Chapter 7. Climate Change and the GCC: Economic and Environmental Impact

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Abstract

The economies of the GCC countries, having been negatively impacted by Covid-19, now face the longer-term challenge of climate change. Over the coming decades, this phenomenon will affect these countries in several ways. First, there will be direct effects: climate change will bring higher temperatures and humidity, reduced and more erratic precipitation, a rise in sea-level and stronger and more frequent storms of various kinds. Higher temperatures and humidity will necessitate the use of more energy for air-conditioning and will also put the residents of GCC countries at risk if there are failures in electricity supply, as summer temperatures will be "unlivable" without air conditioning. Sea-level rise will require large sums to be spent on protecting or rebuilding or moving infrastructure in coastal areas. Moreover, there will be severe environmental damage, because of phenomena such as the rise in sea temperatures and more frequent and more severe dust-storms and sand-storms. Second, countries that consume hydrocarbons may, as part of the transition to renewable energy, buy less oil and gas, so reducing the revenues available to GCC governments. Third, the countries which produce the food on which GCC countries depend may themselves suffer climate-change impacts that damage their agricultural sectors, rendering GCC food supplies less secure. GCC governments will need to find ways of responding to these major challenges. This chapter does not examine the separate question of the contribution of GCC states, whether actual or potential, to the mitigation of greenhouse-gas emissions.

7.1.The impact of the Covid pandemic on GCC countries' adaptation to climate change[1]

It is not yet clear how the pandemic has affected the efforts of GCC governments to adapt to climate change and to prepare for the energy transition. There certainly seems to have been little if any impact on the climate change mitigation projects in, for example, Saudi Arabia and the UAE. While climate change mitigation is a separate issue (and not the subject of this chapter), the lack of impact in this area of activity may well indicate that there has been little or no effect on adaptation work either. One reason for believing that this is the case is that not much effort was being put into adaptation (as witness the repeated flooding of cities in GCC countries): in the area of climate change work, "green projects" designed to demonstrate official commitment to mitigation have had a higher priority.

As regards the GCC governments' preparation for the energy transition and the likelihood of declining demand for oil and gas, the pandemic (by reducing global demand for energy) may have served as a reminder of the need to diversity economically as broadly and as genuinely as possible. GCC countries will need such diversification to create economies that can withstand the worldwide drive to reduce the use of fossil fuels. However, the increased demand for oil and gas from sources

[1] The author is very grateful to Dr Christopher Davidson of the Henry Jackson Society (email, 13 May 2022) for his input to this section of the chapter.

other than Russia as a result of the Ukraine crisis may have lessened any sense of greater urgency concerning diversification that the pandemic has created.

7.2.The likely direct impacts of climate change on GCC countries

Climate change is a reality. But it is impossible to predict with certainty what it will bring to Planet Earth. This is mainly because we do not know how far the transition to renewable energy will go or how fast it will occur – and thus how effective the mitigation of climate change will be, in terms of limiting the emission of GHGs (greenhouse gases). The most recent report by the Intergovernmental Panel on Climate Change (IPCC) examines five "illustrative scenarios" that range from very low levels of greenhouse gas emissions (GHGs) to very high. [2]

Climate scientists are more confident about projections for temperature and sea-level rise (SLR) than for rainfall. Moreover, modelling for the globe as a whole, despite its imperfections, is still more reliable than it is for individual regions like the Gulf. The smaller the region, the less confidence we can have in projections of climate change and its impacts.

Nevertheless, it seems safe to say that the direct impacts of climate change on GCC countries will include:

- higher temperatures and humidity;
- on average (in terms of any given year or series of years), reduced rainfall but more intense rainfall events, over most parts of the region, although Oman and the south-western corner of Saudi Arabia (and Yemen) may receive more rainfall than they do today;
- a rise in sea-level;
- more storms over the sea (including cyclones), causing surges at high tide and sometimes the over-topping of coastlines and coastal defences;
- higher sea-surface temperatures (SSTs); and
- more dust-storms and sand-storms.

There is one crucial consideration to bear in mind when considering the effect of climate change on the economic and social life of GCC countries and indeed of countries elsewhere in the world. This is that the average figures only tell us part of the story – and not the most important part. In fact, the impact of climate change will be most strongly felt through extreme events: heatwaves, intense rainstorms, protracted droughts, storm surges along low-lying coasts etc. Such extreme events will pose major challenges to governments in various ways. This will be particularly so when one considers the possibility of these events combining with one another, for example, an intense rainfall event might coincide with a storm surge to bring extensive flooding to coastal areas.

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[2] "Summary for Policymakers", in "Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change", Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf. According to the IPCC's website, "The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change."

7.3.Higher temperatures and humidity

Climate change is already bringing higher temperatures to Gulf countries. For instance, the average maximum daytime temperature in summer in Saudi Arabia increased 2.05ºC between 1960 and 2010.[3] And a temperature of 53.9ºC was recorded in Kuwait in 2016.[4] Temperatures of 50ºC or above are now being recorded 'regularly' in Kuwait.[5]

As to the future, most climate models predict longer and more intense heatwaves for the Middle East generally and the Gulf in particular. Today's extremes will become the norm. By 2050, the maximum temperatures on the hottest days in GCC countries will have increased by 3-4ºC. In summer, temperatures in GCC cities will often go above 50ºC.

