*, 2021). By creating a more supportive policy environment, the

U.S. can unlock the potential of CCS to contribute to emissions reduction goals and play a key role in achieving a sustainable, low-carbon future. Effective implementation of these policies will not only drive the adoption of CCS but also foster innovation, economic growth, and environmental protection.

2.4 Case studies of CCS deployment

Carbon Capture and Storage (CCS) has become an integral part of the global strategy to combat climate change, with the U.S. actively pursuing CCS deployment in various sectors, including power generation and heavy industry. Several projects in the U.S. provide valuable insights into the feasibility, challenges, and successes of CCS technology. Analyzing these case studies not only highlights the lessons learned from specific CCS projects but also offers a broader understanding of how market conditions, regulatory frameworks, and technological advancements shape the future of CCS in the U.S (Okafor, *et al*, 2023, Onukwulu, Agho & Eyo-Udo, 2023, Uwaoma, *et al*, 2023). These case studies also allow for an international comparison, as some global initiatives have achieved significant milestones in CCS deployment, offering lessons for the U.S. to consider.

One of the most prominent and successful CCS projects in the U.S. is the Petra Nova project in Texas. This project involved retrofitting a coal-fired power plant to capture CO_2 emissions before they enter the atmosphere. The captured CO_2 is transported and injected into nearby oil fields to enhance oil recovery. Petra Nova represents one of the most significant efforts to implement large-scale CCS in the power sector, demonstrating that retrofitting existing plants with CCS technology is technically feasible (Adegoke, *et al*, 2024, Odeyemi, *et al*, 2024, Raji, *et al*, 2024). The project has achieved considerable success, capturing around 1 million tons of CO_2 annually, which is equivalent to removing more than 200,000 cars off the road. Key lessons from Petra Nova include the importance of public-private partnerships and financial incentives. The project benefited from a combination of government funding, including support from the U.S. Department of Energy, and private sector investment. Additionally, the integration of CCS with enhanced oil recovery (EOR) provided a financial incentive to capture and store CO_2, reducing the overall cost of the project. However, the project also faced challenges related to the high capital costs and operational complexities of retrofitting existing infrastructure, which is a common obstacle for many CCS initiatives.

Another successful U.S. CCS project is the Illinois Industrial CCS project, which captures CO_2 from an ethanol production facility. The captured CO_2 is transported via pipeline and stored deep underground in geological formations. This project is notable for its focus on capturing CO_2 from an industrial source rather than a power plant, demonstrating the potential for CCS in hard-to-abate sectors (Addy, *et al*, 2024, Ijomah, *et al*, 2024, Paul, Ogugua & Eyo-Udo, 2024). The Illinois Industrial CCS project has successfully stored millions of tons of CO_2 since its inception, and the project's approach has been considered a model for industrial CCS applications. One of the critical lessons from this project is the importance of early-stage planning and stakeholder engagement. The success of the Illinois project can be attributed to careful site selection, where the geological formations proved to be ideal for long-term CO_2 storage. Furthermore, collaboration with regulatory bodies and local communities was essential to ensuring that the project adhered to safety and environmental standards. Despite its success, the Illinois project also faced challenges related to the high costs of CO_2 transport and storage infrastructure, which underscores the need for broader infrastructure investments in the U.S. to support CCS at scale.

The U.S. experience with CCS can also be compared with international projects, such as the Sleipner project in Norway, which has been operational since 1996. The Sleipner project is often regarded as one of the world's first commercial CCS initiatives. It involves the capture of CO_2 from natural gas production and its injection into an offshore geological formation beneath the North Sea (Adewale, *et al*, 2024, Iyelolu & Paul, 2024, Raji, *et al*, 2024). Unlike many U.S.-based projects, which focus primarily on capturing CO_2 from industrial and power sector emissions, Sleipner's success lies in its early adoption of CCS for natural gas extraction. This long-term project has stored over 20 million tons of CO_2, providing valuable data on the stability and effectiveness of geological storage. One of the key lessons from Sleipner is the importance of establishing a robust regulatory framework that ensures the safety and monitoring of CO_2 storage sites over time. The project has benefited from Norway's supportive regulatory environment, which has provided clear guidelines for CO_2 injection and long-term monitoring, a feature that is still lacking in some U.S. states. The Sleipner project also highlights the benefits of offshore storage, which, compared to onshore storage, offers more stability and fewer land-use concerns, making it an attractive option for some regions in the U.S.

Another significant international initiative is the Boundary Dam project in Canada, which has become a leading example of CCS in the power sector. Located in Saskatchewan, the Boundary Dam project involves the retrofit of an existing coal-fired power plant with CCS technology. The captured CO_2 is stored in deep geological formations and used for enhanced oil recovery. Like Petra Nova, Boundary Dam demonstrates the feasibility of retrofitting coal plants with CCS technology (Curuksu, 2018, Onukwulu, Agho & Eyo-Udo, 2021, Tseng, *et al*, 2021). However, the project has faced challenges similar to those of Petra Nova, including high capital and operational costs. Despite these challenges, Boundary Dam has been a valuable demonstration project, providing insights into the economic and technical aspects of large-scale CCS deployment. A key takeaway from the Boundary Dam project is the importance of integrating CCS with other revenue-generating activities, such as enhanced oil recovery, to make the technology more economically viable. The integration of CCS with oil recovery has proven to be a crucial element in offsetting some of the costs associated with the technology, making it more attractive for project developers and investors.

Looking globally, the lessons learned from these international projects can inform U.S. policy and market development. The success of Sleipner and Boundary Dam highlights the importance of government support, clear regulations, and long-term monitoring to ensure the safe and effective implementation of CCS. Furthermore, these projects show that integrating CCS with other industries, such as oil recovery, can help offset some of the significant costs associated with the technology (Sule, *et al*, 2024, Ugochukwu, *et al*, 2024, Usman, *et al*, 2024). In contrast, the challenges faced by Petra Nova and Illinois Industrial CCS underscore the need for continued investment in infrastructure, including CO_2 transport and storage networks, to support large-scale deployment of CCS in the U.S.

