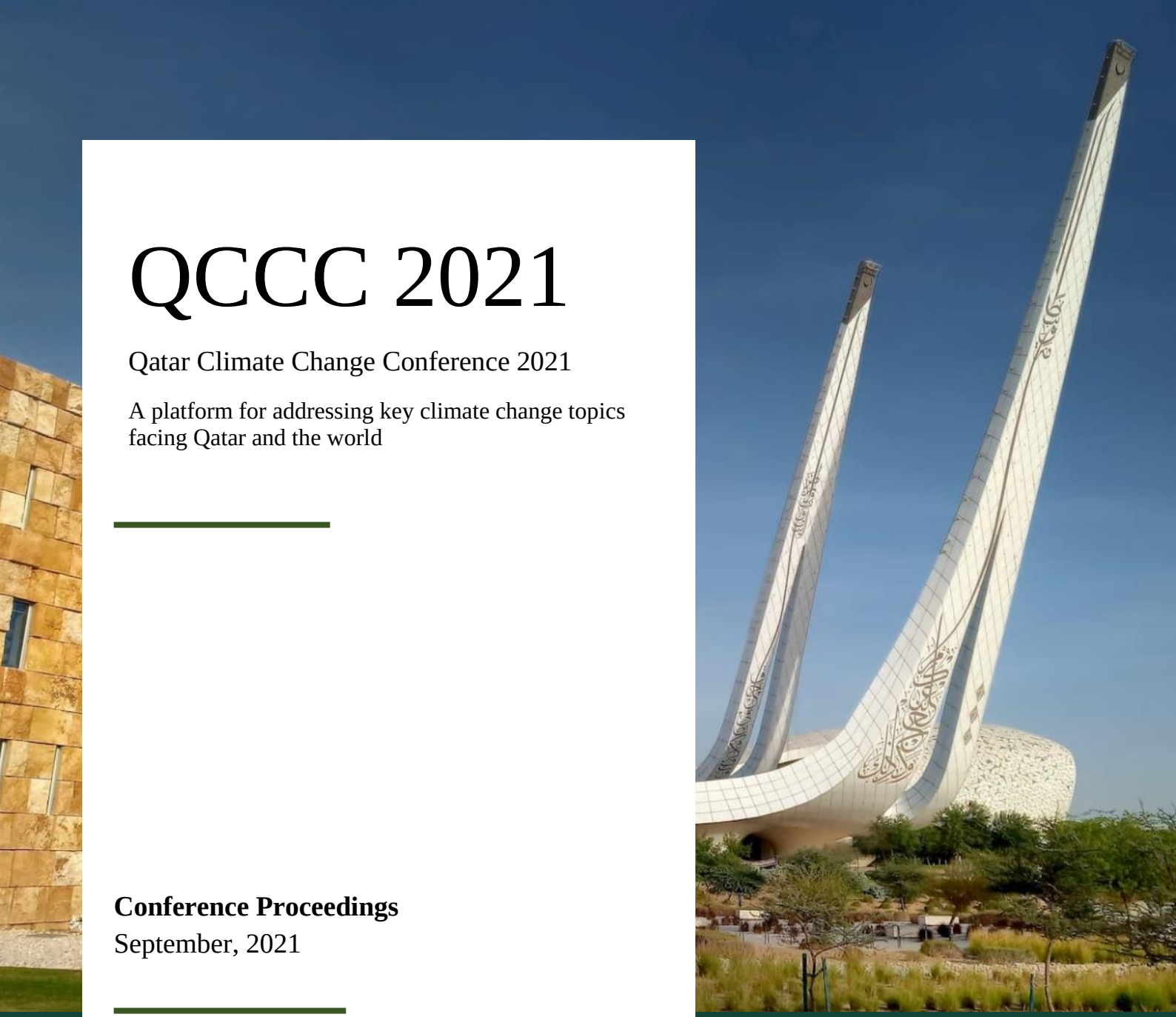

QCCC 2021

Qatar Climate Change Conference 2021

A platform for addressing key climate change topics facing Qatar and the world

Conference Proceedings

September, 2021

Edited by:
Dr. Sami G. Al-Ghamdi
Dr. Soud K. Al-Thani

The Abdullah Bin Hamad Al-Attiyah International Foundation for Energy & Sustainable Development

Strategic Partner

QATAR FUND FOR DEVELOPMENT
صندوق قطر للتنمية

Publishing Partner

مؤسسة قطر
Qatar Foundation
لإطلاق قدرات الإنسان
Unlocking human potential

Hamad Bin Khalifa Bin Khalifa University Press
P. O. Box. 5825
Doha, Qatar

Furqan Tahir[1], Salah Basem Ajjur[1], Mohammad Zaher Serdar[1], Mohammed Al-Humaiqani[1], Doyoon Kim[2], Soud K. Al-Thani[2] & Sami G. Al-Ghamdi[1]

[1] Division of Sustainable Development, College of Science and Engineering, Hamad Bin Khalifa University, Qatar Foundation. Doha, Qatar
[2] Sustainability Directorate, Qatar Foundation. Doha, Qatar

The online version of this book can be found at:
https://www.qscience.com/content/books

DOI: https://doi.org/10.5339/conf_proceed_qccc2021

This document can be cited as:

Tahir F., Ajjur S.B., Serdar M.Z., Al-Humaiqani M., Kim D., Al-Thani S.K., Al-Ghamdi S.G. (2021) Proceedings of the Qatar Climate Change Conference (QCCC) 2021: A platform for addressing key climate change topics facing Qatar and the world. Doha, Qatar. DOI: https://doi.org/10.5339/conf_proceed_qccc2021

Abstract

Extreme heatwaves and rising wet-bulb temperatures would damage the human habitability of vital urban centers in the Middle East by the end of the 21st century, according to several published research documents, particularly in some regions in the Gulf Cooperation Council (GCC) countries. This may result in widespread social and economic disruptions and challenges driven by climatic change impacts in the rapidly growing urban areas of the Middle East. Middle East countries expect to face the major impacts of global warming due to the vulnerability of critical urban systems and infrastructure, and they are in necessity of developing climate change adaptation strategies to establish more robust urban centers resilient to climate change-driven events. Social and economic stability can be preserved by effectively preparing for the impending risks provided by climate change, allowing growth in a changing environment.

The Qatar Climate Change Conference (QCCC), 2021, addressed key climate change topics of national importance to Qatar, bringing together high-level representatives from the public and private sectors. Understanding that climate change is the most pressing challenge facing the world today, the conference supports Qatar's ongoing contributions to global conversations around environmental policy and action.

Hosted in the Education City on the 13th of September 2021, the conference was organized by Qatar Foundation with support from Abdullah bin Hamad Al-Attiyah International Foundation for Energy & Sustainable Development (Strategic Partner) and ExxonMobil (Gold Sponsor). The conference was held at a critical time, opening broad discussions about how Qatar can cope with global climate challenges and thrive sustainable development without impeding Qatar's hydrocarbon-based industries and economic prosperity ahead of the United Nations Climate Change Conference of Parties (COP 26) in Glasgow in November 2021.

Keywords: *Climate Change; Mitigation; Adaptation; Climate Action & Policy; Carbon Market & Pricing.*

Abbreviations

COP	Conference of the Parties (United Nations Climate Change Conference)
EU	European Union
GCC	Gulf Cooperation Council
GHG	Greenhouse Gas
HBKU	Hamad Bin Khalifa University
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquefied Natural Gas
MSEs	Mega Sports Events
NDCs	Nationally Determined Contribution (National Climate Plans)
PA	Paris Agreement
QFZA	Qatar Free Zone Authority
QP	Qatar Petroleum
QA	Qatar Airways
SDGs	Sustainable Development Goals
UN	United Nations

Table of Contents

1. Introduction & Background

The use of fossil fuels accounts for leading anthropogenic greenhouse gas (GHG) emissions. It is estimated that fossil fuel combustion releases 30 billion tons of CO_2 every year [1]. Limiting GHG emissions is the primary challenge in the fight against climate change. Energy efficiency and conservation, carbon tax and carbon trade, low-carbon technologies such as renewables [2], and other measures aimed at reducing the demand for fossil fuels have been promoted by national policymakers and international accords for decades. The Paris Agreement's (PA) objective is to keep the rise in average global temperature well below 2 °C above pre-industrial levels, with a preference for below 1.5 °C [3]. Thus, an increasing amount of research focuses on the confluence of climate policy and fossil fuel development [4]. Furthermore, putting a price on carbon has the potential to help achieve this goal [5].

The Gulf Cooperation Council (GCC) consists of countries that are among the world's top oil and gas producers. Around 40% and 23% of the global oil and gas reserves are found in this region; respectively. More specifically, Qatar is one of the largest natural gas suppliers in the world. Global warming will significantly impact Qatar and the GCC countries regarding the environment, economy, and possibly even politics and security. When combined with increasing population, climate change will exacerbate water and food shortages and could create new social and economic difficulties by negatively impacting human health, economic development, and the environment. Qatar and other GCC countries are economically vulnerable to global climate actions to reduce greenhouse gas emissions due to their heavy economic dependence on oil and gas industries [6].

Cities established in coastal or riverside areas are highly vulnerable and sensitive to climate change impacts, posing significant threats to urban infrastructure, citizens' lives, and the overall metropolitan system [7]. Most of Qatar's border is surrounded by the sea, and more than 90% of the population resides in Doha, the capital city situated on the central-eastern coast. Furthermore, the hot and humid climate of the region makes the country vulnerable to climate change impacts. Recurring heatwaves and harsh weather conditions will necessitate more infrastructure maintenance and cause disruptions in operational factors, such as a reduction in viable working hours due to higher temperatures and humidity levels.

In Qatar, the cooling load is the dominant energy demand in buildings, and hence more energy would be needed to keep inhabitants comfortable indoors because of global warming. Qatar's water needs are primarily met by seawater desalination, and with the rising temperature and seawater salinity, the required

energy to desalinate seawater will also increase. Climate change may indirectly impact human well-being by the global temperature rise such as undernutrition and malnutrition because of food scarcity, risk of bacterial infections due to food and water contamination, and spread of vector-borne diseases.

