

Chapter 19

Pathways for a Sustainable Future



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Abstract The strategic vision of the State of Qatar seeks to pursue development while aiming for a balanced approach to the social, human, economic, and environmental pillars of the vision. The legal and governance mechanisms supporting this transition are only effective when implemented, and can be hindered by limited access to data for decision-making. In the last decade, significant changes have taken place, catalyzed by commitments made to host the FIFA World Cup 2022 as well as innovations led by the Qatar Foundation. Yet, as a country with heavy reliance on hydrocarbon resources, the transition toward a more sustainable future involves trade-offs, the options for which present different pathways (from pragmatic to transformative). Climate change will present significant challenges for Qatar, including sea level rise and increasing temperatures, but also impacts on terrestrial and marine biodiversity. Domestically, key areas of the economy (energy, water, food, urban development, waste management) require integrated, systems approaches for moving toward greater sustainability. This future needs to be enabled by new ways of teaching and learning as well as new ways of thinking about and doing business. Not all issues could be covered in this collection (most notably, transportation, heating and cooling systems, desalination, health, and air quality, among others). However, this book has provided a wealth of evidence on diverse subjects, and this concluding chapter brings these diverse options and recommendations together.

Keywords Qatar · Sustainability · Transition · Policy · Pathways

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19.1 Introduction

Sustainability is a comforting word, pliable enough to embrace the environment, society, and economy—all should be “sustainable”—but sufficiently ambiguous to seem uncomplicated. It was coined as a policy concept in 1987 in the Brundtland Commission’s *Our Common Future*, where it was joined to “development” as a guide for economic policy, then further extended to embrace the environment with the Rio Declaration in 1992. As the environment broadened to include climate, and then the various dimensions that both contribute to and are affected by climate change, the concept retained its earlier roots in economic policy, but now includes almost everything—societies and economies are to be sustainable; water, fish, and wildlife are to be managed sustainably; cities have to be smart and sustainable; lifestyles and even the most minute personal behaviors should be calibrated for sustainability, and moreover for their contributions to sustainable futures (which are plural, since they vary by locale). More tellingly, this is not simply a conceptual or philosophical framing—it has institutional foundations in the United Nations system and global agreements, prominently the 2015 Paris Climate Accord as well as the 2030 Agenda and the Sustainable Development Goals. With international agreements and institutions come processes, and with those processes come national commitments to meet global standards and contribute to global outcomes. As this book shows, “sustainable Qatar” is a massive and complicated undertaking, as is a true “sustainability agenda” for any country.

Our chapters discuss almost every aspect of sustainability (though as the next section argues, there are still some areas that require more analysis), and three broad themes emerge from the analysis. The first is that while sustainability is a global challenge, the responses have to be tailored to regional, national, and local conditions. Localizing responses to these conditions are not only environmental or climatic, they include social and economic factors. A sustainability agenda for northern European countries will have to be different than one for equatorial nations. The agenda will also be affected by population size, level of economic development (and hence the financial resources to transition to clean energy), key industries and their energy demands, consumption patterns, and even culture. As noted in the introductory chapter, to understand sustainability in Qatar, we must first understand the unique conditions, opportunities, and challenges of Qatar as a nation.

A second theme embedded in many of the chapters is the current array of policy frameworks and legal instruments that give effect to Qatar’s sustainability goals. The core of these frameworks focuses on environmental issues and on climate change, but since almost everything we do and all the ways in which we live affect the environment (not least through carbon emissions), a “sustainability agenda” in principle will cascade through almost every conceivable public policy—as an example, this book has chapters on smart cities and on education. That said, our chapters provide an impressive catalog of equally impressive policy and legislative efforts undertaken by the State of Qatar since the early 2000s, when the government began to address environmental issues, gradually evolving into a sustainability agenda.

Given the scope and breadth of that agenda, weaving together everything from bicycles to biodiversity, the coordination and capacity challenges can be immense. This is particularly true of larger countries, with multiple sub-national jurisdictions and different environmental and economic eco-systems (e.g., the United States, China, or Brazil), but our chapters show that it has been a challenge for even a small unitary state like Qatar. Exemplary of these challenges is that they require policy coherence across sectors and scales. Chapters on the domestic energy and water systems showcase the importance of multi-scale engagement, while chapters on the marine and terrestrial ecosystems highlight the importance of multi-sectoral responses.

