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Review

Agri-Food Markets in Qatar: Drivers, Trends, and Policy Responses

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Abstract: Agri-food markets are vital in achieving food security, especially for resource-poor, food-importing countries such as Qatar. The paper provides an overview of the evolution of agri-food markets in Qatar and explores the implications of past and ongoing changes in terms of food security and food system sustainability. In particular, the review analyzes drivers of changes, trends, and challenges as well as policy responses to address the emerging challenges while ensuring the country's food security. It draws upon a systematic review of scholarly literature indexed in the Web of Science as well as data from gray literature (e.g., reports) and databases (e.g., FAOSTAT). Different drivers (e.g., population growth with huge expatriate inflow, urbanization, income increase) affected the functioning of agri-food markets as well as the structure of the food chain (viz. production, processing, distribution, consumption) in Qatar. In addition to drivers, the food-related trends were also shaped by numerous environmental (e.g., land/water scarcity), economic, health, and trade challenges. To ensure long-term food and nutrition security for its population, Qatar implemented various policies and strategies (e.g., National Food Security Strategy 2018–2023). In this context, agri-food markets, as functional links between production and consumption, can foster transition towards sustainable food consumption and production patterns in Qatar.

Keywords: agricultural market; food market; agriculture; Qatar; Gulf Cooperation Council; food policy; food security; nutrition; food import; climate change; environmental footprints

1. Introduction

Markets can be defined as the "collective devices that allow compromises to be reached, not only on the nature of goods to produce and distribute but also on the value to be given to them" [1] (p. 1229). However, there are different understandings of market [2]; these range from 'marketplace' (cf. concrete, empirically observable institution) to 'market logic'. For instance, Kotler [3] states that "market consists of all the potential customers sharing a particular need or want who might be willing and able to engage in exchange to satisfy their need or want." Indeed, exchange of goods and services is the main function of markets and is affected by different factors, such as context, public regulations, and cultural and civic norms [4]. Consequently, markets play a vital role in economic development [5–7]. They were also put forward as an instrument to achieve the Sustainable Development Goals (SDGs) in the context of the 2030 Agenda for Sustainable Development [8,9]. As for the agri-food sector, markets aggregate supply of agri-food products [5,10] and connect producers and consumers [11–13], thus

affecting the structure and operation of the whole food chain from production, through processing and distribution, to consumption [13] and even waste management [14,15].

Different scholars and practitioners [9,13,16–19] highlighted the role of markets in achieving the targets of SDG 2 "Zero Hunger" [8], namely food security, improved nutrition, and sustainable agriculture. However, there is an ongoing debate on the sustainability of modern agri-food markets and their contribution to sustainability transitions in agriculture and food systems [13,20–23], as well as their effects in terms of food and nutrition security [13,16–18,24–29]. Other scholars linked the development of agri-food markets to diets and dietary diversity [30–38] and 'nutrition transition' [39–46], as well as 'food environment' [47] and its impacts on overweightness/obesity [48,49] in different contexts worldwide. This debate denotes that the contribution of agri-food markets is uneven, dynamic, and highly context-specific. Its dynamicity is due, among other things, to the fact that agri-food markets have been transforming quickly over the past decades, driven by different factors [6,18,25,50–58]; Borsellino et al. [13] suggest that these drivers include "globalization, trade liberalization, population growth, urbanization, income increase, policy change, shifts in food consumption patterns and diets, technological changes, and environmental degradation" (p. 2). There are also notable differences between food importing and exporting countries, on the one hand, and developed/rich and developing/poor countries, on the other hand [17,59–63]. Agri-food markets are particularly vital in achieving food and nutrition security in resource-poor countries that depend on imports and trade to meet the food demand of their populations, such as the Near East and North African (NENA) countries. Indeed, the whole NENA region is highly dependent on food imports [64–66]. However, even within the NENA region, there are further differences between poor and unstable countries (e.g., Somalia, Yemen), middle-income countries (e.g., North Africa) and high-income countries, such as those of the Gulf Cooperation Council (GCC) (viz. Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates) [67–69].

In terms of income per capita, Qatar is the richest country in the GCC and one of the richest in the world with a GDP per capita at 115,979 USD in 2018 [70], but also one of the poorest countries in terms of natural resources (water, land, etc.) [71,72]. Qatar is a small country located in the Arabian Peninsula; it is surrounded by the Arabian Gulf, and the only terrestrial border is with Saudi Arabia. It covers an area of about 11,437 km^2 and has a population of 2.7 million [73]. The country has 13.3% of the proven world gas reserves in the world, ranking third behind Russia and Iran [74]. However, Qatar still imports about 90% of its food, which has effects on its long-term food security [67,75]. Furthermore, the geopolitical instability in the Gulf region, such as the Blockade of 2017, could threaten Qatar's food supply [69,76–79]. This makes Qatar an interesting case study to analyze the strengths and weaknesses of reliance on markets to achieve sustainable food and nutrition security.

Therefore, the present paper offers an overview of the evolution of agri-food markets in Qatar and explores whether such changes make them more resilient and sustainable. In particular, this review paper analyzes drivers of changes in agri-food markets and food consumption and production systems (Section 3), change patterns and trends (Section 4), and the challenges that they determine (Section 5), as well as policy responses to address the emerging challenges while ensuring the long-term food and nutrition security of the Qatari population (Section 6). The topics for the sections (viz. drivers, trends, challenges, policy responses) were established from the call for the special issue "Agri-food markets towards sustainable patterns: Trends, drivers, and challenges" [80] and its inaugural article [13].

2. Methods

The paper draws upon a systematic review of scholarly literature as well as data from gray literature and databases. The review of literature follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [81]. The methodology adopted is similar to that suggested by Moher et al. [81] and used by El Bilali [82,83]. In particular, a search was performed on 13 March 2020 using all databases of Clarivate Analytics—Web of Science (viz. Web of Science Core Collection, Current Contents Connect, KCI-Korean Journal Database, MEDLINE®, Russian Science Citation Index, SciELO Citation Index). The search included all of the documents that were indexed by that date, without defining any time range or excluding any document based on publication date. In the case of the main search on agri-food markets in Qatar, broader geographical areas (viz. Gulf Cooperation Council, Middle East, Near East, West Asia) were considered in order not to miss any piece of research dealing with Qatar. Indeed, the initial search on agri-food markets in Qatar was carried out using the search string *("agricultural market" OR "food market") AND (Qatar OR "Gulf Cooperation Council" OR "Gulf countries" OR "Middle East" OR "Near East" OR "West Asia")* and yielded 35 documents, but, after selection and scrutiny, none of them had appropriate results. Given that no document directly addressed agri-food markets in Qatar (articles dealt with other Middle Eastern and Gulf countries, such as Egypt, Iran, Kuwait, Lebanon, Saudi Arabia, and Turkey)—which is a clear indicator of the research gap regarding this topic in Qatar—different combinations of keywords have been used to cover all of the themes addressed in the paper (Table 1). As for the search on agriculture and agri-food in Qatar, articles dealing with agronomic research (e.g., plant protection, genetic selection) without any relation to the paper subject matter were discarded. In order to be selected, a document should deal with the specific topic and focus on Qatar (articles that deal with Qatar in addition to other GCC countries were considered).

Gray literature included reports, discussion papers, and policy briefs of different institutions, in Qatar and abroad, such as:

- Qatari ministries and public bodies (e.g., Ministry of Municipality and Environment, Ministry of Public Health, General Secretariat for Development Planning, Planning and Statistics Authority, Qatar Tourism Authority, Qatar National Human Rights Committee, General Tax Authority, Qatar National Bank);
- Research centers (e.g., Middle East Institute, National University of Singapore; Center on Governance, University of Ottawa; Royal Institute of International Affairs, Chatham House; Economist Intelligence Unit);
- Consulting firms (e.g., Alpen Capital, Future Directions International);
- International organizations e.g., the Food and Agriculture Organization of the United Nations (FAO), the International Food Policy Research Institute (IFPRI), the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD), the United Nations Conference on Trade and Development (UNCTAD), the United Nations Development Programme (UNDP), the World Bank.

Table 1. Summary of literature searches carried out on the Web of Science databases.

