COP27 Making a Case For a Net Zero-Carbon Emissions Future By Implementing Technological Solutions and Mindset Transformation

Abstract
Carbon emissions pose a massive risk to our planet's health. According to the Paris Climate Agreement, nations pledged to limit global warming to 1.5 °C to mitigate climate change's impacts. This target will not be achieved without immediate and deep emissions reductions across all sectors. Unfortunately, the Russian-Ukrainian conflict and the new natural gas discoveries in some countries have also slowed down the pace of decarbonization. Aside from that, a faint light at the end of the tunnel could be seen from the new Intergovernmental Panel on Climate Change (IPCC) report, which pointed to increasing actions on climate change. Fortunately, achieving future zero carbon emission is still possible via the implementation of holistic frameworks that promote existing and emerging green technologies and helps the community to transform. This policy paper proposes a framework that integrates technology use and mobilizes the transformation of communities' mindsets to cope and adapt to climate change. The proposed framework will then be implemented in the country hosting the 27th Conference of the Parties of the UNFCCC (COP 27), Egypt, and it is recommended to be used by scholars and policymakers for future assessment of the country's climate change performance. Finally, the paper provides a set of recommendations to governments, policymakers, and communities to accelerate the movements toward a net zero-carbon future.

Key Words: Net Zero Emissions, Mindset Transformation, Energy Policy, Innovative Solutions

1. Introduction
The industrial revolutions of the 18th and 20th centuries contributed to the mass economy, prosperity of nations, and mass urban development, but at the expense of nature, which is currently suffering from the negative impact of greenhouse gas emissions, deforestation, and the depletion of natural resources. Consequently, nature is raging by unprecedented levels of climate change, causing humanity to suffer from heat waves, rising sea levels, extensive precipitation, fires, species extension, and much more. Humanity is entering a vicious cycle, starting with the increased energy consumption during the industrial revolution leading to climate change, then accelerating climate change leading to higher energy consumption, as shown in figure 1.

In response to climate change and following two weeks of intense negotiations, including an additional day added and lengthy overnight discussions, over 190 countries signed onto the Paris Agreement in 2015 to reduce greenhouse gas emissions that cause climate change. This legally binding agreement marked the first time that all countries, both rich and poor, committed to deep reductions in the pollutants that cause global warming - the previous emissions treaty, the 1997 Kyoto Protocol, only included commitments from rich, developed nations (United Nations, 2015). From the presented data, it is clear that the world needs to transform toward a carbon-free economy. This is highlighted in the global goal of reaching net zero carbon by the year 2050 presented in the Paris agreement.

Considering Pareto's 80-20 rule, which states that 80 percent of something relates to 20 percent of the associated factors. Applying this to climate change would mean that 80 percent of emissions derive from 20% percent of specific nations or 20% of particular sectors. International reports have proven this true; for example, as per the World Bank, few countries contribute to the majority of greenhouse gas emissions. For example, China, India, the US, Canada, Australia, and Europe constitute more than 65% of the total global emissions. From another perspective, high-income countries have higher per capita emissions than any other region. For example, although India contributes around 7% of the global emissions, its emissions per capita are almost 1.91 Kg of CO_2; on the other hand, a country like Canada only contributes 1.89% of the total global emissions, but the emissions per capita is one of the highest in the world reaching 18.58 Kg of CO_2. The same comparison between the US and China shows that US emissions per capita are around 15.52 Kg of CO_2, while China's is around 7.38 Kg of CO_2 (World Bank, 2022). Moreover, it is worth drawing global attention to the source of emissions; it has been reported that 72% of the world's greenhouse gas emissions are generated for energy. The two main energy sectors are electricity and heating, contributing to about 31% of the emissions, and the transportation sector contributes about 15% of the global emissions (Center of Climate and Energy Solutions, 2018).

Based on these findings, it can be concluded that the energy sector and the mindset of some nations are the main reasons for climate change, as per the Pareto. Thus, this work sheds light and suggests a comprehensive framework for a net zero carbon future, showing that it is possible to utilize technological advancements in the energy sector and capitalize on the mindset transformation of communities. This work will also suggest a set of recommendations to governments and individuals to fulfill the net zero carbon target. Egypt will be considered as a case study and evaluated against the proposed framework to assess the Egyptian government's efforts in the climate change context.

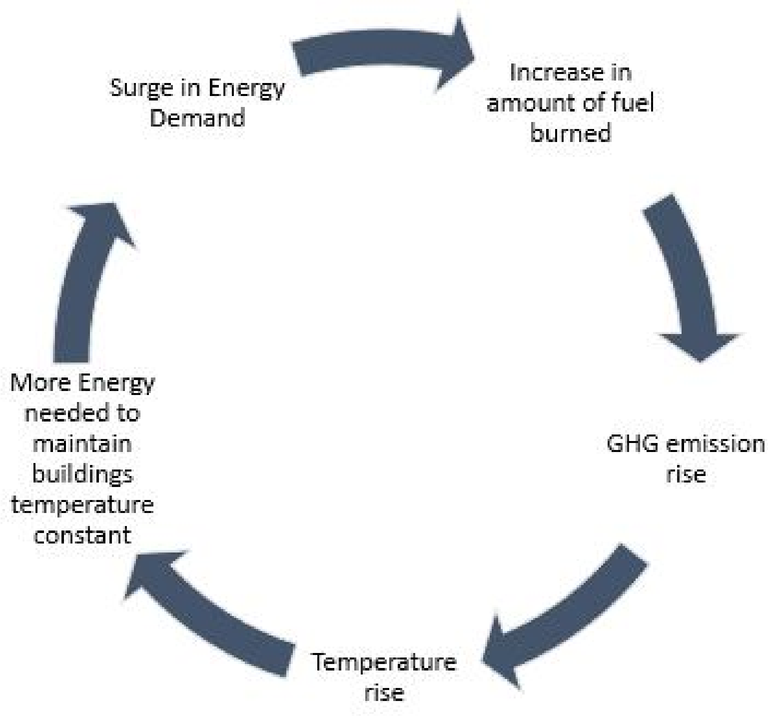

Figure 1: Climate Change Loop

2. Framework For Net Zero Carbon Future

To achieve the net zero carbon target, a comprehensive approach must be followed. As stated, one of the primary sources of greenhouse gas emissions is energy generation, with the contribution of a few nations to the majority of those emissions. This issue can be viewed from two different perspectives: first, the increasing demand for energy due to industrial development, world population growth, and improved living standards of nations. Second is the dependence on fossil fuels as the primary source of production.