The third theme that emerges from this collection is related to the implementation challenges, and in particular, the transition from a carbon-based society and economy to a post-carbon future. Even imagining what that might mean is daunting. Most projections of the global energy mix, say to 2050 or 2060, provide scenarios where hydrocarbons retain a key share of energy supply. If there is a mix, in what proportions? For which sectors? With what energy sources, and in what combinations? As noted earlier, these transitions will be tailored to local conditions, and thereby varied. Post-carbon implies post-industrial, and while “knowledge-based economy” trips off the tongues of policy wonks, specifying what that might mean both in general terms and specifically for any given country, workforce, or educational system, is something else. The particular challenge of this transition for Qatar is given by one single fact—its current economy is highly dependent on fossil fuel extraction and export (liquefied natural gas “LNG”). For Qatar, the transition is not simply from one set of energy sources to another, but a transformation of its entire economy.

We treat each of these themes below, then briefly consider some remaining gaps in our coverage of topics, before turning to a summary of recommendations for a sustainable Qatar.

19.2 Qatar: Unique Conditions, Challenges, and Opportunities

Sustainability as a policy destination depends on where you begin, and almost every chapter in this collection considers the unique conditions in Qatar. The overarching context is that the country is a relatively small, peninsular country in the Arab Gulf region, molded by four key factors—gas reserves, heat, sand, and Islam. Our chapters went well beyond this, and in the aggregate, they paint a detailed portrait of the country and the implications for sustainability policy. The following summarizes some of these key contextual factors, which mark the initial starting point for sustainability discussions:

1. *Size*: Small, with a land mass of only 11,521 km². Qatar is only 85 km wide, or about an hour’s drive. While there are some islands, Qatar is primarily a

peninsula, surrounded by seawater. It is also flat, with only a few hills that are about 100 m above sea level. Up to 18% of the country is liable to inland flooding, with 96% of the population living in coastal areas (Chaps. 9 and 11). These factors highlight a key risk related to sea level rise (Chap. 9).

2. *Land surface*: Groundwater has high salinity, and there are few areas suitable for agriculture. Nearly all the country is sandy desert covered with scrub plants and loose gravel. A key challenge emerging from this is limited opportunities for agriculture (Chap. 11), at least in the forms we have commonly known it (future research may explore opportunities for vertical farming and aquaculture—both in their infant stages within the country).
3. *Population*: The total population is 2.8 million, of which about 88% are foreigners. In 1939, Qatar had a population of only 28,000. Almost the entire population resides in Doha and one or two adjacent communities (Al Wakra, Al Khor). As a result, urban planning is critical for reducing reliance upon personal vehicles, and creating community spaces that embody the sustainability values outlined in the national vision (Chaps. 11, 14 and 15).
4. *Biodiversity and eco-systems*: There are only 19 species of terrestrial wild animals in Qatar, with a possible six mammal species, but records are limited. Plant species (adapted to a hot, dry climate) are estimated at 400 (see Chap. 13). While these species are comparatively few compared to other biological “hotspots”, they are of particular importance to this environmental setting. Maintaining this biodiversity requires integrated approaches, such as strengthening the tracking and record keeping of existing species.
5. *Water*: Scarce precipitation, limited groundwater, and high levels of salinity result in few sources of water, combined with no natural lakes or rivers as sources of freshwater. At the same time, demand for water is rapidly increasing alongside population growth and economic development, leading to Qatar having one of the highest per capita water consumption rates in the world (430 L/person per day; Chap. 11). Other than groundwater used for the agricultural sector, desalination is the primary source of water for the country, which is energy intensive. Research and innovation are required to increase efficiency, and more efficient technologies that are already available need to be more widely employed. Given the energy intensity of obtaining fresh water via desalination, water leakage or loss in the water system requires attention; water leakage is a major problem (real loss is about 5.28%). Water storage is also an issue, with the country having only two days of strategic water stock (Chap. 11).
6. *Temperature*: The temperature averages around 17 °C in both spring and autumn months, but goes up as high as 50 °C in July and August (Chap. 11). Although not explored in this book, temperature rise will have implications for energy and water demand, on human health, and on systems functionality during heatwaves. Climate projections, therefore, need to be integrated across sectors to ensure that planning takes into account not only the average temperature rise but also the potential for more intense and prolonged heatwaves.
7. *Energy*: Qatar has 24.29 trillion cubic meters (Tcm) of proven gas reserves, about 12% of the world total, and has the third-largest single reserve in the