While dealing with climate change and lowering GHG emissions are challenging for Qatar and the GCC, they provide an opportunity to diversify Qatar's economics and lead the transition to cleaner technologies (renewables, hydrogen, and carbon capture, etc.) [8]. Nevertheless, vital research gaps remain in this field, such as lack of scientific awareness of the processes of the urban sector in climate change mitigation, lack of understanding of the intersection between climate change mitigation and sustainable development, absence of the carbon market and trading, and insufficient climate change mitigation strategies and local actions. For this purpose, Qatar Foundation organized the Qatar Climate Change Conference, 2021 (Doha, Qatar). The conference aimed to address key climate change topics of national importance to Qatar, bringing together high-level representatives from the public and private sectors.

Experts from Qatar and across the world called for immediate actions to protect the planet. To meet the objectives of the Paris Agreement in 2030 – and to achieve net-zero carbon emissions by 2050 – nations must continue to educate people while investing in innovation and technologies to drive solutions. The one-day conference hosted industry leaders and stakeholders worldwide in an endeavor to discuss how to pursue economic development alongside achieving sustainability goals.

In a keynote speech, His Excellency Abdullah bin Hamad Al-Attiyah praised the timeliness of the conference:

"This event is happening at a time when nations and major stakeholders are preparing for the upcoming United Nations climate change conference COP26 in Glasgow," he said. "Expectations are very high. Global leaders are expected to reaffirm their net-zero ambitions and provide an updated road map on how they intend to reach this target."

The conference was comprised of three sessions: (1) Qatar national climate action and policy, (2) Climate change mitigation and adaptation in Qatar, and (3) Carbon market and pricing. Individuals from governmental, industrial, academic, and international stakeholders participated in the discussions (Figure 1). The details of entities presented at the conference are shown in Figure 2.

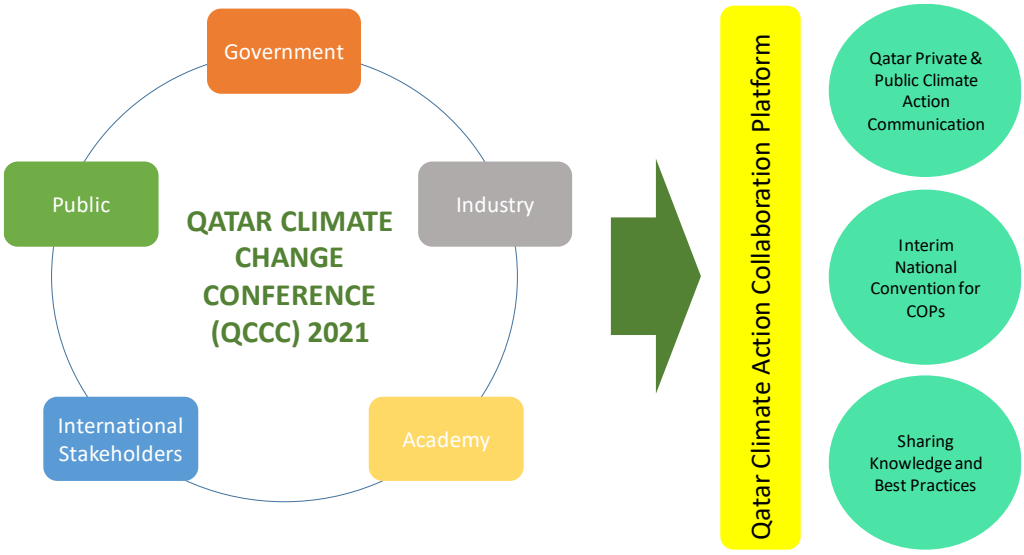

Figure 1. *Qatar climate action collaboration platform*

Figure 2. *Entities participation in Qatar Climate Change Conference, 2021*

2. Qatar National Climate Action & Policy

The first session began with an overarching discussion of Qatar's intended policies, plans, and actions for climate change, with perspectives from national and international leaders. The session gathered insights from policymakers and advisors, helping inform Qatar's future climate change strategies.

Speakers:

H.E. Abdullah bin Hamad Al Attiyah	Chairman, Al Attiyah International Foundation for Energy & Sustainable Development
H.E. Dr. Abdullah bin Abdulaziz Al-Subaie	Minister of Municipality and Environment
H.E. Akbar Al Baker	Group CEO of Qatar Airways and Secretary-General of Qatar Tourism
Mr. Omran Al-Kuwari	CEO, Qatar Foundation International
Mr. Dominic Genetti	President, ExxonMobil Qatar
H.E. Hyoeun Kim	Ambassador of Climate Change, MoFA, Republic of Korea
Mr. Borge Brende	President, World Economic Forum

2.1. Key Topics Discussed

- Qatar National GHG Inventory Updates.
- Qatar National Mitigation Actions & NDCs.
- Qatar's Global Climate Change Leadership and Participation.
- Qatar's Roles and Responsibilities in Global Climate Change.
- Coalitions and Dialogues.
- The Private sector's contribution to climate change.

2.2. Summary of Discussion

In recent months and years, extreme weather events, including heatwaves in North America, flooding in China and central Europe, and wildfires in Australia and California, have affected the lives of millions of people. Many scientists view these events as a warning that we must act now and lower our carbon emissions as pledged in the Paris Agreement. Qatar has affirmed its commitment to fulfilling its pledge through the National Climate Change Plan (NDC) approved by the cabinet recently [9]. The conference discussed the efforts and contributions of various stakeholders in Qatar to align with the announced NDC and the preparation for COP26.

The COVID-19 pandemic has caused widespread disruption, including a decline in economic activities and a subsequent albeit temporary decrease in

carbon emissions. The recovery has created an opportunity to direct post-pandemic investments as a tool for sustainable and green economy transition. Using the COVID-19 catastrophe as a catalyst for developing policies can strengthen societies and limit the impact of climate change. There is a need to show leadership and mobilize resources to demonstrate climate solidarity to meet the outcome expectations of the 2021 United Nations Climate Change Conference (COP26) that was held in Glasgow in November 2021.

Climate change is happening faster than ever predicted, threatening the environment, human health, and the global economy. 65% of these emissions come from energy consumption [1]. The concentration of GHG continues to rise as the world economy grows, driven by the increase in living standards in developing countries, increasing the consumption of a wide range of energy sources. There is an urgent need to accelerate the transition to cleaner energy through joint efforts, including public support, governments, and the private sector, in the bid to fulfill Paris Agreement (PA) pledges [10]. Countries representing 70% of the world economy have pledged to reach net-zero emissions by 2050, including many major and emerging economies. Similarly, large corporations, including major oil and gas companies, have committed to the same target. Meeting such pledges requires the development and implementation of new technologies and greener sources of energy.

As the largest supplier of Liquefied Natural Gas (LNG), Qatar has a major potential to contribute to the global fight against climate change. LNG produces 50% fewer emissions than coal and is considered to be the cleanest fossil fuel that may prevent the disturbance resulting from the sudden transition from coal to renewable. Hence Qatar has a huge role in contributing to cleaner energy and can help many nations to cut their emissions. It is a chance for world leaders to reaffirm their countries' commitments, share their approaches to achieve net-zero, and provide an updated road map regarding their progress.

Climate change is the most pressing challenge of our time and can only be addressed with a shared vision, bold ideas, and strong leadership. Qatar is already taking tangible actions to mitigate climate change risks and develop adaptation strategies; such strategies engage with all stakeholders, including the government, private sector, society, and research institutes. Qatar's Climate change policy is built on three pillars:

1. Balancing economic growth and climate protection:

Building a diverse and stable economy with inherent resilience to sustain all potential future disturbances is an essential part of Qatar National Vision 2030 (QNV2030). At the same time, QNV2030 identifies environmental protection and development as important pillars. Qatar aims to strike this balance between

economic diversification and environment protection, investing in innovative technologies and sustainable practices to minimize emissions such as CO_2 sequestrations, renewable energy, green buildings, smart networks and infrastructures, recycling, smart agriculture, circular local economy, resources efficiency. Furthermore, to meet its environmental and economic goals, Qatar supports "home-grown" research and development to generate knowledge, including new concepts and technologies to address climate change issues.

2. Establishing policies and regulations to accelerate the green transition:

Qatar aims to foster market development and build capacity in the public and private sectors by introducing new regulations and standards. This provides the foundation for climate change actions within a clear framework that considers the interaction between businesses and people, encourages conventional, non-conventional, and eco-friendly initiatives, and raises awareness.

3. Engage and enable stakeholders to achieve the shared vision of our future:

This has two levels, domestic and international:

- Domestically, actions should be taken as a joint enterprise between government, businesses, and the public, as any law or action is ineffective without society's sense of ownership and partnership. Climate actions require awareness and behavioral change, mainly implemented through education; education is the main tool to create a sustainable society mindset. To this end, Qatar will continue to invest in integrating environmental studies and climate change programs into curriculums, and training to equip its population with knowledge and skills to ensure a sustainable and greener future.
- As climate change is a global challenge, it is crucial to be addressed as a shared vision to build a sustainable world; one country's efforts will not be sufficient to meet our challenges. A global problem needs a global response; Qatar coordinates its efforts with the wider international community and actively engages in global discussions, initiatives, and treaties, including UNFCC, Kyoto Protocol, and Paris Agreement. Additionally, in the NDC, Qatar has affirmed its commitment and efforts for international mutual exchange of knowledge and solutions.

Due to Qatar's high volume of natural gas production compared to the size of the country, Qatar's per capita emissions have been ranked on the top in the world. Qatar is working hard to lower the emissions in its energy industry to reduce the domestic GHG emissions as well as the global GHG emissions by providing economically viable and less carbon-intensive energy before the global transition to a net-zero economy, as follows:

1- Qatar, through its massive LNG production, is enabling many countries to use a cleaner source of energy (Natural gas has 50% less emission compared to coal),
2- Qatar has an excellent record for reducing emissions from Oil and Natural Gas operations. For example: since 2014, Qatar has been reclaiming LNG boil-off Gas, typically flared in other countries thus, significantly reducing the emissions,
3- Qatar is investing a lot to minimize and end flaring,
4- Qatar is a leader in Carbon Capture and Storage through its state-of-the-art facility and continuous investment in the research and development of such a promising technology,
5- Qatar Energy (QE), in a bid to prove its transparency, has released a full sustainability report.

The aviation industry can play a vital role in sustainable growth and environmental protection. For example, Qatar Airways (QA) is committed to sustainability and global climate change actions with a clear set of strategies and goals to decarbonize the aviation industry. QA strategies to this end include:

1- Operates the youngest fleet of its size in the world with an average age of fewer than six years,
2- Uses fuel that generates low emissions,
3- Supports 70 fuel optimization research programs,
4- First airways in the Middle East to achieve the highest level of certification of IATA's environmental assessment,
5- Aims to reach carbon neutrality by 2050.