To tackle both perspectives, the suggested framework will focus on two main pillars: employing innovative technological solutions and transforming societal mindset. Under these two main pillars, eight sub-pillars are proposed, as shown in figure 2. This framework shows the link between using innovative technologies and the efforts needed by the community to adopt such changes and embrace new technologies in their lifestyle.

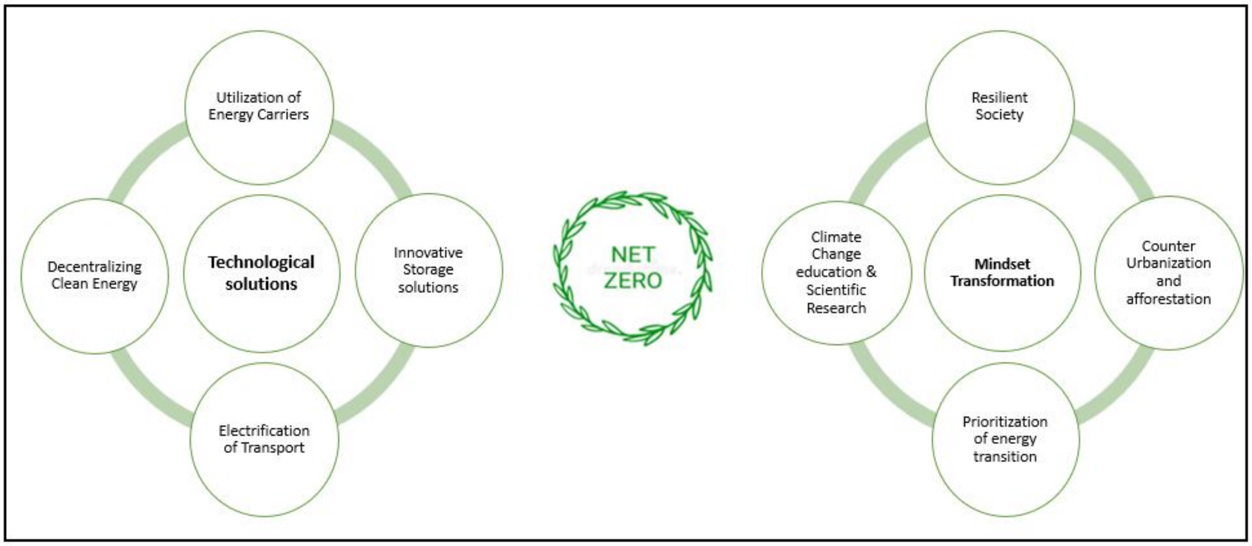

Figure 2: Proposed Framework For Net Zero Emissions

2.1. Technological Solutions

Nowadays, the global community is focusing on renewable energy sources and their advancement. However, numerous barriers exist to employing renewable energy on a large scale. For example, almost all renewables require a significant surface area, and it takes more capital and energy to construct the same nominal generating capacity compared to fossil fuel-based plants (Gross, 2020). However, in the past decade, the cost of renewables has decreased significantly, with the Levelized cost of energy (LCOE) for wind energy dropping below that of fossil fuels (IRENA, 2021).

Another challenge is that most renewables have a lower capacity factor (the fraction of life over which they operate at full capacity) (Miller & Keith, 2019). The exception is geothermal power, a "democratic" energy source as it is available worldwide, and anyone can take advantage of it, regardless of the conditions at the Earth's surface, such as the weather (IRENA, 2017).

Moreover, obtaining the required materials to build enough renewable energy to cover global needs takes time. Most renewable sources utilize rare earth elements; that is not found abundantly. A high material intensity would be manageable if the material in question had large reserves and low embodied energy and carbon footprint. Some materials meet this ideal: iron and carbon steel, concrete, wood, and commodity polymers. The resource demand plots have assumed that one-sixth of the predicted 2050 energy requirements will be met over a period of 10 years from new installations providing an additional 200 GW of power per year. But the sheer scale of this demand would put pressure upon material supply, significantly exceeding the current production capacity of the scarcer ones (Ashby & Attwood, 2011).

Intermittency of energy generation is the main challenge facing adopting renewable energy as the main energy source. As the natural resources are intermittent and unstable, it is challenging to match the electricity required at a time with the electricity generated from the natural source. This creates a need for energy storage (Duan, 2021). The electricity storage system acts as a buffer to store the excess energy generated and supply it when the induced energy drops due to natural source intermittency; solar energy only operates during daylight hours when the sun is available, for example. Storing electricity is challenging. The most common method used for energy storage is lithium-ion batteries, which usually degrade with time and eventually need to be replaced, causing the cost of a standalone renewable energy system to escalate (Edge et al, 2021).

Those challenges with renewable energy sources set barriers to their adoption on a large scale and maintain the global dependence on fossil fuels. Although renewable energy sources are a part of the solution, they cannot be the only aspect of it; technologists are finding ways to improve the efficiency and productivity of renewable sources. For example, one of the main approaches is electricity decentralization and linkage via smart microgrids (Al-Shetwi et al, 2020). Decentralization in the electricity sector is a significant step in the spread of renewable energy sources and, therefore, can reduce dependence on fossil fuel. A microgrid consists of energy sources and loads that, together, can operate independently and are connected to a surrounding, larger electricity grid. A vital feature of a microgrid is the ability to separate and isolate itself from the utility during a disturbance with little or no disruption. When the utility grid returns to normal, the microgrid then automatically resynchronizes and reconnects itself to the grid. The microgrid can operate using decentralized, autonomous control, allowing each of the active elements within a microgrid to operate in coordination with one another through locally available information. The microgrid consists of a data acquisition unit where the demand profile is detected. It also contains a static load component to stabilize household grid connection (Das et al, 2020).

