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Perspective

The Rising Impacts of the COVID-19 Pandemic and the Russia–Ukraine War: Energy Transition, Climate Justice, Global Inequality, and Supply Chain Disruption

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Abstract: This perspective paper explores the rising impacts of the COVID-19 and the Russia–Ukraine war from different perspectives, with an emphasis on the role of climate financing in achieving equitable and just transition mechanisms and that of peace in expediting this pursuit and sustaining this drive. It is motivated by the realization that there is an urgent need for accelerating the decarbonisation agenda, as highlighted in pre-COP26 debates and in the resulting Glasgow Climate Pact, through the mitigation measures that can be unpacked at both cost and scale. This is further reiterated in the third instalment of Assessment Report 6 (AR6) the Intergovernmental Panel on Climate Change (IPCC) report, dwelling on Mitigation of Climate Change, underlining the required policy shifts and technology developmental needs. Green technology, however, comes at a green premium, being more expensive to implement in geographies that cannot absorb its cost in the immediate short term. This engenders an inequitable and unjust landscape, as those that require green technology are unable to have access to it but are most often on the frontlines of the impacts of climate change. While it is urgent to review this issue and to encourage more cooperation for technology development and transfer, the COVID-19 pandemic and the Russia–Ukraine war are posing mounting challenges for achieving these objectives. These two crises are causing an unprecedented rise in commodities and labour pricing, with further knock-on impacts on global supply chains for technology. This is in turn rendering green technology unattainable for developing and less developed countries and Small Island Developing States (SIDS).

Keywords: COVID-19 pandemic; Russia–Ukraine war; sustainability; resource management; energy transitions; climate justice; climate change; green premiums; supply chain

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1. Introduction

The impacts of climate change in this decade are becoming more apparent, especially in the frequency and intensity of diverse range of climate events and the cascading impacts of these events on socio-economic systems. As expressed in the latest IPCC report (Working Group III of the Sixth Assessment Report), events such as erratic and unpredictable weather are now more frequent [1]. The aftermath of these is a widespread consequence that includes irreversible losses of ecosystems, especially in coastal and low-lying regions and reduced food and water security [2] in many parts of the globe. This is due to issues such as increased desertification, acidification of soils and water [3] and the emergence of vector diseases. Climate change is also contributing to increasing adverse economic effects, resulting from losses in tourism activities, destruction of infrastructures and establishments

that support different businesses and establishments. Such impacts have escalated even on the community levels, leading to forced migration (over 30.7 million climate refugees were estimated in 2020 [4]), and further loss of livelihoods and loss of lives are expected in the forthcoming decade.

The 6th IPCC report calls for cross-sectoral mitigation policies and actions that would help create sufficient capacities for resilience and adaptability for economies, ecosystems, human societies and biodiversity. Among steps that could be adopted include a strong focus on decarbonisation, as was emphasized in 2021 during the COP26 Summit in Glasgow [5]. Further, such actions and policies could draw insights from proposals made in the Sustainable Development Goals (SDGs), highlight 17 fundamental objectives. Further, such policies and actions could be achieved by emphasizing on developing and revamping diverse infrastructural programs as well as investing on technology development. This is particularly important as there already exists a significant imbalance in the scale and geography of climate mitigation investment, where countries in the global north have already taken the initiative to expand their infrastructure networks and invest heavily in modern technologies with capacities to mitigate climate change.

Despite these robust investments, countries from the Global North are responsible for over 75% of the global emissions, which is triggering climate events that are having the greatest impacts in the Global South. This imbalance does not augur well in the quest for climate justice, as most economies in the Global South do not have sufficient financial capacities to adequately invest in expensive climate mitigation infrastructural developments. As a result, a majority of them are forced to risk their public assets in the quest for climate mitigation investment, which can also further derail notable growth due to indebtedness [6,7].

The investment in infrastructure and technology is low in a majority of developing and least developed economies [8], and this has significant ramifications on these economies 'efforts to develop as well as mitigate impacts of climate change. The World Bank notes that these disparities are not good for the global economy, as a majority of these countries also have insufficient capacities for resilience and adaptability; ensuring impacts of climate change events will also have a cascading impact in limiting global economic growth [9]. This calls for a more equitable global landscape in respect to investment, which can only be achieved when attention to terms of financial support, and when the availability of resources and expertise is widespread and rooted in practical policy reforms at regional, local and urban scales. However, these activities have not been forthcoming, with most economies in the Global South experiencing notable financial challenges, to a point of some of them plunging in debt crises, as noted in a report by UNCTAD [10].

Besides financial challenges, there has also been a serious concern regarding global equitability of access to resources and technologies due to ongoing supply chain disruptions. These disruptions are causing price increases and limited availability of certain resources, technologies, and components need for climate mitigation and infrastructure development. In most cases, these are not always seamless, robust and well defined across different geographies, and are having the impact of widening the inequality gap between developed, developing and least developing economies. For instance, Adeoti et al. [11] note that the costs of infrastructure development and maintenance in the Small Island Developing States (SIDS) is greatly affected by the cost of imported goods and the remoteness of these States. Exports of products from these States are also impacted by the current state of the global supply chain, reducing SIDS' access to international markets and trade.