One academic study projects that, after 2070, under a high-emissions scenario, 45ºC would become the usual summer maximum in Gulf cities.[6] In some years, 60ºC would be seen in places like Kuwait City. Cities, because of the 'urban heat island' effect, would be tough places to live in.[7] This impact would be all the stronger because the GCC is one of the most urbanized parts of the world, with more than eight out of 10 people living in towns and cities.[8]

Al-Mazroui (2020) uses a parameter that quantifies just how trying these conditions could become, namely, the Survivability for a Fit Human Threshold (SFHT). (The SFHT is the highest temperature that is tolerable for a healthy human under well-ventilated outdoor conditions.) He concludes, 'The adjusted summer maximum temperature will likely cross the SFHT temperature limit of 42°C at all capital cities of the GCC states and the four major cities in Saudi Arabia by the end of the twenty-first century. This indicates that climate change has to be considered in the long-term planning of the region, since exceeding the SFHT limit will most likely cause human health-related casualties.'[9]

Higher humidity will exacerbate the effect of extreme temperatures. Although much of the hinterland of GCC countries is desert (where low humidity is the norm), coastal areas experience very high humidity because the Gulf and the Red Sea have a low albedo (the fraction of light that is reflected by a surface), resulting in strong absorption of solar radiation.[10] The very high

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[3] Hilal M.S. Al-Maamarya, Hussein A. Kazemb and Miqdam T. Chaichanc, "Climate change: The game changer in the Gulf Cooperation Council Region", *Renewable and Sustainable Energy Reviews*, 76 (2017), 555–576, www.elsevier.com/locate/rser

[4] Yasmena Al Mulla, "Why Kuwait is one of the hottest places on earth", *Gulf News*, 6 July 2021, https://gulfnews.com/world/gulf/kuwait/why-kuwait-is-one-of-the-hottest-places-on-earth-1.80465689

[5] "Life at 50C: Surviving in Kuwait's 'unbearable' heat", 27 October 2021, BBC News, https://www.bbc.co.uk/news/av/world-middle-east-59054893

[6] Jeremy S. Pal and Elfatih A.B. Eltahir, "Future temperature in southwest Asia projected to exceed a threshold for human adaptability", *Nature Clim Change* 6 (2016), 197–200

[7] "Heat Island Effect", United States Environmental Protection Agency (EPA) website, https://www.epa.gov/heatislands , last visited 29 October 2021.

[8] Al-Maamarya *et al.*, "Climate change: The game changer …"

[9] Mansour Almazroui, "Summer maximum temperature over the gulf cooperation council states in the twenty-first century: multimodel simulations overview", *Arabian Journal of Geosciences,* 13(12), (2020), DOI: 10.1007/s12517-020-05537-x

[10] Pal and Eltahir, "Future temperature in southwest Asia"

evaporation rate which results intensifies the concentration of water vapour in the air, while sea breezes bring this moist air inland.[11] Moreover, as Bolleter *et al.* put it,

> '… the effects of the most lethal heatwaves are due to not only elevated temperatures but also the effects of humidity. Extremely high heat combined with elevated humidity diminishes the human body's ability to regulate temperature by sweating. Hence, hot and humid conditions can be more dangerous than equivalently hot dry conditions ...'[12]

The relevant parameter in this situation is the wet-bulb temperature (WBT). Exposure to a WBT of 35°C (an air temperature of 46°C combined with humidity of 50 per cent) for several hours will kill a healthy person as their body will not be able to cool itself adequately through sweating.[13] WBTs of 35ºC will probably not occur if global average surface temperature rises are kept to less than 2°C relative to 1986–2005 but are likely to do so at higher levels of warming. At these higher levels of warming, for some places in the Gulf (including Abu Dhabi, Dubai, Doha and Dhahran), the WBT is projected to exceed 35°C several times in the 2071-2100 period.[14]

Even if the threshold of a WBT of 35ºC is not crossed, some sizable groups of people will be at risk. The 'danger' threshold WBT will be 3ºC degrees lower for those doing manual labour outside and may be much lower for people who are vulnerable because of their age (the elderly or very young) or pre-existing medical conditions.

In these circumstances, GCC economies would be spending even more on air-conditioning (and using more energy in the process) than they do today. That may be affordable but, even if it is, there remains the possibility of a failure of the electricity supply during a heatwave. This could happen if there is a sudden surge in demand and the system breaks down due to overload. It could also happen if the network is attacked by a hostile power or sabotaged by a terrorist group, whether physically or using cyber methods.

In these circumstances, the most vulnerable members of society might die. We should remember that death as a result of excessive heat is not merely theoretical: in the 2003 heatwave in Europe, 'tens of thousands' of people died from heat stress.[15]

Moreover, not everyone can work indoors. Construction and farming are perhaps the most obvious categories of jobs that have to be done outdoors. Working outdoors in extreme heat lowers productivity and endangers the health of workers (soldiers needing to train or fight outdoors would also be at risk). As a report for the International Labour Organisation points out,

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[11] Julian Bolleter *et al.,* "Wet-bulb Temperature and Sea-level Rise in the United Arab Emirates – Planning Responses", *Planning Practice & Research*, 36 (2021), Issue 4, 408-429, DOI: 10.1080/02697459.2020.1859199

[12] Ibid.

[13] The WBT is the temperature read by a thermometer covered in water-soaked cloth (a wet-bulb thermometer) over which air is passed. Pal and Eltahir ("Future temperature in south-west Asia") describe it as "a combined measure of temperature and humidity or degree of 'mugginess'".

[14] Bolleter *et al,* "Wet-bulb Temperature"

[15] Ethan D Coffel, Radley M Horton and Alex de Sherbinin, "Temperature and humidity based projections of a rapid rise in global heat stress exposure during the 21st century", *Environ. Res. Lett.* 13 (2018): 014001 https://iopscience.iop.org/article/10.1088/1748-9326/aaa00e

> 'the lowest income-bracket work – heavy labour and low-skill agricultural and manufacturing jobs – are among the most susceptible to climate change.'[16]

Moreover, if GCC countries get as hot as the models suggest, skilled expatriate workers might be reluctant to come to live and work in the Gulf, even if their jobs do not require them to do any outdoor work. (Such workers, who have some choice as to where they work, may not wish to live in countries in which, for example, their children cannot play outside during the day in summer.[17]) And the hajj, when it occurs in summer, would be dangerous to all but the hardiest of pilgrims.[18]

Higher temperatures and humidity may create conditions that encourage the spread of certain diseases, including dengue, malaria, hantavirus and cholera.[19] When combined with the presence of standing water, the result of flooding (brought about, for example, by intense downpours), elevated temperatures may result in increased outbreaks of salmonellosis, cholera and giardiasis.[20] Moreover, malaria-carrying mosquitoes can breed in any standing water, creating conditions for diseases such as West Nile virus, Ebola, and Zika.[21]

Higher temperatures will also produce higher evapotranspiration from crops, meaning "less crop per drop". More irrigation water will therefore be needed per unit of yield. Where GCC countries are drawing on groundwater for irrigation, those resources will be depleted even more rapidly than they already are.[22]

Another economic effect of higher temperatures will result from increased salinity of sea-water in the Gulf, the Gulf of Oman and the Red Sea, due in turn to higher rates of evaporation from that body of water. To desalinate water with a greater salt content, more energy will have to be used by desalination plants.