world (Chap. 11). Currently, about 60% of its LNG exports go to Asia, but production capacity is planned to increase from 77 million ton to 126 million ton per year by 2027 (Chap. 6), and given the Russian invasion of Ukraine, the global energy market is re-orienting with Qatar finding new demand for its LNG. While this presents an economic opportunity, it also has an environmental cost. The implication is that for the coming decades, it is likely that Qatar will continue to be a major LNG producer and exporter. This is both an opportunity (for revenues) and a challenge (as countries increasingly move to renewables). Explorations of how Qatar could be a leader in transitioning to hydrogen highlight how opportunities also exist to utilize resources in ways that are cleaner and offer long-term economic potential.

8. *Emissions:* Qatar's has one of the world's highest emissions rate per capita annually, coming primarily from industrial activities related to LNG (extraction, manufacturing, and heat production), and power and water production (Chap. 6). On a per capita basis, this makes Qatar the top CO₂ emitter in the world, though only 0.28% of the world total. As the world transitions away from fossil fuels, there will increasingly be pressure to reduce emissions, for example through carbon capture (Chap. 7), which Qatar might actually lead, with suggestions that by 2035 the country has the potential to reduce the carbon intensity of Qatar's LNG facilities by 35%. These reductions will require research and infrastructural investment, but will make progress toward climate commitments, and help position Qatar's resources in a more favorable light.
9. *Electricity consumption:* Qatar has the fourth-highest per capita electricity consumption per capita in the world (Chap. 11). Virtually all of this energy is generated through fossil fuels (over 80% from natural gas). Despite abundant, blazing sunshine, Qatar only opened its first large-scale solar power plant in 2021. Despite having enough natural gas to power its national electricity needs, there is both a need and an opportunity to shift to renewables (especially solar).
10. *Food production and security:* Before the blockade of 2017, Qatar imported about 90% of its food. Despite climate and soil conditions, the government decided to make food security a national priority (see below), and there has been an expansion of local agricultural produce (including dairy), with an increase of 20% in the number of farms, organic vegetable production, and the potential for exports. Food waste was a challenge before 2017, however with new domestic production food loss is also a key challenge—particularly given the enormous resources needed to strengthen domestic food production (Chap. 12). Given the newness of the industry, research and development can enhance production and reduce food loss, while new and innovative policy approaches are required to reduce food waste. Redistributing edible food and collecting organic waste for composting or biochar are important, but addressing the source of food waste requires much more attention (including in revising curricula in the education system; Chap. 17).
11. *Solid Waste:* Qatar is one of the highest per capita waste-generating countries in the world, producing about 10 million metric tons per year. The good news

is that production peaked in 2013, and has been declining (largely construction waste emerging out of a construction boom and associated demolition waste; Chap. 16). Municipal waste is largely not segregated, resulting in large amounts of waste that could be re-used, re-cycled, or transformed into other value-adding commodities are ending up disposed in landfills. Remaking the waste management system has not attracted as much policy attention as it should, given the costs and opportunities available therein (Chap. 16).

12. *FIFA and World Cup 2022*: This may seem an odd thing to list with the preceding items, but ever since the World Cup was awarded to Qatar in 2010, it has affected national development in everything from construction (e.g., eight soccer stadiums, a completely new metro system, hotels, and destination venues), to population growth (massive recruitment of migrant labor to work on construction projects and in the hospitality sector), and hence energy consumption and emissions. At the same time, the FIFA World Cup 2022 Sustainability Strategy, with its five pillars and over 70 initiatives, has created a parallel policy framework to achieve the first carbon-neutral World Cup. The pillars, for example, comprise sustainable buildings, mitigation of greenhouse gas (GHG) emissions, air quality offsets, waste minimization, and water conservation (Chap. 4). Preparations for the World Cup over the last decade have driven changes in the construction sector, and hence energy and water consumption, population growth and waste production. The FIFA Sustainability Strategy, combined with the Qatar—FIFA joint venture of Qatar 2022 LLC, has highlighted sustainability as one of the key features of the World Cup, which offers the opportunity to have a legacy that accelerates and supports transitions to higher levels of sustainability.