Today, the quest to create a more equitable global landscape in respect to supply chains for different products is expected to encounter two major challenges of scale: the impacts of COVID-19 and the impact of Russia–Ukraine war. The COVID-19 pandemic outbreak in the early 2020 forced almost half (3.9 billion people) of the global population in lockdowns by the second quarter of the year [12], and triggered a worldwide, negative spiral effect on supply chains, specifically due to the restrictions on major transportation modes, border restrictions on a majority of countries, and reduced activities in major sectors such as

manufacturing [13]. Even after the resumption of normalcy in most countries, especially after the introduction of vaccinations, supply chains have not fully recovered [14]. It is now understood that the pandemic is expected to have long-term impacts on global supply chain, especially noting that the virus has continued to mutate prompting new, and occasionally extreme lockdowns call in major export countries, such as China, India, and US which at the time of writing are currently experiencing a fourth wave [15]. The interconnected nature of supply chains is expected to render them even more vulnerable, not only due to long-term impacts but also the cascading impacts of conflict from the ongoing Ukraine and Russian war [16] and related European security and energy issues. Such would also be impacted by the reactionary approach by Russia on the numerous economic sanctions imposed on the country by a number of global economies. For instance, in the recent past months, Russia has been conducting unusual oil pipeline maintenance procedures, affecting supplies in a number of European countries. This is in addition to the 40% reduction on gas flow to most European countries [17].

The long-term impacts of these two global challenges of scale are already being experienced globally with rising prices for basic commodities such as food and fuel [18]. As highlighted in a report by the UNFCCC [18], UNFCCC [19] the impact of the COVID-19 pandemic on the global sustainability agenda will be severe, with most economies failing to meet their Nationally Determined Contributions under Paris Agreement [19]. Coupling this with the complications triggered by Ukraine–Russia war, especially on supply chains for green technology, which now comes at a consequent green premium, is expected to prolong the journey toward sustainability transitions. This is discussed in the succeeding sections below.

2. The Link between Sustainability Transitions and Resource Management

The global sustainability agenda has the potential to benefit and be enriched from collaboration between players drawn from diverse disciplines, including academicians, political class, scientists, civil societies and others based on different parts of the globe. In particular, as expressed by Talens Peiró et al. [20], this is important as most sustainability pursuits are dependent on products and goods that are sourced from diverse geographical locations, thereby underlining the need for a seamless flow in the entire supply chain. That is, there needs to be a coherent understanding between people, manufacturing/production plants and the different systems that allow products (especially) to be moved with minimum delays and at reduced costs. On this note, due to the technological advancement that has been achieved as a result of the emergence of fourth industrial revolution, massive technologically oriented products with capacities to influence positive sustainability practices are being produced [21].

The movement of these products is subsequently benefiting from the supply chain networks that have equally benefitted from the impacts of globalisation as well as the improvements in technology. For instance, in the recent past, numerous countries have embraced the global calls to transition from using non-renewable sources for their energy production, to renewable sources. As a result, there, has been an increase in demand, and economies of scale in development, production and deployment of these technologies; meaning that these technologies and related components can now be produced cheaply and quickly and implemented on a citywide scale (see [22]) for illustrative case studies from Europe). This scaling of production of renewable energy technologies has led to global networks and supply chains of parts manufacture for the energy sector, that navigate complex legislative and fiscal pathways to finished goods, albeit at a high embodied energy weightage [23]. Jelti et al. [24] explain that the ability to move raw materials across different geographical locations has been among the main contributors to the increased penetration of renewable energies in the recent past. This has in part been made possible by manufacturing companies managing to maintain healthy re-order levels due to emergence of concepts such as Just-in-Time (JIT) that promotes efficiency in shipping different products [25].

However, in the quest to respond to resource needs for sustainable technology and related products (PV Panels, Sustainable Wood, Lithium-Ion Batteries, Microchips, Synthetic Cotton, Smart rotors et cetera), there also need to avoid unsustainable practices in acquiring and managing these resources as well as other possibilities for inequalities. On unsustainable practices, Talens Peiró, Martin, Villalba Méndez and Madrid-López [20] note that most of the raw materials used in manufacturing diverse technology products occur naturally in limited quantities and are unequally distributed across different geographical areas. Therefore, they require to be mined, utilized and recycled optimally to avoid unsustainable practices. In addition, their utilisation and supply, including after they are converted into finished products, need to be done in a diligent fashion to avoid bottlenecks and unequal supply chains that has the potential to derail sustainable transition in some economies, especially those in the south. There are also reports that the world is willing to offset the 'dirty' task to China, in the form of pollution intensive manufacturing, which is readily accepting the burden in exchange of economic growth. Lotfi et al. [26], the unsustainable supply chains may be presented in diverse forms including forced labour, child labour, under payment and over-consumption of resources such as water such as in the case of cotton farming.

In 1991, the Den Bosch Declaration was made by government officials drawn from 120 countries all yearning for a sustainable global commodity market. This underlying agenda was aimed at ensuring that there was uniformity and sustainability processes across the entire supply chain, especially in regard to food production and supply [27]. However, this global agenda has not helped to solve the sustainability challenges of supply chains, more so in regard to movement of goods and parts to the markets. This, as noted by Saada [28] explains why there is increased attention toward adoption of Green Supply Chain Management (GSCM). However, the GSCM cannot also hold if the key ingredients, a functional link between producers, suppliers and consumers, is not upheld at all stages, especially in regard to planetary ecological balance. That is, the need to ensure that all stages within the supply chain corresponds with eco-friendly resource management.