Additionally, a microgrid system is equipped with a central storage unit. This storage unit sorts out the intermittency challenge of renewable energy sources as it can act as a buffer for the downtime of the renewable sources (White, 2019). Decentralizing energy production proved to be in line with the sustainable development goals due to its affordability, short building time, high reliability, and ability to respond to failures and low losses due to electricity distribution.

Additionally, two more technological solutions can help with the energy intermittency challenge; the first is the use of chemical energy carriers such as hydrogen, and the second is the employment of more innovative battery storage mechanisms. Gaseous hydrogen can be transported through pipelines like natural gas today. Studies showed that hydrogen could be dealt with like how we currently deal with natural gas, with only minor changes in infrastructure. Adopting hydrogen as a chemical carrier will aid in speeding the pace of the energy transition from fossil fuel. Hydrogen–gas blend can be moved in our existing pipelines, and future plans can include using fiberglass reinforced plastic (FRP) pipes for 100% hydrogen transportation and 20% lower cost than the needed pipelines for natural gas (US office of energy efficiency and renewable energy, 2019). As an energy carrier, hydrogen possesses the advantage of familiarity, the use of the existing power generation cycles and transportation means without the need for changes in the lifestyle of nations (National Research Council and National Academy of Engineering, 2004)

Innovative storage techniques such as gravity battery (Graviticity, 2021), pumped hydro storage (Borri et al, 2020, Blakers et al, 2021), and compressed air storage (Quident Energy, 2019) can also be a solution. By eliminating the degradation of batteries, the price of the renewable energy system will drop, making it feasible to use it as the primary energy source. In this case, higher efficiency can be achieved as electricity is directly harnessed from the renewable energy source. Albeit the risk of blackouts exists because of massive drops in natural energy source availability. An idea of merging both approaches, where the backup scenario is hydrogen-operated power plants, can be done. However, this approach might not be economical as producing hydrogen in small quantities won't be cost-effective. A proper solution to that is a hybrid energy production system; hydrogen can be used for fueling cars in the form of fuel cells and also as a backup to the direct renewable systems utilization maintaining the economy of scale for hydrogen production and benefiting from the enhanced efficiency. This would also limit the use of any non-recyclable battery system; cars won't need to store electricity in batteries by using fuel cells. Based on the prior literature and research, figure 3 summarizes the suggested use of technologies in this framework; information is adopted from (Center of Climate and Energy Solutions, 2018 & White, 2019 & Duan, 2021 & European Union Agency for the cooperation of Energy Regulators, 2021 & Christopher & Dimitrios, 2012 & Verfondern, 2008 & Edge et al, 2021 & Graviticity, 2021 & Renews Ltd, 2021 & Cryo Energy, 2021 & Buysee & Miller, 2021).

Lastly, the electrification of the transportation system represents a temporary technological solution that can curb carbon emissions. Although using electricity as a source of energy for transportation is not carbon-free, it can curb carbon emissions generated from the current usage of fossil fuel as the main source of energy for road transport. Milovanoff et al. (2018) argued that vehicle electrification is like a silver bullet that can mitigate climate change through employing technological advancement. Similarly, it has been recently claimed by Zhang and Fujimori (2020) that switching to electrified road transport provides an optimistic window for low-carbon transition, even in the absence of a decarbonized power sector, and can reduce the mitigation cost generated by the two-degree Celsius climate stabilization target.

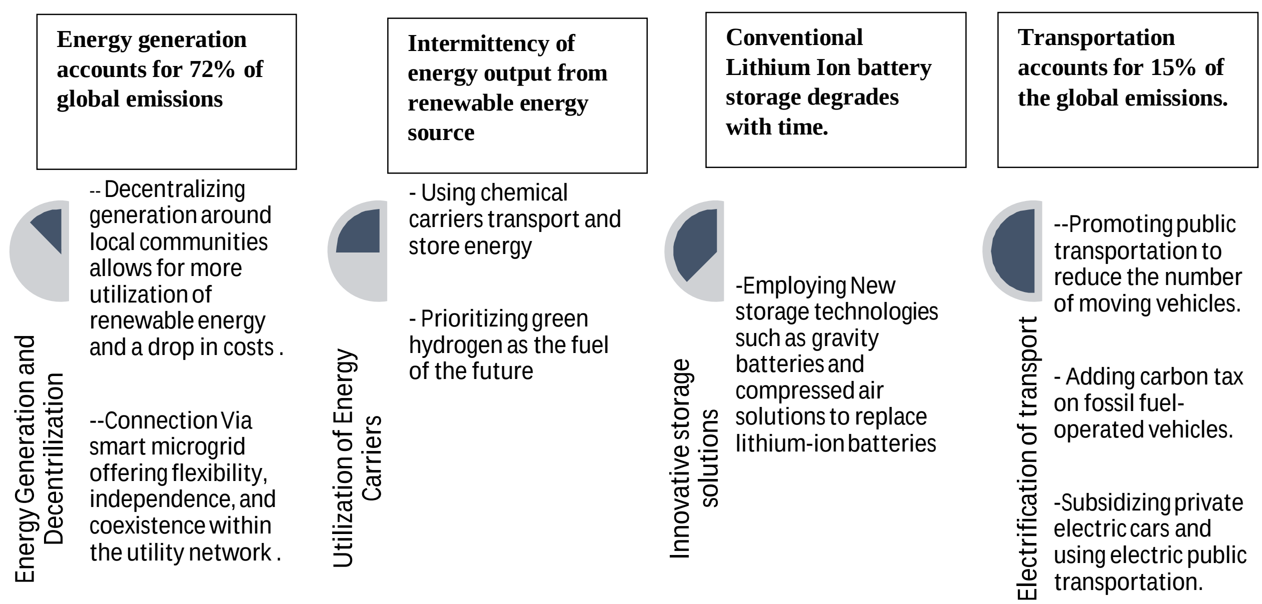

Figure 3: Technological Solutions utilizations in the Net-Zero Framework

2.2. Mindset Transformation

Incorporating new technologies is crucial for our future goals. However, technology alone is insufficient to guarantee a smooth transition; how our societies are built and how we think and behave constitute a significant challenge in reaching the net zero target. Transforming society's mindset is crucial when planning to transition to a greener society with net zero emissions.