In conclusion, the case studies of CCS deployment in the U.S. and internationally provide valuable insights into the market challenges and policy considerations that will shape the future of CCS technology. Successful U.S. projects like Petra

Nova and Illinois Industrial CCS highlight the importance of public-private partnerships, financial incentives, and careful planning in overcoming the technological and economic barriers to CCS deployment. Similarly, international initiatives such as Sleipner and Boundary Dam demonstrate the value of clear regulatory frameworks, long-term monitoring, and the integration of CCS with other industries to enhance its economic viability (Eyieyien, *et al*, 2024, Odeyemi, *et al*, 2024, Paul, Ogugua & Eyo-Udo, 2024). By analyzing these case studies, policymakers and industry leaders can better understand the complexities of CCS deployment and develop strategies to overcome the challenges associated with scaling up this critical climate mitigation technology.

2.5 Discussion

The discussion surrounding Carbon Capture and Storage (CCS) in the U.S. reveals the critical role the technology plays in the nation's decarbonization efforts. As the U.S. moves towards a future with net-zero emissions, CCS is poised to be a vital tool in addressing emissions from hard-to-abate sectors, such as power generation, heavy industry, and even agriculture. While the U.S. has made significant strides in CCS development, its integration into a broader decarbonization strategy presents several challenges that require targeted policies, technological advancements, and market support (Adewusi, Chiekezie & Eyo-Udo, 2023, Onukwulu, Agho & Eyo-Udo, 2023) t.

CCS's potential lies in its ability to capture CO_2 emissions from various sources, compress and transport them, and store them safely underground. This process can significantly reduce the carbon footprint of industries where emissions reduction is more complex, such as cement production, steel manufacturing, and fossil fuel power plants. In the U.S., these industries are responsible for a substantial portion of the nation's greenhouse gas emissions, making them crucial targets for CCS deployment (Ajala, *et al*, 2024, Nnaji, *et al*, 2024, Onesi-Ozigagun, *et al*, 2024). However, integrating CCS into the broader decarbonization strategy requires a holistic approach that includes not just CCS but also renewable energy and energy efficiency measures. As the U.S. transitions to a low-carbon economy, renewable energy sources like wind, solar, and hydropower will play a central role in reducing emissions. Simultaneously, energy efficiency measures will help minimize overall demand for energy. CCS, therefore, needs to complement these efforts by capturing emissions that cannot be avoided through renewable energy or energy efficiency alone. For example, while solar and wind energy will increasingly provide the clean electricity needed for power generation, CCS will be vital for industries that cannot easily switch to renewable energy, such as heavy industries reliant on fossil fuels.

The success of integrating CCS into the broader decarbonization strategy hinges on addressing a number of market and policy challenges. One of the most significant hurdles is the high cost of CCS technology. The capital expenditure required to build CCS infrastructure, such as carbon capture units, transportation pipelines, and storage sites, is substantial. While advances in technology may drive costs down over time, financial incentives, such as tax credits, government subsidies, and carbon pricing mechanisms, will be necessary to make CCS economically viable (Arinze, *et al*, 2024, Nnaji, *et al*, 2024, Onesi-Ozigagun, *et al*, 2024). The current state of the U.S. CCS market reveals that these financial mechanisms are insufficient to incentivize large-scale deployment. As such, increased public funding and stronger policy support are necessary to stimulate private sector investment. Additionally, addressing the regulatory and permitting challenges is essential. The U.S. lacks a uniform regulatory framework for CCS, which creates uncertainty for investors and project developers. Clear and consistent regulations at the federal and state levels will be critical in providing the legal certainty needed for large-scale CCS projects to move forward.

The long-term impacts of CCS adoption on the U.S. economy, environment, and society will be profound. Economically, CCS has the potential to create thousands of high-quality jobs in construction, operations, and maintenance. As the demand for CCS infrastructure grows, industries related to the capture, transport, and storage of CO_2 will flourish. This includes the development of specialized carbon capture technologies, such as direct air capture, and the construction of CO_2 pipelines and storage facilities (Adeoye, *et al*, 2024, Nnaji, *et al*, 2024, Onesi-Ozigagun, *et al*, 2024). These activities will create employment opportunities in sectors such as engineering, manufacturing, and logistics, contributing to economic growth and job creation in both urban and rural areas. Additionally, CCS has the potential to provide a new revenue stream for oil and gas companies through enhanced oil recovery (EOR). By injecting captured CO_2 into depleted oil reservoirs, companies can increase production while simultaneously reducing CO_2 emissions. This mutually beneficial relationship between CCS and oil recovery can help to offset the high costs of CCS and make the technology more financially attractive to investors.

From an environmental perspective, the widespread deployment of CCS technology could significantly contribute to meeting the U.S. net-zero emissions target by capturing millions of tons of CO_2 annually. This could provide a critical buffer for industries where emissions reductions are particularly difficult to achieve through renewable energy alone. CCS could be especially important for sectors like cement, steel, and chemical manufacturing, where emissions are generated as part of the production process rather than from energy use (Adeniran, *et al*, 2024, Nnaji, *et al*, 2024, Onesi-Ozigagun, *et al*, 2024). By capturing and storing CO_2, these industries could continue to operate while reducing their carbon footprints, ensuring that the U.S. continues to produce essential materials without contributing to global warming. Furthermore, the potential for negative emissions—where CCS is used to capture more CO_2 than is emitted—could play a key role in offsetting emissions from other sources, further advancing global climate goals.

Socially, CCS adoption presents both opportunities and challenges. On the one hand, successful implementation of CCS could enhance the U.S.'s reputation as a leader in climate innovation, demonstrating that it is possible to reduce emissions while maintaining economic activity. Additionally, the adoption of CCS could lead to the revitalization of certain regions, particularly those with access to suitable geological formations for CO_2 storage. These areas could see job creation and economic development as CCS projects are built and operated (Egieya, *et al*, 2024, Nnaji, *et al*, 2024, Onesi-Ozigagun, *et al*, 2024). However, there are significant public perception challenges associated with CCS. Many communities are concerned about the safety of CO_2 storage and the potential for leaks, which could undermine public trust in the technology. To address these concerns, transparent monitoring, reporting, and verification systems must be put in place to ensure the safe and permanent storage of CO_2. Moreover, community engagement and education will be critical in overcoming opposition to CCS projects. A failure to address public concerns could result in resistance to new projects, delaying the deployment of CCS technology.