Search Theme	Search String	Number of Records Identified through the Search	Number of Selected Records	References of Selected Records	Main Paper Sections Where Data from the Search Were Used *
Agriculture and agri-food in Qatar	*Qatar AND (agriculture OR "agri-food" OR "agro-food" or "agrifood")*	55	36	Abu Baker et al. [84]; Ahmed and Al-Hajri [85]; Aktas et al. [86]; Al-Ansari et al. [87]; Al-Ansari et al. [88]; Alsheyab and Kusch-Brandt [89]; Al-Thani and Yasseen [90]; Blattner [91]; Dare and Mohtar [92]; Dare et al. [93]; Darwish and Mohtar [94]; Darwish et al. [95]; Darwish et al. [96]; Das et al. [97]; Elobeid et al. [98]; Eltai et al. [99]; Ganji et al. [100]; Govindan and Al-Ansari [101]; Grichting [102]; Grichting et al. [103]; Hussain et al. [104]; Issaka et al. [105]; Jaafar et al. [106]; Jasim et al. [107]; Lang and Mason [108]; Latif et al. [109]; Manawi et al. [110]; Mohammed and Darwish [111]; Mubarak [112]; Pirani and Arafat [113]; Rehrah et al. [114]; Shomar et al. [115]; Sippel [116]; Streetly and Kotoub [117]; Woertz [118]; Woldesellasse et al. [119]	3. Drivers 4. Trends 5. Challenges 6. Policy responses
Climate change in Qatar	*Qatar AND "climate change"*	69	27	Ahmadi et al. [120]; Ahmed and Nasrabadi [121]; Al Mamoon et al. [122]; Al Mamoon and Rahman [123]; Al-Ansari et al. [124]; AlSarmi and Washington [125]; AlSarmi and Washington [126]; Alsheyab [127]; Cheng et al. [128]; Doukas et al. [129]; El Shaer [72]; Freeman [130]; Hameed et al. [131]; Makido et al. [132]; Mamoon et al. [133]; Olabemiwo et al. [134]; Patlitzianas et al. [135]; Pilcher et al. [136]; PourMirza [137]; Qader [138]; Rafiee et al. [139]; Reiche [140]; Riegl and Purkis [141]; Shirkhani et al. [142]; Wabnitz et al. [143]; Wei et al. [144]; Zhang et al. [145]	3. Drivers
Food security and nutrition in Qatar	*Qatar AND ("food security" OR nutrition OR diet)*	21	11	Al-Ansari et al. [88]; Al-Ansari et al. [87]; Al Thani et al. [146]; Blattner [91]; Darwish et al. [95]; Darwish and Mohtar [94]; Darwish et al. [96]; Limam Mansar et al. [147]; Mohammed and Darwish [111]; Pirani and Arafat [113]; Woertz [118]	4. Trends 5. Challenges
Environmental footprints in Qatar	*Qatar AND footprint*	26	16	Al-Ansari et al. [148]; Al-Ansari et al. [124]; Alhaj et al. [149]; Al-Yaeeshi et al. [150]; Charfeddine [151]; Cosgrove [152]; Darwish et al. [153]; De Jong et al. [154]; Jaafar et al. [106]; Mohammed and Darwish [111]; Mourad et al. [155]; Mrabet and Alsamara [156]; Mrabet et al. [157]; Saboori et al. [158]; Sakhel et al. [159]; Woldesellasse et al. [119]	5. Challenges
Qatar and agri-food trade	*Qatar AND food and (import OR export OR trade)*	32	6	Blattner [91]; Elobeid et al. [98]; Latif et al. [109]; Mohammed and Darwish [111]; Pirani and Arafat [113]; Woertz [118]	4. Trends 6. Policy responses
Food waste in Qatar	*Qatar AND ("food waste" or "food wastage")*	9	8	Abdelaal et al. [160]; Aktas et al. [86]; Bennbaia et al. [161]; Bennbaia et al. [162]; Elkhalifa et al. [163]; Irani et al. [164]; Mustafa [75]; Seed [165]	5. Challenges
Agriculture and food policies in Qatar	*Qatar AND (policy OR strategy OR law) AND (agriculture OR food)*	57	21	Aktas et al. [86]; Al-Abdulrazzak et al. [166]; Al-Kandari and Jukes [167]; Balkhy et al. [168]; Blattner [91]; Coats et al. [169]; Donnelly et al. [170]; Hameed et al. [131]; Hussain et al. [104]; Irani et al. [164]; Lang and Mason [108]; Mohammed and Darwish [111]; Moussa [171]; Mubarak [112]; Mustafa [75]; Nasreddine et al. [172]; Samara et al. [173]; Seed [165]; Shomar et al. [115]; Sippel [116]; Woertz [118]	6. Policy responses

* This indicates only the main sections where the bulk of data was used, while data for each search were used throughout the whole paper.

Furthermore, data for the present review were also retrieved from different databases, e.g., FAOSTAT [174], World Bank Open Data [175], the Statistical Center for the Cooperation Council for the Arab Countries of the Gulf (GCC-STAT) [176].

3. Drivers

The Qatari population has grown quickly. Indeed, from 2000 to February 2020, the population rose from 613,969 to 2,782,106 [177]. Moreover, 70% of the population is in the working-age group of 25–54 years (median age: 30). The government's economic diversification efforts, in line with the preparations of the FIFA 2022 World Cup (21 November–18 December 2022) and Qatar National Vision 2030, have attracted massive expatriate inflow to Qatar [178]. From 2013 to 2018, the population of Qatar grew at a compound annual growth rate (CAGR) of 6.3%, the highest rate in the GCC region (Figure 1).

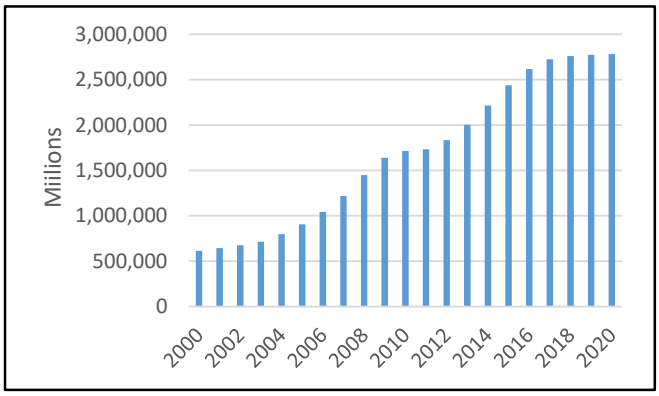

Figure 1. Population growth in Qatar between 2000 and 2020. Source: Authors' elaboration based on data from the Planning and Statistics Authority [177,179].

Qatar has an urbanization rate (99.1%) that is among the highest in the world, and the rural population represents only 0.9% [174]. About 85% of the Qatari population are expatriates (mostly from other Arab countries, India, Nepal, the Philippines, and Bangladesh), and the share of Qatari citizens in the labor force remains low at 6%. The influx of expatriate workers is likely to continue until the 2022 FIFA World Cup infrastructure projects are finalized [180]. Furthermore, vast gas reserves, associated with a modest national population, have made Qatar one of the richest countries in the world, with a GDP per capita based on purchasing power parity (PPP) of 126,898 USD in 2018 [70]. From 2000 to 2018, the GDP per capita (PPP) increased by 47%, from 86,168 to 126,898 USD (Figure 2).

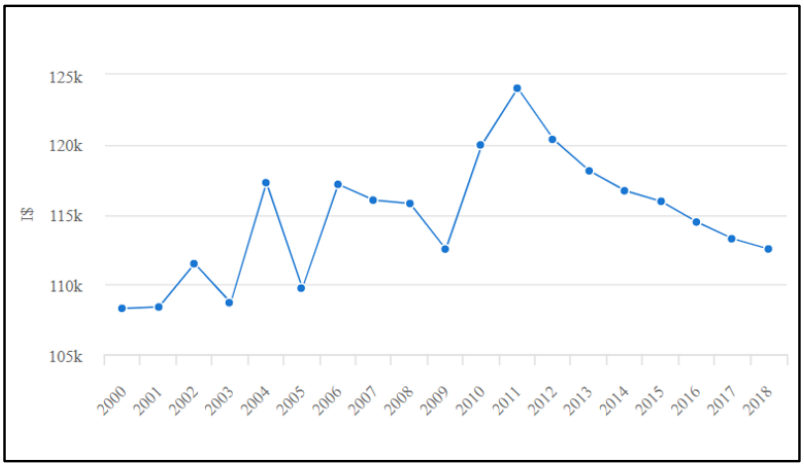

Figure 2. Evolution of the GDP per capita (purchasing power parity (PPP)) from 2000 to 2018 in Qatar (constant 2011 international $). Source: FAO [174].