Scholars have suggested several factors that can transform societies' mindsets to be more proactive toward climate change. For example, the climate resilience of a society is explained by Berkes and Jolly (2002) as the ability of a community to employ both copying and adaptive climate strategies to mitigate the risks associated with climate change. They defined coping strategies as the short-term strategies in which individuals or households respond to climate emergencies. In contrast, adaptive strategies are long-term strategies employed on a larger spatial scale in which individuals, families, and communities change their productive activities and modify their cultural values and consumption behavior. The range and extent of these short- and long-term responses shape society's resilience toward climate change.

Resilience to climate change has been demonstrated by the agricultural communities in Nigeria, who increased their per capita agricultural production during times of increased aridity. Similarly, the mortality rates in Bangladesh declined when governments increased their investment in human shelters during the time of cyclones. In the same vein, indigenous hunting communities in the Canadian Arctic were reported to be resilient and were able to cope with the impact of climate change by switching species of hunting and adapting in the longer term by showing flexibility in seasonal hunting patterns (Berkes et al., 2002, Adger et al., 2016). Those communities provided evidence that a resilient society can combat climate change, whether during extreme events or in the longer term, to provide a sustainable solution for climate change. Thus, it has been argued that building a resilient society can play an integral part in curbing carbon emissions and is essential for combating climate change (Sarker et al., 2018).

Another sub-pillar that was explained in the literature to reflect mindset transformation is counter-urbanization, which was explained by a plethora of scholars as a means by which societies can change and combat climate change. Counter-urbanization was defined by Halfacree (2008) as being a demographic and social process where people move from urban areas to rural areas. McGee and York (2018) claimed that the relationship between the growth/decline in urban population with carbon dioxide emissions is asymmetrical. They concluded that the decline in urban population reduces emissions to a much greater degree than the increase in emissions due to urbanization. This has been explained by the ability of counter-urbanization to disrupt the production and distribution of goods/services as well as interfere with access to energy sources.

In the same vein, Jimenez et al. (2022) claimed that counter-urbanization is currently generating new patterns of afforestation and considered it as an alternative way for forest recovery.

knowing the positive impact of counter-urbanization and the negative consequences of urbanization that progressively influence carbon emissions, increase energy consumption, and increase the vulnerability of societies to natural disasters (Li & Lin, 2015, Wang et al., 2016, Dogan et al., 2016, Zhang et al., 2017, Coskuner, 2020), scholars argue that attention is to be paid to counter-urbanization (Buckle et al., 2022), especially that the United Nations report on world urbanization prospects in 2019 indicate that urbanization trends are exponentially increasing around the globe as shown in figure 4, and if the current trends continue, the global urban share is expected to rise from one-third to two-thirds in the 100 years between 1950 and 2050.

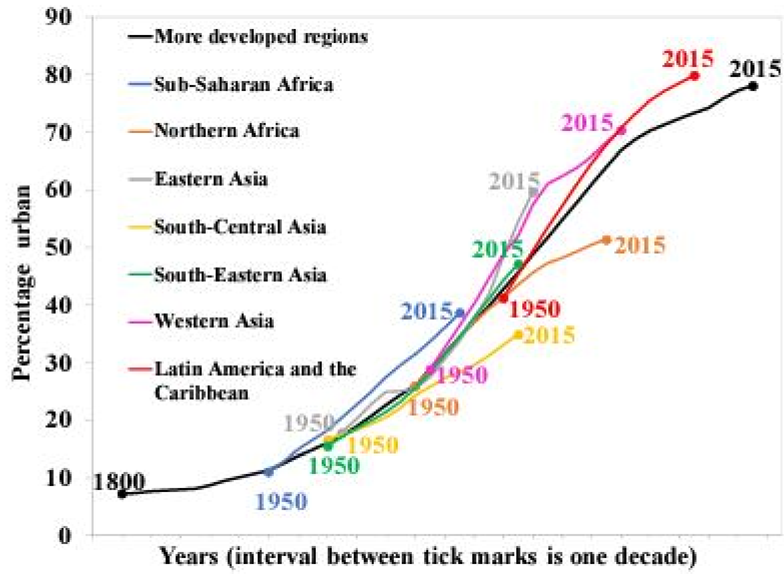

Figure 4: levels and trends of urbanization in different parts of the world (United Nations, 2019)

Currently, governments are paying attention to developing policies on the spatial distribution of the population to limit carbon emissions. Around 56% of the countries had reported implementing policies that promote decentralization from large urban cities, as shown in figure 5. however, further attention to this sub-pillar is needed from policymakers as well as communities to promote counter-urbanization rather than just decelerate the current pace of urbanization.

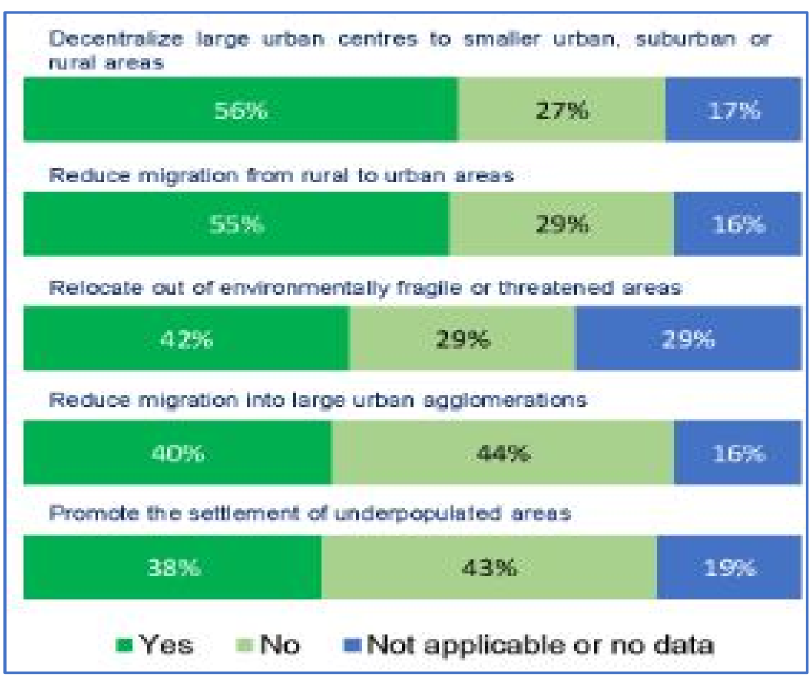

Figure 5: proportion of governments with policy measures to promote decentralization from large urban cities (United Nations, Department of economic and social affairs, population division 2019, World population policies, 2019)