While there are numerous sustainability agendas to be pursued, including mitigation of climate change events, the aspect of resource management is urgent and has the capacity to help address many other issues in tandem. For instance, there is a need for all stakeholders within the supply chains to adopt best practices emerging in global markets aimed at promoting optimal resource consumption as envisioned in the SDG12. Such include the circular economy concept where emphasis is on extending the lifecycle of a product or its parts to the maximum by adopting practices such as re-using, repairing, refurbishing, leasing, up-cycling and recycling [29], hence reducing its carbon footprint. The circular economy concept would help the pursuit of resource management by (i) help minimize wastage and pollution, (ii) ensure consumers get the highest value from products and materials and (iii) allow nature to regenerate. Circular economy programmes would further help to stimulate the emergence of new alternatives via eco-innovations that would eventually reduce excessive resource consumption.

Other best practices include emphasizing on using renewable energy in all stages of the supply chain, including mining, production, manufacturing, transportation, storage and during consumption of products. On this, Yu et al. [30] note that the use of non-renewable sources in different stages of the supply chain does not only contribute to climate change but compromises the integrity of natural resources and jeopardizes the quest for sustainability in the supply chain. It also contributes to defeating all other actions that are set in place to address challenges such as climate change, high price of commodities, food insecurity, and so on. It is key in this respect to look at supply chains not only at local level, but to also include challenges linked at regional and global levels, including the need to reduce friction flows when moving products.

3. Impacts on Global Supply Chains

3.1. The Case of the COVID-19 Pandemic

The outbreak of COVID-19 'caught' the global community unprepared, and as outlined by Allam [31], most of the policies, actions and frameworks to contain the pandemic were not in place. As a result, Meyer et al. [32] noted that the pandemic exposed the vulnerability and lack of resilience of the global supply chains. In particular, the supply chain networks showcased their inability to respond effectively to the unprecedented demand-supply pressures. Such pressure was exerted by factors such as the abnormal demands and consumption of medical supplies in different parts of the world. It was also catalysed by enormous demand for consumer goods encouraged by factors such as panic buying, successive waves of the pandemic, and restricted movement of goods and people due to global lockdowns [33,34].

The simultaneous, widespread outbreak of the pandemic in different parts of the globe elicited numerous challenges on diverse sectors such as mining, manufacturing, and transport. For instance, as a majority of people retreated to confinement, most factories and manufacturing industries were experiencing labour shortages as well as scarcity of raw materials. A case in point is the airline industry which, as a critical component in seamless supply chain networks, was short staffed by approximately 4.8 million people as a result of the global containment measures [35], prompting a 7.7%, reduction in air cargo capacities [36]. In the shipping industry, a report by the United Nations Conference on Trade and Development (UNCTAD) highlights these challenges, such as shortages of raw material, prolonged lead time, ocean blank sailings and port closures, among others, intensified during the height of COVID-19 pandemic [37].

For factories and manufacturing plants with raw materials needs, border restrictions and grounding of different modes of transport triggered issues such as labour shortages, transport capacity constraints, and surplus supplies—since it was not possible to move finished products to the consumers, among other obstacles, that eventually compromised smooth supply chain operations and trade flows. According to Freight Right [38], as of October 2021, there were approximately 353 container ships still stranded outsides different ports spread across the globe. The congestions were occasioned by the containment measures that had been instituted almost a year earlier (2020). The impacts of COVID-19 continue to be felt with the backlog for stranded cargo ships continuing even in 2022, where, as of January, there were over 82 container ships that were waiting outside ports in China ready to take cargo, while Hong Kong had 61 and Long Beach, Los Angeles had 61 [39].

The stranding of those ships translated to container shortages in the millions. For instance, as of September 2021, it is reported that there was a global shortage of over 2.4 million 20ft containers, which amplified that congestion in ports [40]. Coupled with these challenges were fuel shortages and increased prices of petroleum products which eventually translated to increased shipping freight rates. For instance, between 2020 and 2021, freight rates from China to South America are reported to have increased by approximately 443%. Between China and other Asia countries and North America, the costs had increased by approximately 63% [41]. Even with the increased charges, the Just in Time (JIT) that had previous helped activities at sea to move seamlessly and flawlessly became inefficient, as normal operations had been greatly disrupted because attention had shifted to containing the pandemic [42].

The impact of this supply chain disruption includes relatively high (compared to pre-pandemic) costs of final products, prolonged transportation time, reduced access to raw materials and increased inequalities in the supply chains. According to Carrière-Swallow et al. [43] of International Monetary Fund (IMF), with the average shipping costs increasing by more than double the previous cost, final consumers have had to put up with not only high costs of products, but also increasing inflation. For instance, in 2021, in a study covering about 143 countries, it was established that the inflation rose by an average of 7% and by 2022, as the challenges in the sea continued to manifest, inflation is

expected to increase by another 1.5% [43]. In particular, the high rates of inflation are being experienced in many western countries, reminiscent to situation in the 1970s.