All Qatari citizens enjoy a good standard of living and strong purchasing power, coupled with a record average salary and an unemployment rate of almost zero (close to 0.1% in 2017) [73]. In addition, Qatari citizens receive extensive economic benefits from the state without paying taxes [181]. Between 2011 and 2017, the economy has grown by a cumulative 22% [182], and Qatar has one of the fastest rates of growth, driven by increasing hydrocarbon prices and the distribution of the resultant surplus into other sectors, such as real estate, education, and health and sport infrastructures [183]. Economic performance improved in 2019. Qatar's economy has efficaciously absorbed the shocks from the 2014–2016 drop in oil prices and the 2017 Blockade. Real GDP growth is estimated at 2.6%, up from 2.2% in 2018 [184]. During 2018–2023, per capita income and real GDP are likely to increase at a compound annual growth rate (CAGR) of 3.5% and 2.8%, respectively [178].

The growth of the population and improvement of living standards increased the consumption of resources, such as water (mainly desalted seawater) and energy [94]. Urbanization and population growth are driving not only the transformation of agri-food systems, but also that of the natural environment in Qatar. Indeed, "rapid urbanization which is not integrated with ecological landscape design is contributing to urban sprawl, fragmented landscapes, and to the loss of biodiversity" (p. 21) [102].

The growth of the Qatari economy and the increase of the country's population determined an increase in waste generation and pollutant emissions. Indeed, Rehrah et al. [114] stated that the "Qatar economy has been growing rapidly during the last two decades, during which waste generation and greenhouse gas emissions increased exponentially, making them among the main environmental challenges facing the country" (p. 1093). As highlighted by the Planning and Statistics Authority [180] "The increase in the number of vehicles and construction equipment required for the growing population is also causing more greenhouse gas emissions and air pollution, as well as bigger amounts of construction and domestic waste" (p. 21). Indeed, waste in Qatar is one of the main environmental challenges due to the growing rate of generation. The generation rate of household solid waste is estimated at 1.6 kg/capita/day in Qatar. Domestic solid waste in Qatar is the second largest cause of waste after construction [180]. Domestic waste in Qatar contains mainly organic materials (57%), and also recyclable materials, such as plastics, glass, and papers [185]. It is estimated that the volume of waste will gradually grow until 2020, and then drop slightly with the probable decline in population [180].

Due to the lack of awareness among Qataris about the recovery of material as well as the lack of government initiatives, households waste is not source-segregated. Recyclable materials are mixed with organic waste, which results in a very low recovery rate [185]. To remedy the situation, the Qatari government is making significant efforts to reduce domestic solid waste and increase the waste recycling rate. Different waste management strategies, such as production of biochar [114] or compost from organic waste [161], have been proposed. One of the most encouraging developments has been the creation of the Domestic Solid Waste Management Center (DSWMC) at Mesaieed (about 36 km south of Doha) in 2011, which is considered as the first integrated solid waste facility in the Middle East. The facility is designed to generate energy from waste by installing advanced technologies for separation, mechanical and organic recycling, and waste-to-energy and composting technologies, with less than 5% of the materials entering the facility diverted to a landfill. The center is expected to generate a surplus of 34.4 MW to the national grid [186]. In 2018, the DSWMC was generating nearly 100 metric tons of recycled manure and compost for agriculture daily [187]. In addition, Qatar adopted several construction specifications that include recycled materials [180].

Nowadays, climate change represents one of the most important challenges facing agriculture [188–192] and, consequently, food and nutrition security [190,193–195]. The effects of climate change are expected to be particularly severe in the NENA region [196,197] in general and in the Middle East and GCC in particular [198]. Different studies indicate that Qatar is, and will be, affected by climate change [72,120,123,125,126,128,130,131,142,143,145]. Climate change will determine an increase of temperatures [125,126,128,132,145] as well as changes in rainfall patterns [122,123,125,126,133,145].

Indeed, focusing on the coastal region of Qatar (cf. Doha) over a 30 year period (1983–2012), Cheng et al. [128] show that "warming trends were represented by an increase in the number of warm days and nights and a decrease in the number of cool nights and days" (p. 193) and argue that "the rapid economic expansion, increase of population since the 1990s, and urban effects in the region are thought to have intensified the rapidly warming climate pattern observed in Doha since the turn of the century" (p. 193). According to the Planning and Statistics Authority [180], in Qatar, the average annual temperature rose by 0.3 °C over the past 40 years. This rise is expected to increase by 1.5–3 °C by 2050 and by 2.3–5.9 °C by 2100, which will cause several negative effects. Other studies show the contribution of Qatar to greenhouse gas (GHG) emissions [121,134,137,138,140,152,199], and thus climate change. Indeed, the per capita environmental footprint is exceptionally high in GCC, especially in terms of energy consumption and CO_2 emissions (cf. carbon footprint) [152], and Qatar has one of the highest per capita CO_2 emissions worldwide [134,138,199] (Table 2). Nevertheless, "the GCC countries have recently adopted a more pro-active approach toward ecological modernization" (p. 2395) [140], and Qatar has been deploying many efforts in carbon capture and storage to mitigate its CO_2 emissions [121,127,139,150,154] and in promoting the use of renewable energies [129,135].

Table 2. CO_2 emissions in Gulf Cooperation Council (GCC) countries (2014).

	CO_2 Emissions per Capita (Tons)	**World Ranking**
Qatar	43.9	1
Kuwait	25.8	4
Bahrain	23.5	5
UAE	22.9	6
Saudi Arabia	19.4	9
Oman	15.2	15

Source: World Bank [175].

It is argued that climate change will affect all of the components of the Food–Energy–Water (FEW) security through multifaceted impacts on drivers of FEW systems that include "water security, extreme events, economic growth, urbanization, population growth, poverty, and political stability" [131]. Moreover, it has been assumed that climate affected marine biodiversity [136,141,143,144] and fisheries in the Arabian Gulf [143]; as for fisheries, among GCC countries, "Qatar and the UAE were particularly affected, with more than a 26% drop in future fish catch potential" [143]. These impacts on fisheries are due to climate-change-induced environmental changes, such as sea level rise, warming, and shifts in salinity and oxygen [143]. Qatar is also highly vulnerable to sea level rise. A rise of less than five meters will put 18.2% of Qatar underwater by the end of the century. This will have damaging repercussions on life and livelihoods, since most of the population lives in coastal areas, mostly in the capital, Doha [180].

4. Trends

Since the 1970s, Qatar has depended greatly on food imports to sustain its growing and more affluent population. Thanks to its vigorous financial position, Qatar—like the other GCC countries—was rather successful in bridging the shortfall in domestic agricultural production [76] and became more resilient to food price spikes and volatility than many other food-importing countries [69]. For that, in the Global Food Security Index (GFSI) 2019, Qatar ranked 1st in the Arab world and 13th globally (Table 3).

Table 3. Ranking of Qatar and the countries of the GCC in the Global Food Security Index (GFSI) 2019.

Country	Global Rank	Rank in the Arab world
Qatar	13	1
UAE	21	2
Kuwait	27	3
Saudi Arabia	30	4
Oman	46	5
Bahrain	50	6

Source: The Economist Intelligence Unit [200].

In addition, Qatar ranked high in terms of food affordability, food availability, and food quality and safety [200]. GCC countries generally have high scores for food availability, which is based on the dietary food supply [69].

At the level of the retail market, according to Seyfert et al. [201], Qatar, like the NENA region, has witnessed changes in the retail food procurement sector, called the "supermarket transition", with the rise of supermarkets. In Qatar, supermarkets account for the vast majority of retail sales (Table 4), and the sector is currently expanding. The government is determined to develop the retail landscape to meet the growing demand of the population's high level of personal consumption.

Table 4. Main players in food distribution in Qatar.

	Year	Number of Stores
Al-Meera	2005	52 supermarkets
Carrefour	1999	5 hypermarkets and 5 supermarkets
LuLu Hypermarket	-	11
Family Food Centre	1978	5 large retail stores
Mega Mart	-	5
Monoprix	2018	5

Sources: Authors' elaboration based on data from Al-Meera [202], Carrefour [203], Family Food Centre [204], and LuLu Hypermarket [205].

These organized retailers act primarily as 'one-stop shops', offer an extensive range of products, and not only increase the changing needs of consumers, but also meet the emergent preference for international trademarks [206].

