Review

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Criteria for Selecting Carbon Subsurface and Ocean Storage Site in Developing Countries: A Review

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Abstract: Important first phases in the process of implementing CO_2 subsurface and ocean storage projects include selecting of best possible location(s) for CO_2 storage, site selection evaluation. Sites must fulfil a number of criteria that boil down to the following basics: they must be able to accept the desired volume of CO_2 at the rate at which it is supplied from the CO_2 source(s); they must as well be safe and reliable; and must comply with regulatory and other societal requirements. They also must have at least public acceptance and be based on sound financial analysis. Site geology; hydrogeological, pressure, and geothermal regimes; land features; location, climate, and access, etc. can all be refined from these basic criteria. In addition to aiding in site selection, site characterization is essential for other purposes, such as foreseeing the fate and impacts of the injected CO_2, and informing subsequent phases of site development, including design, permitting, operation, monitoring, and eventual abandonment. According to data from the IEA, in 2022, emissions from Africa and Asia's emerging markets and developing economies, excluding China's, increased by 4.2%, which is equivalent to 206 million tonnes of CO_2 and were higher than those from developed economies. Coal-fired power generation was responsible for more than half of the rise in emissions that were recorded in the region. The difficulty of achieving sustainable socio-economic progress in the developing countries is entwined with the work of reducing CO_2 emissions, which is a demanding project for the economy. Organisations from developing countries, such as Bangladesh, Cameroon, India, and Nigeria, have formed partnerships with organisations in other countries for lessons learn and investment within the climate change arena. The basaltic rocks, coal seams, depleted oil and gas reservoirs, soils, deep saline aquifers, and sedimentary basins that developing countries (Bangladesh, Cameroon, India, and Nigeria etc) possesses all contribute to the individual country's significant geological sequestration potential. There are limited or no carbon capture and storage or clean development mechanism projects running in these countries at this time. The site selection and characterization procedure are not complete without an estimate of the storage capacity of a storage location. Estimating storage capacity relies on volumetric estimates because a site must accept the planned volume of CO_2 during the active injection period. As more and more applications make use of site characterization, so too does the body of written material on the topic. As the science of CO_2 storage develops, regulatory requirements are implemented, field experience grows, and the economics of CO_2 capture and storage improve, so too will site selection and characterisation change.

Keywords: CCUS Site Selection; Carbon dioxide capture and storage (CCS); CO_2 Sequestration; CCS Governmental Regulation; CO_2 Environment Impact; Geological storage

1. Introduction

Prior to CO_2 storage is developed and implemented, it's critical to ensure the reliability of the technology to be use, establish criteria for the evaluation of storage locations, safe, dependable, reliable, ecologically responsible, and economically viable. This is particularly key in the event that there are neither regulations nor practices in place to guarantee ethical management. For businesses to make informed decisions about the costs and benefits of potential investments, the site assessment process must provide clear inputs in the form of evaluation criteria and recommendations (Knoope et al. 2015).

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2. Key Selection Criteria

Research conducted by (Zhang and Bachu 2011) and (Bachu 2010) reveals the following are the most important factors to be considered when choosing a location for the confinement of CO_2 in geological reservoir formations:

a. Geothermal

b. Hydrodynamic

c. Geohazards

d. Geological

e. Basin maturity

f. And hydrocarbon potential

g. Economic, societal, and environmental issues

There are currently 65 commercial CCUS facilities across the globe as of the year 2020 (Figure 1 below). Of these facilities, only 26 are operational, three are in the process of construction, 13 are in the advanced development stage, 21 are in the early development stage, and 2 have had their development halted altogether. Together, they are responsible for the annual production of 40MT of CO_2. In order to put this into perspective, the total world emissions in 2019 came to 52 billion tonnes. If the overall conversion rate stays the same, it will take the present plants 130 years to sequester CO_2, and that's assuming there won't be any further emissions. This is an improbable occurrence, which is why there must be more plants of this kind developed. Figure 1.1 below also confirmed there is no active CCUS plant in any of the developing countries especially countries with big economic activities like Nigeria, Bangladesh, India and Cameroon. In 2018, the Intergovernmental Panel on Climate Change (IPCC) published a special study in which they analysed some 90 potential projects that would limit global warming to 1.5 degrees Celsius. To reach the goal of 1.5 degrees Celsius, they will need to permanently sequester 10 billion tonnes of CO_2 by the year 2050. The potential for carbon sequestration at this time is consequently shown to be woefully inadequate. To reach the IPCC targets (Senthilkumar 2021) that were voted upon at the Paris Summit, there will need to be approximately 2000 CCS plants.