Complementing climate resilience and counter-urbanization, promoting climate education, and fostering scientific research can play an integral role in reaching net zero carbon. Scientific research is the driver for any technological advancements. Today's technologies were once an idea in the mind of scientists; for example, the solar photovoltaic system started at very low efficiencies of 3%, reaching 45% in today's laboratories. Directing enough funds toward research on climate change can significantly impact our future. However, acquiring knowledge about climate change from research does not always guarantee the move of societies to action (DeWaters & Powers, 2013). Thus comes the role of education, which can serve as a vehicle for mindset transformation as it helps to transfer scientific knowledge across all societal sectors, not only the research community with privileged access to information.

The role of education has been explained in the literature as a tool for developing appropriate adaptation and coping strategies for communities, which in turn improves community resilience to climate change. Several frameworks have been proposed by scholars to promote education for sustainable development, integrate disaster risk reduction, and environmental and climate change education, which has been claimed to be central to achieving climate goals (Anderson, 2010, United Nations General Assembly, 2015).

Scholars argue that climate change education should extend beyond the curriculum content and should tackle the whole process of education. For example, developing student skills for gathering and analyzing raw data, employing active learning and interdisciplinary activities, cultivating problem-solving and critical thinking skills, and emphasizing educators' climate illiteracy to be able to provide quality climate change education (Anderson, 2013, Vaughter, 2016). Advocates for the role of education on climate change argue that learning from education, rather than experience, is necessary to avoid the negative repercussions of climate change. It has also been claimed that closing the emissions gap can only be achieved if the similar gap between scientific and societal understanding of climate change is also closed (Ledley et al., 2017).

Finally, the literature points to the prioritization of energy transition as a critical sub-pillar that can help reach zero-carbon emissions. Energy transition has been defined by Bond (2018) as the shift from fossil fuel to renewable energy systems.

Recently, the increasing demand for energy supply combined with the scarcity of clean energy sources has pushed some countries to revert to the use of coal, one of the most carbon-emitting energy sources on the planet, and therefore slow the pace of energy transition. Moreover, the global pandemic, the Russian-Ukrainian conflict, and the new natural gas discoveries have also slowed down the transformation to renewable energy sources prolonging environmentally damaging fossil-fuel subsidy programs. Thus, Komendantova (2021) argues that currently, there is a tendency to prioritize security and economic factors over energy transition. In the same vein, La Peña and his colleagues (2022) claim that different countries are experiencing energy transition at a different pace and sometimes resist the transition due to the social and economic costs associated with energy transition. Therefore, to achieve zero net carbon, it is essential that more countries commit to carbon neutrality and set targets and legislations that foster the energy transition.

Based on the literature mentioned above, we propose in figure 6 a summary of the suggested framework regarding mindset transformation and actions that tackle each of the four sub-pillars: namely, building resilient societies, prioritization of energy transition, counter-urbanization and afforestation and fostering climate change education and scientific research.