The aviation industry is wrongly labeled by many as the biggest polluter. The COVID-19 pandemic has exposed part of the reality regarding the role of aviation and how it is a better option than sea freight, which is the biggest polluter [11]. The aviation industry is pushing for collaboration with many stakeholders to reduce its emissions and create sustainable aviation. These stakeholders include aircraft manufacturers, engine designers, and oil companies. The goal of carbon neutrality can only be achieved through the teamwork of all stakeholders and investment in research and development of the needed solutions.

Experience exchange between different nations can facilitate dialogues on how to address the impacts of climate change. There are many similarities between the Qatari and South Korean economies. Both heavily rely on a carbon-emitting source of income; Qatar is a major LNG provider, while Korea is a global manufacturing hub. The Korean manufacturing industry constitutes more than 27% of its GDP; petrochemicals, semiconductors, and automobiles represent a huge part of the Korean industrial complex and are all carbon-intensive. The dilemmas that the South Korean government must resolve are similar to the

conundrums facing Qatari ministries; how can carbon emissions be reduced without having a negative impact on the economy? How can economic growth be attained without contravening environmental protection measures?

Three elements contribute to such aim:

1. Long term vision,
2. Ambitious mid-term target,
3. Effective implementation mechanisms.

Considering these axes and the IPCC recommendations, in 2020, Korea announced a net-zero target by 2050, despite the challenges created by the COVID-19 pandemic. This target is based on the vision that considers three scenarios as options to reach that goal. By setting this target, the government of South Korea aimed to send a clear signal to the private sector and society that this is the direction for the industries to move forward, and there will be no return to previous methods. The mid-term goal focuses on the ambitious and hard alternative choices to achieve 2030 target as a stepping stone for the 2050 goal. This target is developed with the involvement of all stakeholders, including the government, private sector, civil society, and the public.

To affirm Korea's commitment towards its environmental obligations and the net-zero 2050 goal, the Korean parliament in August 2021 has passed a law that creates a framework act on carbon neutrality and green growth. This framework provides the legal basis for all sectors and stakeholders to contribute and effectively implement strong climate actions; thus, it is clear that the green transition is a major challenge, but the government should give the green signal to encourage and direct other stakeholder efforts, as there is no other option or plan B. Examples of such actions are the engagement of youth representatives at the highest levels of decision-making regarding the environment and integrating environmental education into the curriculum from as early stage as kindergarten.

The investment in renewables could be an excellent approach for sustainable economic growth. Still, the investment should focus more on technology development as the main enabler for wide-scale implementation and adoption of this solution. Over the past ten years, technological breakthroughs reduced the cost of solar energy to 1/10 of its price, and similarly, wind energy cost dropped to one-seventh [12]. These exciting numbers highlight the importance of investing more in research and development to reach carbon neutrality by 2050.

However, the energy challenge can be described as a triangle representing three main questions:

1. Access:
    - We should remember that more than 700 million people on our planet do not have access to basic electricity, representing enormous energy shortage challenge and causing low economic effectiveness. Hence, we need to achieve higher level of economic growth to support the world's population. However, we need to find ways to decouple it from CO_2 emissions.
2. Security:
    - Energy is still the engine of growth in the global economy; this was clearly experienced during the COVID-19 pandemic, so we need to reinforce the supply chains and maintain security and predictability for access to energy.
3. Mitigation:
    - We need to start by changing the mentality from relying on fossil fuel to a renewable and technology-oriented society. This transition is a challenging process, and the availability of LNG, produced by Qatar, can facilitate this process as it reduces the emissions from coal by 50%. The LNG prevents the disturbance resulting from the sudden transition from coal to renewables, providing a reliable energy source with far fewer emissions that can be offset with much lower investments. Additionally, the development and implementation of carbon capture and storage technologies would create a suitable factor that contributes to the role of LNG in substantially decreasing the emissions; Qatar's investments in these technologies are a clear sign of its leadership and commitment towards combating climate change.

To reach the emissions neutrality goal by 2050, we need to implement policies that incentivize and promote entrepreneurship to motivate creativity and facilitate the application of research outputs. Investing in education and increasing the support for research institutes are vital contributors to achieving all the sustainable development goals and carbon neutrality.

Estimates suggest that more than 50% of the emissions we aim to cut are linked to consumer choices on a global average. However, these choices are different from one country to another and change during each stage of development. We can observe that higher emissions are associated with high living standards in high-income countries, resulting from higher meat consumption and a high level of private cars ownership. Technological advancement can solve or reduce the emissions arising due to these habits, however, reaching carbon neutrality requires serious behavioral changes.

Another important factor is learning from our history and culture. The Middle East has a challenging environment, and our ancestors survived and thrived despite all the harsh conditions. We need to revisit their approaches and reflect

on their techniques to learn and mix them with the available technologies extracting the better of two eras. In this regard, Qatar Foundation is conducting the world's largest and first downtown regeneration project in Doha, Msheireb district, aiming to redevelop the traditional markets and preserve the historical context while making it more energy-efficient and less waste producer. Msheireb development project adheres to strict sustainability requirements to meet LEED gold rating, with several buildings achieving a platinum rating. This project sets an example for modern sustainable architecture inspired by Qatari history and culture and presents Qatar Foundation's leadership in promoting sustainable and green developments.

In line with the National Plan for Climate Change, several initiatives are suggested:

1- Produce and control our natural and financial resources responsibly,
2- Motivate innovation and entrepreneurship to address the most challenging climate change impacts,
3- Complete the transition from a resource-depending economy to low carbon knowledge-based economy,
4- Support research universities and research centers, especially focusing on sustainability challenges, Like Hamad Bin Khalifa University and Qatar Energy and Environment Research institutes.

Qatar's main contribution to the global efforts to reduce CO_2 emissions can be by expanding its LNG capacity from 77 MTA to 126 MTA within the next six years. This might seem counterintuitive, but it would allow many countries to reduce their emissions proportionately. Climate change is a generational issue, one that will require decades to solve; thus, the effort of behavioral change should focus on three pillars:

1. National plan:
    - A national plan that clearly defines the target and approaches based on the country's conditions and challenges ensures continuous economic growth while addressing the environmental challenge. The Qatari national climate change plan is an excellent example of such an effort.
2. Social responsibility of companies:
    - Companies should contribute and invest in raising awareness in the community through outreach initiatives, energy labs, and school tours. Such practices equip future generations with a toolkit mentally to deal responsibly with the environment and address the climate change challenge.
3. Technology:
    - Technological solutions and research and development efforts are the primary enablers of the clean energy transition.

Furthermore, the development of technological alternatives could stimulate the behavioral change towards more environment-friendly options, like electric vehicles and lab-grown meat.

3. Climate Change Mitigation & Adaptation in Qatar

This session was being led by the leading state and non-state climate change actors in Qatar, discussing ongoing plans, initiatives, and research insights related to monitoring, reducing, and offsetting greenhouse gas emissions to mitigate climate change.

Speakers:

HE Dr. Mohammed S. Al Sada	Former Minister of Energy and Industry, State of Qatar
Mr. Abdullah-Al-Misnad	Deputy CEO and Chief of Sector Development, Qatar Free Zones Authority
Dr. Soud Al-Thani	Sustainability Director, Qatar Foundation
Mr. Andrei Marcu	Executive Director, European Roundtable on Climate Change and Sustainable Transition
Mr. James Grabert	Director, UNFCCC
Dr. Sami G. Al-Ghamdi	Associate Professor of Sustainable Development, College of Science and Engineering, Hamad Bin Khalifa University (HBKU)

3.1. Key Topics Discussed

- Non-state actors' climate change mitigation actions.
- Emissions reduction actions from the industries.
- Qatar climate change risk and impact assessment.
- Climate-resilient urban development in Qatar.
- Climate adaptive infrastructure plan in Qatar.
- Climate change public awareness and training in Qatar.
- Climate Change Research Presentation by Massachusetts Institute of Technology (MIT), Hamad Bin Khalifa University (HBKU), and Weill Cornell Medicine - Qatar (WCM-Q).

3.2. Summary of Discussion

Climate change impact is rapidly being exacerbated on humans and ecosystems. Therefore, there is growing urgency on climate change actions for mitigation and adaptation. According to the Intergovernmental Panel on Climate Change (IPCC) [1], the effective implementation of climate change adaptation and mitigation depends heavily on policies and cooperation by all parties. The successful performance can be achieved through integrated responses that link

mitigation and adaptation with other socioeconomic objectives. The second session in the Qatar Climate Change Conference 2021, titled Climate Change Adaptation & Mitigation in Qatar, aimed to share insights from leading climate change actors about this topic, i.e., climate change mitigation and adaptation measures and plans.

A pool of local and international scientists and experts in the climate change arena were invited to share insights on Qatar's primary practices and measures on climate change mitigation and adaptation actions. (See Figure 1). In-person participants in this session included H. E. Dr. Mohammed S. Al-Sada, Former Minister of Energy and Industry in Qatar; Mr. Abdullah Al-Misnad, Deputy CEO in Qatar Free Zones Authority; Dr. Soud K. Al-Thani, Sustainability Director at Qatar Foundation (QF); and Dr. Sami G. Al-Ghamdi, Professor at the College of Science and Engineering, Hamad Bin Khalifa University (HBKU). Two other panelists who participated online are Andrei Marcu, Executive Director at European Roundtable on Climate Change and Sustainable Transition (ERCST), and James Grabert, Director of Mitigation at the United Nations Framework Convention on Climate Change (UNFCCC).

Figure 3. *Panelists during the second session of the Qatar Climate Change Conference 2021* [13]

The session discussed the ongoing plans, initiatives, and research insights related to monitoring, reducing, and offsetting greenhouse gas emissions (GHG) to mitigate climate change impact. It also shared implementations and strategies from leading organizations in Qatar to climate change adaptation and mitigation. More specifically, six key topics were discussed. These topics are non-state actors' climate change mitigation actions, necessary actions for the industries to reduce GHG emissions, quantifying climate change risk and

impact; Qatar urban development resiliency under climate change impact; infrastructure adaptation against climatic changes; and raising awareness among locals regarding climate change topics. The session started with three speeches from in-person panelists, followed by a discussion with in-person and online panelists. The session concluded with a presentation about the ongoing research by HBKU on climate change topics.