To paraphrase Tolstoy, every national sustainability strategy is sustainable in its own way. Considering the unique combination of features above—geographical, geological, ecological, demographic, and economic—it is clear that sustainability strategies in Qatar cannot be the same as Sweden’s or Samoa’s. Within that context, we can better appreciate the policy challenges. How can the country achieve some measure of food security in an arid climate, without much arable land and next to no fresh water supplies? How will it reduce electricity consumption for air-conditioning when summer temperatures are routinely in the 40s and sometimes the 50s °C? How will the population mitigate the threat of rising sea levels when 96% of the population lives in coastal areas, and almost all of that population is clustered in and around one city (Doha)? Those are challenges. This book has provided feasible options for ways forward, but which will require commitment and consistency. Qatar also has some advantages. It is small, and size matters, in this case in the sense that Qatar is essentially a city-state, similar to Singapore. In principle, this can encourage greater policy coherence and focus (though capacity and implementation are always problems, as they are everywhere). It is rich, has abundant supplies of energy through its natural gas reserves, and despite a volatile global economy, looks well-positioned

for continued growth in LNG exports over the next 20 years. Through FIFA, Qatar lashed itself willingly to the mast of sustainability, and as we will see below, has genuinely committed itself to the required policy frameworks.

19.3 Sustainability: Policy Frameworks and Legal Instruments

The second theme that emerges from our chapters is the country's existing sustainability policy frameworks and legal instruments. As Chap. 3 noted, Qatar ratified the Kyoto Protocol in 2005 and was one of the first countries in the Arab world to ratify the Paris Agreement, also accepting the Doha Amendment in 2020. Like all other countries in the world, Qatar also supported the United Nations Sustainable Development Goals (SDGs) and Agenda 2030. Together, these agreements form the highest international scaffolding for national sustainability strategies. Within that scaffolding, each country has additional agreements, as well as its own strategies, policies, and laws. The following are the most notable instruments of Qatari sustainability policy and law.

1. *International Agreements*

Qatar is a signatory to United Nations Framework Convention on Climate Change and the Paris Agreement. It has enhanced its original Intended Nationally Determined Contribution (INDC), and in 2021 proposed a 25% reduction in GHG emissions, relative to its baseline scenario. We will not list them all here (see Table 3.1 in Chap. 3), but it is also a signatory to at least nine sustainability declarations and instruments in the Arab region. These are more than rhetorical flourishes—Qatar has shown leadership in some niche areas. As Chap. 3 notes, it has contributed \$100 million to support climate action among small island states, and the Qatar Fund for Development is also focusing its support there (with the Gates Foundation, in 2022 it committed \$200 million to support smallholder farmers with climate-adaptive agriculture and developing resilient food systems). Qatar is also a signatory to the Convention on Biological Diversity (Chap. 13). These international agreements not only set forth agendas, but in some cases involve reporting, as Qatar has done with the Voluntary National Review in 2021. This advances accountability and transparency regarding these agreements.

2. *Constitution, National Vision, National Development Strategy, and National Environment and Climate Change Strategy*

Very few countries have a quartet of overlapping and reinforcing policy frameworks of the sort that Qatar does. Chapter 2 discusses the first three (Constitution, QNV, and NDS) in detail. A unique feature of the Qatari Constitution (adopted in 2005—the country only became independent of Britain in 1971) is its Article 33: “The State shall preserve the environment and its natural balance in order to achieve comprehensive and sustainable development for all generations.” Another notable feature of the constitution and the culture of the country

is that Islam is the official religion, and Qatar's principal (though not sole) source of law is *Shari'a* law. As Chap. 3 points out, this leads to an emphasis on stewardship rather than ownership (*khalifa*), and on fiduciary obligations (*waqf*). Further extensions of Islamic principles in Qatari law can be seen in Islamic finance and in *zakat*, or charitable giving, and both of these have been modernized to support environmental stewardship.

