Climate Change Innovations: a golden opportunity for Africa

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Abstract

Climate change is real and has been affecting Africa disproportionally. This is because the majority of Africans depend on nature to advance their livelihoods. Energy transition seems to be the most trending strategy to fighting it. Fortunately, at the centre of energy transition are critical minerals that are vastly available in Africa. This study reviews 60 relevant academic works to argue that climate change calls for innovations which could create not only a net good for society, but also help Africa to grow economically. This would happen if Africa shifts from investing in supply chains to engaging in global value chains through investing in downstream activities that go beyond refinery. It is, however, important for Africa to ensure that investing in global value chains does not compromise economic, social and environmental requirements of sustainable development.

Keywords: Climate change; energy transition; critical minerals; supply chains; value chains; Africa

Introduction

Africa, a vast continent, hosts diverse climatic conditions ranging from very humid to arid climates. It should be noted from the onset that while climate change affects all continents, its impact is more pronounced in Africa given the continent's limited capacity as far as mitigation and adaptation are concerned. It is not surprising then that Nyiwul (2021) shows that there is a robust negative relationship between climate change policy actions in Africa and social inequality. Climate change innovative policies could thus help to redress this situation.

It is important to note that even without factoring in climate change; Africa is already facing huge socioeconomic challenges. For instance, over 300 million Africans neither have safe drinking water nor adequate sanitation thereby, recording the lowest water coverage in the world, with rural Africa affected the most given the fact that it has only 47 per cent coverage as compared to 85 per cent in the urban settings (Nkomo *et al*., 2006). Africa is also severely affected by various diseases such as malaria with the continent accounting for 85 per cent of malaria-related deaths worldwide (ibid). It follows then that climate change effects only serve to worsen an African situation that is already generally dire.

Nevertheless, it has to be said here that since Africa is not a country, different African countries are at different levels of development and, therefore, the said countries are not equally affected by climatic change. However, in general terms, climate change impacts have impoverished African people and have significantly slowed down the development trajectory of the continent (Meyer and Odeku, 2006; Nkomo *et al*., 2006; Hope Sr., 2009; Moomaw *et al*., 2011; Pelizzo *et al.,* 2018; Nyiwul, 2021).

It should be noted that with climate change realities facing the globe, countries have opted to reducing carbon emissions by, among other strategies, pursuing greener technologies. In this particular case, transition of energy use from fossil fuels to greener solutions has become the focus of global attention. Mining is considered to be one of the biggest carbon emitting sectors in the world (Kinyondo, 2023). Ironically, energy transition towards greener options is largely fueled by critical minerals which are vastly available in Africa. The continent, therefore, could potentially offer the solution to global climate change challenges and benefit in the process.

Unfortunately, most studies (Meyer and Odeku, 2006; Nkomo *et al*., 2006; Hope Sr., 2009; Moomaw *et al*., 2011; Pelizzo *et al*., 2018; Nyiwul, 2021) mainly focus on negative effects of climate change in Africa thereby disregarding potential positive externalities that the fight against climate change can bring in the continent. It is in this context that this study is set to highlight the realities of climate change effects and the way Africa can take full advantage of the fact that it is richly endowed with minerals that are critical to transitioning to a low-carbon future. In so doing, 60 works relating to climate change, energy transition and poverty reduction in Africa were reviewed with the view to assessing the way fighting climate change in Africa could pave a way for advancing the continent sustainably.

The foregoing section introduced the study. The next section highlights the plight occasioned by climate change in Africa. This is followed by a section that identifies the impact of climate change in Africa. Thereafter, critical minerals are introduced before their link to energy transition is established. A discussion on how critical minerals could advance Africa then follows before the paper winds up with a conclusion and recommendations.

Climate Change in Africa

There is a consensus that global temperatures are unsustainable and are expected to rise by between 1.5 and 6 degrees Celsius by 2100 (Nkomo *et al*., 2006). Meanwhile, as temperatures are expected to rise, ice caps and glaciers are expected to melt and the sea levels are projected to increase by up to 95 centimeters which, if left unabated, will result in flooding and salt water intrusion which will unsettle people, thereby, forcing them to migrate to other places (Meyer and Odeku, 2006; Nkomo *et al*., 2006).

While as explained earlier, African countries do vary in terms of their stage of development and therefore capabilities to fight climate change, the continent has generally experienced warming starting from the 20th century at the rate of up to 6 degrees Celsius per decade (Nkomo *et al*., 2006). The situation is equally dire elsewhere across the world. To avoid the punishing effects of climate change, the Cancun Agreement sought to limit global temperature increases to a maximum of 2 degrees Celsius with a preferred target of 1.5 degrees Celsius (Moomaw *et al*., 2011).