Combating climate change is a serious challenge bound to be acted upon globally. The wait and see option does not exist anymore. Despite pledges and efforts by world organizations, these efforts are not enough. For instance:

- CO_2 emissions have increased by 60% since the UN Climate Change Convention was signed in 1992.
- The impact of climate change has manifested itself in various ways. For instance, extreme heat events are reported to occur nearly five times as they did historically. The same trend goes for fire, weather, droughts, heavy storms, and flooding.

Successful climate change plans and policies could be achieved only if these measures have been taken into account in the context of:

- Comprehensive Sustainable Development Goals and Strategies,
- Considering the genuine long-term effects on the environment,
- Social and economic costs for communities in combating climate change.

The strength of developed infrastructures and its institutions' world-class academic and research capacities are examples of why we are gathered here today. The question that has to be raised for climate change adaptation and mitigation in Qatar is "How can integrated approaches be developed to build on co-benefits and manage trade-offs. What are the views and suggestions on how Qatar can develop integrated climate change adaptation and mitigation models and responses?". This question should consider the various climate actors in Qatar and the roles they may play in the governance of climate change adaptation and mitigation.

The state of Qatar has stepped up important efforts in the fight against climate change, as the cabinet lately sanctioned an ambitious National Climate Change Plan prepared by almost 50 different property entities. The plan contains 35 mitigation and more than 300 adaptation initiatives, which hugely catalyze and hasten economic diversification. Qatar has implemented CO_2 capture and storage as well as controlling the possible fugitive methane. In addition, Qatar has the potential for hydrogen energy production with enormous natural gas reserves and operational experience.

From the adaptation perspective, when decision-makers in Qatar sit down with communications and marketing teams, the Qatar Free Zone Authority (QFZA) often hears questions about how the free zones respond to climate change adaptation. Qatar has heavily invested in green buildings, which are important to adapt and mitigate the climate change impact. Qatar also has sustainable water and some allowance for rooftop solar panels. All these remarks are very significant. Qatar often talks about the implications and risks of climate change, and it requires significant efforts and investments from everyone. However, it is necessary to think about turning the climate change transition risks into opportunities in Qatar. There have been discussions already on creating great opportunities in finance, health, and industry.

Another important question is "*How will Qatar be able to generate opportunities from the climate change transition risks successfully?*". Beyond the built infrastructure, it is about what Qatar is doing in the free zone, and as an economic development agency, Qatar Free zone acts as a foundation for new economic activities within the country that are not directly related or dependent on existing fossil fuel or mineral fuel businesses. Qatar is already witnessing a huge number of announcements from companies that hopefully will deliver innovative sustainable solutions to reduce GHG emissions and increase the efficiency of the energy sector. Qatar recently had extensive effort with other governmental agencies to innovate sustainable ways and technologies to produce food by reducing water consumption. The point here is that we should know that these are the crucial steps QFZA is taking now. But ultimately, to think about adaptation, we have to consider diversifying this pool of potential and economic clusters. So, when QFZA thinks about the adaptation of the free zones, this fuels the whole framework that we have been thinking about.

Combating climate change requires people from all different sectors to work together in sync and harmony. Planning climate change mitigation and adaptation are not only limited to academic or research entities union. Some of Qatar's climate change mitigation and adaptation actions have been led by the QF. When it comes to mitigations, QF follows the normal routine for mitigation, which is the first step to knowing where you are standing. One should start with the measure, then the second phase should be addressed, which is about the GHG emissions reduction. Climate change mitigation is a continuous effort to minimize the need for materials used for operations.

Further, QF tries to improve the way people behave to climate change by involving the end-users of the building and the equipment. When it comes to offsetting, there are many ways of offset; QF does follow, in many ways, an offset scheme in carbon emissions, like buying credit internationally from some developing countries. But there are other ways where QF wants to invest some of the money internally. QF already has an existing facility for solar panels and

plants in the Education City and is also thinking about increasing the number of plants in the future. This application aims not only to have a new project within Education City but also to create an entity eventually, where education and academic research institutions have the opportunity to study and understand climate change mitigation in Qatar. QF also follows the GHG emission protocol guidelines and manually collects data at many stages, which takes a lot of time and effort.

It is crucial to think about evaluating the main risks associated with climate change impact when it comes to adaptation. These climate-related risks include heavy rains and floods, extreme temperatures, and destructive storms. A particular question must be raised: "*Considering broad potential climate impact in Qatar and various parties and stakeholder groups associated, how Qatar's climate mitigation and adaptation can be effectively prioritised and implemented?*" QF mainly focuses on:

- Assessing the adaptability of Qatar infrastructure, such as that in the Education City,
- Proposing novel ideas for climate change adaptation improvement,
- Enhancing Qatar's resiliency against climate change.

The work is not limited to QF or the Education City; the reach is out internationally. The QF organized the first Climate Change Conference in Qatar. The conference aims to safeguard our private and public sector organizations to mitigate climate change risks through knowledge sharing and mutual cooperation by taking into consideration Qatar's sustainable development. In addition, QF will also introduce the Qatar climate change knowledge portal, where Qatar-specific climate science, climate change actions, and climate policies will be posted and shared with the public in Qatar.

The successful implementation of climate change adaptation and mitigation plans depends heavily on strategies and cooperation by all parties in Qatar. To this end, Qatar should connect mitigation and adaptation measures with other goals. Decision-makers need to think about turning the climate change transition hazards into opportunities through innovative solutions. Qatar should aim to be a national climate change action through sharing experience before the international representation of countries on climate change issues such as the COP26.

Some vital research was conducted by the Sustainable Built Environment (SBE) group at HBKU in collaboration with internal and external institutions. The research aimed to assess climate change impacts and hence enable setting up adaptation and mitigation measures in Qatar and the MENA region. During the talk, five main topics were highlighted. These topics are:

- The latest disruption of the seasonal characteristics of the Arabian Peninsula,
- The high scarcity of water in the MENA region due to global warming,
- The unprecedented increase in absolute temperature in several global regions,
- The major impact of climate change on Qatar's built environment,
- How infrastructure such as Metro and highway networks can be designed to be resilient against future weather extremes?,
- The assessment of climate change implications on human health, energy sector, and water production.

3.3. Climate Change Research

The details of some of the key research projects conducted in the College of Science and Engineering at HBKU are as follows:

3.3.1. Disruption of the Arabian Peninsula seasons characteristics

Climate change has influenced the characteristics of seasons in the Arabian Peninsula and negatively affected agriculture, water availability, and ecosystems. Within the HBKU, efforts to understand the consequences of seasonal changes in the Arabian Peninsula, Ajjur and Al-Ghamdi [14] determined the disruptions in the onset, cessation, and duration of the Arabian Peninsula seasons. The study tracked the intra-annual changes in 12 climatological parameters from 1950–2019 (Figure 4). Results presented a new definition for seasons, which differs from conventionally defined seasons. This includes a remarkable prolongation in summer and a shortening in winter, aligning with the recent warming and drying of the region. For instance, during the last 30 years, summer extended for 126 days, while winter shrank to only 76 days.

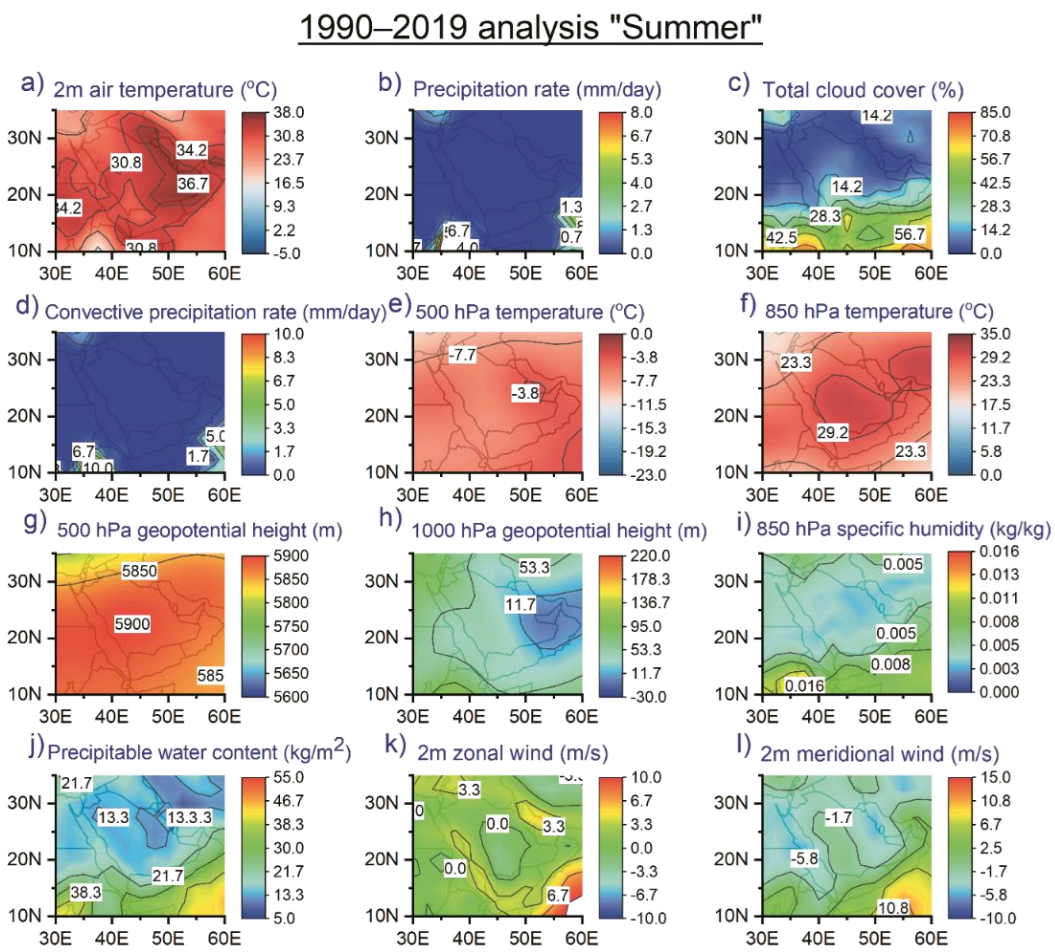

Figure 4. *The mean patterns of the studied climatic parameters for the central date of summer (13 June) during the last three decades* [14].