Food markets in Qatar as well as in other NENA countries have been affected and largely shaped by international trade rules (cf. World Trade Organization—WTO) regarding Technical Barriers to Trade (TBT) and Sanitary and Phytosanitary Measures (SPS) as well as different certification schemes, such as Halal food certification [207]. The trend is towards increased and wider use of food safety and quality certification schemes in the Qatari food market. Indeed, increasing attention is paid to the safety of agri-food products imported into Qatar [98,167,208–214]. For instance, Elobeid et al. [98] determined cadmium, arsenic, and lead contents in imported rice and found that the "arsenic content is approximately 5.5 times higher than the maximum allowable concentration" (p. 99), which represents a source of concern, given the adverse effects of heavy metal on health. There are also growing concerns about antibiotic resistance (AR) [99,168] especially regarding the breeding of some animals, such as chickens [99]. Indeed, Eltai et al. [99] argue that "the uncontrolled use of antibiotics in food-producing animals is a major factor in the generation and spread of AR" (p. 302), and pathogens carrying AR can be transmitted to humans through consumption of food or noncompliance with hygiene standards. In this context, it is important to also consider the attitudes of Gulf consumers towards genetically modified foods [215].

Food security is still, and will likely continue to be, an issue for the GCC countries in general and Qatar in particular. In this respect, Latif et al. [109] argue that "despite the steady growth of the economic indicators of the Gulf countries (GDP growth rates of the GCC countries are higher than the world average) and tremendous success in strengthening positions in the world economy, the problem of food security in the region is quite acute. Actually, these countries focused on what they consume and will continue to do so, since local production of most of the food they need is not viable" (p. 9). Likewise, Pirani and Arafat [113] highlight that food security is a critical issue in the GCC countries, as "these countries import most of what they consume and will continue to do so, since locally producing the majority of food needed is not a viable option" (p. 1). Moreover, they argue that the development of tourism also contributes to the increase in food imports. Indeed, there is an increasing reliance of Qatar on food imports to meet the growing needs of its population. Referring to GCC countries, Todd [209] highlights that "much food today is imported to satisfy the requirements of expanding populations, especially foreign workers on temporary visas who make up more than half the residents in many of these Gulf States" (p. 341). Qatar remains a net food importer, particularly regarding cereals (e.g., wheat, rice), which represent the main staple foods (Figure 3).

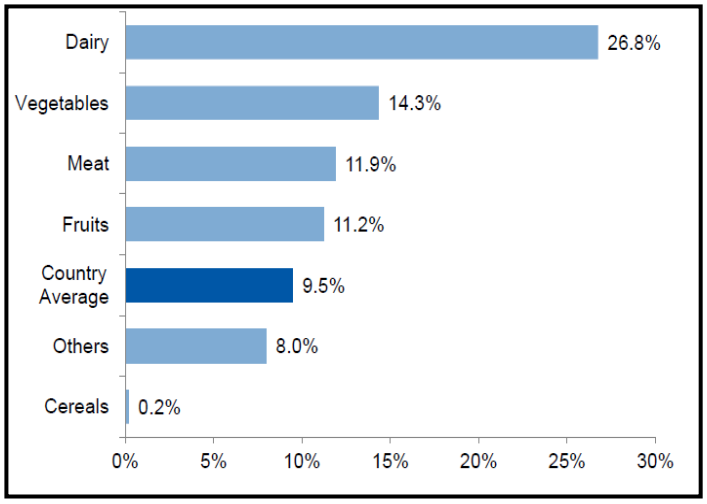

Figure 3. Food self-sufficiency ratio in Qatar in 2016. Source: Alpen Capital [178].

The heavy reliance of Qatar on food imports makes it vulnerable to supply shocks (related to import disruption) and food price fluctuations as well as trade restrictions, as demonstrated by the 2007/2008 global food crisis and the blockade of 2017 (by Saudi Arabia, UAE, Bahrain, and Egypt). Qatar cannot control food availability in cases of political, sanitary, or disease-related shocks in food-producing countries, or disruptions to its supply chain [76]. Furthermore, as a small country, Qatar has relatively limited bargaining power in international food markets, especially after the blockade [216]. As highlighted by Efron et al. [69], "potentially more critical to GCC food security is availability risk, which arises when an import-dependent country is not able to obtain food, even if it has sufficient funds to purchase it" (p. 11).

Additionally, Kaitibie et al. [217] highlighted that from 2004 to 2014, in Qatar, there was an important concentration at the import market, with large amounts of numerous food items coming from a small number of trade partners. This makes it difficult to implement a reliable food security plan with food imports as one of its main pillars. Prior to the blockade of 2017, 27.4% of Qatar's food imports came from Saudi Arabia and the UAE. In the meantime, 80% of Qatar's food imports passed through a bordering country: 40% pass through Saudi Arabia and 60% of dairy products come from Saudi Arabia and the UAE (Figure 4).

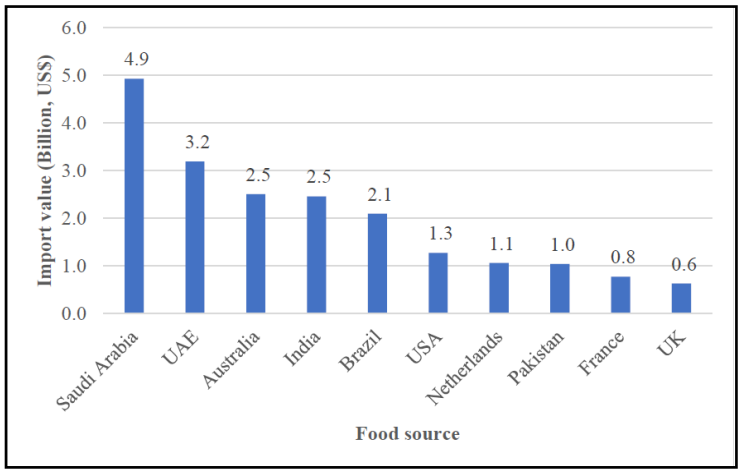

Figure 4. Top 10 food import sources for Qatar (1998–2017). Source: Miniaoui et al. [78].

Moreover, as for the whole GCC region, the future of Qatar's food supply is challenged by several factors [67]. Firstly, since climate change could profoundly affect agriculture production through yield reductions [218], agricultural commodity prices are expected to remain volatile for the near future, which could result in export restrictions and speculation [219,220]. Secondly, despite the recent decline in food prices, numerous structural factors influencing rising and volatile prices—such as population growth, the rise in income, and demand for biofuels—seem to persist. International markets are expected to remain tight and thin as production growth lags behind demand and stock-to-use ratios struggle to recover, leaving global supply vulnerable [221]. For example, the FAO Food Price Index (FFPI) averaged 180.5 points in February 2020, down 1.9 points (1.0 percent) from January, but still 13.5 points (8.1 percent) higher than in February 2019. The slight decline in February 2020 is the first month-on-month decline in the value of the FFPI following four months of successive increases [222].

Furthermore, Qatar's food consumption is expected to grow at an annualized rate of 2.3%, from 1.7 million MT in 2018 to 1.9 million MT in 2023 [178], boosted by three major factors: Population growth with an increasing number of expatriates, high and increasing disposable income (highest in the GCC region), and a growing influx of tourists [39,43]. Meanwhile, the food and beverage sector demand is expected to grow in line with the population growth rate (1.7%) to reach approximately 2.93 billion USD by 2022 [182]. The upcoming 2022 FIFA World Cup is expected to attract 3.1 million tourists for the 28 day sporting event, and bring a one-time boost of 1.7 billion USD to Qatar's food and beverage sector [183]. The number is quite high when compared to the 2.3 million tourist arrivals in 2017 [44]. In addition, the Qatar National Tourism Sector Strategy 2030 (QNTSS) aims to boost the number of international tourist arrivals to Qatar to around 7 million visitors in 2030, up from 1.2 million visitors in 2012 [223].

5. Challenges

Population growth, urbanization, and economic growth increase pressure on the scarce natural resources in Qatar. Shomar et al. [115] stated that "increasing population growth coupled with tremendous urbanization and industrialization add more stress to the existing renewable water resources, and newly produced water, namely desalted seawater and treated wastewater" (p. 2781). Darwish et al. [95] nicely summarize the dichotomy between economic development and natural resource poverty (e.g., water and land) in Qatar; they put that "Qatar's significant wealth in natural gas and oil brings the country to the highest income per capita worldwide. The drastic economic and social development gained by these revenues modernizes the country's infrastructure and improves the population's living standards in all aspects ... Meanwhile, Qatar faces real challenges due to very limited natural freshwater resources. Water scarcity creates water and food security problems" (p. 18639). Likewise, Darwish et al. [96] argue that "the significant wealth in natural gas and oil makes

Qatar the country of the highest income per capita in the world. Meanwhile, Qatar is among the world's poorest countries in natural freshwater resources" (p. 2302). Darwish and Mohtar [94] stress that the natural renewable water resources (71 m^3/capita/year in 2005) are far below the water poverty line (viz. 1000 m^3/capita/year).