Most nations in the Global North have dispensed with formal vision statements or national economic and development strategies, leaving these for annual pronouncements by their presidents or prime ministers, and annual national budgets. But in the Global South, national development strategies coupled to some overarching and long-term vision are quite common. Qatar has both, and they do inform and shape national policy discussions. The QNV 2030 was announced in 2008, virtually at the beginning of the country's soaring LNG revenues and the rapid acceleration of its economic and social transformation (and just two years before being awarded the World Cup). It remains a national touchstone. As Chap. 2 explains, it has four pillars (social, human, economic and environmental), and the environmental pillar highlighted challenges specific to Qatar's ecosystem: rising sea levels, water, pollution, and environmental degradation. The pillar also projected the need for an environmentally aware population, adequate legal mechanisms, effective institutions to build awareness and stimulate green technologies, urban planning, and international cooperation. The NDS (there have been two to date, 2011–2016, 2018–2022, and a third (2023–2027) is being crafted) are detailed extensions of the QNV 2030, extending each of the four pillars into specific policy initiatives, complete with implementation strategies and Key Performance Indicators. Chapter 2 outlines the targets in the two NDS (which grew increasingly ambitious).

The fourth interlocking framework for sustainability is the National Environment and Climate Change Strategy, adopted in 2021. It identified five priorities (emissions and air quality, biodiversity, water, circular economy and waste management, and land use), and further reinforces the QNV 2030 and the NDS.

3. Sectoral Instruments

Both the international agreements and the overarching frameworks mentioned above are just that—agreements (with commitments) and frameworks. A further level of policy and legal specification is usually required through sector-specific instruments—e.g., food or transportation. In principle, those sectoral instruments will reflect and amplify the higher-level commitments enunciated in the framework documents, but institutional and collaborative challenges begin to arise the closer one gets to the ground. We will turn to these complications in a moment, but first, a partial list of some of the sectoral instruments discussed in our chapters.

- Qatar's Law No. 30 of 2002 on Environmental Protection (Chap. 3)
- The *Executive By-Law for the Environment Protection Law* contains provisions on reducing air pollution, and GHG emissions (Chap. 3)

- Executive By-Law, *Qatar’s Resolution of the Council of Ministers* establishes a Committee on Climate Change and Clean Development Mechanism (CDM) (Chap. 3)
- Global Drylands Alliance (established in 2017), is an international agency addressing food security and dryland ecosystems (Chap. 3)
- National Biodiversity Strategy and Action Plan (NBSAP) (Chap. 2)
- The Environmental Sustainability Strategy (ESS), launched by the Ministry of Municipality and Environment with the first and second NDS for the periods 2011–2016, and 2018–2022 (Chap. 2)
- Law No 19 (2004) is dedicated to conserving wildlife and natural habitats and led to the establishment of several nature reserves (Lusail Reserve in 2005; Al Mashabiya, Al Eraiq, and Al Thakhira Reserves in 2006; Khor Al Adaid Reserve in 2007; Southern Area Reserve in 2018; and Al Rafaa Reserve in 2020) (Chap. 2)
- Qatar National Food Security Strategy (2018–2023), developed after the 2017 blockade. Aimed at boosting local production through farm support programs, increasing strategic storage, as well as domestic production of vegetables, fruit and dairy products (to secure 30–70% self-sufficiency) (Chaps. 11 and 12)
- Qatar National Master Plan and Municipal Spatial Development Plans set targets for population densities across the country (Chap. 14)
- National Campaign for the Conservation and Efficient Use of Water and Electricity *Tarheed*. Launched by Kahramaa in 2012 to educate energy and water conservation, sustainability, and environmental awareness (Chaps. 11 and 16)
- District Cooling Program, aiming to reach 100% usage of non-potable water in cooling plants (Chap. 11).