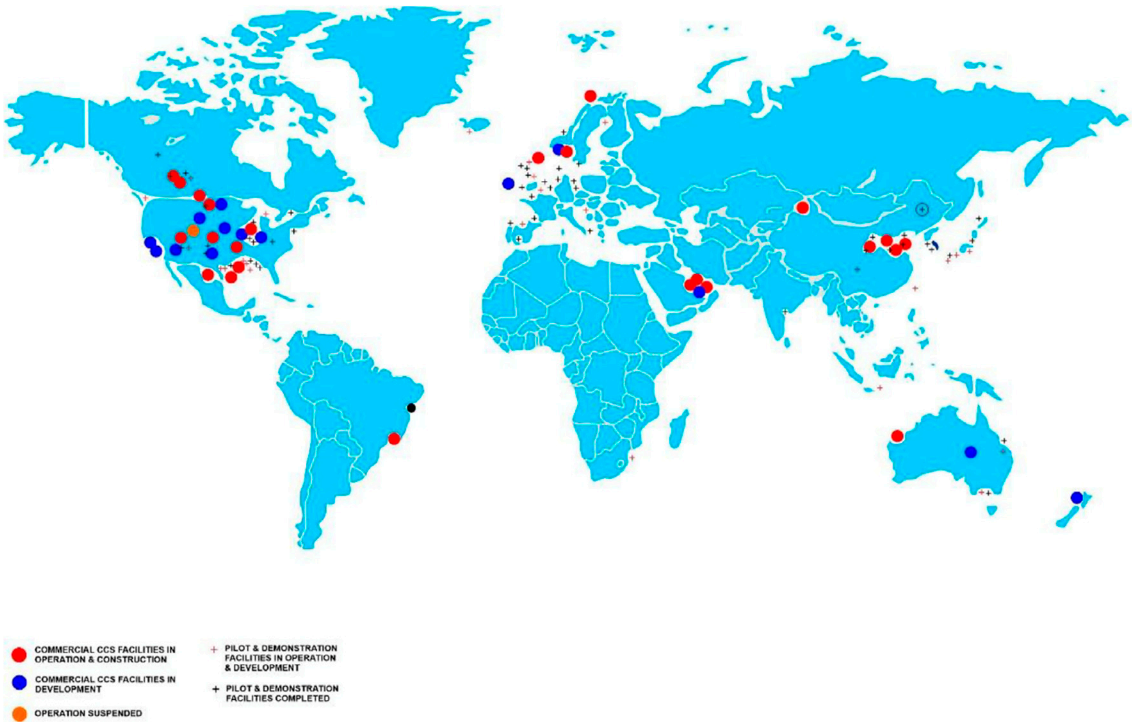

Figure 1. A map of the world that depicts the many carbon capture and storage facilities at various phases of operation (extracted from the Global CCS Institute's GCCSI 2020).

This article presents a general overview of carbon capture and storage (CCS) in the context of the CO_2 predicament. The primary focus of the paper is on analysing the selection potentials, technologies, and current situations in the developing countries CCS arena. Highlighted researches on CCS selection criteria from the point of view of developing countries researchers. On the other hand, several breakthroughs have been made in the sector over the course of the past 15 years; hence, a review article that is brought up to date was required especially with an African and Asian focus. We are aware that each sub-section in this article has the potential to expand into individual contributions, and we have taken that into consideration.

As written in the IPCC report 5th assessment, there is a widespread climate change impact globally both continentally and in the oceans. This effect gives rise to severe disruption of the food chain and ecosystem, hydraulic system, biodiversity, production of food, related health issues, and agriculture. (Munang et al., 2008) reaffirmed the impacts of climate change as one of the major concerns facing humanity in the 21st century.

Developing countries including South East Asia and Africa is at the epicentral of climate change concern as its one of the most vulnerable continents in the world (OSS/UNEP, 2010). (IPCC, 1998) report shows that the exposed region to the effects of climate change is mainly developing countries. And so far, many studies have shown that Africa is one of the most affected continents by climate change.

Indeed, Africa faces the most severe impacts of climate change and some of these impacts include flooding, droughts, and storms of which the intensity and frequency are more likely to increase as time goes by if various risk mitigation is not evaluated and strategic adaption are not put in place. Likewise, the pattern and among of rainfall would effectively change.

The vulnerability of the African continent to the impact of climate change shows that these impacts are more prevalent in the Sub-Saharan African countries especially Cameroon and Nigeria just to name a few.

According to a report published by the IPCC, the mean global temperatures have increased by approximately 1°C over the past two century dating back to 1850. Interestingly, the last decade has seen the highest recorded period globally. It is also claimed in the IPCC AR5 report that global average temperature will rise from some 1°C to approximately 6.4°C as GHG emissions continue to increase.

2.1. The Gradient of Geothermal Energy

Past studies (van der Meer 1993) showed that a little shift in the geothermal gradient with depth might push CO_2 above its critical point. Hydrostatic pressure distribution across a sedimentary basin requires a minimum depth of roughly 800m for injecting CO_2 at its supercritical phase with a temperature gradient of about 86°F/km and the surface temperature of 50°F (see Figure 2.1). Not all basins have the same hydrodynamic and geothermal characteristics, and even locations within the same bay might have very different hydrodynamic and geothermal environments. Some of the following factors would limit the geothermal regime in every sedimentary basin:

a. The kind of basin, its age, and the sort of tectonism that occurred there

b. The movement of heat in the basement

c. In the sedimentary succession, thermal conductivity and heat generation

d. The temperature of the sedimentary rock at the very top of the series.

Only if CO_2 is adsorbed by coal can the minimum depth for ECBM projects be 800m. The Ketzin project is a prototype CO_2 storage experiment at a depth of 800m Govindan et al. 2014) . However, owing to worries about leakage, this initiative did not gain widespread public support (Szizybalski et al. 2014, Anon n.d.). CO2 has also been proposed as a geothermal working fluid, because its thermodynamic properties is considered to be better in comparison to other water-based system (Esteves et al. 2019). However, the development has not been fully understood and would require further investigation into it practically impacts and usefulness.