While the war is still unfolding, and impacts are expected to perdue in time and across sectors, a first set of global challenges are already observed. Figure 1 below highlights some of the global crises that have arose and continue to escalate due to the outbreak of the COVID-19 pandemic as well as the continuing Ukraine–Russia conflict.

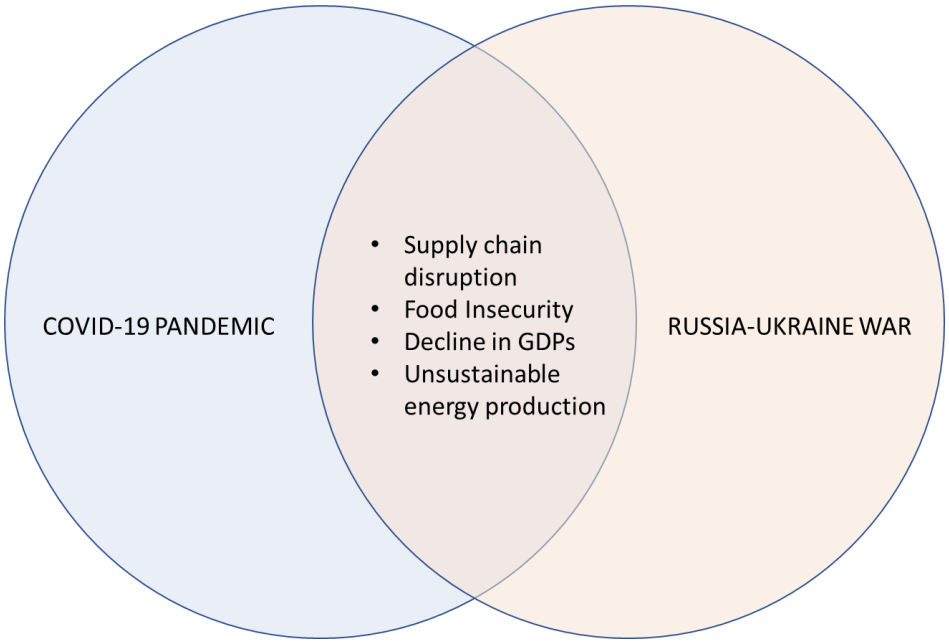

Figure 1. Venn Diagram describing some emerging global crises arising from the COVID-19 Pandemic and the Russia–Ukraine war.

3.2. The Case of the Russia–Ukraine War

The current conflict between Ukraine and Russia that escalated into full blown war, prompted abrupt impacts on the global community, leading to unprecedented challenges. For instance, as a result of the war, there has been an increase in oil prices, global food shortages and uncertainties on the supply chain leading to from the two countries and their neighbours [44]. While the hostility between the two neighbouring countries began in 2014, the situation had not precipitated into the current situation where most of the global communities have resulted into instituting harsh sanctions on Russia. The sanctions by the USA, the European Union (EU), Australia and other regions targeted the financial sectors (capital market, Banking system), real estates, imports and exports of different products and services, technology and others [45]. Though a majority of these economies, especially in Europe, have not yet stopped completely trading with Russia regarding oil and energy, there are plans to gradually detach from the country in terms of reliance on such resources [46]. However, the USA, which was one of the main oil trade partners with Russia, completely banned trade in all energy-related products (Oil, Liquefied Natural Gas and Coal) through an Executive Order signed by President Biden on 8 March [47].

Despite standing with Ukraine, most European countries still rely heavily on oil and related products from Russia, not only for fuelling automobiles, but also for heating, manufacturing industries, and so on. From a report by Eurostat [48], it is evident that Russia has been the largest supplier of Crude oil to the EU. In 2020 alone, the EU imported approximately 25.5% of petroleum oil from Russia and 24.7% in the first semester of 2021 as per the Eurostat database. Further, in terms of entire energy products, between 2017 and 2021, it was reported that Europe increased their imports from between 45% and 48% [48].

With these major importers of oil from Russia banning any importation, this has left other competitors straining to meet the global energy demands. In a report by the

International Energy Agency (IEA) on EU, following the boycott on Russian oil, IEA members had agreed on the 1 March 2022 to release 62.7 million barrels of emergency oil reserves, but the demand pressure escalated such that by the 1st of April, they were forced to announce another 120 million barrels from their emergency stock [49]. This however did not suffice to stabilize the oil supply chain, leading to global markets reacting accordingly, with prices soaring to unprecedented levels globally. For instance, by March 2022, the price of oil per barrel increased by approximately 15% to reach approximately USD 130. Whereas the prices reduced in the following months, to approximately USD 95 by September, the overall impacts are still high especially regarding electricity generation [49].

Besides the oil market, the Russia–Ukraine war has also impacted the global market for consumer products especially food supplies such as wheat, corn and edible oils (sunflower oil). Both Ukraine and Russia are among the major exporters of global wheat, which accounts to approximately a quarter of the total exports from the region [50]. These two economies supply approximately 70% of grain requirements for countries such as Turkey and Egypt, while Ukraine alone is the top supplier of corn to China. Ukraine is also reported to be the global top export of sunflower oil; accounting for approximately 50% of the total global export [51].