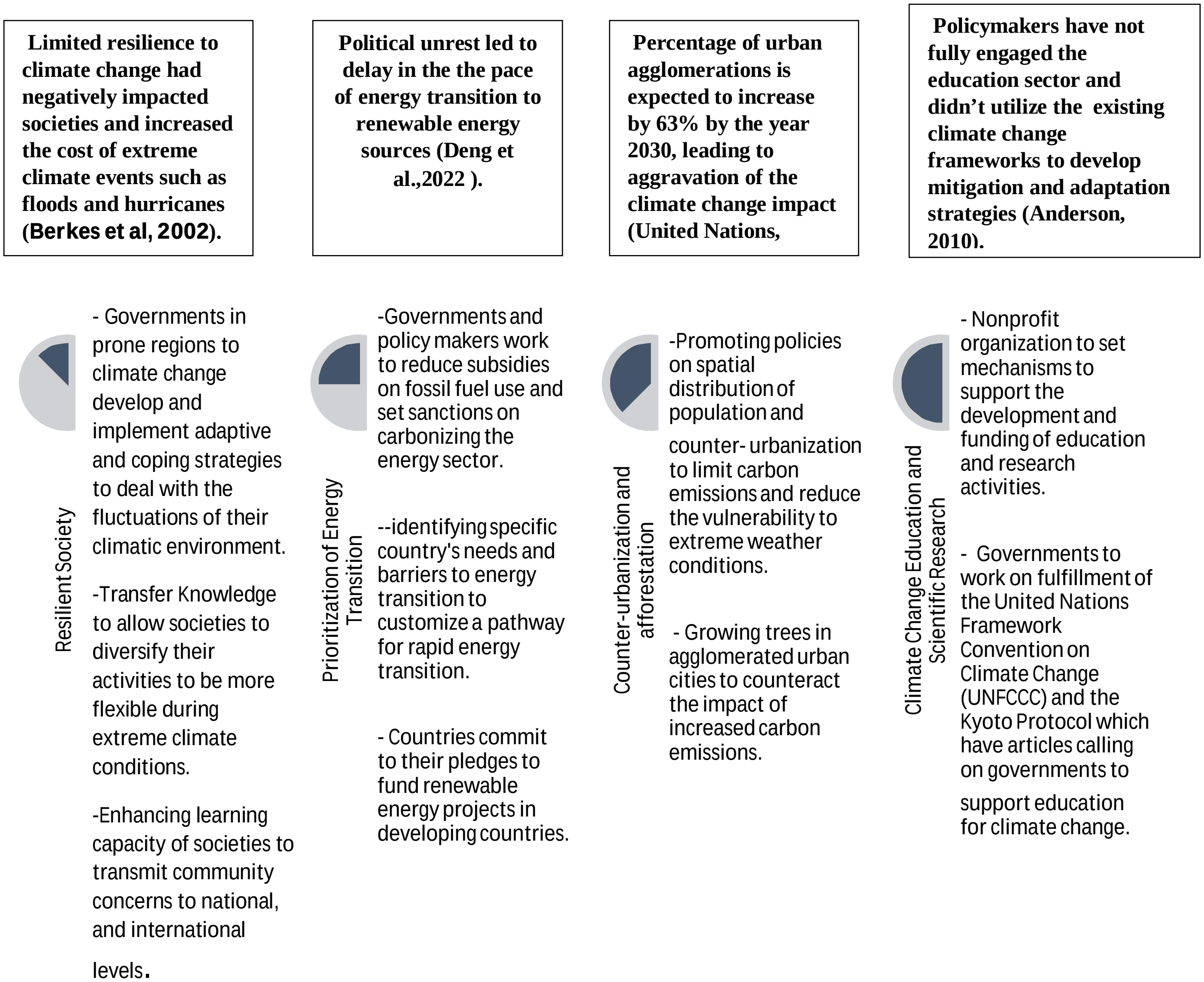

Figure 6: Mindset Transformation for Net-Zero Carbon framework.

3. The Case of Egypt

Due to its strategic location in the heart of the Arab region and North Africa, Egypt has one of the most strategic transportation routes, the Suez Canal and the Suez-Mediterranean pipeline (SUMED). Egypt is also the second most populous African country, with a population exceeding 100 million (Hussein & El Baz, 2019). As an essential player in the energy sector, it is crucial to analyze efforts made by the Egyptian government to reduce greenhouse gas emissions. This work will present the efforts done by the Egyptian government in the context of climate change as the host of COP27.

Reflecting on the proposed framework, the authors will identify the sub-pillars that Egypt has tackled in the last decade. A sub-pillar is considered satisfied qualitatively if a tangible action has been taken regarding this specific sub-pillar. Qualitative assessment has been adopted in this research since the contribution of Egypt to global emissions is considered to be one of the lowest, estimated at 0.6% of the global emissions (World Bank, 2022), and hence quantitative numbers will still be insignificant to achieve the global target of net-zero carbon, albeit the qualitative contribution still has its significance in presenting the willingness and the capacity of developing countries to contribute to the achievement of the global carbon targets.

It has been found that the Egyptian government had tackled three out of the four sub-pillars under technological solutions. Simultaneously, Egypt tackled two of the four sub-pillars under the mindset transformation. Figure 7 shows the sub-pillars tackled by the Egyptian government, highlighted in yellow, and evidence of satisfying each of the six sub-pillars is discussed below.

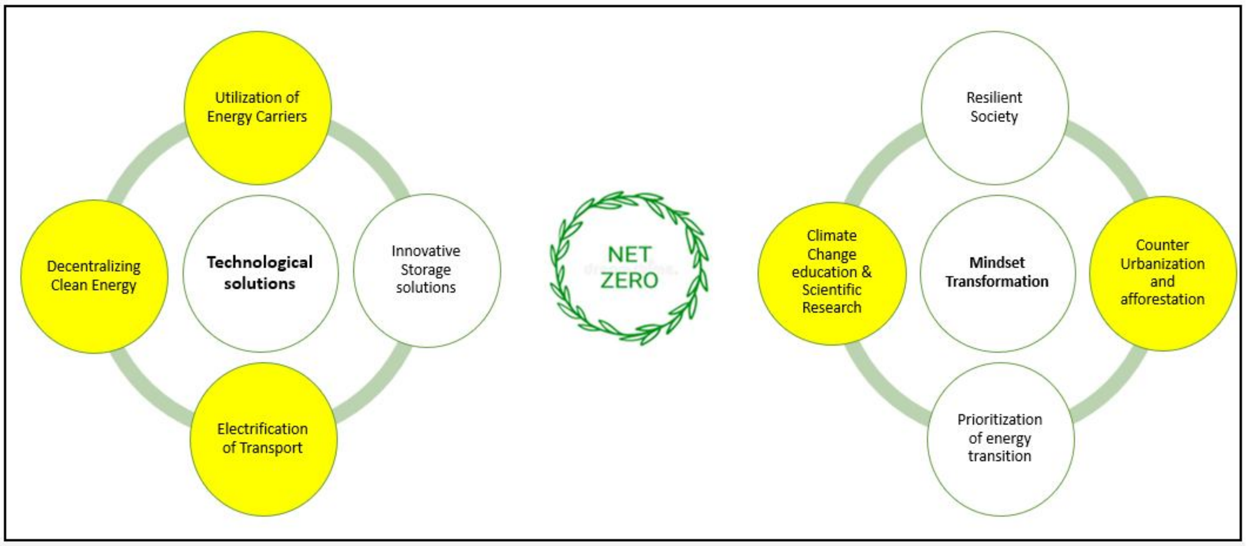

Figure 7: Egypt Climate Action Efforts VS The Proposed Framework

3.1. Utilization Of Energy Carriers

The Egyptian government also made plans to incorporate green hydrogen production. Egypt's pipeline for green hydrogen projects stands at 11.62 gigawatts (GW), equivalent to over 1.57 million tons of green hydrogen, ranking the country in the top three green hydrogen pipelines. Egypt's approach can be summarized in the following points (E&MC, 2022, H2-View,2022):

- The government of Egypt plans to release a $40-billion national hydrogen plan in the coming months.
- Establishing, operating, and managing hydrogen projects has been simplified, requiring a single permit.
- Unique custom points for export/import, utility connection costs being passed on to the state, and the reimbursement of 50% of land allocation costs.
- Several feasibility studies between Egyptian state entities and leading international ammonia and hydrogen market players for developing green ammonia and green hydrogen.