3.3.2. Water availability response to climate change in the Middle East and North Africa,

Quantifying the annual deficit in water availability is a severe challenge in the Middle East and North Africa (MENA) because climatic data needed for such quantifying are not readily available. To bridge this gap, Ajjur and Al-Ghamdi [15] used climatic data retrieved from the Coupled Model Intercomparison Project (CMIP6) and assessed evapotranspiration and water availability evolutions through the 21st century. Outcomes revealed that the MENA is indeed vulnerable to a significant increase in evapotranspiration losses and a decrease in water availability (Figure 5). Relative to 1981–2010, the decline in annual water availability would reach 62 mm by 2100 under the business-as-usual scenario. These projections facilitate accurate and realistic predictions related to evapotranspiration and water availability, which are crucial elements in managing water resources and devising effective climate change mitigation and adaptation plans in the MENA.

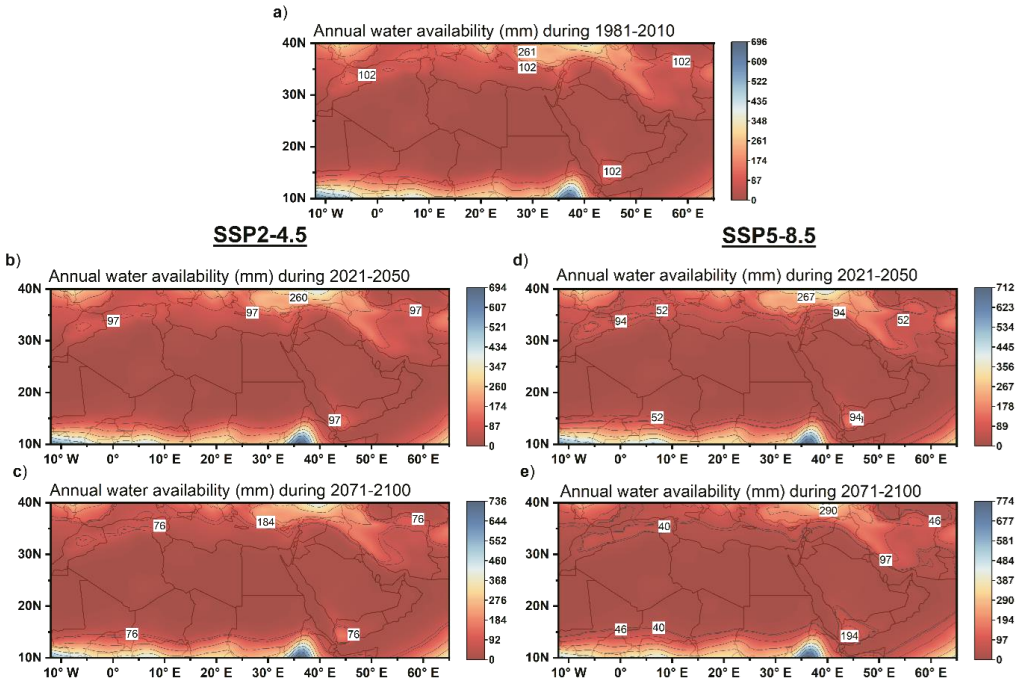

Figure 5. *The projected changes in the MENA annual water availability during the middle and the end of the 21st century, under two shared socioeconomic pathways (SSPs)* [15].

3.3.3. Global hotspots for future absolute temperature extremes from CMIP6 models

Assessing the degree to which global land regions are exposed to future changes in absolute temperature extremes is essential, (however unexplored), for planning climate change mitigation and adaptation. To this end, Ajjur and Al-Ghamdi [16] projected the trend in the warmest and coldest day and night indices through the 21st century using the state-of-the-art observational reanalyzes and bias-corrected climate models datasets. While the global trend in extreme temperature indices was unsurprising, the analysis showed significant regional variations over the 44 studied land regions (Figure 6 depicts the future changes in the coldest night index). Some global hotspots, such as North America, Iceland, Central Asia, Tibetan Plateau, Russian Arctic, Siberia, and the MENA, would be exhibited to an increase by up to 7.4 ^{o}C in the warmest day; 6.6 ^{o}C on the warmest night; 10.9 ^{o}C in the coldest day; and 12 ^{o}C in coldest night.

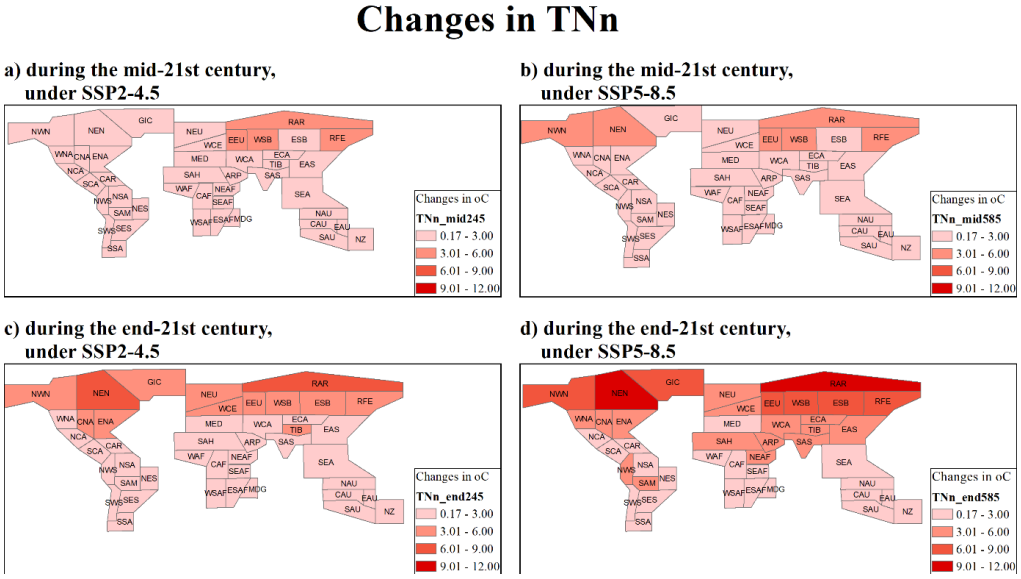

Figure 6. *The future changes in the coldest night during the 21st century for 44 world reference regions according to the IPCC Sixth Assessment Report (AR6) under two shared socioeconomic pathways (SSPs). Future changes are computed in (°C) from the historical period (1981–2010)* [16].

3.3.4. Critical Infrastructures Resilience and Climate Change

Resilient infrastructures are crucial in achieving and retaining Sustainable Development Goals (SDGs), thus contributing to Qatar National Vision QNV2030 and the success of Qatar FIFA World Cup 2022 [17,18]. In the HBKU/SBE research group, we develop and promote resilience-based approaches in municipal planning, assessment, and development projects. These approaches aim to address local and global challenges related to infrastructure networks and their interaction and responses to various disturbances [18,19]. We aim to ensure and reinforce the prosperity and thrive of the state of Qatar; by investigating the infrastructures' resilience during Mega Sport Events (MSEs) [18,20] or critical infrastructures resilience in general [17] and especially under volatile climate change impacts.

According to the results, Metro networks can withstand and preserve functionality under currently adopted, used in design by MME, flooding levels. However, under climate change scenarios, metro stations may be exposed to flooding, as demonstrated in Figure 7. Another example is the highway network, which was vulnerable to extreme flooding hazards, as in Figure 8. The results emphasize the importance of adopting a resilience design approach in the strategic development plans to avoid catastrophic disasters in terms of cost and scale. This approach is critical, especially with the occurrence rate of extreme precipitation increased in the last decade and expected to become more prominent due to climate change [21], and considering MSEs like Qatar FIFA World Cup 2022 would happen during the winter season [18].