The trickle-down effect of scarcity of these products in the global market is the unprecedented increase in their prices and those of other agricultural products that rely on those products as raw materials. For example, in a short-term outlook report published by the European Commission, it is highlighted that most EU countries in particular are bracing for an escalated strain on agri-food sectors. It is expected that the production of milk in the region, for example, is expected to be reduced by approximately 1.5% in the short term, prompting a reduction in products such as cheese, butter and other daily products [52]. The poultry farming is also expected to be impacted as some raw materials for feeds production are sourced from both Ukraine and Russia. According to the UN Food and Agriculture Organisation (FAO) [53], there are possibilities that the overall global prices of food supplies will increase by between 8% and 22% by end of 2022 and 2023, before other alternative sources are established, or the conflict is contained.

Scarcity and high prices for basic products are further expected to trigger an upward adjustment on labour prices in some of the affected countries, as citizenry try to cope with the rising costs of living. For instance, in the United Kingdom, the regular wages have already increased by approximately 4% since the start of this year [54], and with the impacts of war, the demand for wage rises is expected to continue growing [55]. According to the Ratha and Kim [56], the conflict has also prompted a reduction in remittances in most Central Asian countries that have a majority of their residents, especially in Russia. It is projected that remittances from Russia to the Kyrgyz Republic for instance will plummet from 83% recorded in 2021 to approximately 33% this year. Such impacts will then prompt an increase in the domestic labour market as many people will require additional regular income to keep up with rising prices. Overall, the conflated impacts on labour and commodity prices will have substantial ripple effects on other sectors and drive unsustainable prices for various goods and manufactured products, including technology and tech products required for sustainability transitions.

The ripple effects will be felt in sectors such as transport, which, as noted in this paper, is already experiencing notable consequences such as increased freight charges. The agricultural sector in most countries is already experiencing supply chain disruptions, especially for basic farm inputs such as fertilisers, impacting on estimated food production [57]. It is expected that this would have serious ramifications, especially in Africa and other regions that are already strained by reduced food availability prompted by ranging impacts of climate change [58]. In addition, the war has had serious land degradation impacts, including natural resource destruction, pollution, fires et cetera. Sizeable number of farming fields have also become derelict and would take time before they are reclaimed back for agricultural activities [59]. Furthermore, in other scenarios, irrigation systems and agricultural infrastructures have been destroyed. Compounded, all these impacts of the

war would have serious, long-term influence on food production, not only locally, but at the global sphere. Already, months of full-scale aggression has had significant impacts on the global food supply [57], and if a lasting peace solution is not reached urgently, the outcome on food security will be momentous.

4. The Challenges of Green Premiums Additionally, Access to Green Technology

The calls for deep decarbonisation and subsequent, diverse commitments made at COP26 in Glasgow are expected to echo across policy frameworks in countries worldwide. They are anticipated to spark positive outcomes in regard to different countries 'and stakeholders' ambitions for climate action in the pursuit of reaching net-zero emissions by mid-century [5] In recent years, the world has witnessed a plethora of policies, actions and innovations that are expediting sustainability transitions, especially in the energy sector away from fossil fuels towards zero-carbon energy production. To secure a sustainable future, the energy sector needs to rapidly transform from its dependency on fossil fuels to relying on renewable energy sources and smart energy solutions—under the framework of sustainable energy systems. Therefore, energy transition and environmental innovations are high on the agenda of many countries, supranational unions, and international organizations.

The above relates to the Sustainable Development Goal (SDG) 13—Climate Action, which aims to take urgent actions and implement innovative approaches to combatting climate change and thus mitigating its impacts. The energy sector is crucial for transitioning to low-carbon economies and ultimately fossil fuel-free societies through integrating large shares of green energy with smart energy through additional flexibility and decarbonizing other key emitting sectors, notably manufacturing, industry, transport, and buildings. In this respect, one of the key challenges to address and overcome is how to accelerate the transition to low-carbon economies through sustainable energy technologies as a socio-technical system, and what this entails in terms of changes or transitions to the underlying socio-technical processes and their management. Here, more effective policy and governance approaches, coupled with applied new technology solutions, are of crucial importance to enable this purposive transition and spur innovation [60].

The corresponding aim of rapid and deep decarbonization will affect major economic sectors. In this light, innovative but available technologies are regarded by the United Nation's 2030 Agenda as a means to protect the environment, increase resource efficiency, upgrade legacy infrastructure, and retrofit industries (United Nations 2015). A large body of work on transition pathways towards zero-carbon energy or zero-emissions innovations emphasises the role of science, technology and innovation [61] With respect to the latter, the COVID-19 pandemic has accelerated and intensified the digital transformation of the world [62], opening up new windows of opportunity for mainstreaming the adoption and use of science-based technologies across all economic sectors and hopefully for more meaningful innovations in the energy sector.