7.5.Reduced and more variable precipitation, for most of the GCC

Projections concerning precipitation (almost always rainfall in GCC countries) cannot be made with quite as much confidence as those for temperature. Some general statements about the effect of climate change on precipitation can nevertheless be made with reasonable confidence.

While more rain is likely to fall over the Jebel al-Akhdar in Oman and the far southwestern corner of Saudi Arabia (and Yemen), most parts of the GCC region will have less rain in coming decades than they do today. However, these changes will not have much economic impact, even if the decrease is large in percentage terms. A reduction in rainfall would not bring disaster to countries where there is hardly any rainfed agriculture and that get their water from desalination and import almost all their food. Conversely, an increase in rainfall would not offer much in the way of new economic opportunities (although it would serve to narrow the gap between the rate of depletion

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[16] "Climate Change and Labour: Impacts of Heat in the Workplace", (2016), UNDP, https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---gjp/documents/publication/wcms_476194.pdf

[17] "Life at 50C", BBC News

[18] Pal and Eltahir, "Future temperature in southwest Asia"

[19] Xiaoxu Wu *et al*, "Impact of climate change on human infectious diseases: Empirical evidence and human adaptation", *Environment International*, 86, (2016), pp. 14–23. DOI: 10.1016/j.envint.2015.09.007

[20] Ibid.

[21] Abbas El-Zein *et al.*"Health and ecological sustainability in the Arab world: a matter of survival", *The Lancet*, 383(9915), (2014), pp. 458–476, DOI: 10.1016/S0140-6736(13)62338-7

[22] Al-Maamarya *et al.,* "Climate change: The game changer"

of renewable groundwater reserves and the rate at which they are recharged by rainfall), except in the highly unlikely case of a very large increase.

The most significant rainfall-related change (in terms of socio-economic impact) will take the form of less frequent but more intense rain-storms. These rain-storms will lead to flooding where storm drains do not have adequate capacity to carry the water away, as is the case at the moment in many GCC cities. There have already been numerous instances of serious flooding in GCC cities within the last decade or so, for example, those which occurred in Jeddah in 2009, 2011 and 2017, in Riyadh in 2013, in Mecca in 2015 and 2021 and in Doha in 2018.[23] Lives have been lost and a great deal of property destroyed.

7.6.Sea-level rise (SLR) and storm surges

Climate change is causing sea levels to rise in two ways. First, sea-water is expanding as the world warms. Second, more water is added to the seas and oceans as glaciers and ice-caps melt. According to the IPCC, it is

> '*virtually certain* that global mean sea level will continue to rise over the 21st century. Relative to 1995-2014, the likely global mean sea level rise by 2100 is 0.28-0.55 m[etres] under the very low GHG emissions scenario …'

In the highest GHG emissions scenario, the IPCC projects that the rise in sea-level would range from 0.63 to 1.01 metres.[24]

Extraction of oil, gas and groundwater plus the weight of infrastructure are probably causing subsidence in coastal areas of GCC countries. This would compound the effect of SLR consequent upon climate change.

According to Hereher (2020) , a rise in sea-level of one metre would permanently inundate 614 km^2 of Saudi Arabia along the Gulf coast, 270 km^2 of the UAE and 147 km^2 of Qatar.[25] In Saudi Arabia, the low-lying areas North and South of Dammam would be the most susceptible to inundation; in the UAE, it would be the central coast and the Abu Dhabi islands, while for Qatar, it would be the Southeastern side of the country. Kuwait would also suffer inundation, with the most vulnerable locations being Bubiyan Island and the country's southern coast. While the area of Bahrain which would be flooded by a one metre rise in sea-level is only 20.5 km^2, this nonetheless represents almost three per cent of the territory of the country.

The figure for Saudi Arabia above does not include the Red Sea: about 890 km^2 of land along that coast would be inundated by a SLR of one metre.[26] In relative terms, however, the Red Sea coast of Saudi Arabia is less vulnerable to inundation than the country's Gulf coast. The topography of the northern part of the Red Sea coastline is elevated and rocky and the coastal strip is narrow. To

[23] Examples taken from FloodList.com, https://floodlist.com/asia/ , last visited 29 October 2021.
[24] "Summary for Policymakers", B.5.3, page SPM-28
[25] Mohamed E. Hereher, "Assessment of Climate Change Impacts on Sea Surface Temperatures and Sea Level Rise—The Arabian Gulf", *Climate*, 8(4), (2020), p. 50, DOI: 10.3390/cli8040050
[26] Mohamed E. Hereher, "Vulnerability assessment of the Saudi Arabian Red Sea coast to climate change", *Environmental Earth Sciences*, Vol. 75 (30), (2016), DOI: 10.1007/s12665-020-09113-0

the south of Jeddah, however, the coastal strip is broader and lower lying: here, there could be more extensive inundation and marine life could suffer significant damage.[27]

At the same time, we also have to factor in the effect of storm surges, which will cause more coastal flooding than they do today because sea-levels will be higher. Moreover, while the coastal flooding caused by storm surges does not produce permanent inundation, it can be very destructive. Coastal lands contain the greatest concentrations of population in their respective countries, including (apart from Saudi Arabia) the capital cities. They also hold the greatest concentrations of infrastructure, such as oil and gas export facilities, power and desalination plants, ports and roads.

For example, Qatar's 2021 Nationally Determined Contribution (NDC) recognises that there is a 'large coastal population at risk of inundation (particularly during extreme sea level events)' and also notes the vulnerability of 'coastal and offshore installations such as power and water cogeneration facilities, and the oil & gas infrastructure'.[28] The 2015 version of Qatar's NDC stated that 96 per cent of people in the country lived in coastal areas.[29] It is unlikely that this figure will have declined greatly since 2015; indeed, it is, if anything, more likely to have risen.