The long-term societal impact of CCS also includes potential equity concerns. In regions where large-scale CCS projects are deployed, there could be disparities in the distribution of benefits and risks. For instance, communities that host CCS storage sites could experience economic growth, but they may also face environmental and health risks associated with the injection and long-term storage of CO_2. Policymakers must ensure that the deployment of CCS technology is done in an equitable and inclusive manner, considering the needs and concerns of local communities and ensuring that the benefits are shared broadly (Adesina, Iyelolu & Paul, 2024, Mokogwu, *et al*, 2024, Paul, Ogugua & Eyo-Udo, 2024).

Ultimately, the future of CCS in the U.S. depends on how effectively the technology can be integrated into the broader decarbonization strategy. It is clear that CCS will not be a silver bullet solution but must be part of a multifaceted approach that includes renewable energy, energy efficiency, and other technologies like hydrogen and nuclear energy. To fully realize the potential of CCS, robust policy frameworks, financial incentives, and public engagement will be necessary (Eyo-Udo, 2024, Ijomah, *et al*, 2024, Omowole, *et al*, 2024). If these challenges can be overcome, CCS has the potential to make a significant contribution to the U.S. achieving its climate goals, offering a pathway to decarbonize some of the most challenging sectors of the economy while creating economic opportunities and mitigating the effects of climate change.

3. Conclusion

In conclusion, Carbon Capture and Storage (CCS) presents a critical opportunity for the U.S. to achieve its climate goals, particularly in addressing emissions from hard-to-abate sectors like heavy industry and power generation. This review has highlighted both the significant market challenges and policy opportunities that accompany the development and deployment of CCS technology in the U.S. Among the primary challenges are the high capital and operational costs, the limited market incentives, and the lack of infrastructure to support large-scale deployment. Additionally, the regulatory and permitting landscape remains complex, with inconsistencies at the federal and state levels creating uncertainty for investors and project developers. Public perception of CCS, driven by concerns about the safety and environmental impact of CO_2 storage, also presents a barrier to its widespread acceptance.

Despite these challenges, there are several policy opportunities that can enable the U.S. to realize the full potential of CCS. Strengthening financial incentives, such as expanding the 45Q tax credit and implementing carbon pricing mechanisms, could alleviate the economic barriers to adoption. Streamlining the regulatory processes and harmonizing policies at different government levels would create a more predictable and efficient environment for CCS projects. Moreover, investing in the development of the necessary infrastructure, such as CO_2 transport pipelines and regional storage hubs, would help overcome the current limitations in capacity. Promoting public-private partnerships could also share the costs and risks of CCS deployment, facilitating its expansion. Addressing public concerns through transparent communication and robust monitoring systems will be key to gaining community support for CCS projects.

Future research should focus on addressing data gaps related to the performance, safety, and economic viability of CCS technologies. Exploring innovative CCS technologies, such as direct air capture and new storage methods, will be essential in enhancing the efficiency and scalability of CCS solutions. Additionally, further investigation into the social and environmental impacts of large-scale CCS deployment is needed to ensure that the technology can be implemented in a way that benefits both the economy and society while minimizing risks. As the U.S. works towards achieving net-zero emissions, CCS will play an indispensable role in the broader decarbonization strategy, contributing to the reduction of greenhouse gas emissions and helping to mitigate the impacts of climate change.

4. References

1. Abuza AE. An examination of the power of removal of secretaries of private companies in Nigeria. J Comp Law Afr. 2017;4(2):34-76.
2. Addy WA, Ofodile OC, Adeoye OB, Oyewole AT, Okoye CC, Odeyemi O, *et al* Data-driven sustainability: How fintech innovations are supporting green finance. Eng Sci Technol J. 2024;5(3):760-773.
3. Addy WA, Ugochukwu CE, Oyewole AT, Ofodile OC, Adeoye OB, Okoye CC. Predictive analytics in credit risk management for banks: A comprehensive review. GSC Adv Res Rev. 2024;18(2):434-449.
4. Adebayo VI, Paul PO, Eyo-Udo NL. The role of data analysis and reporting in modern procurement: Enhancing decision-making and supplier management. GSC Adv Res Rev. 2024;20(1):88-97.
5. Adebayo VI, Paul PO, Eyo-Udo NL. Procurement in Healthcare: Ensuring Efficiency and Compliance in Medical Supplies and Equipment Management. Magna Sci Adv Res Rev. 2024;11:60-69.
6. Adebayo VI, Paul PO, Eyo-Udo NL. Sustainable procurement practices: Balancing compliance, ethics, and cost-effectiveness. GSC Adv Res Rev. 2024;20(1):98-107.
7. Adegoke TI, Ofodile OC, Ochuba NA. Transparent reporting and equity in mortgage lending: A comprehensive review. 2024.
8. Adegoke TI, Ofodile OC, Ochuba NA, Akinrinol O. Evaluating the fairness of credit scoring models: A literature review on mortgage accessibility for under-reserved populations. GSC Adv Res Rev. 2024;18(3):189-199.
9. Adegoke TI, Ofodile OC, Ochuba NA, Akinrinola O. Data analytics in finance and mortgage: A catalyst for addressing inequities faced by under-reserved populations in the USA. Int J Sci Res Arch. 2024;11(2):338-347.
10. Adeniran IA, Efunniyi CP, Osundare OS, Abhulimen AO, OneAdvanced UK. The role of data science in transforming business operations: Case studies from enterprises. Comput Sci IT Res J. 2024;5(8).
11. Adeoye OB, Addy WA, Ajayi-Nifise AO, Odeyemi O, Okoye CC, Ofodile OC. Leveraging AI and data analytics for enhancing financial inclusion in developing economies. Finance Account Res J. 2024;6(3):288-303.
12. Adeoye OB, Addy WA, Odeyemi O, Okoye CC, Ofodile OC, Oyewole AT, *et al* Fintech, taxation, and regulatory compliance: navigating the new financial landscape. Finance Account Res J. 2024;6(3):320-330.
13. Adeoye OB, Okoye CC, Ofodile OC, Odeyemi O, Addy WA, Ajayi-Nifise AO. Integrating artificial intelligence in personalized insurance products: a pathway to enhanced customer engagement. Int J Manage Entrep Res. 2024;6(3):502-511.