Agriculture in Qatar is constrained, among others, by the scarcity of water resources [85,94–96,112,115,117,149,224] coupled with high evapotranspiration [105]. Shomar et al. [115] argue that "Qatar's average annual evaporation rate is 30 times more than precipitation, and the country depends on desalinated water to meet 99% of its municipal water needs" (p. 2781). Darwish et al. [96] affirm that "water scarcity is the main obstacle to achieving the food self-sufficiency" (p. 2302). Despite its low contribution to GDP and domestic food consumption, agriculture is by far the main driver of the depletion of water resources in the country [94,117,119,149], where annual freshwater extraction from aquifers is about four times the natural recharge rate [119]. Indeed, the agricultural sector consumes about 91% of all renewable freshwater resources in the country [149]. Qatar relies on water desalinization and groundwater to meet its water demand [104,149,225] (Figure 5).

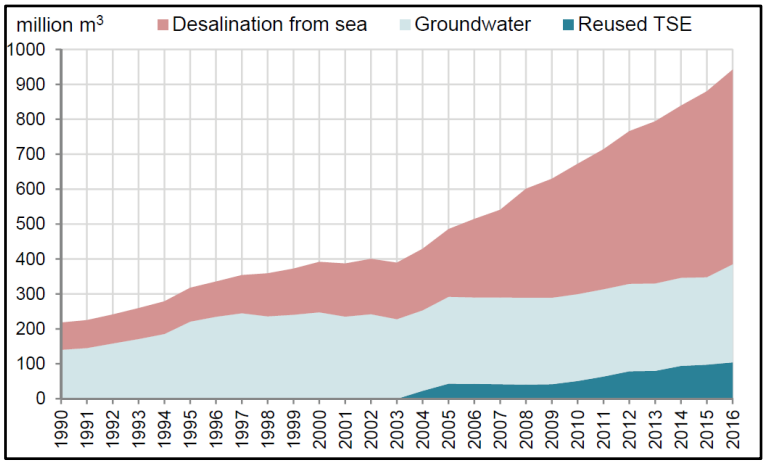

Figure 5. Qatar's water supply mix from 1990 to 2016. TSE: Treated Sewage Effluent. Source: Planning and Statistics Authority [226].

Water desalination plants have many footprints on the marine environment, which include "impingement and entrainment of marine organisms at the intake, higher temperatures and salinity, as well as chemical pollution at the outfall" (p. 113) [153]. Manawi et al. [110] suggest that "in Qatar, many freshwater resources have already been depleted due to the overconsumption as a result of the population and economic growth" (p. 1). Darwish et al. [95] point out that "agriculture in Qatar depends mainly on groundwater, which is over-exploited, depleted, quality deteriorated, and becoming less suitable for agriculture" (p. 18639). Furthermore, the dumping of untreated sewage effluents (cf. septic lagoons) contaminates groundwater resources and worsens the country's water status [110]. In order to address the challenge of water scarcity, many experts put forward the use of novel water sources, such as treated wastewater [85,89,92–94,96,104,107,110]. Non-conventional water resources (viz. greywater, saline water, wastewater) can be used, after proper treatment, for agriculture as well as for the restoration of marginal and degraded lands (cf. forestry, agro-forestry, landscaping) [85,89,95,104]. However, the use of treated wastewater in agriculture (Figure 6) is hindered by the negative attitude of farmers, as most of them view wastewater as unsafe [92]. In fact, Dare et al. [93] note that "in Qatar, despite massive investments in producing high-quality treated wastewater using advanced treatment technologies, there is little demand" (p. 1563). Different religious, social, and cultural factors limit the use of treated wastewater in the country [115].

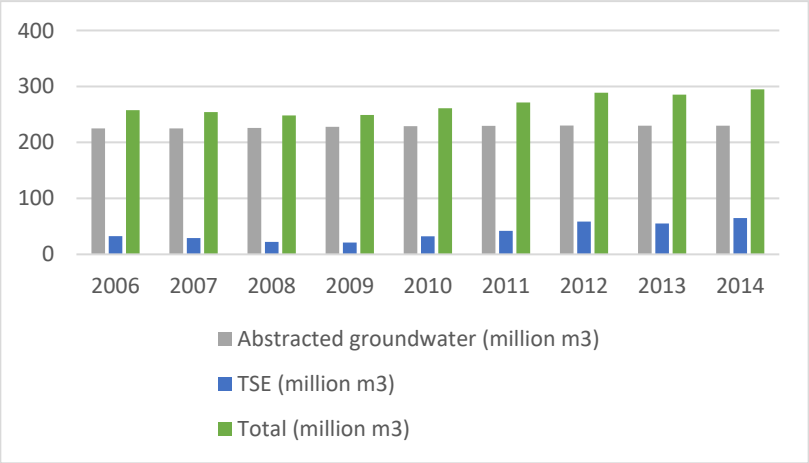

Figure 6. Water used in Qatari agriculture by source: Groundwater and treated sewage effluent (TSE). Source: Authors' elaboration based on data from the Planning and Statistics Authority [226].

Moreover, as Alsheyab and Kusch-Brandt [89] argue, combining "wastewater treatment with advanced resource recovery (water, energy, nitrogen, phosphorous, added value products) [...] can turn wastewater management from a major cost into a source of profit." Strategies for treating non-conventional water include "desalination, wastewater treatment, reuse of agricultural drainage water, groundwater extraction, and rainwater collection" (p. 462) [104]. To remove pollutants from wastewater, different methods of phytoremediation have also been suggested, including the use of native Qatari plants [90]. Another strategy for the efficient use of water resources is that of rainwater harvesting through different structures, such as 'Doha model percolation tanks' [227].

The water footprint (WF) of consumption is high in NENA countries, and a large share of it is due to the consumption of animal-based products [106,155]. Alhaj et al. [149] suggest that water consumption rate in Qatar is 200 m^3/capita/year, while the water footprint is 1554 m^3/capita/year. Different factors explain the high water consumption in Qatar; Shomar et al. [115] assume that "absence of water tariff and a water pricing system along with a lack of conservation awareness places Qatar as one of the highest water-consuming countries in the world" (p. 2781). As the NENA region highly relies on imports, most of the water footprint relating to animal-product consumption is virtual, i.e., water embodied in imported agri-food products. Indeed, Jaafar et al. [106] show that "the MENA region consumes more than 80 billion m^3 of water every year for animal consumption, most of which is imported." In this respect, Mohammed and Darwish [111] highlight the strong relationship between virtual water and food-water security in Qatar. Indeed, in their analysis of WF and virtual water in Qatar, they found that 24,470 Mm^3 (i.e., 1360 Mm^3/year) of water were traded between 1998 and 2015; green water represented 69% of the total virtual water imports, while blue water accounted for 31%. Alhaj et al. [149] found that "Qatar is a net virtual water importer and imports an average of 1.35 billion m^3/year of virtual water" (p. 70). Mohammed and Darwish [111] add that "on average, 70% of the total water requirement is from virtual water import, and Qatar's dependence on virtual water for agricultural products increased to 90% in 2015" (p. 117). Virtual water imported to Qatar came from different river basins in Australia, India, and Pakistan, as well as Saudi groundwater aquifers. Meanwhile, increasing local food production requires an important surge in water and energy resources as well as intensive land use [228].

Furthermore, the NENA region is characterized by degraded, fragile, and limited arable lands [72]. In Qatar, most of the soils are unfertile and arid. They contain low nutrients, and are salty and poor in organic elements [229]. Consequently, only 2.4% of Qatar's total area is suitable for agriculture. However, in 2017, only 17.8% of the land suitable for agriculture was cultivated (Table 5).

Table 5. Cultivated land area in Qatar (2010–2017).

	2010	2011	2012	2013	2014	2015	2016	2017
Cultivated Land Area	16.20%	13.90%	16.20%	19.40%	17.30%	18.20%	17%	17.80%

Source: Planning and Statistics Authority [226].