The figures for the UAE are of the same order of magnitude as those for Qatar. 'Approximately 85 per cent of the population and over 90 per cent of the infrastructure of the UAE is located within several meters of sea level in low-lying coastal areas …'[30] According to one estimate, the country could lose up to six per cent of its populated and developed coastline by the end of the century because of rising sea levels."[31]

In Oman's case, a World Bank report projects that, by 2050, the sea-level at Muscat would have risen by 0.2 metres in a low emissions scenario and by 0.25 metres in a high emissions scenario. Oman's Governorates along the coast of the Batinah Plain (along the Gulf of Oman) are certainly exposed to SLR and storm surges. Using a measure called the coastal vulnerability index (CVI), Hereher *et al* show that 'high vulnerable coastal regions to sea level rise account for 805 km of the coast, mostly along Al-Batinah plain in the north and along some scattered sectors at the eastern coast of the country.'[32] (The parameters used to calculate the CVI are: coastal geomorphology, elevation, slope, tidal range and bathymetry (the depth of the sea adjacent to the coast).) The areas

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[27] Ibid.

[28] "Nationally Determined Contribution", August 2021, Ministry of Municipality and Environment, State of Qatar, https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Qatar%20First/Qatar%20NDC.pdf. A Nationally Determined Contribution is a climate action plan designed to cut emissions and adapt to climate impacts. Each Party to the Paris Agreement is required to establish an NDC and update it every five years: "Welcome to the UN: All About the NDCs", United Nations, https://www.un.org/en/climatechange/all-about-ndcs

[29] "Intended Nationally Determined Contributions (INDCs) Report", November 19, 2015, Ministry of Environment, State of Qatar, https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Qatar%20First/Qatar%20INDCs%20Report%20-English.pdf

[30] "Climate Change", UAE government website, https://u.ae/en/information-and-services/environment-and-energy/climate-change/climate-change , last visited 29 October 2021.

[31] Ibid.

[32] Mohamed Hereher *et al*., "Assessment of the coastal vulnerability to sea level rise: Sultanate of Oman", *Environmental Earth Sciences,* 79, (2020), art. No. 369 The CVI is derived from measurements on five physical parameters, namely, the coastal geomorphology, elevation, slope, tidal range and bathymetry (seabed topography) of the sea adjacent to the coast.

that the study characterizes as having a high CVI are home not only to the capital but also to a great deal of the country's population and infrastructure and extensive areas of farmland. About 60 per cent of the population lives within 15 kms of the sea and most of Oman's roads run parallel to the coast.[33]

Another scholarly calculation (by Al-Awadhi *et al.,* 2016) suggests that 'nearly 400 square kilometer[s] of total land area is projected to be inundated under the smallest SLR scenario', with the coastal areas of the Governorates of al-Sharqiya South and al-Wusta (which lie on the Arabian Sea) most at risk, because of the low-lying nature of their coastal topography.[34] This inevitably creates serious economic risks: the port and special economic zone at Duqm, in which Omani state-owned companies have invested 'billions of dollars', lie in al-Wusta.[35]

Uncertainties about the potential impact of the combination of SLR and storm surges greatly complicate Gulf governments' infrastructural planning. Without knowing how high the sea-level plus storm surges might reach, it is hard to design new infrastructure such as oil-drilling platforms and port installations that can escape damage. At the same time, making provision for higher maximum sea levels than actually occur would be a waste of large sums of money.

7.7.Cyclones

Cyclones produce an especially forceful form of storm surge, as well as intense rainfall. They seem to be happening more often and getting stronger. Their impact has so far been almost wholly confined to Oman – although Cyclone Gonu, which struck Oman in 2007, prompted a precautionary evacuation in Fujairah in the UAE.[36] Gonu was a particularly violent cyclone (it took 50 lives and resulted in damage to the value of some $4 billion) but cyclones have caused destruction in Oman since then.[37] In Oman, most cyclone-related damage is caused by flooding, both along the coast (as a result of storm surges) and inland, as a result of intense rainfall. In future, according to Murakami *et al.*, 'continued anthropogenic forcing will further amplify the risk of cyclones in the ARB [Arabian Sea].'[38]

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[33] Ibid; Bastian Schneider, Gösta Hoffmann and Klaus Reicherter, "Scenario-based tsunami risk assessment using a static flooding approach and high-resolution digital elevation data: An example from Muscat in Oman", *Global and Planetary Change*, 139, (2016), pp. 183-194, https://www-sciencedirect-com.gate3.library.lse.ac.uk/science/article/pii/S0921818116300613

[34] Talal Al-Awadhi *et al.*, "Growth of coastal population: Likely exposure to sea level rise and associated storm surge flooding in the Sultanate of Oman", *Journal of Environmental Tourism and Management* 7 (14), (2016), pp. 341–6. https://journals.aserspublishing.eu/jemt/article/view/341

[35] "Oman's Duqm development plans take shape", MEED, 9 April 2021, https://www.offshore-technology.com/comment/duqm-development-plans/

[36] Mohammed N. Alkhan, "Gonu: Fujairah Evacuates", *Gulf News,* 6 June 2007, https://gulfnews.com/uae/gonu-fujairah-evacuates-1.465492

[37] Mohammed Mahmoud, "Cyclone Shaheen: A reminder of the Arabian Peninsula's vulnerability to extreme weather events", *MEI (Middle East Institute)*, 8 October 2021 https://www.mei.edu/publications/cyclone-shaheen-reminder-arabian-peninsulas-vulnerability-extreme-weather-events

[38] Hiroyuki Murakami, Gabriel A. Vecchi and Seth Underwood, "Increasing frequency of extremely severe cyclonic storms over the Arabian Sea", *Nature Climate Change* 7, (2017): 885–889, https://doi-org.gate3.library.lse.ac.uk/10.1038/s41558-017-0008-6

7.8.Higher sea-surface temperatures (SSTs) and more dust-storms and sand-storms

Warming of the surface temperature of the Gulf has already been observed. During the period 2003-2018, sea-surface temperatures (SSTs) along the western shores of the Gulf increased at a rate of 0.6-0.7ºC per decade.[39]

This increase in the SST will continue and may be above the tolerance limit of the Gulf's coral reefs – SSTs have already increased to the extent that bleaching of coral can be observed in seven locations.[40] Climate change may also bring higher local extinction of marine species and significant damage to fishing in the Gulf region. As well as producing higher SSTs, climate change will increase salinity and reduce oxygen levels in the waters of the Gulf.[41]

Dust-storms and sand-storms have long been part of life in the area.[42] (Dust-storms carry matter with smaller particles than sand-storms.) Climate change is likely to make them more frequent and more severe. They can disrupt flights and road traffic and can lead to accidents as a result of poor visibility. All this naturally has an economic cost and sometimes a cost in lives as well. Dust-storms and sand-storms can also affect human health, by causing or aggravating respiratory conditions.

