Climate Change, Air Pollution and the Associated Burden of Disease in the Arabian Peninsula and Neighbouring Regions

Akasha, Heba; Ghaffarpasand, Omid; Pope, Francis D.

DOI:
10.3390/su15043766

sustainability

MDPI

Review

Climate Change, Air Pollution and the Associated Burden of Disease in the Arabian Peninsula and Neighbouring Regions: A Critical Review of the Literature

Heba Akasha, Omid Ghaffarpasand and Francis D. Pope *

School of Geography, Earth, and Environmental Sciences, University of Birmingham, Birmingham B15 2TT, UK
* Correspondence: f.pope@bham.ac.uk; Tel.: +44-0121-4149067

Abstract: A narrative review on the interlinking effects of climate change and air pollution, and their impacts on human health in the Arabian Peninsula and its Neighbouring Regions (APNR) is provided. The APNR is experiencing the direct impacts of climate change through increasingly extreme temperatures in the summer season, increasing maximum and minimum temperatures, and increased frequency and severity of dust events. The region is also experiencing significant air pollution, of which particulate matter (PM), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) are of specific concern. Air pollution in the APNR is mainly caused by unprecedented industrial, population and motorization growth. The discovery of oil in the early 20th century has been the major economic driving force behind these changes. Climate change and air pollution impact human health in the region, primarily respiratory and cardiovascular health. Despite an increase in research capacity, research intensity was found to be inconsistent across the APNR countries, with Saudi Arabia, the UAE, Qatar and Iraq publishing more research articles than the other countries. In this review article, the existing research gaps in the region are investigated and the lack of synthesis between the interacting effects of air pollution and climate change upon human health is highlighted.

Keywords: climate change; air pollution; health; Arabian Peninsula; GCC; Arabian desert

Citation: Akasha, H.; Ghaffarpasand, O.; Pope, F.D. Climate Change, Air Pollution and the Associated Burden of Disease in the Arabian Peninsula and Neighbouring Regions: A Critical Review of the Literature. *Sustainability* **2023**, *15*, 3766. https://doi.org/10.3390/su15043766

Academic Editor: Joana Ferreira

Received: 1 December 2022
Revised: 18 January 2023
Accepted: 14 February 2023
Published: 18 February 2023

1. Introduction

Climate Change, air pollution and human health are intricately linked, and efforts to improve them represent key aspects of sustainable development within the interlinking spheres of society, economy and environment [1]. To ensure sustainable development, nations need to find a balance between economic development and the associated environmental impacts, ensuring that population and environmental health are optimized.

This review focuses on the Arabian Peninsula and its Neighbouring Regions (APNR). The Arabian Peninsula (AP) is located in Western Asia, bordered by the Red Sea from the southwest and west, by the Persian (also known as the Arabian) Gulf from the northeast, by the Gulf of Oman from the east and by the Arabian Sea from the southeast; see Figure 1 [2]. The AP comprises six countries, with two more countries also extending onto the peninsula. The countries located wholly on the peninsula are Saudi Arabia, Oman, Kuwait, Qatar, Yemen and the United Arab Emirates (UAE). The southern portions of Jordan and Iraq also extend into the peninsula. Geopolitically, Bahrain is also part of the peninsula. The southwestern coastline of Iran is close to the AP's northeastern coast and is found to be impacted by wind events and dust storms originating in the AP [3], and hence, it is considered in this review. The AP is the largest Peninsula in the world, covering a geographical area of 3,237,500 km^2 and, in 2021, was home to over 77.9 million people [4]. Saudi Arabia is the largest country of the APNR in terms of geographic area and population, spanning over 2,150,000 km^2 (66% of the peninsula's total area), and is home to over 33.4 million people [4].

Figure 1. The Arabian Peninsula (AP) and Neighbouring Regions.