However, transitions toward sustainable socio-technical systems are associated with complex and multi-dimensional shifts (e.g., [63,64]) increasingly requiring sophisticated approaches. These are necessary to adapt economies and societies to sustainable modes of whole chains of production and consumption. These changes involve a large number of actors, complex relationship, and dynamic networks that need to be orchestrated as part of management transitions and evolved technological innovation systems. Energy transitions involve "long-term, multi-dimensional, and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption" [65], p. 956). The geographical context for sustainability transitions, policy and governance is a critical dimension to understand. Indeed, as sustainability transitions are constituted spatially, unpacking this configuration is crucial to better understand the underlying socio-technical processes that give rise to these patterns [66]. Many studies of urban transitions have homed in on spatial factors conditioning energy transitions [67]. One of the key research strands in energy transitions is their geographies and the mean-

ingfulness of the analysis of their spatial aspects. Generally, in order for the geography of sustainability transitions to capture the distribution of different transition processes across space [68], it requires analysis of the particular settings in which transitions are embedded and evolve while focusing on spatial relations in terms of geographical connections and interactions [66].

In addition, policies stimulate industrial development of clean/green tech industries [69,70] and facilitate the integration of renewable energy and smart energy technologies as strategic innovative niches [71]. In this area, clean-tech clusters can be mapped and supported through research and development support, training programmes, and funding schemes [72]. This should be based on evidence-based regional innovation policy design using the knowledge of and available research on place specific conditions and their ability to fine-tune policies. What policies should take into account and reflect on in this regard is the difference between the innovation potential and the potential for sustainability transitions due to industrial and technological specialisations [66]. Additionally, the ability to innovate through new knowledge combinations [73], which can be enabled by advanced technologies, is key to smart specialisations based on related sectors with different complementary capabilities.

Several questions are still below the radar in the emerging work on energy transitions. These questions particularly pertain to how policy is analysed and designed, how governance is implemented, and how new technological niches are stimulated and formed based on emerging technologies as part of the socio-technical processes underlying sustainable energy transitions. These are geographical processes that happen in actual locations and through spatial relations and evolve within the spatial configurations and dynamics of networks. The importance of place specificity for sustainability transitions has been extensively examined by geographers [74]. A place-based perspective is, as argued by Coenen, Hansen, Glasmeier and Hassink [67], critical to the understanding of the multifaceted nature of contemporary energy transitions, as well as instrumental to the development of effective policies. The importance of policies reflects the necessity to mobilise the heterogeneous group of local actors of relevance to sustainability transitions and its aims [75]. Governance of sustainability transitions increasingly becomes a collaborative effort involving public and private actors with varied interests and incentives [76]. This results in highly complex processes with, as noted by Hodson and Marvin [77], many disagreements and struggles in terms of ambitions and development of initiatives promoting sustainability transitions. For instance, such disagreements could be in form of pricing of final products, especially in countries further positioned in the supply chain, and also in relation to ensuring that those products are accessible in substantial quantities especially in global south countries. Interestingly, during the process of sourcing raw materials, prices are relatively lower, but after being processed and converted to final products (mostly in countries in the global north), they are marketed at relatively higher prices compared to the cost of production. Therefore, countries especially in the global south with lower purchasing powers are forced to bear those high prices despite the fact that they are key constituents, via the sourcing of raw materials, being a key element in the production cycles.

While the above challenges pertain to the global south, they also have to put up with widespread financial and technological capabilities challenges. In this regard, as rightly acknowledged by the new Global Energy Alliance for People and Planet (GEAPP) that was launched at COP26 [78], access to finances and technology, especially for developing countries, more so those in the global south, will remain an issue that equally require to be addressed urgently. To put this into perspective, it has been reported that currently the compounded CO_2 emissions for energy-poor countries is only 25% of the total global emissions [55]. However, within these economies, there are already at least 243 Gigawatts of coal power plants that are at different stages of completion (planning, being permitted and some being constructed) and expected to operation before mid-term (2041–2060) [79] When complete, such will increase emission capacities for those countries to 75% (equivalent to 38 billion tons of CO_2 emissions) [1]. This will be catastrophic and as has been

captured in the April 2022 IPCC report on mitigation of climate change [1], this means we will not achieve net-zero emissions by mid-century. However, as expressed in a report by the African Development Bank [78], it is not the desire for developing economies to generate their energy from non-renewable sources; however, they have been financially and technologically constrained, promoting them to continue consuming the aforesaid products. This could be changed by initiatives such as the proposed USD 100 billion fund from developed countries, pledged under the Paris Agreement, and anticipated to be in place by 2020, to help developing and less-developed countries in their mitigation programs. The promised USD 100 billion was not achieved, to date it is reported that developing economies have only received approximately 13% of the promised total clean energy financing [78], rendering the fund insufficient in supporting green energy transitions in these countries.

The limited financial resources have made it impossible for countries on the global south to develop their own climate action-oriented technologies. Therefore, they rely on technologies, whose Intellectual Property (IP) is largely owned by the global north [80]. This makes it relatively expensive for developing and least-developed economies to prioritize green solutions, particularly in the energy sector due to costs of accessing different green technologies. Whereas it is important to recognize and appreciate the IP rights protection to promote innovations and creativity, this however should not come at the expense of a global crisis such as climate change, which indeed does not discriminate even against developed economies.