7.8.The energy transition, the demand for hydrocarbons and the availability of forex

As set out in the preceding sections of this chapter, climate change is projected to have several direct impacts on economic and social life in GCC countries. It will also have indirect effects – possibly as great as the direct effects – on these countries as a result of other countries' contributions to a global effort to mitigate the emissions of GHGs by curbing their use of oil and gas (and other fossil fuels).

To restrain these emissions (and also for sound economic reasons), new ways of using energy more efficiently will be introduced. Moreover, countries around the world will turn more and more to renewable sources of energy. More energy will be generated by wind and solar power. Under most scenarios, the *share* of oil and gas in producing the world's energy will fall.

But economies and populations will grow. So, even with more efficient energy use, more energy will be needed. The big questions are these: will the amount of oil and gas being consumed globally fall in absolute as well as relative terms? And, if so, by how much?

To reduce their emissions of GHGs, many countries that currently import oil and gas are switching to renewable energy or at least have expressed the intention of doing so. At the same time, the population of the world and the global economy can be expected to continue to grow and, with them, the demand for energy from whatever source. How will these two countervailing factors play out, in terms of the revenue available to GCC states? Different organisations have made predictions or constructed scenarios in an attempt to get a sense of how much demand there will be for GCC hydrocarbons exports in future – which will determine how much revenue they will have.

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[39] Hereher, "Assessment of Climate Change Impacts"
[40] Ibid.
[41] Al-Maamarya *et al.,* "Climate change: The game changer"
[42] Ibid.

In 2021, OPEC produced a report setting out its projection of the world energy picture in 2045.[43] According to OPEC, global GDP will more than double between now and 2045. That would mean an overall rise in energy consumption, from around 280 million barrels of oil equivalent per day (mboe/d) to around 360 mboe/d. According to OPEC, renewables will not be able to meet all the additional demand, so the consumption of oil and gas will continue to grow until at least 2045.[44] By 2045, oil demand will have increased in volumetric terms by around nine per cent (using 2019 as the baseline), even though oil's share of total global energy consumption will have declined slightly.[45] By the same date, the demand for gas (to which consuming countries will switch where possible because it emits less GHGs than oil) will have increased by around 36 per cent in volumetric terms, with a slight increase in its share of total global energy consumption.

BP's view is somewhat different. The company's Energy Outlook (2022) looks ahead to 2050. It offers three scenarios "which explore a wide range of possible outcomes as the world transitions to a lower carbon energy system." [46] The bp Outlook terms these scenarios 'Net Zero', 'Accelerated' and 'New Momentum'. In all three scenarios, the global demand for oil has declined by 2050, a development driven mainly by the decrease in its use in road transportation. Even in 'New Momentum', the least optimistic scenario in terms of the reduction in the emissions of CO_2, oil demand has fallen by 20% by the middle of the century. In 'Net Zero', the most optimistic scenario, the equivalent figure is 75%; in 'Accelerated', the intermediate scenario, it is 55%.

In 'Net Zero' and 'Accelerated', global gas consumption has declined by around 60% and 35% by 2050 respectively – that is, smaller declines than in the case of oil. In 'New Momentum', however, gas continues to grow, reaching a level of consumption almost 30% greater than that of 2019. That gas holds up more strongly than oil is due to its role as a transition fuel (reducing emissions by replacing coal) and, in the 'New Momentum' scenario, to the increase in demand in emerging economies as they continue to industrialise.

The World Energy Outlook (2020) produced by the International Energy Agency (IEA) adopts a shorter time horizon, looking mainly at the post-pandemic evolution of the global energy market to 2030.[47] The IEA's projections suggest that oil demand will recover from its fall in 2020 but will have reached a plateau by 2030. Demand will be sustained partly by the need for oil as a feedstock for the petrochemical industry. Gas will do better, with demand by 2030 being 14 per cent above the 2019 level and 30 per cent higher than that level by 2040, mainly as a result of additional consumption in South and East Asia.[48]

It is difficult to reconcile the results of these different exercises. However, there is sufficient overlap among them to suggest two tentative conclusions. The first is that, even if demand for oil and gas ceases to rise, it will not have fallen, by mid-century, to the point at which GCC countries will no longer have any significant forex income from the export of hydrocarbons. The second is that gas exporting countries will do better, relatively, than those which are primarily oil exporters.

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[43] "World Oil Outlook", OPEC, 2021 https://www.opec.org/opec_web/en/publications/340.htm
[44] Ibid.
[45] Ibid.
[46] "bp Energy Outlook", bp, 2022 https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2022.pdf
[47] "World Energy Outlook, 2020", International Energy Agency, https://iea.blob.core.windows.net/assets/a72d8abf-de08-4385-8711-b8a062d6124a/WEO2020.pdf
[48] Ibid.

The picture is complicated by other factors. Quite apart from the transition to renewables, energy-importing countries may need less oil and gas per dollar of GDP generated, if (as seems likely) they continue to introduce further efficiencies in the use of those fuels. Moreover, the adoption of renewables and energy-efficiency measures may accelerate over time, such that linear projections made today may under-estimate their impact – and thus the negative impact on the forex income of GCC and other energy-exporting countries.