By any objective standard, this is an impressive list of international commitments, national frameworks, and sectoral initiatives. And we have probably not captured them all. This illustrates our opening point in this chapter—sustainability policy is hard. It begins with pollution and environment and biodiversity, adds water and air, and as it moves to carbon and climate, begins to embrace industry, transportation, education, food and just about everything else. It’s a blend of three-ring circus and multi-dimensional chess, and immediately poses issues of coordination, collaboration, capacity, and implementation. And on top of that, sustainability is not sustainability within current energy and economic configurations—it is a transition to a post-carbon future. Not surprisingly, our chapters have noted these challenges.

19.4 Implementation and Transition

Damilola Olawuyi and Elena Athwal get to the heart of the matter in Chap. 3. They note the “rapid profusion of sustainability policies and laws in Qatar” and the “rapidly increasing volume of ongoing programs and initiatives, as well as the number of administrative and governance bodies with supervisory functions in economic,

social, and environment spheres.” However, for these to be effective there is a need “to promote greater coordination amongst the various agencies and ministries in order to enhance greater cooperation, interoperability, and resource sharing in the implementation of sustainability programs” (what they call a “nexus approach”—see Recommendations below). Marcello Contestabile (Chap. 8) makes a similar point: “It is also a complex problem of systemic nature, as moving towards a low carbon, efficient energy system means that the different parts of the energy system (buildings, transport, power and water, and industry) will become increasingly interlinked and that decisions made today will have major consequences on future systems cost and environmental performance.”

In Chap. 2, Reem Al-Hababi noted some of the problems with the NDS and the QNV, not for their ambition, but for their capacity to deliver on that ambition. The first NDS, for example, had admirable mid-term environmental sustainability targets, but by 2016 only two of them had been fully achieved. They were reduction of gas flaring in energy production (down by about 30%) and reduction in per capita domestic waste generation (down to 1.3 kilos). The second NDS reported on the shortcomings of the initial targets and admitted that there were policy planning and implementation gaps, unclear prioritization, and poor coordination at sectoral and cross-sectoral levels. Al-Hababi also notes some overlap in the responsibilities and mandates of the Climate Change and Clean Development Committee and the Climate Change Department.

Other chapters tended to agree that the apparatus of laws and policies is about as good as it gets for a full-bore national sustainability policy, but that effective implementation will be key. Chapter 16 notes that the second NDS had a target of 15% recycling of solid waste, something achievable in its view as long as the Ministry works with supporting partners. Chapter 11 described the Qatar Water Security Policy and Qatar Water Strategy, and the importance of its accompanying Implementation Plan. Sever and Tok (Chap. 17) explored the implementation of ESD (Education for Sustainable Development) and argue that it is a “complex sphere with a combination of official, top-down initiated efforts, diverging global frameworks and extracurricular school activities in the formal and non-formal forms.” That the outcomes of the Key Performance Indicators and targets have been mixed exemplifies the challenges of capacity and complementarity for coherence.

While recognizing areas in need of attention, our book also shows some encouraging successes and promising examples of collaboration and real efforts to implement for impact. Given that Qatar is effectively a city-state, with almost all of its population living in Doha, the Ministry of Municipal Affairs was a de facto ministry of environment through urban planning and transportation policy. In 2021, the ministry was reshuffled and now is named Ministry of Environment and Climate Change. In a possibly good sign, its building is literally next door to the Ministry of Foreign Affairs and may provide some measure of coordination of local, municipal, national, and international initiatives. Chapter 11 concludes that the achievements in the water sector have been “impressive” and include both growing public awareness and involvement by civil society and local communities in water conservation projects. An example mentioned in both Chaps. 11 and 16 is *Tarsheed*, run by

Kahramaa (the Qatar General Electricity and Water Corporation), which has been effective in reducing water and electricity consumption in the country. In the waste management sector, the effort to reduce landfill waste by 90% by 2022 has led the government to bring in major private sector waste management players such as the Seashore Group of companies, Dulsco Qatar, Power Waste Management and Transport Co. WLL, Green Waste Management, Al Haya Enviro. Chapter 12 provided evidence of both non-governmental organizations (NGOs) (Hifz AlNeama) and the private sector (Wahab) in supporting food security and reducing food waste. Chapters 5 and 16 explained how the Qatar Foundation both supports research around sustainability and provides a test bed for sustainable practices in Education City (indeed, Sheikha Moza, the founder and chairperson of Qatar Foundation, is a UN SDG Advocate—Chap. 17).