The challenge with expensive green energy solutions is that such attracts relatively higher price margins for green products, making them unattractive compared to products developed through unsustainable alternatives. This margin, or the difference between the cost of a product borne of green technologies and one borne of unsustainable conventional technologies is known as the 'Green Premium'. That is, the extra cost that is incurred for choosing presumably cleaner technologies. Whereas green technologies are important in allowing for a gradual progress toward the net-zero agenda, the green premium could however lead to inequitable outcomes, especially for those without express access to the technologies. The green premium for a technology therefore remains active until a technology achieves a scale that could warrant it to be mass manufactured globally and in all geographies. As such, this means that until such a scale is achieved, green technology would continue to remain 'elusive' as noted in the book *How to Avoid a Climate Disaster* by Bill Gates [81]. There is an urgent need to lower the cost of green premiums, and this can be achieved by promoting equitable access to knowledge (human mobility), raw materials, and finished products in an effective manner. The alternative to this, as proposed by Gates [58], is to charge for all the hidden costs of pollution in products and services. However, the most optimal vanguard for achieving a net-zero agenda is lowering the cost of premiums, especially by streamlining supply chain networks for diverse products. The cost of premiums could also be lowered by providing financial support to less developed and vulnerable regions to help them build their capacities to transition to greener options.

According to Cheney [82], the quest to reduce the green premium is further impacted by the financial systems and availability of financial resources. Whereas there has been quests to make financial resources available, including in form of grants (e.g., Green Climate Fund and others) and loans, these have not been sufficient or in some instances not forthcoming (such as in the case of the proposed USD 100 billion for developing economies proposed in the Paris Agreement). Due to the global economic situations in the recent past, the financial systems are seen to focus more on supporting technology developments, which are majorly based in the global north. In most cases, it has not been possible to expand such developments in the global south. Therefore, most developing and least developed countries are forced to pay high costs for those technologies in their pursuits to implement climate change mitigation programs. This then means that most of the products pushed to market have a relatively higher green premium, and this has the potential to derail their uptake. However, as noted by Oyedokun [83], green products are very critical

for most of the developing and least-developed economies, as they are relatively vulnerable to climate change events despite not being the highest emitters.

For global justice and universal achievement of equitable climate change mitigation, there is a need for urgent consideration to reduce green premiums globally to facilitate social and economic growth equity across the board, as highlighted in different New Green Deals (GND) agendas [84–88]. Further, there is also a need to increase financial support in the global south to unlock the development and manufacturing capacities for increased green energy solutions, as emphasized during the COP26 and also in the latest report by the IPCC. It would also be important to address the shortcomings in supply chains by addressing the structural inequalities that exist, making it hard for most countries, especially in the global south, to access clean technologies that would help in addressing climate vulnerabilities. However, doing this will demand a well-functioning supply chain, which is unfortunately stressed with the pandemic and the war in Europe. The next section engages in a discussion on the subject.

5. Discussions

The need for deep decarbonisation has been apparent even before the United Nations Framework Convention on Climate Change (UNFCCC) was instituted in 1992 [89], as the Intergovernmental Panel on Climate Change (IPCC) was established in 1988. Over the period, supported by scores of global international treaties and agreements such as the Kyoto Protocol of 1997 [90], the Paris Climate Action Agreement of 2015 [90,91] and the Glasgow Climate Pact of 2021 [5] among many others, the quest for climate neutrality has not wavered. The increased attention is particularly driven by recent climate change events that are increasing both in frequency and intensity, prompting serious impacts on the global communities. The outbreak of COVID-19 and the subsequent impacts it has had, coupled with the unravelling impacts of the war between Ukraine and Russia, are further catalysing the need for climate neutrality. These two crises have the potential to prompt a return to unsustainable practices as economies increase their pace to return to pre-war and pre-COVID-19 economic levels [92]. One major challenge with these is the return by economies to the use of non-renewable sources, as was observed by Heubl [92], to be the case in 2021. The two crises would be a major hindrance to the achievement of the SDGs, especially 7, 11, 12, 13, 16 and 17.

On taking charge the impact of climate change, it is evident that many countries, including those on the global north where substantial investments on climate mitigation infrastructure development have been done, are facing increased erratic weather patterns, with consequences such as flooding, heatwaves, prolonged seasons, droughts et cetera [93]. Further, the impacts of climate change events are causing irreversible damages to the global economy, including destruction of infrastructure and properties, loss of livelihoods especially in sectors such as tourism and loss of cultural heritage and culture [94,95].

In Europe as a result of climate-related events, it has been reported that between 1980 and 2020, the region experienced an accumulated loss of between 450 million and 520 billion Euros [96]. In North America, it is reported that the impacts of climate change resulted in a USD 99 billion dollars loss in the USA alone in 2020, despite reduced economic activities as a result of COVID-19 [97]. Going into the future, it is estimated that the global economic loss will be equivalent to around USD 23 trillion, this is equivalent to approximately 18% loss on the global Gross Domestic Product (GDP) [98] The challenges of climate change are then as much economic as environmental, hence bridging polarisation gaps for climate action. With the realities of the COVID-19, and the subsequent impacts of the Russia–Ukraine conflict, it is anticipated that the losses might increase even further, more so due to challenges such as untamed inflation, food scarcity, increased pollution and destruction of natural resources among others [44,59]. For instance, due to the Russian-Ukraine war, the global inflation in advanced economies is reported to have risen to an average of 5.7% by April 2022. In emerging and developing economies, the inflation rose to 8.7% with anticipation that if the situation would be contained in this year, the inflation might reduce to 6.5% and to (2.5% in

advanced economies), since it is also being influenced by the impacts of the COVID-19 [99]. With the ranging inflation, as noted in the previous section, food prices globally are on the rise, with estimation that wheat and maize prices increased by over 35% with average global food prices increasing by over 5 points [44].