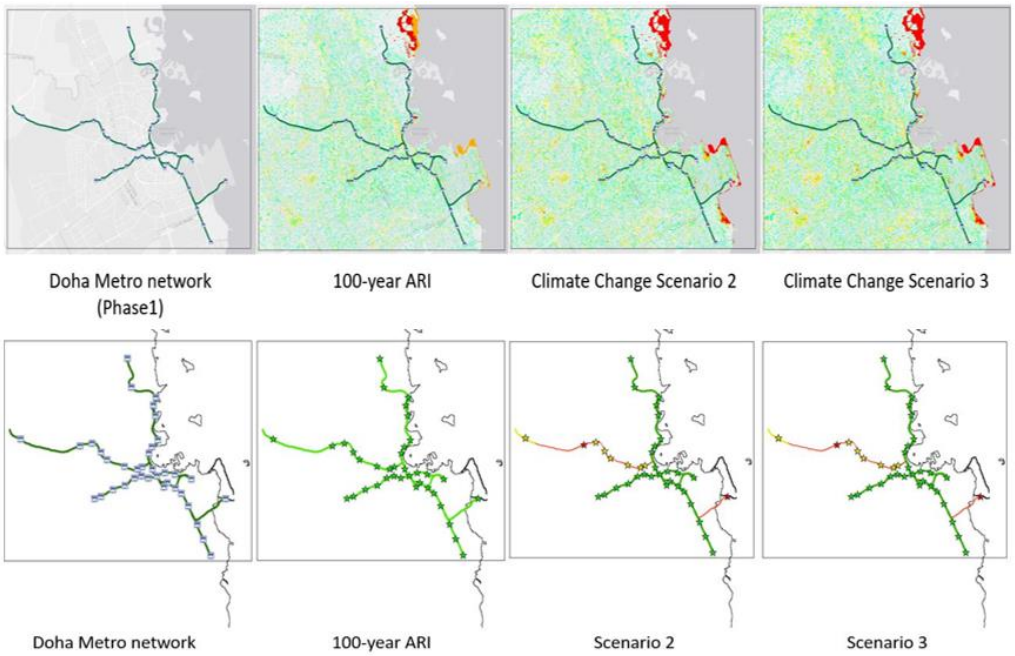

Figure 7. *Metro network assessment under climate change-induced flooding.*

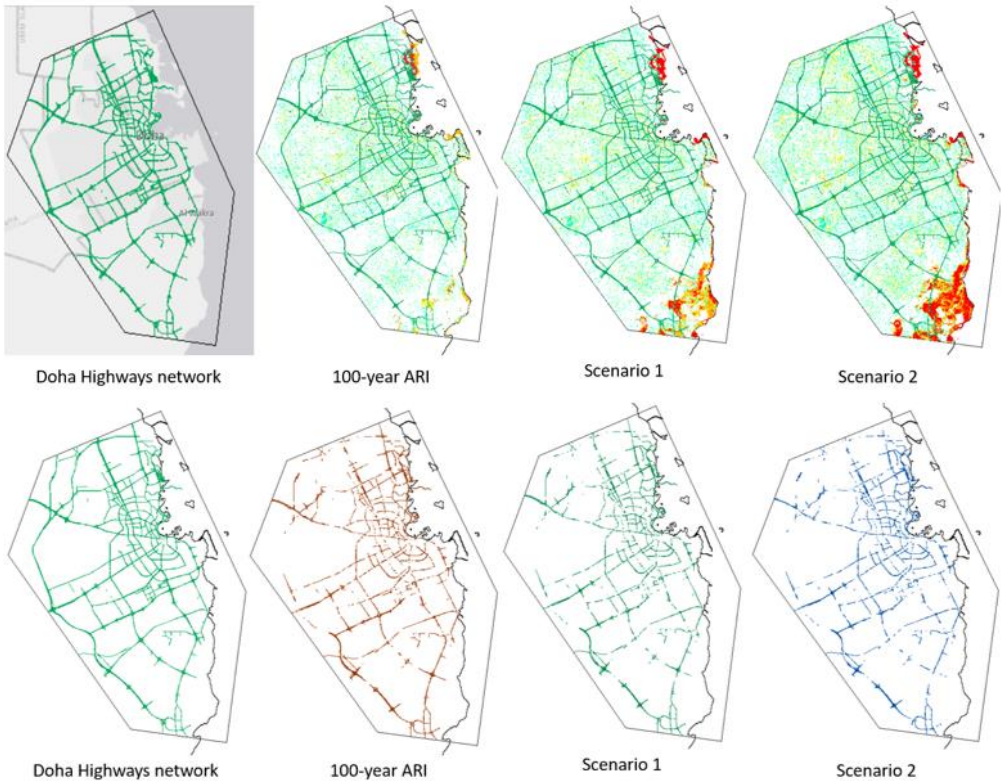

Figure 8. *Highway network assessment under climate change-induced extreme flooding.*

3.3.5. Assessing the Climate Change Resilience Qualities of the Built Environment from the Perspective of Different Sectors

The concept of resilience has become a hot topic in recent years. It aims to enhance the capacity of the communities to withstand, survive, thrive, and adapt to encountered natural, and climate change stresses and shocks. Urban resilience consists of several observable qualities and indicators that make up the built environment. Principally, the built environment should have the ability to assess the current level of resilience and define potential improvements. Official institutions, local stakeholders, and the construction industry should firstly have the ability to reflect and analyze past experiences and leverage them to inform future decision-making (reflectiveness). Secondly, they should be adequately aware of the climate change risks and their implications (resourcefulness) and effectively respond to climate change impacts with a certain amount of flexibility by leveraging previous experiences and developing informed prevention and mitigation measures (flexibility). Thirdly, reconfigurability and spare capacity should be integrated into all existing systems based on the risk assessment to avoid disruption (redundancy). At the same time, future assets should be designed to withstand the anticipated impacts (robustness). Fourthly, a quick recovery of the affected systems and rapidly re-instating the disrupted services are vital characteristics (rapidity). Finally, all stakeholders should have a high level of involvement to develop a sense of shared ownership and joint action, enabling efficient integration and information exchange between the different elements of city systems, improving the consistency in decision making (inclusion & integration).

3.3.6. Climate Change Implications on Public Health

Qatar is a small country with a total land area of 11,600 sq. km and a population of 2.9 million. The urban population accounts for 99% of its total population [22]. The climate in Qatar is hot and humid [23]. The large immigrant force, weather conditions, and most of the population of Qatar reside in Doha city, all of these factors make Qatar susceptible to vector-borne diseases [24,25]. Presently, as a non-endemic country, Qatar's vector control and surveillance initiatives are still underdeveloped [26].

Furthermore, Qatar's weather will become warmer because of climate change impacts. These factors combined further pose a potential threat to Qatar's health care system. In this study, a comprehensive analysis of the environmental impact on the production of different mosquito species is performed with the collaboration of the Ministry of Public Health and Weill Cornell Medicine – Qatar. The favorable environmental conditions for different species are described based on the Naive Bayes prediction. Results show that higher temperatures and lesser humidity enhance the chance of both species (Anopheles – Malaria vector and Aedes). Temperatures between 35 °C and 40 °C and relative humidity levels between 35% and 45% are ideal for Aedes mosquitos (Figure 9). The results reported in this study will help plan and take preventive measures to control the production of mosquitos in the state of Qatar.

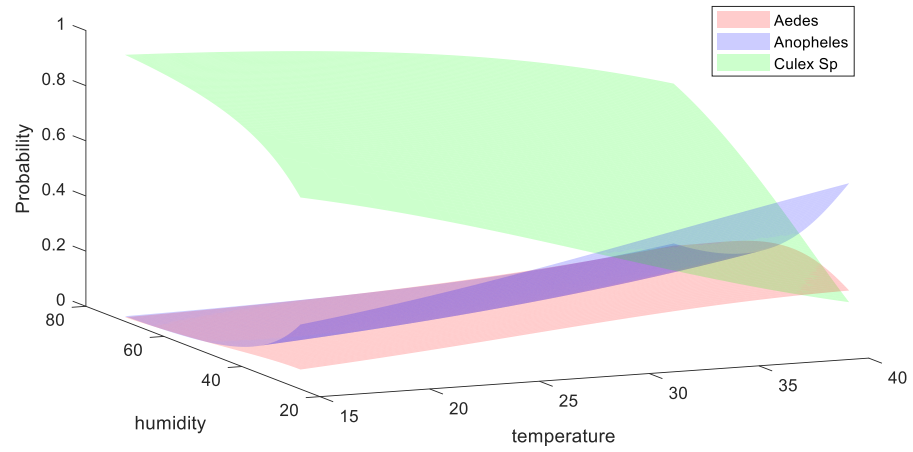

Figure 9. Predicted probability distribution of mosquito species with respect to environmental conditions (ambient temperature and humidity).

4. Carbon Market & Pricing

This session provided an introduction to carbon markets and pricing in relation to Qatar. The session included perspectives from public and private sector representatives and discussed how a market-driven instrument could effectively support future interventions on climate change.

Speakers:

H.E. Dr. Anders Bengtcén	Ambassador, Embassy of Sweden in Qatar
Mr. Saud Abdulla Al-Attiyah	Deputy Undersecretary for Economic Affairs of Ministry of Finance in Qatar and Board Member of Qatar Fund for Development
Mr. Pete Trelenberg	Director GHG and Climate Change, ExxonMobil Corporation
Mr. Wai-Shin Chan	Managing Director, Global Head of Climate Change Centre of Excellence at HSBC
Mr. David Antonioli	CEO, Verra
Ms. Fenella Aouane	Head of Carbon Pricing Global Practice at Global Green Growth Institute (GGGI)

4.1. Key Topics Discussed

- Introduction to carbon market and pricing in Qatar and transition pathways.
- Application and experience of climate change policy and economic instruments.
- Frameworks for incentivizing GHG reduction and societal acceptability.
- Low carbon economy models, regulations, standards, and reporting.

4.2. Summary of Discussion

The first two sessions were more about policy and abstract issues around climate change and how individuals and governments can tackle them. This session focused on who bears the carbon financial price or overhead.

At the start of the year 2021, China launched the world's largest carbon market to help meet the ambitious Paris Agreement targets. For example, Sweden introduced carbon taxing nearly 30 years ago, which was the first of its kind. Carbon pricing can be an efficient tool to reduce emissions and possibly beneficial to not only companies but also to individuals and the wider community. The question is how important carbon pricing is and how it can be combined with other approaches, as no single approach would solve the impacts

of climate change. Furthermore, the policies related to carbon pricing developed in other countries can be adjusted and successfully implemented considering the regional economic dynamics.

Sweden's climate policy framework and financial incentives aimed to reduce carbon emissions. The industrial sector represents one-third of the economy. The industrial sector is energy-intensive such as steel mills and the paper pulp industry. Since the 1970s, the Swedish policy has been focused on energy conservation and efficiency; GHG emissions became the central part of the environmental policy objective in the early 1990s. Following policy measures have been taken in an effort of reducing GHG emissions in Sweden:

- Energy tax was increased more than double in the past ten years (0.05 USD/kg-CO_2 or 0.45 USD/liter of petrol).
- In 1991, the carbon tax was introduced, and gradually, it increased (currently 137 USD/ton of CO_2), the highest carbon tax in the world [27].
- EU emissions and trading system (buy and sell carbon permits).

Because of these measures, energy consumption has been stable (approximately the same) for the last 40 years while industrial production and the GDP have grown more than double. Furthermore, the carbon emissions are reduced by 27%. The Swedish example shows that carbon taxes and trading reduced carbon emissions and increased the competitiveness and innovation in the industry as it has promoted more efficient use of resources and productivity in the industry. The Swedish government aims to further reduce carbon emissions from 45 to 10 million tons of CO_2 eq. by 2045. It can be made possible by focusing on industrial and domestic transportation sectors as they account for major shares in the country's total emissions. To accomplish this ambitious target, the following new measures have been introduced:

- EU average emission targets.
- CO_2-based vehicle tax.
- Purchase bonus for new cars with low or no emissions.
- Tax incentives for company cars with low or no emissions.
- Gradual increase of biofuels in petrol and diesel (28% and 66% of biofuels in diesel and petrol by 2030; respectively).
- Premiums to public transportation authorities to procure buses with low or no emissions.

The implementation of these measures has caused the significant introduction of electric vehicles in the Swedish automotive market. Industries have been applying alternative clean production systems and energy sources that can replace the conventional high carbon-intensive processes. For example, a steel production company has employed hydrogen energy sourced steel production

instead of conventional coal-based energy. The Swedish policies can be referenced in establishing Qatar's carbon market policies to mitigate climate change impacts.

Recently Qatar's cabinet approved a national climate change plan that was developed with the coordination of 50 entities in the country. The national plan aligns with the UN SDGs and Qatar's ambition to be one of the region's leaders to limit carbon emissions. Furthermore, all the stadiums for FIFA world cup 2022 are green buildings. Diversifying the economy, building capabilities, and using natural resources in the best possible way could help in mitigating climate change impacts.

Many countries are using mandatory and voluntary mechanisms in carbon emission credit exchange and trading. Costs and regulatory requirements are the main decision factors for buyers when the entities deal with the exchangers. However, the voluntary carbon market has a different dynamic vision where publicly announced carbonization targets become important decision factors. This still has a smaller share in the global market but is growing. For example, companies like Microsoft have announced carbon-neutral agendas.