Sustainability transitions require a full and integrated policy framework, and their implementation is a colossal challenge (often fraught with difficult trade-offs). Qatar's efforts and commitments, as shown in this book, have been remarkable and serious. Effective implementation and coordination are works in progress, but there are bright lights and successes, and despite its environmental challenges, the country has substantial advantages it can marshal as well. More work is to be done, and we list the book's recommendations below. But we close this section with yet another somber observation. Climate change forces sustainability policy into a higher register—it cannot be sustainability for the status quo of energy sources and consumption. We cannot continue to rely on fossil fuels, and just husband them, reduce and recycle. Sustainability is not about stasis, but about transition and transformation—we must shift from fossil fuels to renewables, and with that shift will come a transformation in our economic systems, a fourth or fifth industrial revolution that will be as profound as the shift from wood and coal to petroleum.

Every country will transition (or not) in its own way. Qatar's unique context will drive a unique transition. To take just three of the unique features we cited earlier: tiny population; substantial wealth based on hydrocarbons and one industry (natural gas); a desert climate. Add to that, the economic and social transformation of the country has all happened in one generation, since about 1996 with the first shipment of LNG (Chap. 6 and 7). Even as it rapidly evolved into a "late-stage petro-developmental state" Qatar has recognized the need to diversify out of natural gas into a knowledge-based economy. The gas fields are endless, but the days of gas consumption are numbered as the world eventually shifts to renewables. Hence the emphasis on education and research (e.g., the Qatar Foundation), and the government's efforts to encourage both entrepreneurship and industries such as smart manufacturing, fintech, sports-tech, and fashion and design (Chap. 18). Winning the World Cup, and then using it as a catalyst for sustainability (the FIFA World Cup 2022 Sustainability Strategy), is an example of this strategy, since Qatar wants to become a global hub for elite sporting events, and the ancillary and supporting economic sectors they can stimulate. In this way, current sustainable practices, from soccer matches to food security, trace an arc that begins to bend to an alternate future.

19.5 Areas for Future Research Attention

This book has examined sustainability in Qatar from various angles, but some topics could not be covered. The key ones that deserve further analysis are:

- Domestic transportation: Some chapters have mentioned the recently operated public transit system, Doha Metro, as an example of major projects that were established with environmental considerations. Transportation is one of the core components that support the socioeconomic systems' interactions and development (Rodríguez, 2020). At the same time, the transportation sector contributes to environmental challenges, including “climate change, human toxicity, terrestrial acidification, and water depletion” (Al-Thawadi & Al-Ghamdi, 2019, p. 3). Transitioning to a more sustainable transportation system in Qatar—as in any other place—involves more than developing infrastructure “to provide an integrated, eco-friendly, reliable, and safe multimodal transportation system” (Al-Buenain et al., 2021, p. 620). Decarbonizing the transportation sector involves a change in society's perception of public transportation and electric vehicles, especially since private automobiles (almost all conventional gasoline) are the primary mode of transport in Qatar.
- Aviation sector: Aviation has undergone significant growth and massive infrastructural development over the past two decades. Although the carbon footprint of airline operations has been halved in comparison with those of the late 1990s, GHG emission values for airline activities are projected to increase drastically due to the expansion of the sector (Elhmod & Kutty, 2020). On the one hand, the development of the sector in Qatar—and in the region generally—has been encouraged by several factors, beginning with geographical location, low operating costs, and the large expatriate population's travel requirements. On the other, the aviation sector—namely its key actor, Qatar Airways—has been contributing to the national economy by the improved connectivity that it has been providing, connecting the local market with foreign markets, and developing tourism. Moreover, in terms of contributing to the GDP, air transport represents half of the value added to the GDP of the entire transportation and communication sector (Petcu, 2021). Given the role aviation plays in Qatar, this is a notable omission.
- International shipping and supply chains: International logistics are significant for global industries since the “mobilization of commodities across the supply chain is propelled by air, land, or sea transportation” (Al-Enazi et al., 2022, p. 2). Shipping activities (e.g. maritime shipping) are responsible for 2.1% of global GHG emissions, and this percentage is projected to rise in the next several years, considering the new trade routes and links expected to be established and the increase in trading of various commodities. The natural gas trade experienced a 1.6% of growth rate on an annual basis between 2017 and 2022, with global demand reaching 300 billion cubic meters. Around 30% of the global seaborne trade is hydrocarbons shipping activities. This is significant to Qatar's gas industry and its corresponding supply chains (Al-Enazi et al., 2022), and it is also important given Qatar's reliance on imports for key commodities, including food.