14. Adeoye OB, Okoye CC, Ofodile OC, Odeyemi O, Addy WA, Ajayi-Nifise AO. Artificial Intelligence in ESG investing: Enhancing portfolio management and performance. Int J Sci Res Arch. 2024;11(1):2194-2205.
15. Adesina AA, Iyelolu TV, Paul PO. Leveraging predictive analytics for strategic decision-making: Enhancing business performance through data-driven insights. World J Adv Res Rev. 2024.
16. Adesina AA, Iyelolu TV, Paul PO. Optimizing Business Processes with Advanced Analytics: Techniques for Efficiency and Productivity Improvement. World J Adv Res Rev. 2024;22(3):1917-1926.
17. Adewale TT, Eyo-Udo NL, Toromade AS, Ngochindo A. Integrating sustainability and cost-effectiveness in food and FMCG supply chains: A comprehensive model. 2024.
18. Adewale TT, Eyo-Udo NL, Toromade AS, Ngochindo A. Optimizing food and FMCG supply chains: A dual approach leveraging behavioral finance insights and big data analytics for strategic decision-making. 2024.
19. Adewusi AO, Chiekezie NR, Eyo-Udo NL. Cybersecurity threats in agriculture supply chains: A comprehensive review. World J Adv Res Rev. 2022;15(3):490-500.
20. Adewusi AO, Chiekezie NR, Eyo-Udo NL. Securing smart agriculture: Cybersecurity challenges and solutions in IoT-driven farms. World J Adv Res Rev. 2022;15(3):480-489.Adewusi, A.O., Chiekezie, N.R. & Eyo-Udo, N.L. (2022) The role of AI in enhancing cybersecurity for smart farms. World Journal of Advanced Research and Reviews, 15(03), pp 501-512
21. Adewusi AO, Chikezie NR, Eyo-Udo NL. Blockchain technology in agriculture: Enhancing supply chain transparency and traceability. Finance Account Res J. 2023;5(12):479-501.
22. Adewusi AO, Chikezie NR, Eyo-Udo NL. Cybersecurity in precision agriculture: Protecting data integrity and privacy. Int J Appl Res Soc Sci. 2023;5(10):693-708.
23. Ajala OA, Arinze CA, Ofodile OC, Okoye CC, Daraojimba AI. Exploring and reviewing the potential of quantum computing in enhancing cybersecurity encryption methods. 2024.
24. Ajala OA, Arinze CA, Ofodile OC, Okoye CC, Daraojimba OD. Reviewing advancements in privacy-enhancing technologies for big data analytics in an era of increased surveillance. World J Adv Eng Technol Sci. 2024;11(1):294-300.
25. Ajala OA, Okoye CC, Ofodile OC, Arinze CA, Daraojimba OD. Review of AI and machine learning applications to predict and thwart cyber-attacks in real time. 2024.
26. Akinrinola O, Okoye CC, Ofodile OC, Ugochukwu CE. Navigating and reviewing ethical dilemmas in AI development: Strategies for transparency, fairness, and accountability. GSC Adv Res Rev. 2024;18(3):50-58.
27. Akter S, Hossain MA, Lu Q, Shams SR. Big data-driven strategic orientation in international marketing. Int Mark Rev. 2021;38(5):927-947.
28. Anjorin K, Ijomah T, Toromade A, Akinsulire A, Eyo-Udo N. Evaluating business development services' role in enhancing SME resilience to economic shocks. Glob J Res Sci Technol. 2024;2(1):29-45.
29. Arinze CA, Ajala OA, Okoye CC, Ofodile OC, Daraojimba AI. Evaluating the integration of advanced IT solutions for emission reduction in the oil and gas sector. Eng Sci Technol J. 2024;5(3):639-652.
30. Beck L. Carbon capture and storage in the USA: The role of US innovation leadership in climate-technology commercialization. Clean Energy. 2020;4(1):2-11.
31. Bui M, Adjiman CS, Bardow A, Anthony EJ, Boston A, Brown S, *et al* Carbon capture and storage (CCS): the way forward. Energy Environ Sci. 2018;11(5):1062-1176.
32. Calfa BA, Agarwal A, Bury SJ, Wassick JM, Grossmann IE. Data-driven simulation and optimization approaches to incorporate production variability in sales and operations planning. Ind Eng Chem Res. 2015;54(29):7261-72.
33. Curuksu JD. Data driven. Management for Professionals. 2018.
34. Daraojimba C, Eyo-Udo NL, Egbokhaebho BA, Ofonagoro KA, Ogunjobi OA, Tula OA, *et al* Mapping international research cooperation and intellectual property management in the field of materials science: An exploration of strategies, agreements, and hurdles. Eng Sci Technol J. 2023;4(3):29-48.
35. Egieya ZE, Obiki-Osafiele AN, Ikwue U, Eyo-Udo NL, Daraojimba C. Comparative analysis of workforce efficiency, customer engagement, and risk management strategies: Lessons from Nigeria and the USA. Int J Manage Entrep Res. 2024;6(2):439-50.
36. Eyieyien OG, Idemudia C, Paul PO, Ijomah TI. Effective stakeholder and risk management strategies for large-scale international project success. 2024.
37. Eyieyien OG, Idemudia C, Paul PO, Ijomah TI. Advancements in project management methodologies: Integrating agile and waterfall approaches for optimal outcomes. Eng Sci Technol J. 2024.
38. Eyieyien OG, Idemudia C, Paul PO, Ijomah TI. The impact of ICT projects on community development and promoting social inclusion. 2024.
39. Eyieyien OG, Idemudia PO, Paul PC, Ijomah TI. Strategic approaches for successful digital transformation in project management across industries. Int J Front Eng Technol Res. 2024;7:1-11.
40. Eyo-Udo N. Leveraging artificial intelligence for enhanced supply chain optimization. Open Access Res J Multidiscip Stud. 2024;7(2):1-15.
41. Eyo-Udo NL, Agho MO, Onukwulu EC, Sule AK, Azubuike C. Advances in circular economy models for sustainable energy supply chains. Gulf J Adv Bus Res. 2024;2(6):300-37. DOI: 10.51594/gjabr.v2i6.52.
42. Eyo-Udo NL, Agho MO, Onukwulu EC, Sule AK, Azubuike C. Advances in green finance solutions for combating climate changes and ensuring sustainability. Gulf J Adv Bus Res. 2024;2(6):338-75. DOI: 10.51594/gjabr.v2i6.53.
43. Eyo-Udo NL, Odimarha AC, Ejairu E. Sustainable and ethical supply chain management: The role of HR in current practices and future directions. Magna Sci Adv Res Rev. 2024;10(2):181-96.
44. Eyo-Udo NL, Odimarha AC, Kolade OO. Ethical supply chain management: Balancing profit, social responsibility, and environmental stewardship. Int J Manage Entrep Res. 2024;6(4):1069-77.
45. Gidiagba JO, Daraojimba C, Ofonagoro KA, Eyo-Udo NL, Egbokhaebho BA, Ogunjobi OA, *et al* Economic impacts and innovations in materials science: A holistic exploration of nanotechnology and advanced materials. Eng Sci Technol J. 2023;4(3):84-100.
46. Grandhi B, Patwa N, Saleem K. Data-driven marketing for growth and profitability. EuroMed J Bus. 2021;16(4):381-98.
47. Henke N, Bughin JL. The age of analytics: Competing in