Although there is progress in carbon emissions initiatives, only 20% of carbon emissions are still covered in these initiatives. The GCC produces 9% of the total carbon emissions in the world, but there is still no operational carbon market. The majority of the carbon credits are based in Europe. However, the US and Chinese markets are growing rapidly. Currently, the GCC countries have postponed the carbon initiatives for a while to avoid financial impacts and added costs on local businesses. However, repeated climate risks and potential positive economic benefits from climate actions will require GCC countries to introduce carbon markets sooner. Recently, Saudi Arabia has launched a plan for the carbon market, but still, it is in the development stage, and Qatar is a relatively small market; therefore, a collaboration between Gulf countries is needed.

Qatar is studying the feasibility of the carbon market. In consideration of the market scale, collective action is critical for successful implementations. Qatar's government considers the carbon market as a larger environmental, social, and governance framework. They are in the process of developing a balanced approach that involves multilateral and local commitments, such as the voluntary contribution of 100 million USD to support the initiatives of the Emir of Qatar in UN climate action summit held in 2019 by improving local building standards and investments in green bonds and several local energy efficiency initiatives.

Qatar is still in the developmental process of the carbon market; most of the energy products are consumed outside Qatar, and there is huge cooling energy demand. All of these factors should be weighed in when assessing the country's emissions. Qatar is a leading exporter of natural gas, which is much cleaner than other fossil fuels; hence Qatar contributes to the global reduction of carbon emissions. However, the introduction of the carbon market to Qatar should be cautious since the cost of the business in Qatar is high compared to other countries. Extra costs on businesses could hamper attracting new investments and the operation of local businesses in Qatar.

Qatar is exploring the following options to develop a carbon market such as:

- Create a GHG exchange coalition and allow GHG trade among participants but keep initial auctioning in Qatar.
- Establish a Qatar-focused voluntary GHG exchange market by promoting credit generators in Qatar.
- Being a hub for credit purchasers from aviation and shipping.

Furthermore, there is a need to develop GCC common market and customs unions. The mix of economic activities will provide greater opportunity for a fully developed and functioning domestic carbon market. The carbon pricing introduction is no longer a choice. Therefore the efforts have been increased to develop a credible plan.

Qatar's Exxon Mobil Research works on environmental management projects, water reuse, LNG safety, and coastal geology. The aim is to significantly cut the carbon footprints in each sector by carbon capture, hydrogen, and advanced biofuels. The technological breakthroughs and supportive governmental policies; encourage sustained investments in the energy transition. The carbon markets and pricing can be powerful tools in reducing global GHG emissions. A properly constructed price on carbon can be the single most effective way to mitigate climate change impacts at a lower cost to society. Carbon pricing would create a clear incentive for companies to operate more efficiently, reduce relative demand for high emissions goods and services, and encourage companies to invest in proven technologies like carbon capture and storage. Carbon capture could have great potential in Qatar along with other technologies like blue hydrogen. Still, these technologies will require government policy to support developing and deploying at a scale large enough to reduce emissions meaningfully.

Every country will develop its solutions and rules to reduce GHG emissions to achieve a net-zero state. Thus, the net-zero emissions target strongly depends on the policies and strategies of each country set. For Qatar, reliance on new technologies and other solutions is considered a practical approach. The cost of

carbon cannot be generalized, but many consider reaching 100 USD/ton of CO_2-eq. Of course, various factors need to be taken into account, including market conditions, the developmental state of the economy, climate commitments of the jurisdiction, and the level of support from the businesses, public, and government. The vital element is that the carbon price should be set at a feasible level. The market needs to start and grow over time while sharing a clear picture with the different sectors and communicating the benefits to all the stakeholders involved. For example, suppose there is a steel producer in Qatar or GCC, and they see that the carbon pricing will increase in the near future. In that case, they will eventually plan to shift towards cleaner processes such as hydrogen usage instead of coal. Therefore, the gradual rise in the carbon price will influence the market behavior in adopting energy-efficient and cleaner technology. Small and medium-sized companies will be more significantly affected by carbon pricing than large corporations. Therefore, a balanced carbon pricing is required, where it is acceptable to all stakeholders. Furthermore, carbon pricing should reflect the regional specifics and the social aspects. The carbon price should not be too low that the people can easily afford nor too high that it creates economic damage.

The carbon pricing and the trade-in system generate revenues for the government and financial institutions. The government can use these revenues in the way they see fit, which supports businesses in climate readiness and capacity building. In addition, these revenues can be utilized to reduce social costs. In Qatar, the subsidized utility tariffs to the citizens and residents hinder energy and water conservation. For this purpose, the Qatari government is working on several initiatives to change the consumption pattern and consumer behaviors of the citizens and residents in Qatar. Qatar is committed to its sustainability strategy, based on the United Nations Sustainable Development Goals, and to support the pursuit of its low carbon goals as defined in the Qatar National Vision 2030 and the ratified Paris Agreement.

The carbon pricing systems created so far are a patchwork that covers only some parts of the world. The European Union emissions trading system and regional initiatives in the US, Canada, and China purchase the right to emit CO_2. In Australia, there is a government-funded auction scheme to purchase abatement from the industry. Since carbon pricing and market are not yet globally introduced, it is important to ensure that any pricing policy does not encourage emissions leakage across borders. The policymakers should consider coupling carbon pricing policy with carbon adjustment, thereby maintaining the competitiveness of exported products such as LNG. Governments will have to further decide on how to manage the revenue the new markets create. One beneficial use of these revenues could help domestic companies reduce GHG emissions and encourage investments in technology solutions.

5. Conclusion & Outlook

In the Qatar Climate Change Conference, 2021, the discussion was focused on how to tackle the globally urgent issues of climatic change impacts, adaptation and mitigation, development of national policies, roles and responsibilities of public and private sectors, and the need and the formation of carbon pricing and market. Such events are essential for the increasing synergy that will hopefully drive more actions against climate change, preserve our planet, and protect humanity. In recent years, disasters such as hurricanes, urban floods, heatwaves, forest fires, and earthquakes have increased. Therefore, the need for collected efforts, innovation, and low emission technologies has become essential in tackling climate change impacts. Some of the key highlights of the Qatar Climate Change Conference are summarized as follows:

- Qatar is committed to its sustainability strategy, based on the United Nations Sustainable Development Goals (UN SDGs), and to support the pursuit of its low carbon goals as defined in the Qatar National Vision 2030 and the Paris Agreement.

- The energy challenge can be described as a triangle representing three main questions:
  - Access:
    - We should remember that more than 700 million people on our planet do not have access to basic electricity, representing enormous energy poverty and causing low economic effectiveness. So we need to achieve more economic growth to support all the world population, but we need to find ways to decouple it from CO_2 emissions.
  - Security:
    - Energy is still the engine of growth and the global economy; this was clearly experienced during the COVID-19 pandemic, so we need to reinforce the supply chains and maintain security and predictability for access to energy.
  - Mitigation:
    - We need to start by changing the mentality from relying on fossil fuel to a more renewable, technology-oriented society. This transition is challenging, but the wider utilization of LNG, produced by Qatar, can provide an interim solution for this process as its carbon emissions are half of the emissions from coal. The LNG prevents the disturbance resulting from the sudden transition from coal to renewables, providing a reliable energy source with far fewer emissions and lower investment costs. Additionally, the development and implementation of carbon capture and storage technologies would make LNG an

even more viable solution, substantially decreasing the emissions from LNG production. Qatar's investments in such technologies are a clear sign of its leadership and commitment towards combating climate change.

- The concentration of GHG continues to increase as the world economy grows, driven by the increase in living standards in developing countries, increasing the consumption of a wide range of energy sources. There is an urgent need to accelerate the transition toward cleaner energy through joint efforts, including public support, governments, and the private sector, in the bid to fulfill the Paris Agreement goals.

- Each country is responsible for setting its own policies to achieve the common global goal. Countries representing 70% of the world economy have pledged to reach net-zero emissions by 2050, including many major and emerging economies. Similarly, large corporations, including major oil and gas companies, committed to the same target. Meeting such pledges requires to research the renewable energies and energy efficiency technologies.

- The COVID-19 has disturbed our world at all levels, causing a decline in economic activities and, subsequently, a temporary reduction in emissions. However, this created a chance to direct recovering investments as a tool for sustainable and green economy transition. Using the COVID-19 catastrophe as a catalyst for developing policies can strengthen societies and limit the impacts of climate change.

- Climate change is a generational issue, one that will require decades to be solved; thus, the effort of behavioral change should be focused on three pillars:
    - National plan:
        - A national plan that clearly defines the target and approaches based on the country's conditions and challenges ensures continuous economic growth while addressing the environmental challenge. The Qatari national climate change plan is an excellent example of such an effort.

    - Social responsibility of companies:
        - Companies should contribute and invest in raising awareness in the community through outreach initiatives, energy labs, and school tours. Such practices equip future generations with a toolkit mentally to deal responsibly with

the environment and address the climate change challenge.

- Technology:
  - Technological solutions and research and development efforts are the primary enablers of the clean energy transition. Furthermore, the development of technological alternatives could stimulate the behavioral change towards more environment-friendly options, like electric vehicles and lab-grown meat.

- The state of Qatar stepped up its efforts in fighting climate change, as the cabinet lately sanctioned an ambitious National Climate Change Plan prepared by almost 50 different property entities. The plan contains 35 mitigation and more than 300 adaptation initiatives, which also hugely catalyze and hasten economic diversification. The success factors for hydrogen production, such as the enormous natural gas reserves and operational experience, have existed in Qatar for decades now. This is being implemented by complemented CO_2 capture and storage as well as controlling the possible fugitive methane.

- The effective implementation of climate change adaptation and mitigation depends heavily on policies and cooperation by all parties. The successful performance can be achieved through integrated responses that link mitigation and adaptation with other socioeconomic objectives.

- On a global level, the State of Qatar has pledged to provide $100 million USD for the support of a small island developing states and the least developed countries to mitigate the impact of climate change, natural hazards and environmental challenges, and to build the capacity and necessary resilience to counter their destructive effects. The contribution was announced by HH Shaikh Tamim bin Hamad Al-Thani, Emir of the State of Qatar during the Climate Action Summit 2019 at the 74th session of the United Nations General Assembly, on the 24th of September, 2019. The announcement was followed by various projects that continue to be implemented through Qatar Fund for Development (QFFD) to support green economy and jobs in numerous countries including Fiji, Kiribati, Papua New Guinea, Samoa, Tonga and Vanuatu.