3.2. Decentralizing Clean Energy

To achieve its development goals, Egypt plans to build new power plants with a total electricity-generating capacity of 30 GW. Added to the current electricity-generating capacity of 60 GW, the country will have a power-generating capacity of approximately 90 GW of electricity by 2030. To address this responsibly, Egypt introduced the green scenario in the Energy transition. Under this scenario, Egypt will ramp up its production using other sources such as nuclear, hydro, wind, solar, and even green hydrogen. Figure 8 summarizes Egypt’s efforts in the field of energy generation; information was adopted from

(Earth Over Shoot Day, 2022, US international trade organization, 2022, United Nations, 2022, Shouman & Shouman, 2015, Alham et al, 2022, Salah et al, 2022, E&MC, 2022, H2-View, 2022).

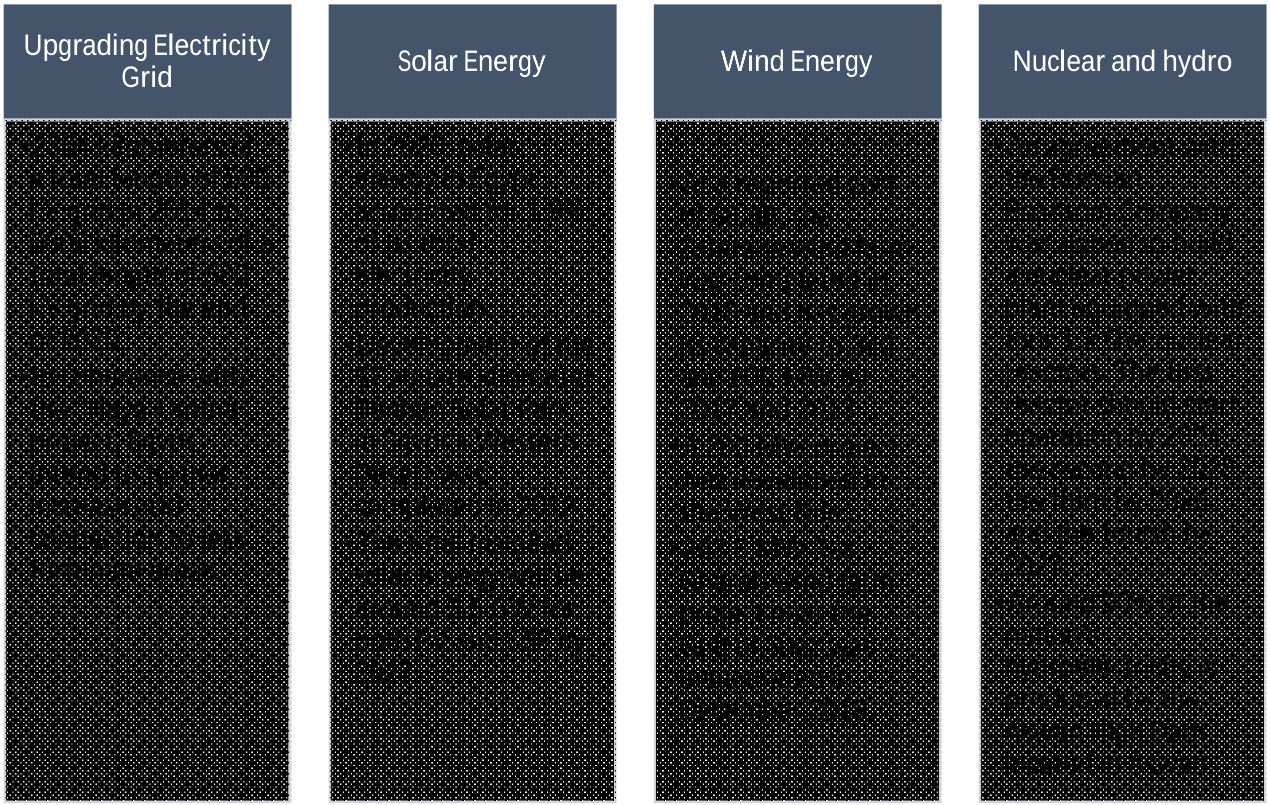

Figure 8: Egypt's Efforts in Energy Generation

3.3. Electrification of Transport

Nearly 52% of this sum is utilized at Cairo's energy stations. Substantial oil and gaseous petrol are the real energy sources utilized for control purposes in Cairo, representing 60% and 40%, respectively (Hegazy et al, 2017). The number of authorized vehicles in Egypt was 7.04 million, most of which are in Greater Cairo's capital. Around half of all vehicles in Egypt are autos, particularly 3.83 million. The number of vehicles consuming diesel fuel is 33%, as verified by the Central Agency for Public Mobilization and Statistics of Egypt, most of which are considered heavy-duty vehicles. According to a study done by Rania Roshdy Mousa (2022), taking a case study of a street with various sections, one heavy traffic, one medium traffic, and one low traffic, it was proven that traffic jam increase emissions. Figure 9 shows a summary of the actions made by the Egyptian government to advance the transportation sector; the information was adopted from (Hegazy, 2022, El-Garhy, 2021, Egyptian National Railways, 2022, Frangoul, 2022, Egypt Today, 2022, Makary, 2022, Orascom Construction, 2022, Ahram Online, 2022, Egypt Independent, 2022, Egypt Today, 2022, Emam 2022, Kadry, 2022)

Road Network

- In early 2020, the Ministry of Transport announced a budget of $9.8bn for road development.
- Egyptian government built an unprecedented 7000 Km of road network, almost double the roads built in the last 200 years combined.

High Speed Train

- Extending from Ain-Sokhna to New Alamein City, the train is said to cover 543 kilometers in its first phase at a speed of 250 kilometers. It will pass through the cities of the New Administrative Capital, the Sixth of October, Burj al-Arab, and Alexandria.

Cairo Monorail

- Connecting the New Administrative Capital far west and 6th of October City far east to Greater Cairo. It is expected to transport around 45,000 passengers an hour in each direction.

Light Rail Transit (LRT)

- Covering more than 100 kilometers with an investment of $ 227 million and is expected to accommodate 500,000 passengers daily.