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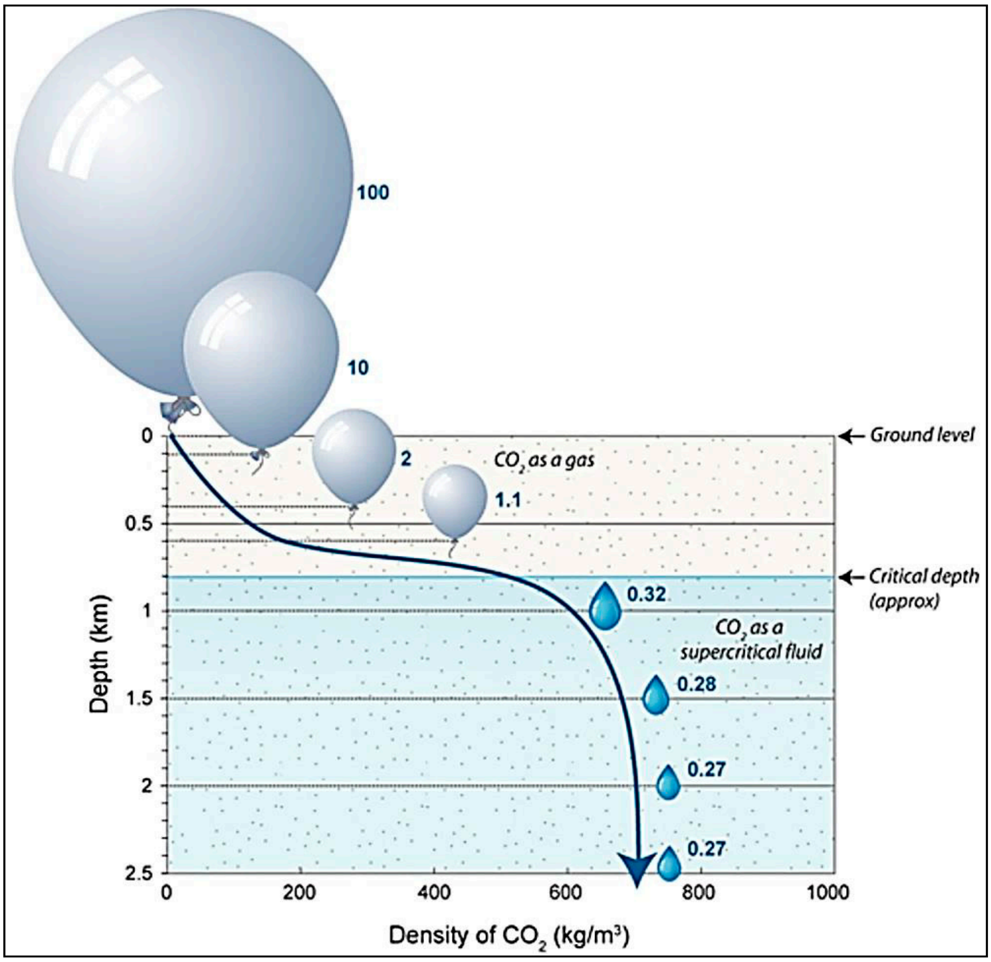

Figure 2. Comparative Volumetric quantities of CO_2 stored in storage reservoirs with respect to depth (CO2CRC, 2015). Please remember that the blue figures in this image indicate the relative amount of CO_2 at each level (Holloway et al. 1993); (Lesne et al. 2011).

2.2. Hydrodynamics Impact

When CO_2 is injected into depleted oil and gas reservoirs, where hydrodynamic entrapment influences the migration of the CO_2 plume within the reservoir, the hydrodynamic regime of the formation water becomes particularly important for CO_2 storage (Heinemann et al. 2016; Wang et al. 2022). This is especially the case when drained hydrocarbon basins are refilled by injecting CO_2. A strong relationship exists between the different kinds of basins and the water currents that arise from the geological formation. For instance, lateral and vertical erosional rebound may have an impact on the development of water flow in intra-cratonic and foreland basins that have been subjected to at least some level of uplift and erosion. As seen in the Alberta basin in Canada, aquifers face the danger of being considerably under-pressured as a result (Thibeau et al. 2022) (Bachu 2010). Because they are able to sustain increasing pressure throughout the injection process, under-pressured formations are well suited for CO_2 sequestration and geological containment. As a result of sealing processes inside the fault bodies, the function of faults in the hydrodynamic regime and their permeability structure needs to be determined (Voltattorni et al. 2009a, 2009b; Quattrocchi et al. 2011).

2.3. Geohazards Effects

Geohazards are considered to be temporary and permanent geological and environmental conditions that have the potential to aggravate substantial harm to geological storage system. They must be evaluated as part of storage site selection criteria. As a result, geologically dangerous regions should be avoided for efficient CO_2 containment following injection. Geohazards in storage systems are mostly linked with seismicity, landslides, and volcanic activity. (Buttinelli et al. 2011) discovered

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that both shallow and deep seismic activity, as well as magmatism, geodynamical domains such as the existence infrastructures that are releasing gas and irregular sources of heat flow that may have a significant impact on storage systems during their investigation of the spatial of cap-rock geological CO_2 storage quality and distribution patterns in Italy's deep saline aquifers. When choosing a prospective injection structure, they found that there are three key geological concerns that need to be taken into consideration:

a. Geophysical and geological investigations revealed seis-mogenic sources and regions
b. The pattern of earthquake activity throughout time
c. Naturally occurring widespread degassing networks

This study might serve as a starting point for cataloguing potential geohazards in Rio del Rey Basin, Southern Cameroon.