One big uncertainty in this area is how quickly "green" hydrogen will supplant hydrocarbons as a source of energy. The production of green hydrogen, if it uses electricity from renewable sources, emits no carbon, as opposed to "blue" hydrogen which is derived principally from natural gas and depends on capturing CO_2 rather than allowing it to escape into the atmosphere. At the time of writing, green hydrogen is two to three times more expensive than its blue equivalent. However, the cost of green hydrogen could fall significantly over the next several years.[49]

In view of all the uncertainties expressed above, it is hard to make any confident statements about GCC countries' revenues from hydrocarbons over the coming decades. At mid-century, these revenues might be more, the same as or less than they were before Covid-19. It is certainly possible than they will be much less than they were in 2019. But they will not be zero. In this sense, GCC countries are much better placed than many other countries in terms of dealing with the effect of climate change, as they will have funds with which to pay for adaptation measures.

Genuine economic diversification might eventually reduce the GCC countries' dependence on revenue from oil and gas exports. It will only do so, however, if there is a shift from the present pattern in which 'private sector activity in the GCC continues to rely heavily on government-funded projects and consumption that are ultimately supported by oil and gas revenues.'[50] Should such genuine diversification occur, together with the necessary fiscal reforms, the impact of any reduction in demand for hydrocarbons will be less keenly felt by GCC countries. If it does not occur, GCC governments will find themselves, by mid-century, in financial difficulties, as their sovereign wealth funds will not (according to the IMF) sustain them indefinitely.[51]

7.9.The possible impact of climate change on food security in GCC countries

'GCC countries import about 85% of their food, with rice imports comprising virtually all consumption, around 93% of cereals, and approximately 62% of meat and 56% of vegetables.'[52] Given the lack of water in GCC countries, the opportunities for changing this situation by growing

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[49] "Green hydrogen cost reduction: Scaling up electrolysers to meet the 1.5oC climate goal", International Renewable Energy Agency (IRENA), Abu Dhabi (2020) https://www.irena.org/publications/2020/Dec/Green-hydrogen-cost-reduction

[50] Nader Kabbani and Nejla Ben Mimoune, "Economic diversification in the Gulf: Time to redouble efforts", *Brookings Institute*, 31 January 2021, https://www.brookings.edu/research/economic-diversification-in-the-gulf-time-to-redouble-efforts/#footref-6

[51] "The Future of Oil and Fiscal Sustainability in the GCC Region", IMF, Middle East and Central Asia Department Research Department, Report No. 20/01 (2020), https://www.imf.org/en/Publications/Departmental-Papers-Policy-Papers/Issues/2020/01/31/The-Future-of-Oil-and-Fiscal-Sustainability-in-the-GCC-Region-48934

[52] Salim Ghazaly, Roger Rabbat and Ahmed Mokhtar, "How GCC countries can ensure their food security", *Gulf Business*, 8 August 2020 https://gulfbusiness.com/how-gcc-countries-can-ensure-their-food-security/

more food at home are very limited.[53] Where there have been drives for greater self-sufficiency, the cost in water resources has been unsustainably high.[54]

Against this background, food security in GCC countries will therefore depend on what climate change does to food-exporting countries. This is especially the case in that food producers will, in 2050, have to provide food for a world population of 9.7 billion people – two billion more than today.[55]

One of the staples of the GCC diet is wheat. Much of the wheat consumed in the GCC comes from the Americas, Western Europe, Ukraine, Russia and Kazakhstan. If extreme weather events (such as droughts) affect yields of wheat in these regions, there may well be years when GCC countries have to pay more for their imports of food. This will not be a huge problem as long as forex from oil and gas exports is freely available but could be challenging if revenues have fallen. Less easily manageable is the possibility that food exporting countries may restrict exports at times of low yields or stocks, in order to protect domestic consumers. There are instances of this having happened already, for example, Russia banned the export of wheat in 2010, following a drought, and restricted exports again in 2020.[56]

In the hope of avoiding becoming the victims of such situations, GCC governments and commercial companies have bought land or otherwise invested in agricultural ventures outside the region. However, these investments have frequently not delivered the hoped-for results.[57] Moreover, some of the countries in which GCC governments have invested may well themselves experience production difficulties because of the result of climate change. For example, both Saudi Arabia and the UAE have acquired land in Morocco, which in most climate-change scenarios will suffer from significantly reduced precipitation during the course of this century.[58]

GCC governments may take some comfort from the fact that major food-producing countries are located in very different parts of the world. That being the case, extreme climate events (especially droughts) may not have a negative effect on food production in all or most of these countries at the same time. Such reassurance can only be partial, however, as different extreme events may occur simultaneously in different parts of the world, for example, there could be drought in one region and floods or storms in another. More reassuring for GCC countries must be the knowledge that, for the foreseeable future, they will have enough money to outbid other countries for food on the global market.

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[53] Sanaa I. Pirani and Hassan A. Arafat, "Interplay of food security, agriculture and tourism within GCC countries", *Global Food Security*, 9 (2016), 1-9, https://www.sciencedirect.com/science/article/pii/S2211912415300377

[54] Ibid; Laura Wellesley, "How Qatar's Food System Has Adapted to the Blockade", Chatham House Expert Comment, 14 November 2019 https://www.chathamhouse.org/2019/11/how-qatars-food-system-has-adapted-blockade

[55] Max Roser, Hannah Ritchie and Esteban Ortiz-Ospina, "World Population Growth" (first published in 2013; most recent substantial revision in May 2019), Our World in Data website, https://ourworldindata.org/world-population-growth , last visited 31 October 2021.

[56] Anatoly Medetsky and Megan Durisin, "Exports of Russian wheat dry up, stoking food security concerns", *Al-Jazeera*, 26 April 2020, https://www.aljazeera.com/economy/2020/4/26/exports-of-russian-wheat-dry-up-stoking-food-security-concerns

[57] Pirani and Arafat, "Interplay of food security"

[58] Dorte Verner *et al.,* "Climate Variability, Drought, and Drought Management in Morocco's Agricultural Sector", World Bank Group, 5 November 2018, DOI: 10.1596/30603

7.10.How can GCC countries adapt to the effects of climate change?