In the APNR, geography is highly significant with respect to climate change, air pollution and human health. The dusty and desert environment presents numerous challenges. Dust storms play an important role in the distribution of pollutants by transferring particulate matter (PM) pollution from one region to another, both internal and external to national boundaries [5]. Dust storms could attenuate or intensify the impacts of climate change in the region, it remains unclear whether dust storms have a net cooling or warming effect on the planet [6]. Health issues follow the trends of air pollution and climate change as a natural consequence. Out of 3.45 million premature deaths related to fine particulate matter pollution worldwide, approximately 12% (400,000 deaths) were related to air pollutants emitted in a region of the world other than that in which the death occurred. In light of the above, transboundary air pollution is one of most serious environmental challenges in many regions around the world [7].

The APNR countries have been a dominant force in the global oil and gas sector since the discovery of oil in the region, producing about 35% and 25% of the world's natural gas and crude oil, respectively. The discovery of fossil fuels led to exponential, unprecedented economic and wealth growth in the region [3]. This economic prosperity was accompanied by exponential growth in the population [8].

A hydrocarbon-fuelled economy, with increasing wealth and population, has led to the region emitting millions of tons of greenhouse gases (GHGs) responsible for climate change [9]. GHGs are climate change agents that trap heat in the atmosphere [10]. The main GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases [10]. GHGs interact with solar and terrestrial radiation and perturb the planetary energy balance, leading to changes in climate or a phenomenon referred to as "global warming" [10]. Globally, the precise location of release of long-lived GHGs, such as CO_2, is of minor importance because of their long atmospheric lifetimes (>50 years) that lead to global mixing. Hence, the effects of climate change upon APNR are a result of net global emissions, not just those from the APNR region. However, it is worth highlighting that the APNR has some of the highest CO_2 emitters per capita across the globe; Qatar, the UAE, Bahrain, Kuwait, and Saudi Arabia were in the top ten global emitters of CO_2 per capita in 2016 [11]. Climate emissions are mainly generated from burning fossil fuels in the 113ation, industrial and electricity generation sectors, which are directly linked to the development and economic growth of the APNR [12–14]. Most of the APNR countries have shown their commitment to reducing GHG emissions through the Paris agreement by submitting their Nationally Determined Contributions (NDCs). The NDCs describe their strategy and action plan to reduce emissions and adapt to climate change. Saudi Arabia, Bahrain, Oman, Kuwait, Jordan and Qatar are among the countries that submitted their first NDCs. The UAE is one of the few countries in the world to have submitted their second NDC in 2020, while Iran and Yemen have not yet adopted the Paris agreement [15].

Air pollution is often associated with increased economic, agricultural and industrial activities, which is also required for national growth and prosperity [13,14,16]. International organizations such as the WHO (World Health Organization), CDC (Center of Disease Control and Prevention) and EPA (United States Environment Protection Agency) define major air pollutants ultimately as a function of their impact on human health and environmentally based criteria [17,18]. Accordingly, the main air pollutants are particulate matter (PM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and ground-level ozone (O_3) [19]. Out of the regulatory air pollutants, PM is found to have the greatest effect upon health [19]. Accordingly, the main air pollutants are particulate matter (PM), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and ground-level ozone (O_3) [19]. Out of the regulatory air pollutants, PM is found to have the greatest effect upon health [19]. PM is typically separated into two regulatory sizes: PM_{10} and $PM_{2.5}$, with PM_{10} and $PM_{2.5}$ particles having diameters of less than 10 and 2.5 μm, respectively. The health effects of $PM_{2.5}$ tend to be more important than the larger fraction of PM_{10}. It would seem obvious that PM composition would be important for health, yet composition-dependent PM metrics for ambient air quality are not available due to the lack of suitable evidence for differential effects of composition upon health. The particle matter distribution ($PM_{2.5}$ to PM_{10} ratio) differs between desert regions ranging from 20% to 60% and is an important consideration when looking into the health impact of desert dust [20].