It is important to note here that Africa is the least polluting continent having less than 10 per cent of total global greenhouse emission most of which is being contributed by South Africa alone (Hope Sr., 2009; Nyiwul, 2021; United Nations, 2023). Moreover, it is noted that forests can internalize carbon emission and Africa hosts massive acres of forests with capacity to store a stock of carbon that is estimated to be equal to 60 billion tonnes (ibid). With the top five emitters[1] responsible for over 50 per cent of greenhouse gases emissions, there have been calls for richer countries to be more responsible for their actions by financing the fight against climate change particularly, for least emitters such as African countries (Kinyondo, 2023).

[1] Those countries include the United States, China, India, Japan and Russia.

The Impact of Climate Change in Africa

Apart from the impact of climate change in Africa, there are many non-climate issues affecting the continent. Indeed, these impacts of climate change are unfolding in circumstances of fragility and instability, making them that much more challenging to address in Africa. Specifically, Africa is a continent that is plagued by social, political, economic, environmental and historical challenges that have together consigned it to vicious cycle of vulnerabilities. Some of these vulnerabilities include debt burden, poor governance, high population growth, poverty, malnutrition, low literacy rates, diseases, wars, and environmental disasters just to mention some (Kinyondo and Byaro, 2024; Byaro *et al*., 2023; Kinyondo *et al*., 2022; Kinyondo *et al*., 2021; Kinyondo and Huggins, 2021a; Kinyondo and Huggins, 2021b; Kinyondo and Pelizzo, 2021; Kinyondo and Byaro, 2020; Kinyondo and Pelizzo, 2020; Pelizzo *et al*., 2018; Nkomo *et al*., 2006).

Climate change is especially hard for Africa because it tends to exacerbate existing problems. Perhaps the biggest effect of climate change in Africa involves reduction in rainfalls. The situation is at its worst in some parts of Africa. For instance, the Sahel region has experienced a 25 per cent reduction of rainfall over the past three decades with other parts such as Mozambique receiving abnormally heavy rainfalls on regular basis (Nkomo *et al*., 2006). Consequently, there have been increasing episodes of droughts and floods in Africa over the past 30 years which have not only led to deaths of humans and animals but also loss of property and financial security (Nkomo *et al.,* 2006). For example, the year 2000 floods in Mozambique resulted in the displacement of two million people, loss of 350,000 jobs (ibid).

Furthermore, agriculture, the biggest employer in Africa that accounts for up to 40 per cent of Africa's Gross Domestic Product (GDP), is still rainfall-dependent (Nkomo *et al*., 2006). However, variability in rainfalls coupled with the decrease in arable lands and an ever ballooning population have meant that food output per capita in the continent has remained stagnant since 1980 (Nyiwul, 2021; Nkomo *et al.,* 2006). This is to be expected since according to Nyiwul (2021), a 2.5 degrees Celsius warming can result into a $23 billion reduction in revenues from farming. Meanwhile, climate change could raise the prices of various staples in Africa by up to 60 per cent thereby, increasing poverty rates to up to 50 per cent by 2020 (Nyiwul, 2021). Moreover, lack of arable lands has brought about conflicts from

skirmishes between farmers and pastoralists to full-fledged civil wars such as that happening in the Sudan's Darfur region (Nkomo *et al*., 2006).

But a more nuanced take on the impact of climate change in Africa must look at the problem from the socioeconomic angle. Indeed, while the population in the continent is tipped to hit 2.9 billion by 2100, the continent is tipped to have less food and water at the same time, due to among other factors, climate change (Nkomo *et al*., 2006). It is not surprising then to witness an increase in the number of people living in poverty in Africa with the number expected to rise in the absence of robust measures to reverse climate change effects.

It is therefore, obvious that African countries need to adapt to climate change effects. However, the continent lacks the adaptive capacity necessary for it to navigate out of the climatic effects. Nkomo *et al*., (2006) lists lack of strong institutions, financial and technical resources as well as lack of technological capabilities to be the ones limiting Africa's ability to adapt. It should be noted that climate change adaptation costs amount to $30 billion a year with the Sub-Saharan African region suffering more as the cost is 1.8 percent of its GDP compared to 1.4 per cent in other regions (Nyiwul, 2021).