a data-driven world. 2016.
48. Hosen MS, Islam R, Naeem Z, Folorunso EO, Chu TS, Al Mamun MA, *et al* Data-driven decision making: Advanced database systems for business intelligence. Nanotechnol Percept. 2024;20(3):687-704.
49. Igwe AN, Ewim CPM, Ofodile OC, Sam-Bulya NJ. Comprehensive framework for data fusion in distributed ledger technologies to enhance supply chain sustainability. Int J Front Res Sci. 2024;3(1):76-89.
50. Igwe AN, Ewim CPM, Ofodile OC, Sam-Bulya NJ. Leveraging blockchain for sustainable supply chain management: A data privacy and security perspective. Int J Front Res Sci. 2024;3(1):61-75.
51. Ihemereze KC, Ekwezia AV, Eyo-Udo NL, Ikwue U, Ufoaro OA, Oshioste EE, *et al* Bottle to brand: Exploring how effective branding energized Star Lager Beer's performance in a fierce market. Eng Sci Technol J. 2023;4(3):169-89.
52. Ihemereze KC, Eyo-Udo NL, Egbokhaebho BA, Daraojimba C, Ikwue U, Nwankwo EE. Impact of monetary incentives on employee performance in the Nigerian automotive sector: A case study. Int J Adv Econ. 2023;5(7):162-86.
53. Ijomah TI, Idemudia C, Eyo-Udo NL, Anjorin KF. Innovative digital marketing strategies for SMEs: Driving competitive advantage and sustainable growth. Int J Manage Entrep Res. 2024;6(7):2173-88.
54. Ijomah TI, Idemudia C, Eyo-Udo NL, Anjorin KF. Harnessing marketing analytics for enhanced decision-making and performance in SMEs. 2024.
55. Ijomah TI, Idemudia C, Eyo-Udo NL, Anjorin KF. The role of big data analytics in customer relationship management: Strategies for improving customer engagement and retention. 2024.
56. Iyelolu TV, Paul PO. Implementing machine learning models in business analytics: Challenges, solutions, and impact on decision-making. World J Adv Res Rev. 2024.
57. Kaggwa S, Onunka T, Uwaoma PU, Onunka O, Daraojimba AI, Eyo-Udo NL. Evaluating the efficacy of technology incubation centres in fostering entrepreneurship: Case studies from the global south. Int J Manage Entrep Res. 2024;6(1):46-68.
58. Mokogwu O, Achumie GO, Adeleke AG, Okeke IC, Ewim CP. A data-driven operations management model: Implementing MIS for strategic decision-making in tech businesses. Int J Frontline Res Rev. 2024;3(1):1-19.
59. Nnaji UO, Benjamin LB, Eyo-Udo NL, Etukudoh EA. Incorporating sustainable engineering practices into supply chain management for environmental impact reduction. GSC Adv Res Rev. 2024;19(2):138-43.
60. Nnaji UO, Benjamin LB, Eyo-Udo NL, Etukudoh EA. Advanced risk management models for supply chain finance. World J Adv Res Rev. 2024;22(2):612-8.
61. Nnaji UO, Benjamin LB, Eyo-Udo NL, Etukudoh EA. A review of strategic decision-making in marketing through big data and analytics. Magna Sci Adv Res Rev. 2024;11(1):84-91.
62. Nnaji UO, Benjamin LB, Eyo-Udo NL, Etukudoh EA. Effective cost management strategies in global supply chains. Int J Appl Res Soc Sci. 2024;6(5):945-53.
63. Nnaji UO, Benjamin LB, Eyo-Udo NL, Etukudoh EA. Strategies for enhancing global supply chain resilience to climate change. Int J Manage Entrep Res. 2024;6(5):1677-86.
64. Odeyemi O, Okoye CC, Ofodile OC, Adeoye OB, Addy WA, Ajayi-Nifise AO. Integrating AI with blockchain for enhanced financial services security. Finance Account Res J. 2024;6(3):271-87.
65. Odeyemi O, Oyewole AT, Adeoye OB, Ofodile OC, Addy WA, Okoye CC, *et al* Entrepreneurship in Africa: A review of growth and challenges. Int J Manage Entrep Res. 2024;6(3):608-22.
66. Ofodile OC, Odeyemi O, Okoye CC, Addy WA, Oyewole AT, Adeoye OB, *et al* Digital banking regulations: A comparative review between Nigeria and the USA. Finance Account Res J. 2024;6(3):347-71.
67. Ofodile OC, Oyewole AT, Ugochukwu CE, Addy WA, Adeoye OB, Okoye CC. Predictive analytics in climate finance: Assessing risks and opportunities for investors. GSC Adv Res Rev. 2024;18(2):423-33.
68. Ogbu AD, Eyo-Udo NL, Adeyinka MA, Ozowe W, Ikevuje AH. A conceptual procurement model for sustainability and climate change mitigation in the oil, gas, and energy sectors. World J Adv Res Rev. 2023;20(3):1935-52.
69. Ogunjobi OA, Eyo-Udo NL, Egbokhaebho BA, Daraojimba C, Ikwue U, Banso AA. Analyzing historical trade dynamics and contemporary impacts of emerging materials technologies on international exchange and US strategy. Eng Sci Technol J. 2023;4(3):101-19.
70. Ojebode A, Onekutu P. Nigerian mass media and cultural status inequalities: A study among minority ethnic groups. Technium Soc Sci J. 2021;23:732.
71. Okafor CM, Kolade A, Onunka T, Daraojimba C, Eyo-Udo NL, Onunka O, *et al* Mitigating cybersecurity risks in the US healthcare sector. Int J Res Sci Innov. 2023;10(9):177-93.
72. Okafor C, Agho M, Ekwezia A, Eyo-Udo N, Daraojimba C. Utilizing business analytics for cybersecurity: A proposal for protecting business systems against cyberattacks. Acta Electronica Malaysia. 2023.
73. Okeke NI, Alabi OA, Igwe AN, Ofodile OC, Ewim CP. AI-powered customer experience optimization: Enhancing financial inclusion in underserved communities. Int J Appl Res Soc Sci. 2024;6(10).
74. Okeke NI, Alabi OA, Igwe AN, Ofodile OC, Ewim CP. Customer journey mapping framework for SMEs: Enhancing customer satisfaction and business growth. World J Adv Res Rev. 2024;24(1).
75. Okogwu C, Agho MO, Adeyinka MA, Odulaja BA, Eyo-Udo NL, Daraojimba C, *et al* Exploring the integration of sustainable materials in supply chain management for environmental impact. Eng Sci Technol J. 2023;4(3):49-65.
76. Okoye CC, Addy WA, Adeoye OB, Oyewole AT, Ofodile OC, Odeyemi O, *et al* Sustainable supply chain practices: A review of innovations in the USA and Africa. Int J Appl Res Soc Sci. 2024;6(3):292-302.
77. Okoye CC, Ofodile OC, Nifise AOA, Odeyemi O, Tula ST. Climate risk assessment in petroleum operations: A review of CSR practices for sustainable resilience in the United States and Africa. GSC Adv Res Rev. 2024;18(2):234-45.
78. Okpeh OO, Ochefu YA. The Idoma ethnic group: A historical and cultural setting. Manuscript. 2010.
79. Olufemi-Phillips AQ, Igwe AN, Ofodile OC, Louis N. Analyzing economic inflation's impact on food security and accessibility through econometric modeling. 2024.
80. Olufemi-Phillips AQ, Ofodile OC, Toromade AS, Ngochindo Abbey I, Eyo-Udo L. Utilizing predictive analytics to manage food supply and demand in adaptive supply chains. 2024.
81. Olufemi-Phillips AQ, Ofodile OC, Toromade AS, Eyo-Udo NL, Adewale TT. Optimizing FMCG supply chain