The combination of increasing air pollution and climate forcing presents a significant challenge to human health in the region. An assessment of climate change and air pollution's impacts on human health has become crucial for the region, as evidenced by the growth of environmental health studies since 2010 [21–28].

The APNR exhibits a growing trend in climate change and air pollution research. Figure 2a highlights the number of studies on climate change and air pollution annually published on the region from 2010 to 2020. From a geographic perspective, regional studies are more abundant than country-specific studies, yet there exist inconsistencies in research abundance across the countries. The country-specific studies are highlighted in Figure 2b. Saudi Arabia, the UAE, Qatar and Iraq are leading the region with respect to publications on climate change and air pollution research.

This review focuses on surveying the academic and grey literature that relates to the APNR in the three interrelated topics of climate change, air quality and human health. The review specifically aims to answer the following questions:

- How is climate change impacting the weather patterns/conditions in the APNR?
- What are the linkages between climate change and air pollution in the APNR?
- What are the main air pollutants and their sources in the APNR?
- What are the main health risks related to climate change and air pollution in the APNR?
- How consistent is research output throughout the APNR countries?
- What are the research gaps for the climate, air pollution and human health nexus in the APNR?

The following sections are organized as follows. Section 2 includes the scope and literature review methodology. Section 3 discusses the results of the review, including climate change in the APNR and extreme weather conditions observed in the region in the recent decade, particularly extreme temperatures and dust storms. This is followed by a detailed survey of health studies associated with climate change and air pollution in the region. The last section provides a critical discussion of the literature and concludes the review, providing an analysis of research gaps and recommendations for future research.