- Cooling systems: Buildings (whether residential or commercial) are responsible for the majority of energy and electricity uses and, accordingly, energy-related GHG emissions. The demand for electricity is expected to increase, especially with the population growth in developing economies that are located in hot-climate regions, such as the Arab Gulf region. In such regions, the cooling energy consumption in typical buildings is three times higher than that of similar buildings in moderate climate regions. Moreover, in hot-climate regions, space cooling loads vary based on season and time of the day, which results in straining electricity grids. These challenges and cooling requirements will be exacerbated by climate change (Eveloy & Ayou, 2019). Much work has been done in Qatar, particularly by the Qatar Green Building Council (now within Earthna), but more work needs to be done on heating and cooling demands.
- Social aspects of sustainability: The book also lacks a chapter on the implications of sustainability efforts on social aspects in Qatar, such as gender equality and topics that relate to women’s participation in the private sector workforce or science, technology, engineering and math (STEM) attainment and whether such transitions would yield an impact in this respect. Relatedly, a chapter on the implications of sustainability efforts (e.g., transitioning to smart cities, knowledge-based economy) on migration in Qatar is not included in this collection as well. The link between developing smart cities and migration trends is considered a novel research area; existing literature highlights “the relevance of planning for smart cities, city development and infrastructure projects, and the migration of educated workers” (Mouazen & Hernández-Lara, 2021, p. 123).
- Public health: The implications of environmental degradation and climate change on public health and the state’s efforts toward them are not covered in this volume. Air pollution and rising temperatures are adding to existing human health concerns and the increased frequency of certain diseases and health issues (Longlong et al., 2018; Skelhorn, 2019).
- Emergency planning: Climate change may not be gradual, but might spike, with climatic tipping points, and so there is the need for climate-related emergency planning. The tipping points might be in the form of sudden sea level rise or intense heat stress, but preparatory work needs to be done on what these could mean for Qatar.

19.6 Recommendations

The chapters in this book converge on five broad recommendations for a sustainable Qatar.

1. From a policy governance and monitoring perspective, an oversight body should be created to evaluate the development of sustainability initiatives, and provided with the assessment tools and methodologies to serve this purpose. This includes ensuring that required capacity is available across sectors to enable nexus approaches for policy coherence.

2. On implementation, areas for progress include establishing a governance approach to enhance the coordination and coherence between various stakeholders in carrying out and delivering sustainability initiatives and projects, and improving the technical and institutional capacities of relevant entities. Enhancing transparency of data will allow for the implementation gaps to be more quickly identified and addressed. This can leverage the strong research environment that has been established in Qatar.
3. Sustainability policy planning should include developing a systems perspective on sustainability, adopting an integrated approach with a mix of policy instruments, and enhancing information sharing and data availability for policymakers and relevant stakeholders. There should be active engagement of various stakeholders during policy design, and regional and international collaboration to make sure that local or national policies and actions are aligned with those at higher levels.
4. Businesses and private actors should be encouraged to integrate sustainability into their operations and value chains and to engage with civil society and NGOs in sustainability efforts. This is also the case for public sector actors, including the Ministry of Education and Higher Education, within its leadership role for the education sector.
5. Sustainability of the gas sector and the overall economy requires investments in technologies and methods to reduce emissions, increasing the share of renewables in the energy mix, and investing in new energy sectors while utilizing gas and oil revenues in diversification strategies. There are opportunities to take a global leadership role in the transition to new energies, such as hydrogen, an option for which the State of Qatar is well positioned.

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