Considering the scarcity of arable land, Qatar has been experimenting with strategies to cultivate marginal lands. For instance, halotolerant pants (e.g., *Tetraselmis* sp.) offered promising results when cultivated in saline desert soils in Qatar [97]. However, it is also important to consider that alteration and degradation of natural environments, determined by the intensification of agriculture and other land uses, can have far-reaching consequences on biodiversity, especially that of vertebrate populations such as birds. Indeed, Abu Baker et al. [84] stated that the "transformation from dry lands to 'islands of fertility' is often extreme" in the Middle East countries, which affects spatial organization and movement patterns of animals. More sustainable forms of agriculture, such as permaculture [102], can help in combining the imperatives of food security and environmental protection in Qatar. Similarly, there is a need for innovative approaches to create an enabling food environment, thus ensuring food access in Qatari cities, such as 'Food Urbanism', 'Edible landscapes' [102], and 'productive landscapes' [103].

Despite the scarcity of arable land, the ecological footprint (EF) of Qatar is among the highest in the world. Indeed, the development of the country increased its EF. Mrabet et al. [157] argue that income and oil prices significantly increase EF in Qatar. Charfeddine [151] show that, on the one hand, urbanization and trade openness worsen EF and, on the other hand, financial development and electricity consumption are positively associated with EF.

Given the numerous interrelations and interdependencies between resources, more attention also is devoted to the energy, water, and food (EWF) nexus in Qatar [87,88,95,101,124,148,230]. Indeed, the EWF nexus framework is proposed for the assessment of synergies and trade-offs between the three sectors [87,88,101,124,131]. As highlighted by Efron et al. [69], despite poor levels of renewable fresh water, GCC countries are able to make potable water available by desalinating sea water using their energy resources. For instance, Darwish et al. [96] underline the "possibility of using Qatar's abundant energy to generate desalted seawater or wastewater treatment for agriculture purposes" (p. 2302). Al-Ansari et al. [88] show, through the use of an EWF nexus system, that the food system is the largest contributor to global warming. For the nexus system analyzed, it was demonstrated that the global warming potential (GWP) can be decreased by up to 30% by using solar energy to replace fossil fuels, which, however, comes with a substantial requirement for land investment.

The current consumption is not sustainable, and the low cost of water and energy in Qatar seems to be among the largest difficulties in conserving the scarce resources [231]. The scarcity and low efficiency of the use of natural resources are exacerbated by food losses and waste. Food waste is also a serious issue in the NENA region [64,232–237]. In fact, food wastage is high in the NENA region [64,234–236,238] and exacerbates water scarcity and environmental footprints of food consumption while increasing food import dependency [65,66,234,238]. Bennbaia et al. [161,162] suggest that "Qatar is one of the top 10 countries in the world in terms of per capita food waste, which ranges from 584 to 657 kilograms per year" (p. 2495). Nevertheless, there are different food waste recovery strategies, ranging from food waste prevention [86,160,164,165] to food surplus redistribution [164] and food waste reuse (e.g., compost, energy) [161–164]. Indeed, food waste represents a promising source to produce different fuels and chemicals. For instance, Elkhalifa et al. [163] investigate the pyrolysis of food waste for the production of biochar in the Qatari context and add that "the produced chars can be utilized in carbon sequestration when applied as soil amendment and as precursors for higher value-added products, such as adsorbents" (p. 901). Al-Maaded et al. [239] state that 57% of municipal solid waste (MSW) in Qatar is organic, hence compostable. Bennbaia et al. [161] argue that "the use of recycled food waste as compost improves the soil health and structure, increases drought resistance, and reduces the need for supplemental water, fertilizers, and pesticides" (p. 1340). Meanwhile,

Rehrah et al. [114] suggest that "production of biochar from municipal solid organic wastes (SOWs) for soil application may offer a sustainable waste management strategy while improving crop productivity and sequestering carbon" (p. 1093). Therefore, application of biochar to agricultural soils could help in mitigating anthropogenic GHG emissions [114].

In a context of high reliance on food imports, all events that affect trade represent a serious challenge for Qatar and its capacity to ensure access to sufficient, nutritious, and safe food on a regular basis for all of its population. This high food import dependency makes GCC countries susceptible to price and supply shocks [75]. According to Rowell et al. [211], imports also make Qatar susceptible to compromises of food safety and quality in the global market.

Qatar, as well as other GCC countries, faces several food- and nutrition-related challenges [171–173]. According to Seyfert et al. [201], a number of developing countries, such as those in the NENA region, have witnessed a 'nutrition transition', with a shift from traditional diets, based on foods high in fiber, such as cereals and legumes, to modern and western diets, with foods rich in saturated fats, sugar, and processed foods, and low in fiber. Subsequently, Coats et al. [169] point out that the "Arabic-speaking region is experiencing a dual burden of undernutrition and increasing rates of overweightness and obesity" (p. 1129). Sedentary and physically inactive lifestyles, bad food habits, and dietary choices have led to a higher prevalence of diabetes, cardiovascular disease, and obesity in the GCC population [206]. In particular, obesity is a big challenge for GCC countries [172,173,240] that have "alarming obesity rates that are on the rise and keep increasing" [173]. Indeed, Qatar has numerous health challenges, such as overweightness, obesity, and chronic diseases. Obesity is often associated with unhealthy diets and lifestyles with low levels of physical activity (Table 6). At the same time, the prevalence of obesity in the adult population has increased since 2000 [241].

Table 6. Main health challenges in Qatar in 2018.

Challenges	Statistics
Overweight and obesity	• 70.1% of Qatari adults are overweight • 68.3% of Qatari women are overweight (BMI ≥25 kg/m^2) and 43.2% are obese (BMI ≥30 kg/m^2) • 18.8% of Qatari boys and 15.5% of Qatari girls less than 20 years of age are obese
Chronic diseases	• 69% of mortalities occur from chronic conditions, particularly cardiovascular diseases (24%), cancer (18%), and diabetes (7%)
Low levels of physical activity	• 43.9% of Qatari adults have low levels of physical activity • 82.7% of women report not engaging in any vigorous activity

Source: Ministry of Public Health [241].

Limam Mansar et al. [147] argue that the increase of obesity rate in Qatar "[. . .] can be attributed to several reasons, including sedentary lifestyles imposed by a harsh climate and the introduction of Western fast food" (p. 658149). Elobeid and Hassan [242] highlighted that even the traditional Qatari cuisine includes ingredients that are risk factors for obesity, such as high-fat ingredients (e.g., fatty meats) and refined carbohydrates (e.g., polished rice). Later, the appearance of fast-food chains in Qatar has led to the dissemination of unhealthy eating habits. Donnelly et al. [170] point out that "physical inactivity and unhealthy diets increase the risk for diabetes, cardiovascular diseases, and cancer" (p. 1) and show, through a cross-sectional community-based survey, that "participants exhibited insufficient physical activity and poor dietary habits" (p. 1), thus highlighting the need for a nationwide program to promote a healthier lifestyle in Qatar. Indeed, many studies underline unhealthy dietary habits among Qataris [170,240,243–245]. Nasreddine et al. [172] highlight the double burden of malnutrition (under- and over-nutrition) in the region, and call for prioritizing policies that aim at improving the nutritional status of the population. Good nutrition also implies addressing micronutrient deficiencies.

These include deficiencies of vitamins, such as Vitamin D, especially among vulnerable groups, such as women [100] and children (Figure 7).

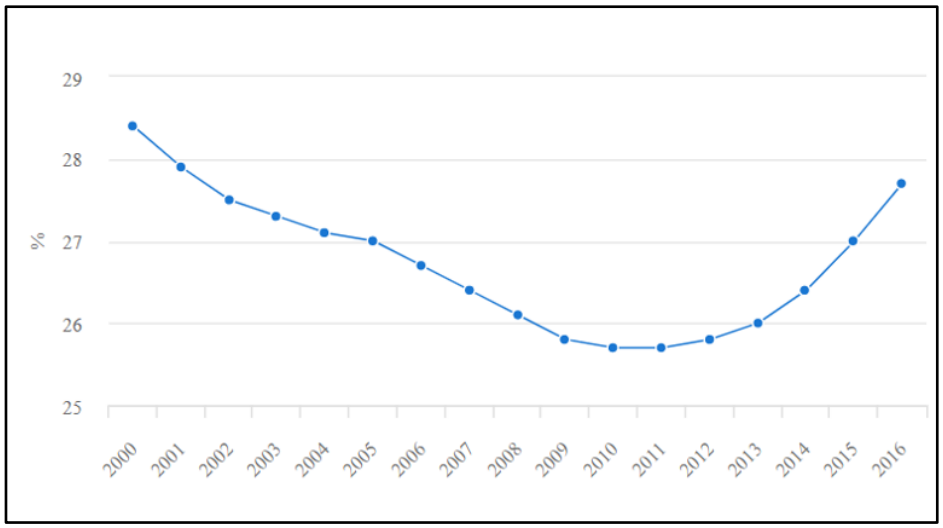

Figure 7. Prevalence of anemia among women of reproductive age (15–49 years) in Qatar. Source: FAO [174].