There are numerous measures that GCC governments could take to lessen the impact of climate change in their countries. Some of these measures are set out in the following section of this chapter. The list is intended merely to suggest possibilities and is certainly not exhaustive. Where the author is aware of existing measures being taken by GCC governments, these are briefly alluded to.

7.11.Official adaptation strategies

According to Luomi report (2020), the UAE and Oman have developed strategies to guide their adaptation to climate change (although these are not publicly available); Bahrain is in the process of developing such a strategy.[59] The other three GCC states do not appear to have such strategies.

7.12.How GCC states can adapt to climate change

In terms of coping with extreme climate events, GCC states could establish shared systems to give early warning and coordinate responses. Oman and UAE are members of the Indian Ocean Tsunami Warning System (IOTWS).[60] While this organisation is not related to climate-change impacts, it could nevertheless provide a model for regional organisations that could be set up to provide early warning of extreme climate events.

To counter the impact of higher temperatures and humidity on those who live in their countries, GCC governments could introduce more efficient air conditioning, so that there is less pressure on power generation and distribution systems at times of high demand during heatwaves, while making sure there are robust back-up systems for power generation and distribution so that air conditioning does not fail in heatwaves. Governments could also regenerate existing rapidly-build cities (such as Dammam in Saudi Arabia's Eastern Province) to make them less vulnerable to heatwaves (and other climate-change impacts such as intense rainfall events and SLR/storm surges) and locate new urban development away from the coast, where humidity is lower and therefore WBTs are lower too.[61] (Both these steps would also reduce vulnerability to other climate-change impacts such as SLR and storm surges; additionally, regenerating existing cities could make them less vulnerable to intense rainfall events.) Other useful counter-measures could include the automation of outdoor work to the maximum extent possible and, where automation is not an option, the introduction of protective measures for outdoor workers, for example, statutory work breaks when the WBT reaches a certain point, or shading from the sun on construction sites.[62]

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[59] Mari Luomi, "Gulf States' Climate Change Policies Amid a Global Pandemic", *Arab Gulf States Institute in Washington*, 25 September 2020, https://agsiw.org/wp-content/uploads/2020/09/Luomi_Climate-Change_Online-1.pdf

[60] Intergovernmental Oceanographic Commission website, http://www.ioc-tsunami.org/index.php?option=com_content&view=article&id=72&Itemid=70&lang=en , last visited 27 October 2021.

[61] Bolleter *et al.,* "Wet-bulb temperature"

[62] Antar A. AbouKorin, "Impacts of Rapid Urbanisation in the Arab World: the Case of Dammam Metropolitan Area, Saudi Arabia", paper presented at 5th International Conference and Workshop on

There are also measures that can help control flooding occasioned by the sudden arrival of too much water, whether this occurs as a result of intense rainfall events or of SLR combined with storm surges.

In the short term, the authorities in GCC countries could adopt ways of providing early warning of imminent flooding. Technologies that offer early warning of flooding are becoming available; these include solar-powered detectors mounted on lamp-posts that can monitor flood levels and can work independently of the central electricity supply, which may not function during flood events.[63] These could be further developed and scaled up, with official or commercial support.

It would also be useful to identify areas of cities that are particularly at risk of flooding.[64] This would require detailed studies for which the necessary data may not yet be available.[65]

Armed with this information, GCC governments could install drainage that is capable of coping with intense rainfall events. This is perhaps more challenging than it sounds, given that cities have often been built without any thought being given to the likelihood of severe flooding and therefore of the need for such drainage. Jeddah, Saudi Arabia's second-largest city, is a case in point.[66] Installing it now would cause a great deal of disruption to the existing urban fabric but will be necessary if further loss of life and destruction of property through flooding are to be averted in future.

More effective enforcement of planning regulations could prevent building on natural flood-plains. Moreover, when wholesale regeneration of rapidly-built towns and cities is being undertaken, there is an opportunity to build in areas less vulnerable to flooding and also to incorporate adequate drainage into urban design.[67] A yet more radical approach would be to build new towns and cities away from the coast, as already noted above as a means of reducing exposure to excessive WBTs.

These measures will take time to implement. Meanwhile, existing coastal infrastructure could be protected with stronger flood defences. Thus, Oman has instituted some measures of this kind, for example, siting critical infrastructure inland, building protective jetties at its port of Duqm and replacing old roads with elevated ones along the Batinah coastal plain.[68] However, one should note that,

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Built Environment in Developing Countries (ICBEDC 2011), at Universiti Sains Malaysia, December 2011, https://www.researchgate.net/publication/263847805_Impacts_of_Rapid_Urbanisation_in_the_Arab_World_the_Case_of_Dammam_Metropolitan_Area_Saudi_Arabia

[63] For example, "Sadeem: A Saudi Technology to warn of floods and landslides before they occur", *EmTech MENA*, 9 December 2019, https://emtechmena.com/sadeem-a-saudi-technology-to-warn-of-floods-and-landslides-before-they-occur/

[64] Mohamed Daoudi and Abdoul Jelil Niang, "Flood Risk and Vulnerability of Jeddah City, Saudi Arabia", *Intechopen* (2019), DOI: 10.57772/intechopen.82073, https://www.intechopen.com/books/recent-advances-in-flood-risk-management/flood-risk-and-vulnerability-of-jeddah-city-saudi-arabia

[65] Abdullah Mamoon *et al*., "Flood Study in Qatar – Challenges and Opportunities", (2015), paper presented at 36th Hydrology and Water Resources Symposium (HWRS), Hobart, Tasmania, Australia, 7-10 December 2015), https://www.researchgate.net/publication/286931749_Flood_Study_in_Qatar_-_Challenges_and_Opportunities

[66] Daoudi and Niang, "Flood Risk and Vulnerability of Jeddah City"

[67] AbouKorin, "Impacts of Rapid Urbanisation in the Arab World"

[68] Hereher *et al*., "Assessment of the coastal vulnerability"

> '[w]hile coastal fortification may be workable in [the] short to medium term, fortification responses to SLR will likely be futile in the longer term … given the projections that sea levels will still be rising in hundreds of years from now.'[69]

Natural coastal defences may prove more effective and have the added benefit of conserving the marine environment.[70]

As far as addressing the opposite challenge (far too little water, most of the time), GCC governments have responded to their countries' water-stressed situation in two main ways. The first has been to desalinate sea-water – and without desalination, the present levels of population and economic activity in the GCC would be completely impossible. The second has been to abstract groundwater at rates much higher than those at which these reserves are replenished by rainfall.