Bus Rapid Transit (BRT)

- The Rapid Transit (BRT) system will run through the 106-kilometer highway. This electric bus is said to cover Cairo's longest internal road revolving around the entire city.

Transforming Cars and Buses

- Egypt aims to convert 400,000 vehicles to operate on natural gas within three years. Currently, 170,000 are transformed into natural gas with a budget of 1.2 billion Egyptian Pounds.
- The country aims to operate 70 electric buses in a deal worth LE323 million and increase the number of car charging stations.

Promoting Bikes

- New bikes project in collaboration with UN-Habitat was launched in 2022.
- 26 solar-powered bike stations are said to be distributed throughout Cairo, aiding in internal transportation within neighborhoods.

Figure 9: Egypt's Efforts in Transportation

3.4. Counter Urbanization and Afforestation

In 2019, Egypt launched the Go Green initiative, which addresses 36 environmental issues. The initiative aims to incentivize young generations to protect the environment by curbing air pollution to achieve its strategic goal of reducing air pollution caused by solid particles by 50 percent in 2030. The initiative currently has nearly planted more than 10000 trees to foster afforestation and increase the per capita share of green space (Egypt Today, 2022c)

3.5. Climate Change Education and Scientific Research

Recognizing the strong impact of education and research, the Ministry of Higher Education and Scientific Research (MHESR) of Egypt, The Academy of Scientific Research and Technology (ASRT), Egyptian universities together with international collaboration has set strategic objectives and policies aiming at redirecting research, development and innovation (RDI) projects toward supporting Egypt's efforts in adaptation, confrontation and coexistence of climate changes. This strategy showed major results that can be summarized in the following:

- Pilot plants facilities in renewable energy in the region, such as the MATS station for concentrated solar power and water desalination in Borg El Arab.
- China-Egypt Joint Lab for PV in Sohag.
- National projects in the conservation of plant genetic resources (Encyclopedia of Wild Plants), reintegration of Mangrove Forest in the red sea, gene bank unit, and smart and green experimental integrated Agricultural Farm in Matrouh governorate.
- The Egyptian science, technology, and innovation community published in the last five years more than 6722 international publications with more than 51,759 citations and an average Field-weighted Citation Impact 1.1.

4. Conclusion and Recommendation

This work presented a comprehensive review of the current world status showcasing global agreements, current technologies, and challenges facing the transition to net zero carbon was highlighted. Main polluting sources such as electricity production and transportation were identified, and a solution to that was put in place later in the suggested framework. Additionally, actions required to transform the mindset of nations to act in line with the global direction of curbing the carbon footprint were presented and discussed in the proposed framework. It is worth highlighting that both pillars, technological solutions, and mindset transformation, must move parrel to reap the fruit of the available technology and the intention to transform.

It is the responsibility of policymakers to take this framework forward into action and set policies to which governments commit to curbing global emissions. It is also the responsibility of every global citizen to be self-conscious of their actions, taking decisions out of their comfort zone to save the planet. Adopting new technologies and working on mindset transformation is critical for global sustainability. The model of Egypt has been taken as an example; however, the framework can be applied to all other countries, both developing and developed ones, to assess the current gaps and to customize ways for bridging the existing gaps in each country. The world is going towards a serious disaster with the rise in global temperatures and action must be taken before an irreversible damage takes place.

All the recommended actions will need legalizations to be enforced; this will intensely depend on the case of each country. For more polluting countries, more rigorous measures might be needed. Ideally, all countries should adopt as many of these actions as possible as they will aid in economic growth without side effects. A synergistic impact will be materialized if all community members, as government, policymakers, nations, and scholars, work together to implement the recommended actions below. The followings are the main takeaways and suggested activities to head towards a net zero-carbon future

Building Resilience

- Promoting the concept of adaptation, emphasizing its importance to local communities.
- Awareness campaigns on the impact of individual actions on society, linking it to climate change.
- Issuing laws easing the means of a self-sufficient household in the context of the energy, food, and water nexus.

Prioritizing Energy transition

- Media campaigns convey the message that there is no way back to conventional energy sources.
- Constitutional clause stating that climate change is a part of national security.
- Protecting climate change clause from being changed or removed in the future.

Promoting counter-urbanization and afforestation

- Providing tax incentives to promote the motion from large agglomerated cities to rural areas.
- Providing subsidized seedlings for the general public and laws encouraging corporates to afforest their surrounding.
- Issuance of an abiding decision fostered by the UN and security council forcing nations to contribute to the afforestation of the amazon basin. Each country's contribution shall depend on its contribution to climate change and its economic state.

Fostering Scientific Research and education for climate change

- Creating Local research centers for energy, food, and water nexus shedding light on local needs and resources.
- Encouraging the link between research and industry via issuing incentives for corporates who try new solutions, such as tax relief.
- Adapting high school and undergraduate curricula to reflect the dynamic state of climate change through the inclusion of project- based learning.

Promoting decentralized Generation

- Improving feed-in tariff quota as an incentive for the household.
- Using renewable energy sources as the main drive for streetlights.
- Allowing for on-grid small-scale wind turbines as it offers higher overall energy yield due to a higher capacity ratio.

Adopting Smart Microgrids

- Creating a digital twin of the grid with the estimated renewable energy sources installed offers the possibility to predict output energy and maintenance required beforehand.
- Integrating artificial intelligence and machine learning into the digital twin to predict results.
- Establishing new, advanced, and data-driven control centers.

Energy Carriers and Storage

- Creation and abiding by national strategies for green hydrogen
- Releasing subsidies from fossil fuels while applying them for green hydrogen instead
- Refurbishing the national natural gas network to incorporate the transportation of hydrogen.
- Issuing laws in support of startups working on new innovative energy storage systems and adopting them on a national level
- Intensifying available renewable energy resource evaluation for each region.
- Creating a hydrogen resource atlas for each region.

Electrification of Transport

- impose a tax incentive scheme for electric cars and spread electric charging stations.
- Building a nationwide electricity-based transportation system with a subsidized price, an excellent example is Germany's 9-euro ticket.
- Planning new cities to be more bike and walking-friendly.

Figure 10: Net Zero Recommendations

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