6. Policy Responses

Food security is a prominent objective in the Qatar National Vision 2030 [246]. Achieving sustainable food security implies transformation in the use of natural resources (cf. decreasing resource use intensity and increasing resource use efficiency), as well as transition towards sustainable food consumption and production patterns. It also implies reducing reliance on food imports. Nevertheless, given the scarcity of domestic natural resources and the continuous increase of consumption (driven by the growth of the population and increase of affluence), Qatar will likely continue to depend on imported food to meet the needs of its citizens. In this context, Qatar is promoting a policy mix that addresses many criticalities of its agri-food markets in the context of the wider national food system.

The NENA countries have been called to make efficient use of their narrow agricultural natural resource base through, among others, strong demand management policies [112]. However, besides the efficient use of domestic natural resources, they had to rely on natural resources located in other countries to meet their food security. Pirani and Arafat [113] highlight that "multiple pathways … can be used to secure food imports, particularly foreign agricultural land acquisition" (p. 1). Gulf countries (e.g., Qatar, Saudi Arabia, UAE) have become among the main foreign investors in agriculture [116,118,247], including animal production [91]. Indeed, "in the wake of the 2008 global food crisis and export restrictions imposed by major food exporters, Gulf states announced plans for foreign agro-investments, including major land deals, in the name of national food security" (p. 87) [118]. Some Gulf countries, such as Qatar and Saudi Arabia, went even further and created new, ad-hoc governance institutions to ensure better coordination of land investments (cf. land deals) and food security policies [118]. Following the 2007–2008 food crisis, Qatar pursued a strategy of investments in farmland abroad through Hassad Food, a company launched in 2008 by the Qatar Investment Authority (QIA), Qatar's sovereign fund. This strategy aims to build food security by producing abroad what cannot be grown locally so that the country can keep control over the food supply chain. Since 2008, Hassad has bought or rented thousands of hectares of land and taken major holdings in agribusinesses around the world, specifically in Sudan, Turkey, Ukraine, Brazil, and Australia, which are countries that have high-quality farmland [69,248,249].

However, some scholars [91] argue that by their agro-food investments and land deals, GCC countries foster intensive agriculture, such as mass-adoption of concentrated animal feeding processes, in countries where they have such investments (e.g., Iran, Pakistan). Blattner [91] states that "intensified animal agricultural production systems are known to cause environmental pollution, threaten public health and food security, and pose a moral hazard for animals", thus calling for encouraging more responsible investment and trade flows. This clearly shows that the attempt of Qatar and other GCC countries to achieve their food security may generate some negative externalities in other countries; indeed, it can even impact the food security of investment-importing countries [116], especially developing ones. In this context, Woertz [118] suggest that foreign agro-investments and land deals created new political and governance concerns for the Gulf states, such as Qatar and Saudi Arabia, as "their prominent role in the global land grab requires them to navigate new political spaces, including engagement with global civil society, water politics in countries where they are investing, and in emerging global governance initiatives related to food security and investment in land" (p. 87). Other authors highlight the importance of diversification of investment in agri-food sectors of the Gulf countries, which implies strengthening cooperation with countries such as Russia [109].

Following the 2017 blockade, the Qatari government has multiplied the initiatives to support the local food production: Loans for farmers with reduced interest rates, guidance, and support for farms with agricultural production requirements, such as seeds, fertilizers, pesticides, and marketing/packing. Before the blockade, local food production covered only 10% of domestic demand for vegetables. Of the 1400 farms operating in Qatar, only one third are commercial; the remaining farms are used by families for their own consumption. The crisis has, however, encouraged Qatar to strengthen its local production capacities: Dairy products, vegetables, meat, etc. [250]. Between 2017 and 2018, production from Qatari farms quadrupled, allowing Qatar to cover more than 90% of its chicken and dairy product needs. Furthermore, Qatar has adopted a long-term strategy for food security, viz. Qatar National Food Security Strategy 2018–2023, which is based on four main pillars [251]. The first is increasing local production for all of the products that can be produced locally, such as milk, dairy products, poultry, fish, fresh vegetables, and meat, because they consume less water and soil. The second pillar is to create strategic reserves of products that could not be grown in Qatar, such as grains. The third pillar is based on international trade to diversify the sources of importing instead of relying on fixed sources, in anticipation of any emergency crisis that might affect the imports. Finally, the fourth pillar of the strategy focuses on the domestic market with the aim of improving the supply chain in Qatar in order to deliver products and food commodities in good quality and at a fair price, in addition to developing market and auction mechanisms (Table 7).

Following that, in March 2019, the department of food security (part of the Ministry of Municipality and Environment (MME)), which is in charge of the agri-food sector, revealed its projects to increase production of several food items, including eggs, fish, shrimps, vegetables, and red meat, to reach self-sufficiency by 2023 (Figure 8).

Table 7. Qatar National Food Security Strategy (2018–2023).

Pillar	Initiatives
International trade and logistics	• Geographically diversify trade partners for critical commodities to reduce Qatar's exposure to external factors by having 3–5 partners per critical commodity • Proactively put contingency plans in place to limit the impact of trade shocks or other exogenous disruptions
Self-sufficiency	• Increase vegetable production by establishing a hydroponics greenhouse cluster to reach 70% self-sufficiency for greenhouse vegetables (e.g., tomatoes, pepper, cucumber, squash, lettuce) • Expand and improve production capacity for red meat (fattening units and breeding farms for sheep and goat) and fisheries (fish farms) • Cap production of fresh milk and poultry to 100% self-sufficiency by discontinuing tenders and redirecting capacity to other purposes (shifting poultry surplus to egg production) • Reduce ground water-based fodder production by switching to TSE
Strategic reserves	• Leverage the private sector to store a broad range of products to act as a permanent short-term buffer against shocks to the system • Put strategic reserves of perishables and select non-perishables in place as an insurance against potential trade and production disruptions • Increase potable water reserves as an insurance against potential crisis scenarios, balancing risk-exposure and 'insurance' cost • Reduce net depletion of the Aquifer by optimizing water usage in agriculture
Domestic markets	• Establish an integrated food waste program, including collection and treatment/alternative usage of organic waste • Streamline the domestic go-to-market model (farm-gate to retail) to ensure transparency in the price-setting process and assist farmers in improving their productivity and quality of produce • Optimize and simplify the governance of food standards in Qatar, to monitor food safety in the country and to supervise quality certification more effectively

Source: Ministry of Municipality and Environment [251].

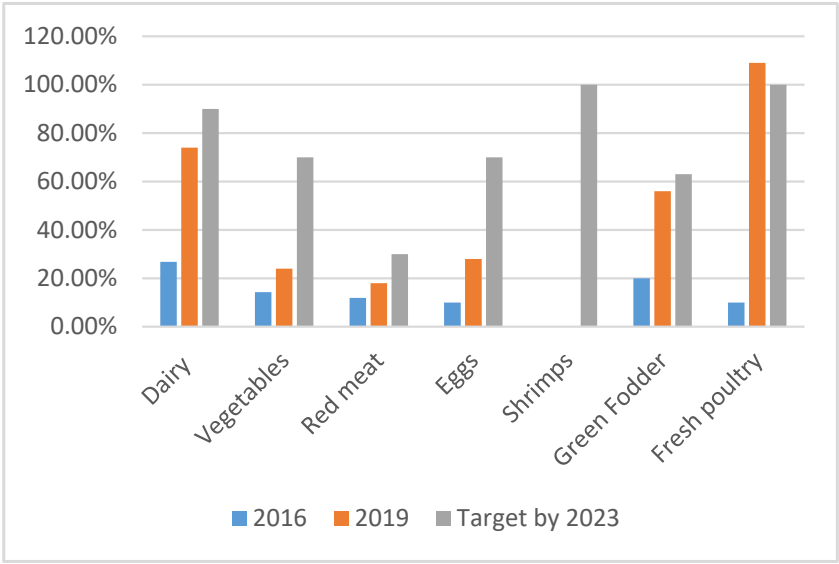

Figure 8. Evolution of self-sufficiency for some agricultural products in Qatar. Source: Authors' elaboration based on data from Alpen Capital [178] and Ataullah [252].