- The QFFD is the provider of development cooperation and humanitarian assistance for the State of Qatar. As such, QFFD also administers the $100 million pledge for climate change. The Fund's climate change strategy supports enhancing community resilience through promoting mitigation and adaptation solutions to climate change.

- This is in addition to projects that aim to support communities at risk of food insecurity resulting from climate-related hazards and to better mitigate the humanitarian impact of such shocks such as flooding in Bangladesh, Somalia and others.

- The pricing systems created so far are a patchwork that covers only some parts of the world. The European Union emissions trading system and regional initiatives in the US, Canada, and China are based on purchasing the right to emit CO_2. In Australia, there is a government-funded auction scheme to purchase abatement from the industry. Since carbon pricing and the market is not yet globally introduced, it is important to ensure that any pricing policy does not encourage emissions leakage across borders.

- The policymakers should consider coupling carbon pricing policy with carbon adjustment, thereby maintaining the competitiveness of exported products such as LNG. Governments will have further decisions on how to manage the revenue the new markets create. One beneficial use of these revenues could help domestic companies reduce GHG emissions and encourage investments in technology solutions.

6. **Speakers**

Chairman, Al Attiyah International Foundation for Energy & Sustainable Development

H.E. Abdullah bin Hamad Al Attiyah

Minister of Municipality and Environment

H.E. Dr. Abdullah bin Abdulaziz Al-Subaie

President, ExxonMobil Qatar

Mr. Dominic Genetti

Group CEO of Qatar Airways and Secretary General of Qatar Tourism

H.E. Akbar Al Baker

Chief Executive Officer of Qatar Foundation International

Mr. Omran Hamad Al-Kuwari

Ambassador of Climate Change, MoFA, Republic of Korea

H.E. Hyoeun Kim

President, World Economic Forum

Mr. Borge Brende

Former Minister of Energy and Industry, State of Qatar

H.E. Dr. Mohammed S. Al Sada

Deputy CEO and Chief of Sector development, Qatar Free Zones Authority

Mr. Abdullah-Al-Misnad

Sustainability Director, Qatar Foundation

Dr. Soud Al-Thani

Executive Director, European Roundtable on Climate Change and Sustainable Transition

Mr. Andrei Marcu

Director, UNFCCC

Mr. James Grabert

Associate Professor, Sustainable Development College of Science & Engineering - HBKU

Dr. Sami G. Al-Ghamdi

Ambassador, Embassy of Sweden in Qatar

H.E. Dr. Anders Bengtcén

Deputy Undersecretary for Economic Affairs, Ministry of Finance, Qatar

Mr. Saud Abdulla Al-Attiyah

Director GHG and Climate Change, ExxonMobil Corporation

Mr. Pete Trelenberg

Managing Director, Global Head of Climate Change Centre of Excellence at HSBC.

Mr. Wai-Shin Chan

CEO, Verra

Mr. David Antonioli

Head of Carbon Pricing Global Practice at Global Green Growth Institute (GGGI)

Ms. Fenella Aouane

Moderators

Host & Executive Producer, The Agenda

Mr. Stephen Cole

UK/Europe Correspondent - CGTN Europe

Mr. Nawied Jabarkhyl

Founding Director, E.Treanor Marketing Management

Ms. Eithne Treanor

7. Acknowledgments

The Qatar Climate Change Conference (QCCC), 2021, was organized by Qatar Foundation for Education, Science, and Community Development (QF) in a strategic partnership with Abdullah bin Hamad Al-Attiyah International Foundation and was sponsored by ExxonMobil and Qatar Fund for Development. The proceedings of the conference were prepared by the College of Science and Engineering (CSE), Hamad Bin Khalifa University (HBKU).

The research project discussed in section (3.3.) was funded by the National Priorities Research Program (NPRP) grant (NPRP12S-0212-190073) from the Qatar National Research Fund (QNRF), a member of the Qatar Foundation (QF). Any opinions, findings, conclusions, or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of QNRF or QF.

8. References

1. The Core Writing Team IPCC. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Ipcc. Geneva, Switzerland; 2015.

2. Imteyaz B, Lawal DU, Tahir F, Rehman S. Prospects of large-scale photovoltaic-based power plants in the Kingdom of Saudi Arabia. Eng Reports [Internet]. 2021 Mar 17; Available from: https://onlinelibrary.wiley.com/doi/10.1002/eng2.12398

3. Rogelj J, den Elzen M, Höhne N, Fransen T, Fekete H, Winkler H, et al. Paris Agreement climate proposals need a boost to keep warming well below 2 °C. Nature [Internet]. 2016 Jun 30;534(7609):631–9. Available from: http://www.nature.com/articles/nature18307

4. Lazarus M, van Asselt H. Fossil fuel supply and climate policy: exploring the road less taken. Clim Change [Internet]. 2018 Sep 2;150(1–2):1–13. Available from: http://link.springer.com/10.1007/s10584-018-2266-3

5. Boyce JK. Carbon Pricing: Effectiveness and Equity. Ecol Econ [Internet]. 2018 Aug;150:52–61. Available from: https://linkinghub.elsevier.com/retrieve/pii/S092180091731580X

6. Raouf MA. Climate change threats, opportunities, and the GCC countries. Middle East Inst Policy Br. 2008;12(5).

7. Vermeer M, Rahmstorf S. Global sea level linked to global temperature. Proc Natl Acad Sci [Internet]. 2009 Dec 22;106(51):21527–32. Available from: http://www.pnas.org/cgi/doi/10.1073/pnas.0907765106

8. Meltzer J, Hultman NE, Langley C. Low-carbon energy transitions in Qatar and the Gulf cooperation council region. Brookings Pap Econ Act. 2014;

9. Gulf Times. Cabinet Okays National Climate Change Plan.

10. Qadir SA, Al-Motairi H, Tahir F, Al-Fagih L. Incentives and strategies for financing the renewable energy transition: A review. Energy Reports [Internet]. 2021 Nov;7:3590–606. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2352484721004066

11. IATA. Air Cargo Carbon Footprint. 2021.

12. IRENA Renewable Cost Database. Renewable Power Generation Costs in 2020. International Renewable Energy Agency. 2020. 160 p.

13. Qatar Foundation. Education is the key to a sustainable future, QF's Qatar Climate Change Conference 2021 is told [Internet]. QF Stories. 2021 [cited 2021 Sep 23]. Available from: https://www.qf.org.qa/stories/education-is-the-key-to-a-sustainable-future-qfs-qatar-climate-change.

14. Ajjur SB, Al-Ghamdi SG. Seventy-year disruption of seasons characteristics in the Arabian Peninsula. Int J Climatol [Internet]. 2021 May 11;joc.7160. Available from: https://onlinelibrary.wiley.com/doi/10.1002/joc.7160

15. Ajjur SB, Al-Ghamdi SG. Evapotranspiration and water availability response to climate change in the Middle East and North Africa. Clim Change [Internet]. 2021 Jun 2;166(3–4):28. Available from: https://link.springer.com/10.1007/s10584-021-03122-z

16. Ajjur SB, Al-Ghamdi SG. Global Hotspots for Future Absolute Temperature Extremes From CMIP6 Models. Earth Sp Sci [Internet]. 2021 Sep 10;8(9). Available from: https://onlinelibrary.wiley.com/doi/10.1029/2021EA001817

17. Serdar MZ, Al-Ghamdi SG. Preparing for the Unpredicted: A Resiliency Approach in Energy System Assessment. In: Energy Systems Evaluation (Volume 1) [Internet]. 2021. p. 183–201. Available from: https://link.springer.com/10.1007/978-3-030-67529-5_9

18. Serdar MZ, Koc M, Al-Ghamdi SG. Urban Infrastructure Resilience Assessment During Mega Sport Events Using a Multi-Criteria Approach. Front Sustain [Internet]. 2021 Jun 3;2. Available from: https://www.frontiersin.org/articles/10.3389/frsus.2021.673797/full

19. Serdar MZ, Koç M, Al-Ghamdi SG. Urban Transportation Networks Resilience: Indicators, Disturbances, and Assessment Methods. Sustain Cities Soc [Internet]. 2021 Oct;103452. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2210670721007253

20. Serdar MZ, Al-Ghamdi SG. Resiliency Assessment of Road Networks during Mega Sport Events: The Case of FIFA World Cup Qatar 2022. Sustainability. 2021 Nov;13(22):12367.

21. Salimi M, Al-Ghamdi SG. Climate change impacts on critical urban infrastructure and urban resiliency strategies for the Middle East. Sustain Cities Soc [Internet]. 2020 Mar;54:101948. Available from: https://linkinghub.elsevier.com/retrieve/pii/S2210670719315872

22. Qatar [Internet]. Index Mundi. [cited 2021 Sep 29]. Available from: https://www.indexmundi.com/facts/qatar/#Environment

23. Climate: Qatar [Internet]. Climate-Data. [cited 2021 Sep 29]. Available from: https://en.climate-data.org/asia/qatar-183/

24. Farag E, Bansal D, Chehab MAH, Al-Dahshan A, Bala M, Ganesan N, et al. Epidemiology of Malaria in the State of Qatar, 2008-2015. Mediterr J Hematol Infect Dis [Internet]. 2018 Sep 1;10(1):e2018050. Available from: https://www.mjhid.org/index.php/mjhid/article/view/2018.050

25. Schaffner F, Bansal D, Mardini K, Al-Marri SA, Al-Thani MHJ, Al-Romaihi H, et al. Vectors and vector-borne diseases in Qatar: current status, key challenges and future prospects. J Eur Mosq Control Assoc [Internet]. 2021 Mar 19;1–12. Available from: https://www.wageningenacademic.com/doi/10.52004/JEMCA2021.x001

26. Schaffner F, Bansal D, Al-Thani MHJ, Al-Romaihi H, Farag EABA. Preventing vector-borne diseases at major sport events: Addressing the challenges for FIFA 22 in Qatar. Fuehrer H-P, editor. PLoS Negl Trop Dis [Internet]. 2021 Mar 11;15(3):e0009135. Available from: https://dx.plos.org/10.1371/journal.pntd.0009135

27. Tvinnereim E, Mehling M. Carbon pricing and deep decarbonisation. Energy Policy [Internet]. 2018 Oct;121:185–9. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0301421518304063


جامعة حمد بن خليفة
HAMAD BIN KHALIFA UNIVERSITY
كليّة العلوم والهندسة
College of Science & Engineering


كيوساينس
QSCIENCE
دار جامعة حمد بن خليفة للنشر
HAMAD BIN KHALIFA UNIVERSITY PRESS