Effects of climate change can also damage the ecosystem (wildlife and eventually tourism) and important infrastructure such as roads, railways and bridges as it has happened in Tanzania earlier in 2024 (Kinyondo and Pelizzo, 2020; Kinyondo and Pelizzo, 2015). However, perhaps the most damaging effect of climate change as far as achieving sustainable development of African countries entails the loss of energy given the fact that most African countries rely on either nature (woods and charcoal) or hydropower for energy generation.

Lack of energy not only limits economic activities necessary for sustainable development but also forces people to use alternative sources of energy such as charcoal which destroy the environment and generate greenhouse gases to the atmosphere. The World Bank reports that only about 44.6 per cent of the Sub Saharan African population has access to electricity and as low as 22 per cent in rural areas (Nyiwul, 2021). Fighting climate change through energy transition can thus provide an opportunity to develop renewable energy that will not only help the continent transit to cleaner energies but also provide access to electricity to the majority of

Africans who currently cannot. At the centre of energy transition are critical minerals which form the main subject of the next section.

Critical Minerals in Africa

The rise of critical minerals dates back to 1915 during World War I, when Germany took control of tungsten production, an ingredient used to make weapons and ammunitions efficiently (Nakanwagi, 2023). Consequently, the war immensely increased the demand for tungsten and related critical minerals at the time. With the Germans dominating tungsten production, the rest of the developed world turned to alternative minerals so as to remain competitive, which brought the beginning of global scramble for critical minerals.

Given the importance of critical minerals, their supply is characterized by complicated global monopolies with value chains that Africa has found it difficult to crack. For instance, critical minerals are essential for the development of green energy technologies such as electric vehicles, solar and wind installations, batteries and renewable power systems. The World Bank posits that to meet the rise in global demand and avoid the worst impacts of climate change, the production of critical minerals will need to increase 500 per cent by 2050 (The African Climate Foundation, 2024).

Of importance to this study is the fact that the Global South and in particular Africa, is richly blessed with minerals that are critical to powering the energy transition which are fondly known as critical minerals. These minerals include graphite, nickel, copper, lithium, cobalt, rare earth, etc. Generally, Africa is home to over 30% of the world's mineral reserves, with almost every single country on the continent rich in at least one critical mineral. Specifically, the Democratic Republic of Congo (DRC) hosts over 70 per cent of the world's cobalt production; Zimbabwe holds the world's largest reserves of hard rock lithium; Mozambique is the world's third-largest producer of graphite; while South Africa accounts for 75 per cent of the world's supply of platinum Group Metals and 72 per cent of platinum (Nakanwagi, 2023), among others.

As explained earlier, the global value chains for critical minerals are rather prohibitive for Africa. Specifically, China, which hosts the biggest processing facilities of critical minerals in the world, is the world's largest

importer of critical minerals mainly from Africa. For instance, while 60 per cent of world's mined copper is processed in the DRC, China continues to host the largest copper smelter in the world with a global refining capacity of 40 per cent (Nakanwagi, 2023). Similarly, while DRC continues to be the world biggest producer of cobalt, the majority of its cobalt products end up in China which in turn is the largest producer and refiner of cobalt-related chemicals that are mostly utilized in the rechargeable battery industry (ibid).

Meanwhile, the largest consumer of end products of such critical minerals from China is the European Union (Nakanwagi, 2023). Thus, while it is clear that there is a huge demand for Africa's critical minerals; Africa is largely not part of the value addition equation. As a result, while the value of critical minerals has increased tenfold over the years due to increased demand by global brands such as Tesla, Dell, Microsoft, Samsung, Huawei and Apple (Nakanwagi, 2023), the same cannot be said about benefits that African countries are getting from of its critical minerals.

It is thus clear that in order to maximize retention of value of the continent's critical mineral industry, focus needs to be redirected towards developing competitive value chains. This is because investment in downstream activities has a potential to unlock job opportunities, technological infrastructure, skills transfer as well as more rents. In turn, these benefits can bring economic growth and sustainable development to Africa.

Moreover, in order for Africa to gain maximum benefits from critical minerals, downstream investments should go beyond mineral processing. In fact, this limitation has been raised by McKinsey and Company (2020) which explained that Africa has over the years invested heavily in supply chains rather than value chains to its economic disadvantage. McKinsey and Company rightly suggests that Africa is focused on investing in logistics aspects that is processing, railroads and shipping which are mainly for exporting raw minerals instead of focusing on comprehensive market approach by investing on assembly and manufacturing, product design and engineering, research and development, among others, which are central to value addition.