The diverse negative impacts of climate change coupled with emerging challenges such as the COVID-19 and the Ukraine–Russia conflict on the global scale have prompted calls for increased attention for green transitions, with the ultimate objective target for net-zero scenarios by the mid-century. However, as was revealed in the wake of COP26 when different countries submitted their Nationally Determined Contributions (NDCs) under the Paris Agreement [18,19] there is much that needs to be done. Indeed, despite most countries having made pledges to reduce emissions, the submissions and communications made in 2021 showcased that a majority were far below their 2030 climate action targets. This then prompts the need to re-look the whole aspect of 'green premiums', which has the potential to derail optimal adoption of green technologies (products) [81].

The green premiums [81] are particularly counterproductive in the global south and developing economies that urgently need to increase their investments in development programs that warrant and guarantee climate mitigation. The negative impacts of green premiums on green transitions ranges from increased costs of technology to the fact that they cannot be effectively measured. These are further expected to be compounded by the impacts of the COVID-19 pandemic that continue to inflict serious economic and social challenges globally, with particular impacts on economies on the global south. The current crisis between Ukraine and Russia is further expected to escalate challenges, especially in relation to market imbalances for different products, which will in turn trigger a further re-emergence of unsustainable practices in different economies.

During the height of COVID-19, the global supply chains for diverse products, including those that support green transitions were greatly affected and even after the resumption of activities in different freight nodes such as ports and airports, there were notable disparities with countries on the global north gaining substantial advantages of their counterparts on the global south. Such disparities are expected to escalate due to the dynamics of the Ukraine–Russia war and the subsequent shortages and scarcity of diverse products, especially consumer goods, food supplies and oil and energy products. As highlighted in the previous section, the war in Ukraine is expected to encourage further escalation of the cost of living globally and these might have a bearing in the financing of green transition programs. Additionally, the war is expected to increase unsustainable practices such as the destruction of natural resources as people explore alternative ways to compensate for scarce fuels and related products. According to Dennison [100], the war has shifted the attention of many European governments in pursuing EU climate goals which include among the important need to transition to clean and sustainable energy.

The two crises—COVID-19 pandemic and Ukraine–Russia war—have prompted challenges of scale in the supply chains networks globally, which in turn are expected to further escalate the disparities in access to green technology due to the ever-increasing issue of green premiums. This gap in development and deployment of green technology is also impacted by disparities in financing, especially with the giant share of climate finance being invested in the global north. However, it is worth noting that despite sharing over 87% of the clean energy financing, developed countries only account for 16% of the global population [78]. The majority of the global population (nearly 60%) living in the global south only receives 13% of the global clean energy financing. However, a majority of these are in the frontline of the climate change events despite contributing less than 15% of the total global emissions [101]. For instance, the SIDS are reported to bear the greatest risks from climate change incidences, yet their contribution is only less than 1% of the global CO_2 emissions [102].

In regard to receiving supplies from global markets, economies in the global south face almost an equal share of inequalities. The remoteness of most of their transportation routes and hub, the increasing freight charges and scarcity of products being part of the many

factors that exacerbates this challenge. All these challenges expose the prevailing climate injustices and global inequality on global climate change support, and this landscape reverberates on supply chain networks being key to develop green technology. The most ideal situation would be to reform, refocus and develop new governance arrangements for financial markets, supply chain networks, and the manufacturing and production systems to promote resilient and more affordable solutions for all players, in a decentralised fashion.

6. Conclusions

The unprecedented impacts of the COVID-19 pandemic, compounded by the Russia–Ukraine war, are expected to continue shaping the global discourse as well as directing it for certain economic and political purposes, especially around sustainability, environmental justice, supply chain management, energy reliability, and food security, among others. This may have serious ramifications on the achievement of the SDGs, which are targeted to be achieved by 2030. Therefore, there is a need to rethink the methodologies deployed for remaining on course to achieve global agendas, including climate change mitigation strategies and goals. In this respect, achieving the numerous global objectives, especially those related to clean energy, supply chain, equality and justice can be done by adopting a raft of strategic pathways and approaches, including legislation (via fiscal mechanisms), and through the formulation of policies that would guide regional and nation-scale development, or by encouraging a set of collaborative paths (shared IP, Knowledge transfer, tech transfer, etc.).

These endeavors would in turn help countries and even possibly regions to consider adopting development models with the potential to spur economic developments, akin to the post WW2 period, which witnessed countries such as Japan and South Korea gaining substantial economic growth. There also is a need for the developed economies to accelerate their supportive role, especially in financial pledges, to ensure that the targeted USD 100 billion aimed at helping developing and the least developed economies are achieved. Further, there will be a need to concentrate on best practices such as the adoption of the circular economy, New Green Deals and others that would ensure that there is some level of decoupling resources from development programs, thereby guaranteeing sustainability transitions in an equitable and just fashion. Further, policy interventions by major global economies, targeting the de-escalation of the Russia–Ukraine war, need to be re-evaluated to encourage the resumption of the exportation of critical components for the production of renewable energy products, such as solar panels and wind turbines.

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