2.4. Geological Elements

Previous studies have shown that storing CO_2 in sedimentary basins, which are often found in close proximity to or at energy-intensive businesses, are the most effective method. These basins include sedimentary rocks that have appropriate levels of porosity and permeability (Hitchon et al., 1999). This shows how crucial it is to minimise the cost of transporting CO_2 to have a relatively large distance between the point source of the gas and the storage facility. To reduce the high transportation costs, other storage options may be more appealing for CO_2 point sources that are not located near appropriate sedimentary formations.

Important geological parameters for assessing storage sites include aquifer properties like reservoir pore volume and permeability, pressure and temperature, sweep efficiency (anisotropy), cap-rock permeability, fracture pressures, reactive mineral quantities, formation thickness the injection of CO_2, solubility of CO_2 in brine, and potential for sequestration. Increasing storage security and determining a site's economic viability are two goals of the injectivity criteria (Grataloup et al. 2009), (Wei et al. 2013). Anisotropy in permeability, rock compressibility, sufficient reservoir thickness, reservoir heterogeneity, reservoir and fracture pressures, and injection depth are all experimental parameters that influenced CO_2 injectivity. In this line of research, comprehensive several reservoir sandstone formations need investigations on CO_2 containment with regard to reservoir storage capacity and cap-rock integrity. These sandstone formations include those in the Gulf of Guinea, the Miocene Rio del Rey basin, and the South West Coastal Region of Cameroon (Owono et al. 2020); (Kissaaka et al. 2020).

Geological site evaluation may be enhanced by employing systematic but widely recognised methods that evaluate and concentrate on injection capacity and containment concerns. Borrowing practises and methods in the petroleum sector is one of the ways that these advancements could be accomplished. In particular, numerical simulation models that are capable of quantifying the functions of significant CO_2 trapping mechanisms for basins are one sort of practise that may be hijacked from this sector of the business. For generated seismicity and potential leakage, it is necessary to conduct geophysical and geochemical risk assessments however, a deeper study at the literature by (Quattrocchi et al. 2013) finds significant gaps and flaws in these analyses.

2.5. The Potential for Hydrocarbons and the Maturity of the Basin

Multiple variables may limit CO_2 storage in basins with low or undiscovered resource potential, as previously studied ((Han and Winston Ho 2020); Yang et al. 2008); some of these factors include:

a. Although most hydrocarbon resources are still unknown, there are worries about contamination
b. Development is still in its early stages; thus, no oil and gas reservoir are fully depleted
c. The geology with basins' hydrogeology is poorly understood due to a lack of an intense investigation.

Putting faith in CO_2 storage in the hydrocarbon reservoirs appeared to be unfeasible because no energy sources have been discovered in such basins. It is only after considering environmental and

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economic aspects exhaustively that storage may be feasible, since deep saline aquifer formations are still a possibility in such basins (Yang et al. 2008). The mixing of CO_2-related compounds with hydrocarbons as a pollution contaminant is the most important issue that must be resolved prior to the use of technology for development and production in basins that have a latest geological record and are known to contain hydrocarbon potentials. This is the case in basins that have both these characteristics. One of the first stages in primary output in CO_2-EOR are also included. Storage site evaluation in developing or little explored basins is hindered by a lack of detailed subsurface information. Nonetheless, in all instances, 3D geophysical and geochemical modelling may help to enhance our understanding of such basins (Shi et al. 2023). Storage of CO_2 (Yang et al. 2008) in mature basins, on the other hand, is highly relevant to a variety of reasons, including the abundance of data on the geothermal regime, hydrocarbon reserves, and coal beds.

When choosing a location, the degree of basin development is another key element that must be taken into consideration. This is due to the fact that a lot of the same elements, alternatively, characteristics of a reservoir that are favourable for the extraction of oil and gas also make the reservoir advantageous for the production of CO_2 storage. To make sure that CO_2 storage and hydrocarbon extraction don't interfere with one another, careful planning is essential. For a basin that has been investigated extensively and has the potential to contain hydrocarbons, a substantial amount of rock-based information exists, reducing geological uncertainty. CO_2-EOR-EGR, which reduces the cost of CO_2 storage, may be made possible due to the availability of oil and gas. Uncertainty in long-term storage may be increased, however, by the presence of thousands of hydrocarbon wells owing to an increased possibility of CO_2 leakage from boreholes.

2.6. Economic, Legal, Environmental and Societal related issues

Yang and team in 2008 put forward the economic concerns of CO_2 geological storage that are often at the core of current or needed infrastructure and are influenced by continuing climate change policies. The existence of operational facilities like pipeline transportation, injection wells, with various transport amenities may already be established in more developed continental basins. These basins have had more time to develop. In young basins, there is a possibility that infrastructure may not exist or would be severely limited. A significant issue in offshore basins is that CO_2 injection and storage may be prohibitively costly owing to the need for additional infrastructure, including lengthy pipeline routes. As a result, a particular obligatory carbon tax, such as the one for features processes may be explored. However, the construction of infrastructure and regulatory frameworks for CO_2 storage must meet expectations and draw the attention of government authorities without jeopardising the safety of the storage facility or its environmental impact. Considering that the deployment of technology able to significantly reduce anthropogenic CO_2 emissions would take decades of significant expenditures, accomplishing these important goals is critical for storage economics.