A comprehensive market approach is not without its hurdles though. For instance, while smelting capacity can increase the possibility of value addition in Africa thereby, allowing the continent to maximize value retention, it requires energy that is not currently available or adequate in

the continent. For instance, Zambia has four major copper smelters at the moment. However, three of them operate at less than 50 per cent of their capacity due to both unavailability/inadequacy of energy and corresponding high costs (Woldu, 2023). A more coordinated approach which appreciates the fact that for mining to work, related sectors such as energy have to also be boosted is the only way forward for value addition in Africa. Africa must act now because as the world is bracing itself for a definite future deficit of critical minerals, there is a possibility of recycling technologies to replace critical minerals possibly leaving Africa's critical minerals stranded (McLellan *et al*., (2016).

Critical Minerals and Energy Transition

Traditionally, critical minerals have been almost exclusively used in healthcare and automobile industries (Nakanwagi, 2023). However, due to climate change effects, the same have increasingly been used to produce green energy solutions. Specifically, energy transition is dependent on the availability of critical minerals such as lithium, graphite, antimony and cobalt which are highly needed to create green products such as batteries for electric vehicles. Other minerals such as nickel, helium, bismuth, caesium, rubidium and copper are essential for producing green energy technologies such as wind turbines, solar panels, and electric vehicles and for energy storage.

With an ever increasing world population, there is a greater pressure to make use of finite resources. This has been done to the detriment of the environment. One of such cases is on the use of critical minerals for energy purposes. Indeed, according to the International Energy Agency (2021), in order for the world to honour the Paris Agreement, the global production of critical minerals has to increase by a factor between three and 42 to meet renewable energy targets.

Africa is still at an infant stage of energy transition. This is in line with the McClellan *et al*. (2016) report which suggests that while OECD countries have considerably moved towards renewables, nuclear and gas as their main sources of energy, the non-OECD countries are still predominantly relying on coal. Traditionally, production of iron and steel uses the most energy, followed by nonmetallic minerals such as cement and non-ferrous metals when considering total production (Ibid). However, based on production per ton, non-ferrous metals lead followed by iron and

steel with the non-metallic metals being the least in terms of energy intensity (ibid).

It is obvious that Africa lacks adequate energy infrastructure to add value to critical minerals. To put this in perspective, let us consider for instance, bauxite refining which requires over 3,000kWh per metric ton of refined product on average while cobalt requires almost 4,700kWh (Hendrix, 2022). Guinea with 23 per cent of world bauxite can only provide electricity to 45 per cent of its population; DRC with 70 per cent of the world's cobalt can only supply electricity to 19 per cent of its population; Similarly, Mozambique which ranks the sixth in global graphite production can only provide electricity to 56 per cent of is population (Hendrix, 2022). Clearly, if Africa has to engage in global value chains it needs to start to produce abundant but low-cost energy.

So far we have established the fact that while climate change affects the entire world, it affects African populations the most because it mostly relies on natural resources such as land, water and forests for their livelihoods and energy needs (UN Women, UNDP and UNEP, 2015). Fortunately, Africa can make use of its vast critical minerals resources to generate green energy sources thereby fighting climate change at the same time achieving sustainable development (Meyer and Odeku, 2006). It is rather encouraging to find that the consumption of renewable energy is on the rise in Africa as it grew by an impressive 10 per cent between 1995 and 2010 (Nyiwul, 2021). Other things remaining constant, the growth is projected to rise by a further 16 per cent by 2040 (ibid).

Critical Minerals, Energy Transition and Africa's Development

Effective management of critical minerals can spur Africa's economic growth and sustainable development (Kinyondo, 2024). In essence, Africa must determine to develop sustainable value chains for critical minerals that are linked to demands in the Global North (Nakanwagi, 2023). Sub-Saharan Africa is unique in the sense that, it is a region mostly affected by climate change, yet it is rich in critical minerals that are at the centre of energy transition and thus it can offer the greatest escape route from absolute poverty among its populace through attainment of economic growth and sustainable development. Indeed, critical minerals could not only benefit African countries through bringing revenues for host countries via production sharing arrangements, royalties and income taxes

but also through generating jobs, transferring skills and technology thereby enhancing inclusive growth and sustainable development (Kinyondo, 2024; UNCTAD, 2015).