If climate change brings even lower average rainfall, as seems likely for most parts of the GCC, an expansion of desalination capacity seems like the obvious answer. Indeed, such an expansion is well under way.[71] However, a reliance on desalination has disadvantages. One is the energy expended in the desalination process and the consequent emission of larger volumes of GHGs, although the progressive adoption of reverse-osmosis technology is reducing the energy demand per cubic metre of water produced. Another is the damage done to the marine environment by the release of ever-larger volumes of highly saline water into the waters off the coasts of GCC countries. As Al-Maamarya *et al.* (2017) put it,

> 'desalinating water processes increase the concentrations of salts and chemicals produced from water treatment and thrown directly into the Arab Gulf, which results in great harm to the marine creatures in it.'[72]

There are other things that GCC governments could do to make better use of such water resources as they have – in effect, increasing the overall availability of water. One possible approach is to encourage farmers to improve the efficiency with which they use water and to plant crops that use less water. In this regard, it is worth noting that agriculture uses between 70 per cent and 85 per cent of the water consumed in GCC countries.[73] Saudi Arabia already has a programme that aims to achieve these goals.[74]

Another way forward would be the widespread introduction of recycling of water already used by domestic, commercial and industrial consumers, for use in the irrigation of crops and parks. This requires the treatment of such wastewater as well as careful management and regulation, for safety reasons; it also requires investment in infrastructure. However, none of this is new territory, whether organisationally or technically: there is a great deal of good practice elsewhere in the world that could be emulated. Following the establishment of diplomatic relations and other ties of various kinds between Israel and several GCC states, the latter could, if they wished, avail

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[69] Julian Bolleter *et al.,* "Wet-bulb Temperature"
[70] Al-Maamarya *et al.,* "Climate change: The game changer"
[71] Jennifer Aguinaldo, "Water security trends upwards in region", *MEED*, 30 December, 2020, https://www.meed.com/water-security-trends-upwards-in-mena
[72] Al-Maamarya *et al.,* "Climate change: The game changer"
[73] Tomas Krampera, "Water in the GCC", *The Euro-Gulf Information Centre*, February 17, 2021, https://www.egic.info/water-in-the-gcc
[74] Al-Maamarya *et al.,* "Climate change: The game changer"

themselves of Israel's extensive expertise in water technology and management.[75] Abu Dhabi adopted a water-recycling policy in 2019.[76]

Policies of this nature should be able to reduce – to some extent – the reliance on imported food. Although this is a worthwhile endeavour, the GCC countries will always be heavily reliant on imports.

With this consideration in mind, GCC governments will need, in order to achieve food security, to stockpile food in case of global shortages. Thus, Qatar has already done this, with its Strategic Food Security Facilities Project, a food storage and processing facility at Hamad Port which has the capacity to stockpile enough rice, sugar and edible oils for three million people – more than its current population – for two-and-a-half years.[77] Cooperative food-storage arrangements among GCC countries would offer greatly increased food security. Cutting wastage of food (which is considerable in GCC countries) would complement stockpiling, by reducing the volumes needing to be held.[78]

Conclusions

Current projections suggest that GCC countries will be hard hit by the direct effects of climate change. The principal impacts on these countries' economies and societies will be even higher levels of temperature and humidity than are experienced today and more frequent and more severe flooding, especially in coastal areas. Much hotter and more humid weather in summer could make normal life in GCC cities virtually impossible at times, during that season. And coastal flooding will put much of the infrastructure on the Gulf, Gulf of Oman, Arabian Sea and Red Sea coasts at risk, unless measures of adaptation are implemented.

For the foreseeable future, their income from the export of hydrocarbons will mean that GCC countries are much better placed to implement such measures than less wealthy countries.[79] There are numerous things that they could do, while they have funds available. Some of these things, such as back-up power networks and adequate storm drainage, are unglamorous, even invisible – and therefore compare unfavourably with more visionary or futuristic projects. They will require careful planning, based on sound data (which in some cases has not yet been collected). In many places, installing the necessary infrastructure will seriously disrupt the existing urban fabric. This will, however, save lives and be less costly financially over the medium and long terms than repeated floods.

The indirect effects of climate change on the GCC countries may be just as severe, although they are harder to predict with confidence. Food security may be impaired by the impact of climate change on those parts of the world from which the Gulf imports its food. Lack of

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[75] Isaac Herzog (President of Israel), "Next stop: Making UAE-Israel relations extraordinary", *Khaleej Times,* 27 October 2021, https://www.khaleejtimes.com/opinion/next-stop-making-uae-israel-relations-extraordinary

[76] Imran Mojib, "DoE launches recycled water policy to fulfil future needs", *Gulf Today*, 29 June 2019, https://www.gulftoday.ae/news/2019/06/29/doe-launches-recycled-water-policy-to-fulfil-future-needs

[77] Peter Alagos, 'Envoy underscores Pakistan's role in Qatar food security', *Gulf Times,* 28 February 2018 Envoy underscores Pakistan's role in Qatar food security (gulf-times.com)

[78] Pirani and Arafat, "Interplay of food security"

[79] Abdullah Mamoon *et al*., "Flood Study in Qatar"

renewable water resources in the region mean that GCC governments can do very little to hedge against such risks by striving for self-sufficiency. Treating and re-using urban wastewater for irrigation could make a contribution to the food security of GCC countries but can never be on a scale large enough to transform this situation of dependency on agricultural regions beyond the GCC.

The more optimistic projections of world demand for oil and gas (more optimistic from the point of view of the exporters, that is) may turn out to be accurate. If they do, the GCC countries will be well placed to outbid others when there are shortages in the global food market. On the other hand, if the demand for oil and gas falls in absolute terms and indeed falls sharply, GCC governments may find themselves having to draw on assets such as their sovereign wealth funds in order to purchase food for the people living within their borders.

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