management with IoT and cloud computing integration. Int J Manage Entrep Res. 2020;6(11).
82. Olufemi-Phillips AQ, Ofodile OC, Toromade AS, Igwe AN, Adewale TT. Stabilizing food supply chains with blockchain technology during periods of economic inflation. 2024.
83. Olurin JO, Okonkwo F, Eleogu T, James OO, Eyo-Udo NL, Daraojimba RE. Strategic HR management in the manufacturing industry: balancing automation and workforce development. Int J Res Sci Innov. 2024;10(12):380-401.
84. Olutimehin DO, Nwankwo EE, Ofodile OC, Ugochukwu CE. Strategic operations management in FMCG: A comprehensive review of best practices and innovations. Int J Manage Entrep Res. 2024;6(3):780-94.
85. Olutimehin DO, Ofodile OC, Ejibe I, Oyewole A. Developing a strategic partnership model for enhanced performance in emerging markets. Int J Manage Entrep Res. 2024;6(3):806-14.
86. Olutimehin DO, Ofodile OC, Ejibe I, Odunaiya OG, Soyombo OT. Innovations in business diversity and inclusion: case studies from the renewable energy sector. Int J Manage Entrep Res. 2024;6(3):890-909.
87. Olutimehin DO, Ofodile OC, Ejibe I, Odunaiya OG, Soyombo OT. The role of technology in supply chain risk management: innovations and challenges in logistics. Int J Manage Entrep Res. 2024;6(3):878-89.
88. Olutimehin DO, Ofodile OC, Ejibe I, Odunaiya OG, Soyombo OT. Implementing AI in business models: strategies for efficiency and innovation. Int J Manage Entrep Res. 2024;6(3):863-77.
89. Olutimehin DO, Ofodile OC, Ugochukwu CE, Nwankwo EE. Corporate governance and stakeholder engagement in Nigerian enterprises: A review of current practices and future directions. World J Adv Res Rev. 2024;21(3):736-42.
90. Olutimehin DO, Ugochukwu CE, Ofodile OC, Nwankwo EE, Joel OS. Optimizing FMCG supply chain dynamics: A novel framework for integrating operational efficiency and customer satisfaction. Int J Manage Entrep Res. 2024;6(3):770-9.
91. Omowole BM, Olufemi-Phillips AQ, Ofodile OC, Eyo-Udo NL, Ewim SE. The role of SMEs in promoting urban economic development: A review of emerging economy strategies. 2024.
92. Omowole BM, Olufemi-Phillips AQ, Ofadile OC, Eyo-Udo NL, Ewim SE. Big data for SMEs: A review of utilization strategies for market analysis and customer insight. Int J Frontline Res Multidiscip Stud. 2024;5(1):1-18.
93. Omowole BM, Olufemi-Phillips AQ, Ofadile OC, Eyo-Udo NL, Ewim SE. Barriers and drivers of digital transformation in SMEs: A conceptual analysis. Int J Frontline Res Multidiscip Stud. 2024;5(2):19-36.
94. Omowole BM, Olufemi-Phillips AQ, Ofadile OC, Eyo-Udo NL, Ewim SE. Conceptualizing agile business practices for enhancing SME resilience to economic shocks. Int J Scholarly Res Rev. 2024;5(2):70-88.
95. Omowole BM, Olufemi-Phillips AQ, Ofodile OC, Eyo-Udo NL, Ewim SE. Conceptualizing green business practices in SMEs for sustainable development. Int J Manage Entrep Res. 2024;6(11):3778-805.
96. Onesi-Ozigagun O, Ololade YJ, Eyo-Udo NL, Ogundipe DO. Revolutionizing education through AI: a comprehensive review of enhancing learning experiences. Int J Appl Res Soc Sci. 2024;6(4):589-607.
97. Onesi-Ozigagun O, Ololade YJ, Eyo-Udo NL, Ogundipe DO. Leading digital transformation in non-digital sectors: a strategic review. Int J Manage Entrep Res. 2024;6(4):1157-75.
98. Onesi-Ozigagun O, Ololade YJ, Eyo-Udo NL, Oluwaseun D. Data-driven decision making: Shaping the future of business efficiency and customer engagement. 2024.
99. Onesi-Ozigagun O, Ololade YJ, Eyo-Udo NL, Oluwaseun D. Agile product management as a catalyst for technological innovation. 2024.
100. Onesi-Ozigagun O, Ololade YJ, Eyo-Udo NL, Oluwaseun D. AI-driven biometrics for secure fintech: pioneering safety and trust. 2024.
101. Onukwulu EC, Agho MO, Eyo-Udo NL. Framework for sustainable supply chain practices to reduce carbon footprint in energy. Open Access Research Journal of Science and Technology. 2021;1(2):12–34. https://doi.org/10.53022/oarjst.2021.1.2.0032
102. Onukwulu EC, Agho MO, Eyo-Udo NL. Advances in green logistics integration for sustainability in energy supply chains. World Journal of Advanced Science and Technology. 2022;2(1):47–68. https://doi.org/10.53346/wjast.2022.2.1.0040
103. Onukwulu EC, Agho MO, Eyo-Udo NL. Circular economy models for sustainable resource management in energy supply chains. World Journal of Advanced Science and Technology. 2022;2(2):34–57. https://doi.org/10.53346/wjast.2022.2.2.0048
104. Onukwulu EC, Agho MO, Eyo-Udo NL. Decentralized energy supply chain networks using blockchain and IoT. International Journal of Scholarly Research in Multidisciplinary Studies. 2023;2(2):66–85. https://doi.org/10.56781/ijsrms.2023.2.2.0055
105. Onukwulu EC, Agho MO, Eyo-Udo NL. Developing a framework for AI-driven optimization of supply chains in the energy sector. Global Journal of Advanced Research and Reviews. 2023;1(2):82–101. https://doi.org/10.58175/gjarr.2023.1.2.0064
106. Onukwulu EC, Agho MO, Eyo-Udo NL. Developing a framework for supply chain resilience in renewable energy operations. Global Journal of Research in Science and Technology. 2023;1(2):1–18. https://doi.org/10.58175/gjrst.2023.1.2.0048
107. Onukwulu EC, Agho MO, Eyo-Udo NL. Developing a framework for predictive analytics in mitigating energy supply chain risks. International Journal of Scholarly Research and Reviews. 2023;2(2):135–55. https://doi.org/10.56781/ijsrr.2023.2.2.0042
108. Onukwulu EC, Agho MO, Eyo-Udo NL. Sustainable supply chain practices to reduce carbon footprint in oil and gas. Global Journal of Research in Multidisciplinary Studies. 2023;1(2):24–43. https://doi.org/10.58175/gjrms.2023.1.2.0044
109. Onukwulu NEC, Agho NMO, Eyo-Udo NNL. Advances in smart warehousing solutions for optimizing energy sector supply chains. Open Access Research Journal of Multidisciplinary Studies. 2021;2(1):139–57. https://doi.org/10.53022/oarjms.2021.2.1.0045
110. Oriekhoe OI, Addy WA, Okoye CC, Oyewole AT, Ofodile OC, Ugochukwu CE. The role of accounting in mitigating food supply chain risks and food price volatility. International Journal of Science and Research Archive. 2024;11(1):2557–65.
111. Orieno OH, Ndubuisi NL, Eyo-Udo NL, Ilojianya VI, Biu PW. Sustainability in project management: A comprehensive review. World Journal of Advanced Research and Reviews. 2024;21(1):656–77.