Sedimentary basins in developing countries offer great potential as CO_2 storage facilities (Angola, Bangladesh, Cameroon, India, Nigeria, and Angola). Multiple recent studies (Sawyer et al. 2008) have shown that improving citizens' quality of life is the top priority for the vast majority of emerging nations. In terms of priority, this goal might even supersede those of combating climate change and implementing CCS. In industrialised regions, such as Europe and North America, the cost of storing CO_2 in a geological medium is expected to be lower. It is possible that the pace of CO_2 storage implementation will be influenced by factors such as the distribution of coal, oil, and gas, as well as other issues of pollution monitoring and ethical governance. There may be complications when trying to build a storage facility in a densely populated location, such as securing land and rights-of-way for the necessary infrastructure. Site characterization attempts must take these concerns into account.

Bangladesh CO_2 emission growth grew by 29.84 metric tonnes (Mt), GDP per capita by 3.5 million, and population by 3.5 million throughout the period of 1979 to 1983, which corresponds with the growth in CO_2 emissions of Bangladesh's power industry. An increase in an economic activity that had an effect on GDP per capita as well as an increase in the effects of population growth were

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the primary elements that contributed to the expansion of carbon emissions during this time frame. The number of people who were impacted by economic activity rose from 3.5033 million in the period of 1979–1983 to 593.309 million in the year of 2014–2018. In general, the trends in increasing emissions are the most relevant elements, although the influence of the expansion in population was not substantial.

During the period of 1984–1988, there was an increase of 152.3 Mt in carbon emissions. The most important contributors to this rise were the expansion of the economy and the population, each of which accounted for 6.83 million and 2.12 million of the total increase. The decrease in CO_2 emissions had an inverse relationship with the 54.8 Mt increase in energy intensity. There was not a discernible impact from the level of energy intensity. Between the years 1989 and 1993, there was an increase in emissions of 152.3 Mt, while the population grew by 32 million and GDP per capita grew by 32 million. These two metrics had the biggest margins. Additionally, the total energy consumption (TEC) emission per unit of GDP has significantly lowered by 6.49 Mt as a result of the reduction in emissions. During the years 2004–2008, the population expanded by 232.96 million, which led to an increase in GDP per capita of 232.96 million. On the other hand, the impacts of sub and EI were negative, with a total of 0.463 Mt and 40.58 Mt, respectively, contributing to the increase in carbon emissions.

This resulted in a 445.97 Mt increase in carbon emissions. The increased consumption of natural gas in Bangladesh is to blame for the country's rising levels of carbon dioxide emissions (Hossain et al. 2011). As a result of this examination into each time, it is possible to establish that population and GDP per capita are the two most essential driving variables for increasing carbon emissions in the power sector of Bangladesh.

In 2008, the government of Bangladesh issued a strategy on renewable energy with the goal of reducing CO_2 emissions in Bangladesh, (Renewable Energy strategy of Bangladesh, 2008).

As a result of the implementation of new rules for renewable and solar energy, including collaborative endeavours with other countries, it is anticipated that there would be a positive shift in the amount of carbon emissions

While also, Cameroon and Nigeria are among many countries located along the line of the equator and in particular it’s located in the Gulf of Guinea. These countries are situated between latitude 1˚ 40′ and 13˚05′ north and longitude 8˚30′ to 16˚10′ east. They are currently undergoing various impacts of climate change. The average temperature in Cameroon for example has increased over the past 90 years (CEEPA, 2006).

In September 2015, Cameroon under the Intended Nationally Determined Contributions (INDC) within the framework of the Paris climate Agreement submitted its new climate action plan to the UNFCCC. The main aim is to reduce greenhouse gas emissions by 32% compared to a business-as-usual scenario for 2035.

The figure 3 below shows illustrate annual $C0_2$ emissions in 2021 for Bangladesh – 93.18 million tonnes, Cameroon – 9.30 million tonnes, India – 2.71 billion tonnes and Nigeria – 136.99 million tonnes, the upward trend is a common factor for all these countries which in turn reflect across all the developing countries.