Sustainable Development Goal 8 seeks to "achieve full and productive employment & decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value by 2030". However, only five million new jobs are created in Africa for more than 12 million youth joining the labour force annually (UNCTAD, 2015). Meanwhile, the extractive sector is currently employing around one per cent of Africa's workforce (ibid). Critical minerals subsector could thus offer job opportunities for millions of youths in Africa if the continent engages in value addition. In fact, more could be created. Specifically, while extractive industries may not create many direct jobs, but their linkages with the broader economy may help generate additional jobs (Kinyondo, 2024). These linkages could generate value retention; create demand for locally produced goods and services; build an enabling environment for new industries using skills and capabilities acquired from critical minerals. Meanwhile, Artisanal and Small Scale Mining (ASM), as a labour intensive mining process, is, well known for generating more direct and indirect jobs than Large Scale Mining (LSM) as it creates more than 8 million direct jobs which support over 45 million people Africa-wide (Tomassi and Kinyondo, 2024; Huggins and Kinyondo, 2019; Kinyondo and Huggins, 2019).

The importance of creating value chains in Africa cannot be overemphasized as it has been ingrained in the Africa Mining Vision (AMV) of 2009. The Vision sees opportunities within the mining sector that, if taken advantage of, it could bring about economic transformation in Africa. Specifically, the AMV (African Union, 2024) proposes that Africa should invest, among others, in the following for it to leverage minerals for economic transformation:

(a) Investment in geological information so as to identify untapped minerals;
(b) Investment in critical inputs particularly, energy;
(c) Investment in local mineral beneficiation and skills and technological transfer;
(d) Investment in designing tax regimes that can accommodate the shifting value of commodities in the global market;

(e) Investment in research and development as well as human capital; and
(f) Investment to secure capital from local and regional sources to enable African businesses to develop local content.

Development Finance Institutions (DFIs)

The AMV approaches value addition from the angle of integrating the mining sector into development policies at local, national and regional levels (African Union, 2024). At the local level, local content policies are encouraged (Kinyondo, 2024; Huggins and Kinyondo, 2019; Kinyondo and Huggins, 2019; Kinyondo and Villanger, 2017). On the other hand, at the national level, different countries have formulated laws which restrict exportation of raw minerals as a means to stimulate local content and development through value addition and achieve a higher amount of local human and material resources for downstream production and, thus, capture higher revenue up in the value chain. Meanwhile at the regional level, the AMV proposes that strengthening linkages between the mining sector and other sectors of the economy would build and encourage economic transformation. This can be achieved through creating:

a. downstream linkages into mineral beneficiation;
b. upstream linkages into mining capital goods, consumables, and services;
c. spatial linkages into infrastructure, power, and logistics; and
d. knowledge linkages into skills and technological development.

It should be noted that more than 15 years later since its promulgation, the implementation of the AMV among African countries has not been forthcoming. Indeed, apart from South Africa, which in the late 1990s invested significantly in beneficiation, other African countries continue to mainly export raw minerals (Brandcom Partner, 2023). Indeed, current estimates show that up to 70 per cent of mined minerals are exported raw to Asia or Europe for refining (ibid).

That said, there has been an increasing eagerness to reverse this situation in Africa. For instance, Tanzania, Zimbabwe and Namibia have implemented national bans on exporting unprocessed minerals in recent past only to overturn them (Huggins and Kinyondo, 2019; Kinyondo and Huggins, 2019; Kinyondo and Villanger, 2017; Kolstad and Kinyondo, 2017). Meanwhile, Ghana announced the approval of the country's Green

Minerals Policy, effectively banning the exportation of unprocessed mineral resources (Brandcom Partner, 2023).

Unfortunately, without clear strategy and diversified ownership structures in place, these policies could actually serve as deterrents to foreign investment while creating export bottlenecks (Kolstad and Kinyondo, 2017). Clearly, Africa continues to experience trade imbalances as it continues to export raw minerals as opposed to finished goods which are valued several times higher. Woldu (2023) illustrates this fact by using the case of Zambia which is one of the biggest copper producers in Africa. The country exports Stage 1 raw and refined copper (13.7 per cent and 54.6 per cent respectively) which accounts for 68.3 per cent of its GDP. Simple calculations by Woldu (2023) reveal that finished copper products from Zambia are sold at a price which is 25.86 times greater than the stage 1 refined copper that the country exports to the rest of the world. This implies that Zambia not only loses much of the value of its copper but also exports jobs, which could have been available in the country if value addition was done locally.