In addition, to improve the efficiency of the supply chain, Qatar created the company Mahaseel in 2018. Mahaseel's main mandate is to enhance the local food production to back the country's self-sufficiency efforts. In particular, the company will support the private sector by promoting the local farmers' production, as well as providing several agriculture-related services [253].

In their analysis of food security scenarios in Qatar and other GCC countries, Pirani and Arafat [113] conclude that "the way forward for the GCC countries must involve diversified food supplies along with decreasing food demand in the first place." This implies that besides food supply, more attention should be paid to food consumption patterns. Indeed, unsustainable food consumption patterns and diets are drivers of high obesity rates, water use rates per capita, and per capita waste footprints [254]. In this context, Qatar is one of the countries that are pioneers in the development of a sustainable diet policy [108,169]. Indeed, Qatar developed national dietary guidelines [146,165,169]. The Qatar Dietary Guidelines (QDGs), developed within the national strategy to prevent chronic diseases [146], outline the types of food to eat as a foundation every day, and the ones to limit or avoid, with the aim to "help people to stay healthy and strong, maintain a healthy weight, and reduce their risk of obesity, diabetes, cardiovascular diseases, cancer, and osteoporosis" (p. 9) [255]. The QDGs also incorporate food sustainability principles (including food waste reduction) [165]. Dietary guidelines are vital, as sustainable diets are considered essential to move towards sustainable food systems, and both the SDGs and Paris Agreement on Climate Change require changes across food systems [108].

There are strong linkages between food wastage and food-related policies that affect the management and efficiency of food chains [164]. Mustafa [75] highlights the high reliance of Qatar on imports to feed its rapidly increasing population, and underlines that to achieve sustainable food security, Qatar has to address the rampant food waste. Indeed, the reduction of food wastage has been side-lined so far in strategies to achieve sustainable food security in Qatar. Likewise, Irani et al. [164] show that the reduction of food losses and waste is crucial to ensure long-term food security in Qatar, and suggest that "interventions to manage and mitigate the effects of food security and food waste should include knowledge transfer, market access, and wider organizational involvement interventions" (p. 381). They also argue that "education and training of stakeholders in the food chain [...] may inherently contribute towards the impact on the reduction of food waste. In doing so, promoting an increase in the recycling of food waste [...] and thus better food quality management" (p. 381). To resolve the issue of food waste in Qatar, the Qatar National Food Security Strategy 2018–2023 included numerous actions to reduce wastage throughout the food value chain, such as reducing maximum time for product clearance, equipping central markets with adequate handling and storage infrastructure, establishing a waste collection program and waste treatment facility, and launching a food bank program (Table 8).

As a result of increasing awareness about health and the environment, demand for healthy and organic food concepts (e.g., low-processed, low-carb) is growing and gaining popularity in Qatar and in the GCC region. The market is supported by increasing awareness about the benefits of healthy food and growing media and government attention towards health issues. Between 2018 and 2023, food retail sales in the GCC are expected to grow at a CAGR of 2.8%, driven by a growing consumer base and demand for healthy food [206]. Meanwhile, restaurants serving salads and healthy sandwiches, such as Subway and Quiznos Sub, have seen a growth in Qatar in the last five years owing to the growing awareness of healthy eating [183].

Table 8. Food waste program in the Qatar National Food Security Strategy 2018–2023.

Value Chain Stage	Issues	Strategic Recommendations
Customs	• Food clearance can take up to 12–24 h, increasing risk of damage • Long procedure times because of: Full inspection on-site (documentary compliance lead time is 6x higher than in the UAE); lack of infrastructure (e.g., labs)	• Set maximum legal time for product clearance to less than six hours • Develop and promote the adoption of a registration system to ensure that most products are approved before arrival
Farmer	• No secondary market for production considered unsuitable for direct consumption • Farmers not trained on best practices to minimize production waste	• Continue to facilitate the development of processing companies' facilities to create a secondary market for production that is unsuitable for direct consumption • Develop extension service to educate farmers on best practices for storage to minimize production wastage
Intermediary players (Central Market, retailers)	• Absence of adequate handling and storage infrastructure at Central Market	• Promote the development of best-in-class handling and storage facilities at new Central Market locations • Promote the development of private sector warehousing cold storage space (e.g., through affordable warehousing)
End-consumers	• Absence of best practice for compost processing • No compost collection program in place	• Establish a waste treatment facility to process compost waste using windrow composting technology • Make leftover out-of-date products available in food banks for a limited amount of time • Launch campaigns to encourage change in behavior

Source: Ministry of Municipality and Environment [251].

In order to effectively address health issues, including emerging diseases (e.g., viruses), Qatari authorities recently embraced the 'One Health Approach' [256]. Such an approach also offers a promise to deal in a more coherent and coordinated way with food-related non-communicable diseases (NCDs). With respect to obesity and referring to the six GCC countries, Samara et al. [173] argue that "among the six states, Qatar, United Arab Emirates, and, to a degree, Oman have shown some development with regard to the implementation and evaluation of obesity-related health promotion policies, and, thus, other Arab Gulf countries could be inspired by existing good practices and move from good intentions to using their available wealth to invest in the implementation and evaluation of published policies and strategies." Furthermore, effective from 1 January 2019, Qatar applied the "excise tax" in line with the GCC Unified Excise Tax Treaty. The tax is imposed on certain items, such as energy and carbonated drinks and tobacco, which are considered to be harmful to consumers' health [257,258].

7. Conclusions

Agri-food markets are vital in achieving food and nutrition security in resource-poor, food-importing countries such as Qatar. The paper provides an overview of the evolution of agri-food markets in Qatar and analyzes drivers of changes, trends, and challenges as well as policy responses.

Different drivers have contributed to changes in agri-food markets and food consumption and production patterns in Qatar. The main drivers are population growth, with huge expatriate inflow, income increase, as Qatar is one of the richest countries in the world with high GDP per capita, and climate change. These drivers determined the patterns of change and trends regarding food production (cf. agriculture) and availability, food processing, food access and food distribution, food utilization and food consumption (cf. diets), food imports, and food and nutrition security status. However, the main trends in Qatari agri-food markets are increased, as is the wider use of food safety and quality certification, as well as the high dependence on food imports. The heavy reliance of Qatar

on food imports makes it vulnerable to supply shocks (related to import disruption). In the near future, food consumption in Qatar is expected to increase, boosted by population growth, high and increasing income, and a growing influx of tourists. As a result, Qatar faces several challenges. Indeed, the food-related trends have been also affected, both in terms of direction and speed, by numerous challenges facing Qatar, such as environmental challenges (e.g., resource scarcity (land, water) and high environmental footprints (water footprint, ecological footprint, carbon footprint)), blockades and trade distortions, and health challenges (e.g., overweightness/obesity, non-communicable diseases). Population growth, urbanization, and economic growth increase pressure on the scarce natural resources in Qatar, such as water and soil. At the same time, the ecological footprint (EF) of Qatar is among the highest in the world. Qatar also faces many food and nutrition challenges. Unhealthy dietary choices have led to high rates of obesity, cardiovascular disease, and diabetes. To tackle these challenges and move towards sustainable food consumption and production patterns that ensure long-term food security for its population, Qatar put various policies in place to increase domestic food production, secure food imports (e.g., foreign agro-investments, land acquisition/land deals, commercial agreements), improve food access (e.g., subsidies, food price control), promote sustainable diets (cf. dietary guidelines), and reduce food waste and/or promote its reuse and recycling (cf. circular economy).

Given the central role of agri-food markets as connectors of production and consumption, the government of Qatar should target them in food policies as levers of change towards sustainable food consumption and production patterns in the country. Indeed, markets represent an appropriate entry point for far-reaching interventions aiming, inter alia, at promoting sustainable agriculture, fostering a shift towards sustainable diets, and reducing food losses and waste along the whole food chain in Qatar.

This review shows that there is a gap in research on agri-food markets in Qatar in general and on the relationship between agri-food markets and food security in particular. Furthermore, research should also address how changes in the structure and functioning of agri-food markets, including agri-food trade and foreign investments (cf. land deals), can help in reducing pressure on the scarce natural resources of the country in the context of climate change. More attention should also be devoted to the effects of food security policies in Qatar and in other GCC countries on agriculture and food systems in investment-receiving countries, especially developing ones.

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