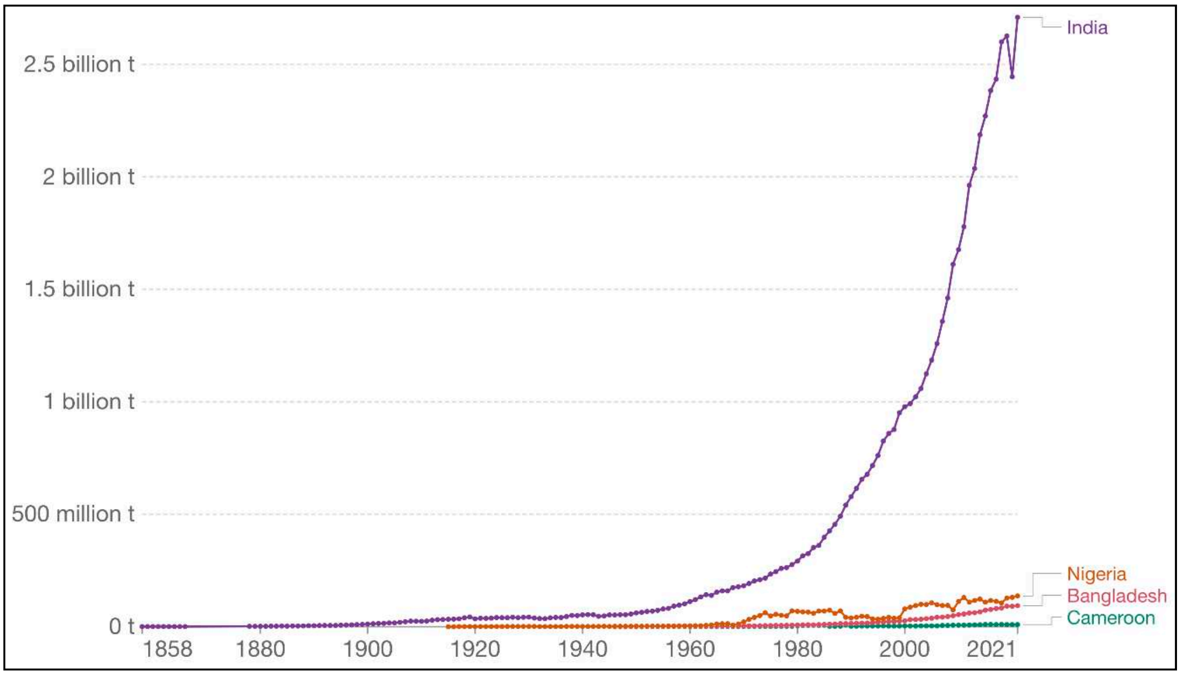

Figure 3. Annual Carbon Dioxide emissions from burning fossils fuels for energy in 2021. Source: Global Carbon Project; Carbon Dioxide Information Analysis Centre, (Adapted from Our World Data, https://ourworldindata.org/).

Figure 4 illustrate the per-capita CO_2 emissions from the burning of fossil fuels for energy and cement production stand in Bangladesh – 0.55 tonnes, Cameroon – 0.34 tonnes, India – 1.93 tonnes and Nigeria – 0.64 tonnes.

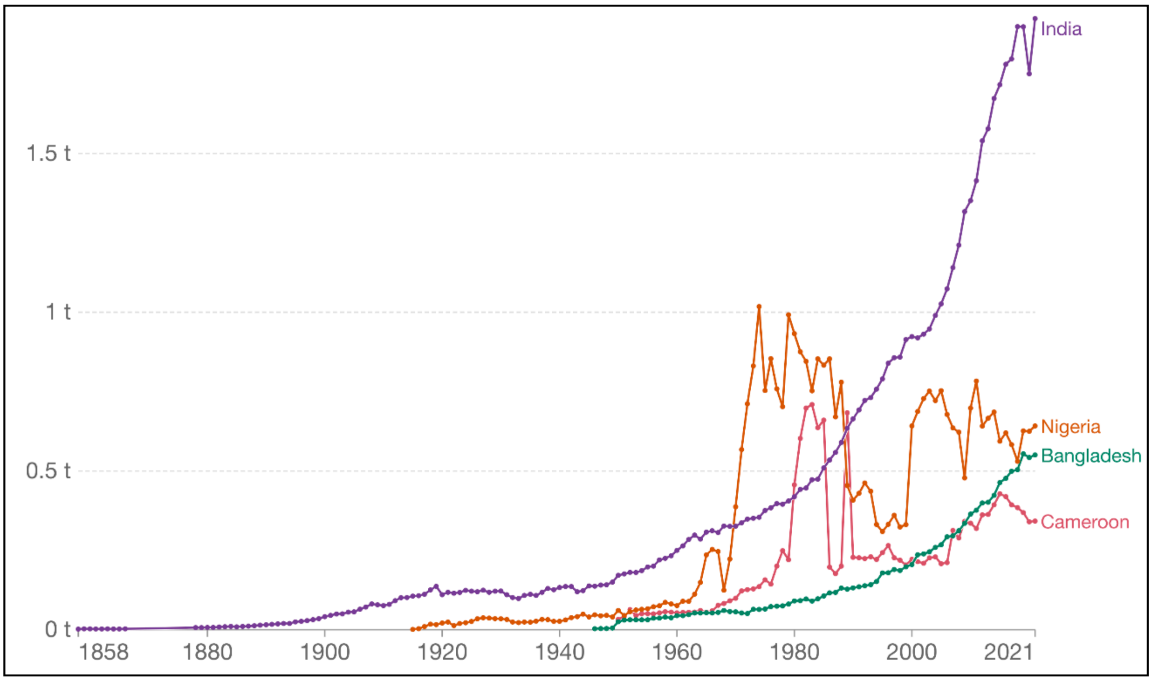

Figure 4. Per Capita Carbon Dioxide emissions from burning fossils fuels for energy in 2021. Source: Global Carbon Project; Carbon Dioxide Information Analysis Centre, (Adapted from Our World Data, https://ourworldindata.org/).

Hence, all these effects demonstrated that developing countries are among the most likely countries to be threatened by the impact of climate change. And the impact of climate change will certainly be a field across the socio-economic development, sustainable development of all the sectors of Cameroon especially the energy and agricultural sectors which appear to be the most vulnerable of the impacts and risks of climate change (UNEP and GEF, 2000; MINEF, 2001).