112. Oyeniyi LD, Igwe AN, Ofodile OC, Paul-Mikki C. Optimizing risk management frameworks in banking: Strategies to enhance compliance and profitability amid regulatory challenges.
113. Oyewole AT, Adeoye OB, Addy WA, Okoye CC, Ofodile OC. Enhancing global competitiveness of US SMEs through sustainable finance: A review and future directions. International Journal of Management & Entrepreneurship Research. 2024;6(3):634–47.
114. Oyewole AT, Adeoye OB, Addy WA, Okoye CC, Ofodile OC, Ugochukwu CE. Promoting sustainability in finance with AI: A review of current practices and future potential. World Journal of Advanced Research and Reviews. 2024;21(3):590–607.
115. Oyewole AT, Adeoye OB, Addy WA, Okoye CC, Ofodile OC, Ugochukwu CE. Augmented and virtual reality in financial services: A review of emerging applications. World Journal of Advanced Research and Reviews. 2024;21(3):551–67.
116. Oyewole AT, Adeoye OB, Addy WA, Okoye CC, Ofodile OC, Ugochukwu CE. Predicting stock market movements using neural networks: A review and application study. Computer Science & IT Research Journal. 2024;5(3):651–70.
117. Oyewole AT, Adeoye OB, Addy WA, Okoye CC, Ofodile OC, Ugochukwu CE. Automating financial reporting with natural language processing: A review and case analysis. World Journal of Advanced Research and Reviews. 2024;21(3):575–89.
118. Oyewole AT, Okoye CC, Ofodile OC, Ejairu E. Reviewing predictive analytics in supply chain management: Applications and benefits. World Journal of Advanced Research and Reviews. 2024;21(3):568–74.
119. Oyewole AT, Okoye CC, Ofodile OC, Ugochukwu CE. Cybersecurity risks in online banking: A detailed review and preventive strategies application. World Journal of Advanced Research and Reviews. 2024;21(3):625–43.
120. Oyewole AT, Okoye CC, Ofodile OC, Odeyemi O, Adeoye OB, Addy WA, Ololade YJ. Human resource management strategies for safety and risk mitigation in the oil and gas industry: A review. International Journal of Management & Entrepreneurship Research. 2024;6(3):623–33.
121. Paul PO, Iyelolu TV. Anti-Money laundering compliance and financial inclusion: a technical analysis of Sub-Saharan Africa. GSC Advanced Research and Reviews. 2024;19(3):336–43.
122. Paul PO, Aderoju AV, Shitu K, Ononiwu MI, Igwe AN, Ofodile OC, Ewim CP-M. Blockchain for sustainable supply chains: A systematic review and framework for SME implementation. World Journal of Advanced Engineering Technology and Sciences. 2024;13(1).
123. Paul PO, Ogugua JO, Eyo-Udo NL. Advancing strategic procurement: Enhancing efficiency and cost management in high-stakes environments. International Journal of Management & Entrepreneurship Research. 2024;6(7):2100–11.
124. Paul PO, Ogugua JO, Eyo-Udo NL. Innovations in fixed asset management: Enhancing efficiency through advanced tracking and maintenance systems. [Unpublished journal; ensure to complete details].
125. Paul PO, Ogugua JO, Eyo-Udo NL. The role of data analysis and reporting in modern procurement: Enhancing decision-making and supplier management. International Journal of Management & Entrepreneurship Research. 2024;6(7):2139–52.
126. Pereira MM, Frazzon EM. A data-driven approach to adaptive synchronization of demand and supply in omni-channel retail supply chains. International Journal of Information Management. 2021;57:102165.
127. Raji MA, Olodo HB, Oke TT, Addy WA, Ofodile OC, Oyewole AT. Real-time data analytics in retail: A review of USA and global practices. GSC Advanced Research and Reviews. 2024;18(3):059–65.
128. Raji MA, Olodo HB, Oke TT, Addy WA, Ofodile OC, Oyewole AT. E-commerce and consumer behavior: A review of AI-powered personalization and market trends. GSC Advanced Research and Reviews. 2024;18(3):066–77.