One thing that is clear is that, the best approach that African countries should adopt to ensure that they benefit from critical minerals is by being more proactive and developing downstream capacity in processing (Hendrix, 2022). In other words, instead of exporting raw minerals, Africa should begin to engage in activities that at least involve refining of critical minerals to the level of intermediate goods before they do export them. For instance, instead of exporting bauxite and iron ore, African countries should at least export aluminum and steel.

Meanwhile, Africa must work to eliminate bottlenecks that hinder it from engaging in global value chains. As Kinyondo (2024) rightly demonstrates, being endowed with numerous mineral commodities is one thing but benefiting from them is another. The continent should, therefore, seek to graduate from just being richly endowed with critical minerals to actually benefiting from them. To do that, Africa must address a number of bottlenecks. Nakanwagi (2023) lists some of the primary obstacles that still prevent Africa from realizing its full benefit potential through value addition which have to be redressed by African countries. They include:

a. Lack of geological information.
b. Scarce or costly energy supply;

c. Lax tax regimes that easily allow multinationals to reduce their tax burdens.
d. Extremely high rates of raw or stage 1 refined mineral exports;
e. Inadequate level of technical skills, technology, and research;
f. Corruption and poor revenue management;
g. Human right abuses, lack of security and electricity; and
h. Poor waste management.

Conclusion and Recommendations

Climate change is real and has been affecting African countries disproportionally. This is because the majority of Africans depend on nature to advance their livelihoods. Consequently, climate change effects such as droughts and abnormally warm weather and heavy rains, among many others, tend to exacerbate poverty situations in Africa particularly, in the Sub-Saharan region. This unfortunate situation happens even when Africa emits the least of greenhouse gases in the world's atmosphere.

In responding to this global challenge, the world came together under the Cancun Agreement arrangement and agreed to limit temperature rises to the maximum of 2 degrees Celsius with the preferred limit being 1.5 degrees Celsius. There are various strategies to aligning to this target. However, energy transition seems to be the most trending one. It involves shifting towards low-carbon technologies.

Fortunately, at the centre of energy transition are critical minerals that are vastly available in Africa. The said minerals are responsible for making green solutions such as wind solar panels, wind turbines and electric vehicles. It follows therefore, that energy transition has a potential to help Africa fight climate change. Moreover, it can provide cheaper and reliable electricity to millions of Africans who do not have access to it at the moment.

Of importance to this study though is the fact that since critical minerals are available in Africa, the continent can use them to advance itself. It is however, noted in this study that Africa needs to change course from merely engaging in supply chains to partaking in value chains. However, this would require that Africa shifts its emphasis from just investing in logistical infrastructure such as roads, railways, shipping to

investing in downstream activities that add value to critical minerals. The new thinking should thus ensure that Africa focuses on:

- building robust databases of geological information in collaboration with relevant institutions such as think tanks and academic and research institutions both local and regional;
- exploring ways to source (affordable, clean & reliable) energy supply to operate refineries and smelters;
- building and/or expanding refineries and smelting facilities using Public Private Partnerships;
- ensuring that African businesses can attract capital from both local and regional sources;
- legislating and enforcing local content policies which focus on technological transfer, research and development, beneficiation and locally supplied goods, services and workers;
- enacting and enforcing legislation that severely reduce the export of raw minerals;
- where possible, establishing and enforcing protectionist policies to protect local businesses (based on merit) and tariffs that are fair, effective, & targeted and;
- Improving intra-African trade and redressing trade imbalance with the rest of the world.

Overall, climate change and the resulting need for energy transition offer Africa an opportunity to not only fight climate change but also attain the Sustainable Development Goals, Africa's Agenda 2063, Africa Mining Vision and ultimately helping it to achieve economic growth and sustainable development. But this, as it has been shown in this study, can only happen if African countries start playing a more substantial role in the value chain for critical minerals rather than just a role as exporters of raw minerals. In other words, Africa's advancement, in the midst of climate change challenges, can be achieved if African countries can use critical minerals to diversify their economies via building an industrial base that can help them scale up production and exports intermediate to finished goods to the rest of the world.

In conclusion, as much as critical minerals have been heralded as possible catalysts for Africa's advancement, further challenges abound. Indeed, production of critical minerals does produce negative externalities such as environmental degradation just like other minerals. Moreover,

production of some of the critical minerals for example copper and lithium require a lot of water, something which has brought water stresses and droughts in some parts of the world such as in Zambia and Chile. African countries should, therefore, be vigilant and ensure that critical minerals boom does not compromise economic, social and environmental aspects of sustainable development it seeks.

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