The main environmental risk associated with CSS in the developing countries relates to the long-term storage of the captured CO_2. Leakage of CO_2, either gradual or in a catastrophic leakage could negate the initial environmental benefits of capturing and storing CO_2 emissions and may also have harmful effects on human health as the Lake Nyos disaster illustrates (Evans et al. 1993). Alternatively, long-term leakage from the geological reservoirs could be actively countered by re-sequestration to stabilize climate at some desired level. However, there will be serious concerns connected with this. It would be difficult to gauge the national leakage rate that would have to be matched by the re-sequestration rate. National long-term monitoring of atmospheric CO_2 concentrations would probably be the best way to address this but natural carbon-cycle fluctuations would complicate this approach.

CSS has the long-term potential to make a substantial positive impact on the amount of CO_2 emitted into the atmosphere by the stationary energy sector. Therefore, the potential risks will need to be weighed against the potential benefits, and as well the possible consequences of inactivity.

Bearing in mind that GHG emissions in Cameroon undoubtedly increasing annually oil and gas industry and the importance to continue exploiting the oil and gas energy resources. This has created a dilemma and which needs addressing with urgency to meet the government climate emergency targets. It is inevitable to mitigate the risk poise by these toxic gases while at the same time supplying the energy required to sustain the economy sustainably. The main issues will include capturing CO_2 from fossil fuel-related energy sources and selecting the right geological sequestration approach safely in the short, mid, and long term. As history has shown, on August 21, 1986, an eruption of CO_2 (lethal gas) from Lake Nyos in Cameroon kills nearly 2,000 people and wipes out four villages. CO_2 though ubiquitous in Earth's atmosphere can be deadly in large quantities, as was evident in this disaster.

The Lake Nyos disaster has often been cited as evidence of the potential risks that have hobbled efforts to commercialize carbon dioxide sequestration which is the only realistic way to satisfy the world's enormous energy needs without accelerating the pace of climate change. Irrespective of the risk, the benefits of CSS make it hard to ignore. Power plants equipped with CSS technology produce about 80% to 90% less carbon than those without it. CS could reduce the cost of climate stabilization by 30%.

In addition, the present of high-quality natural commodities especially oil and gas resources, cement manufacturing and other natural resources and other minerals might be affected by the storage of CO_2 (Li et al. 2013). As a consequence of this, early regional planning on complementary and competing areas of interest is of the utmost importance. It is impossible to achieve a meaningful reduction in anthropogenic CO_2 emissions without the rapid adoption of CO_2 storage technology by the majority of nations, particularly rising ones. As a result, CCS industry players must engage in technology transfer to develop national capacity. For the local population, awareness efforts must emphasise the worldwide significance of storage deployment. Furthermore, CO_2 storage should be market as an ecologically friendly pastime and a way to solve community environmental issues.

With regard to India, according to the estimates carried out in the IEAGHG CO_2 sources inventory, it determined that each individual state might have annual emissions of between 28 and 29 Mt CO_2. If they have a lifespan of 35 years, it is probable that each of them will release around one gigaton of CO_2, and if they are equipped with CO_2 collection, they will transmit substantially more CO_2 for storage.

There is currently no regulatory structure in place in Nigeria that regulates CCS; nevertheless, the Petroleum Industry Act, 2021 recognises the need for decarbonization, and as a result, it offers a legal basis for the implementation of CCS. In order to comply with the requirements of the Act, every concessionaire of a petroleum licence or lease must include an environmental management plan in their field development plan. This plan outlines the measures that the concessionaire plans to take in order to reduce the adverse effects that their operations will have on the surrounding environment.

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If CCS is feasible, the plan can include it as one of the potential preventative and corrective actions that could be taken.

The Climate Change Act 2021 (also known as the "CC Act") provides the legislative framework for achieving low GHG emissions as well as supporting sustainable economic growth, and it establishes a target for the year 2050-2070 for the attainment of a net-zero GHG emission in Nigeria. This objective was established in order to meet the requirements of the Paris Agreement on climate change.

The CC Act does not make any reference to specific technologies such as CCS; instead, it provides a framework for facilitating the coordination of climate change action required to achieve the long-term climate objectives of Nigeria. The nature of CCS places it within the options available for achieving the long-term climate objectives of Nigeria; however, the CC Act does not make any reference to specific technologies such as CCS. The CC Act established the National Council on Climate Change (the "Council"), which is required to, among other things, approve and oversee the implementation of the National Climate Change Action Plan, which establishes the climate adaptation goals and prescribes the mechanisms for achieving Nigeria's climate change goals. The National Council on Climate Change is required to do this because it is required by the CC Act, which states that it is required to oversee the implementation of the National Climate Change Action Plan. The effect of a carbon tax would be to invariably encourage the use of technologies such as CCS to decrease the tax exposure of a corporation and to earn carbon credits to offset the potential liability of carbon taxes. In other words, the subsequent effect of a carbon tax would have the effect of encouraging the use of technology.

The Nigerian Upstream Petroleum Regulatory Commission (NUPRC) has made an effort to recognise CCS. In one of the draught regulations released on acreage management in the upstream oil and gas sector, this draught regulation states that "with the consent of the Commission, the lessee may provide carbon capture and storage services with respect to reservoirs contained in the lease area." This draught regulation was released on the topic of acreage management in the upstream oil and gas sector. When it was finally put into effect, the acreage regulation that is the subject of this discussion would make it possible for dry wells located inside a lease area to be used for carbon storage with the approval of the NUPRC. As was said previously, selection of the location chosen for the carbon storage facility is extremely important. The geological make-up of the storage area needs to be such that the rock at the surface is impermeable. This will ensure that the CO2 will not escape into the surrounding environment.