129. Raji MA, Olodo HB, Oke TT, Addy WA, Ofodile OC, Oyewole AT. Business strategies in virtual reality: A review of market opportunities and consumer experience. International Journal of Management & Entrepreneurship Research. 2024;6(3):722–36.
130. Raji MA, Olodo HB, Oke TT, Addy WA, Ofodile OC, Oyewole AT. The digital transformation of SMEs: A comparative review between the USA and Africa. International Journal of Management & Entrepreneurship Research. 2024;6(3):737–51.
131. Raji MA, Olodo HB, Oke TT, Addy WA, Ofodile OC, Oyewole AT. Digital marketing in tourism: A review of practices in the USA and Africa. International Journal of Applied Research in Social Sciences. 2024;6(3):393–408.
132. Sam-Bulya NJ, Mbanefo JV, Ewim CP-M, Ofodile OC. Blockchain for sustainable supply chains: A systematic review and framework for SME implementation. International Journal of Engineering Research and Development. 2024;20(11):673–90.
133. Sam-Bulya NJ, Mbanefo JV, Ewim CP-M, Ofodile OC. Ensuring privacy and security in sustainable supply chains through distributed ledger technologies. International Journal of Engineering Research and Development. 2024;20(11):691–702.
134. Sam-Bulya NJ, Mbanefo JV, Ewim CP-M, Ofodile OC. Improving data interoperability in sustainable supply chains using distributed ledger technologies. International Journal of Engineering Research and Development. 2024;20(11):703–13.
135. Shoetan PO, Oyewole AT, Okoye CC, Ofodile OC. Reviewing the role of big data analytics in financial fraud detection. Finance & Accounting Research Journal. 2024;6(3):384–94.
136. Sule AK, Eyo-Udo NL, Onukwulu EC, Agho MO, Azubuike C. Green finance solutions for banking to combat climate change and promote sustainability. Gulf Journal of Advanced Business Research. 2024;2(6):376–410. doi:10.51594/gjabr.v6i2.54
137. Tseng ML, Tran TPT, Ha HM, Bui TD, Lim MK. Sustainable industrial and operation engineering trends and challenges toward Industry 4.0: A data-driven analysis. Journal of Industrial and Production Engineering. 2021;38(8):581–98.
138. Tula OA, Daraojimba C, Eyo-Udo NL, Egbokhaebho BA, Ofonagoro KA, Ogunjobi OA, *et al* Analyzing global evolution of materials research funding and its influence on innovation landscape: A case study of US investment strategies. Engineering Science & Technology Journal. 2023;4(3):120–39.
139. Ugochukwu CE, Ofodile OC, Okoye CC, Akinrinola O. Sustainable smart cities: The role of fintech in promoting environmental sustainability. Engineering Science & Technology Journal. 2024;5(3):821–35.

140. Usman FO, Eyo-Udo NL, Etukudoh EA, Odonkor B, Ibeh CV, Adegbola A. A critical review of AI-driven strategies for entrepreneurial success. International Journal of Management & Entrepreneurship Research. 2024;6(1):200–15.
141. Uwaoma PU, Eboigbe EO, Eyo-Udo NL, Daraojimba DO, Kaggwa S. Space commerce and its economic implications for the US: A review: Delving into the commercialization of space, its prospects, challenges, and potential impact on the US economy. World Journal of Advanced Research and Reviews. 2023;20(3):952–65.
142. Uwaoma PU, Eboigbe EO, Eyo-Udo NL, Ijiga AC, *et al* Mixed reality in US retail: A review: Analyzing the immersive shopping experiences, customer engagement, and potential economic implications. World Journal of Advanced Research and Reviews. 2023;[Details missing, ensure volume/issue/page numbers are provided].
143. Uwaoma PU, Eboigbe EO, Eyo-Udo NL, Ijiga AC, Kaggwa S, Daraojimba DO. The fourth industrial revolution and its impact on agricultural economics: Preparing for the future in developing countries. International Journal of Advanced Economics. 2023;5(9):258–70.