That said, the relevant factors for assessing the suitability of potential storage locations have been discussed. The potential of a storage location is evaluated by the combination of these parameters. When analysing storage facilities, in addition to the fundamental requirements outlined, one must also take into account any extra aspects that may be exclusive to that particular storage facility. These additional considerations could also include, but are not limited to, the following:

a. The size and characteristics of the proposed expansion location
b. Partisan considerations, including the potential for local development projects in the future
c. Native title claims are a part of cultural heritage because they allow an individual or group to assert legal ownership of a piece of land or territory without resorting to formal legal action or a formal treaty.

The cost of CCS is the largest expense associated with carbon capture and storage, accounting for between 60 and 80 percent of the total cost of the CCS system (IEA, 2008). However, in these developing economies, such an investigation of the viability of CCS cost has not been carried out to assess the overall feasibility.

2.7. Future Challenge

In developing countries, CCS is still a relatively novel technology. In spite of the fact that several evaluations and potential analyses have been carried out across Bangladesh, Cameroon, India and Nigeria for example, there have only been a limited number of actual pilot commercial implementations. In order to slow down the rate at which the environment in these countries is deteriorating and to encourage CO_2 sequestration, a number of different considerations need to be given priority.

Participation from international bodies is essential to the process of creating and expanding CO_2 sequestration. In a wide variety of spheres, most developing countries such as Bangladesh, India and Nigeria have already initiated a number of CCS pilot initiatives in conjunction with other countries. However, in order to make progress, additional coordinated efforts are required.

The use of technology is the primary factor in determining the success of CCS operations. This includes the methodology behind carbon capture, transportation, evaluation, and storage. The majority of developing countries' oilfields have a complicated formation structure, which manifests as strong heterogeneity, low or ultralow permeability, low porosity, and poor oil property (Z. Xuan et al. 2010). Techniques for CO_2-EOR would face difficulties if high miscible pressure, severe gas channelling, significant solid deposition, and the development of a complex reservoir were to occur (X. A. Yue et al. 2007))

On the other hand, it is advised that appropriate policies be implemented in developing countries in order to stimulate and boost the CCS business. There is a need for the development of alternative methods for capturing CO_2 and reducing CO_2 emissions from a variety of sources.

For these countries to have a future with low carbon emissions, the market mechanism must play a significant role in reducing carbon emissions, R. Y. Li, (2013)

3. Conclusion

The paper provided a comprehensive analysis of the current situation and future possibilities of CCS selection criteria, with a primary focus on developing countries (Bangladesh, Cameroon, India and Nigeria). We are further into a new decade in which climate-related action will be at the forefront, therefore a review of this nature was very much needed. The CCS will be very important to the process of energy transition. Due to the enormous scope of the subject matter, this paper does not dig further into specific selection technologies measures or other subtopics.

This article gives a comprehensive analysis of CCS in the context of developing countries such as Bangladesh, Cameroon, India and Nigeria and paints a clear picture of the current situation in these countries. Each component can be explored further to provide a more in-depth study of the full possibilities and limitations of the CCS selection criteria in question. There are now multiple pilot projects that are in the stage of study and development in some of these developing countries especially Bangladesh, Cameroon, India and Nigeria. In addition to this, developing countries have significant geological storage basins and biological sequestration capacities which CCS process are still in its infantry.

In this context, the framework for private and public partnerships has the potential to play a significant role and should be considered. Site preferences or criteria need to be supplemented with policy measures that are appropriate, adaptive, and walkable, and they should be geared towards CCS in developing countries specific needs. Because the cost of carbon storage continues to make up the majority of the total cost of sequestration, each of these factors needs to work towards lowering that cost on a per-unit basis. The main elements that will be necessary to accomplish this objective are ongoing appraisal as well as policies that are focused.

The next two decades will be essential for the continued development of CCS technology in developing countries (Bangladesh, Cameroon, India and Nigeria). These countries would work to close the technological gap in its power production and distribution sector in order to improve its prospects of successfully implementing CCS technologies in cements/power plants built after the year 2035 or so. This action would secure developing countries place on the global energy map as well as the map depicting the decrease of carbon emissions.

In Bangladesh, Cameroon, India and Nigeria for example, there is potential for storing CO_2 underground in depleted oil and gas reservoirs, salty aquifers, and coal beds. In several regions of these countries, a vast number of initiatives/pilot studies have been carried out to demonstrate the

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viability of CCS, investigate the potential for CCS on a commercial scale, and evaluate the storage capacity and possibility of carbon sequestration and enhanced oil recovery.

Other potential methods for CO_2 sequestration include amending soil, planting trees, and re-using CO_2. The process of lowering emissions can be significantly advanced by the combination of a number of different selective strategies.

When compared to other Western countries, these developing countries are behind in the amount of carbon that it can sequesters. In addition to that, almost all the CO_2 storage projects in developing countries are still in the stage of appraisal and assessment. To make further progress, additional efforts are required, which should involve international cooperation, innovative technology, constructive policy, and societal mechanisms.

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Abbreviations

GHG, IEA, NASA, GCCSI, IPCC, CO_2-EOR, IEAGHG, DOE.

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