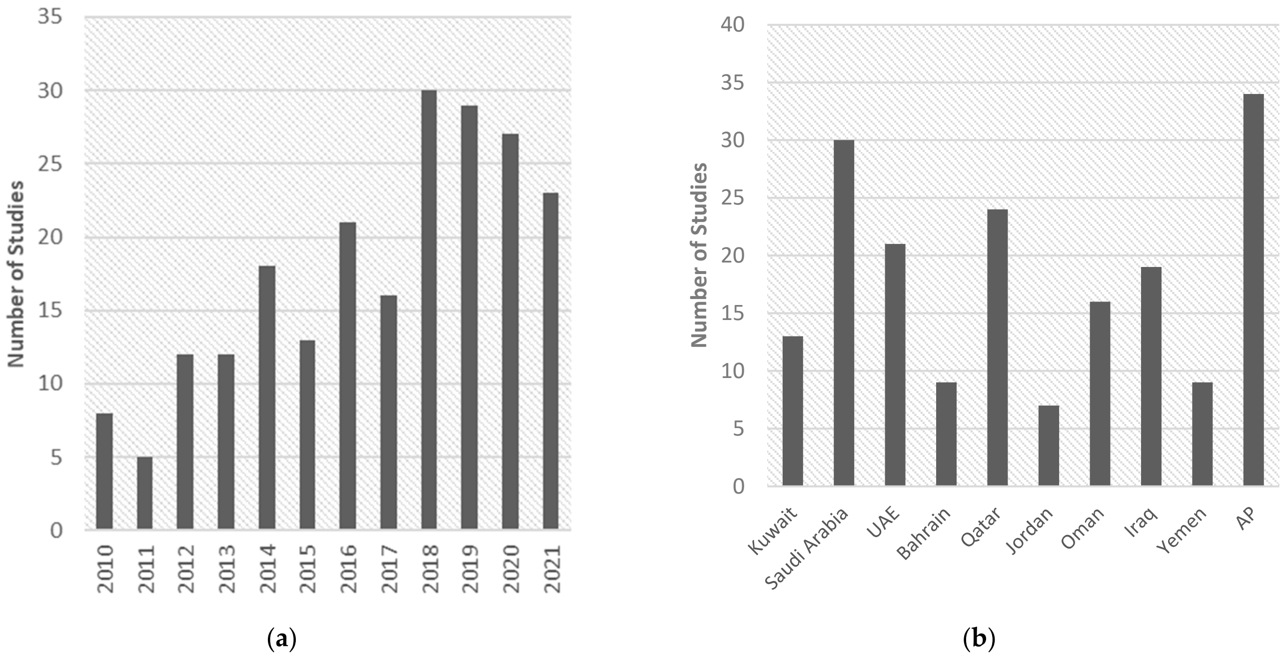


Figure 2. Number of published studies per (**a**) year and (**b**) country on either climate change and/or air pollution research in the APNR in the period 2010–2021. Iran's research contribution was not included in Figure 2b to avoid misrepresentation, since only the Southwestern region of Iran is included in the study region of this review. AP refers to regional papers that are not country-specific.

2. Scope and Literature Review Methodology

This review assesses and synthesizes the literature to identify gaps in research and to propose future opportunities [29] in the fields of climate change, air pollution and health in the APNR. This narrative review uses an integrative review methodology [30]. The literature search was performed using multiple databases including Science Direct, Nature and Google Scholar. Various combinations of keywords were used, including climate change, AP, Persian/Arabian Gulf, health, air pollution, Gulf countries and the names of all the countries in the APNR. A review period of 12 years (2010 to 2021) was selected. To achieve an inclusive sample of recent literature, the review included reports of quantitative and qualitative research, academic literature reviews, theoretical papers, case study research, evaluation studies and recently published book chapters [30]. The articles included for review were selected based on the relevance of the title to search and typically contained at least a combination of two of the keywords mentioned above. The resulting database of papers was reviewed multiple times to eliminate repetition and to ensure relevance [30]. The APNR, similar to the rest of the world, was affected by the COVID-19 pandemic, starting in 2020 and currently ongoing. The papers published in 2020 were related to research conducted prior to the pandemic, whereas most papers published in 2021 were related to the COVID-19 impacts on the APNR, which are beyond the scope of this review.

3. Results

3.1. Climate and Climate Change in APNR

The APNR is located in the subtropical high-pressure region, where the climate is classified as arid, causing significant variations in temperature and humidity [31]. The combination of high evaporation [32], low precipitation rate and a dusty environment renders the complete ecosystem. Water resources and society are vulnerable to the detrimental impacts of climate change [33–40]. Many associated risks have been discussed in the literature, in particular, risks in human development [41,42], crop production [43], food and water security, and national stability and security [35,44–48].

The climate in the APNR can be divided into two main seasons, with two transition periods: summer season (June to September), fall transition (October to November), winter season (December to March) and spring transition (April to May). During the transition periods, the weather is usually unstable, with no well-defined weather patterns, and tropical storms are common [49,50]. Ref. [5] reviewed the climatic conditions in six of the APNR countries, describing the broad climatic spectrum that includes snow in Asir, Saudi Arabia, to extreme heat in Rub Al Khali desert. The region exhibits the highest temperatures over the Rub Al Khali desert area and the lowest temperatures in the north and within the mountainous areas of the Southeast [51]. During the cold season (December, January and February), the climate is impacted by cold weather episodes from the northeast due to the Siberian high, the passage of the Mediterranean systems and the Shamal winds [50,52]. The Shamal wind (Arabian word for North) is the longest and most prominent wind, transporting around 90 million tons of dust per year from the deserts of the Arabian Peninsula, Iraq and Syria into the Gulf (Persian/Arabian) [53]. The winds occur in both the summer and winter but reach their maximum activity in the summer between June and July.

Within the APNR, extreme temperatures occur annually in the summer season, sometimes exceeding maxima of 50 °C, with an average monthly temperature exceeding 32 °C [50]. Due to such extreme temperatures, the region has become a target of increased international climate research in the past decade [54]. Changes in seasonal wind patterns were found to have a high impact on air quality with consequent impacts on human health [20].

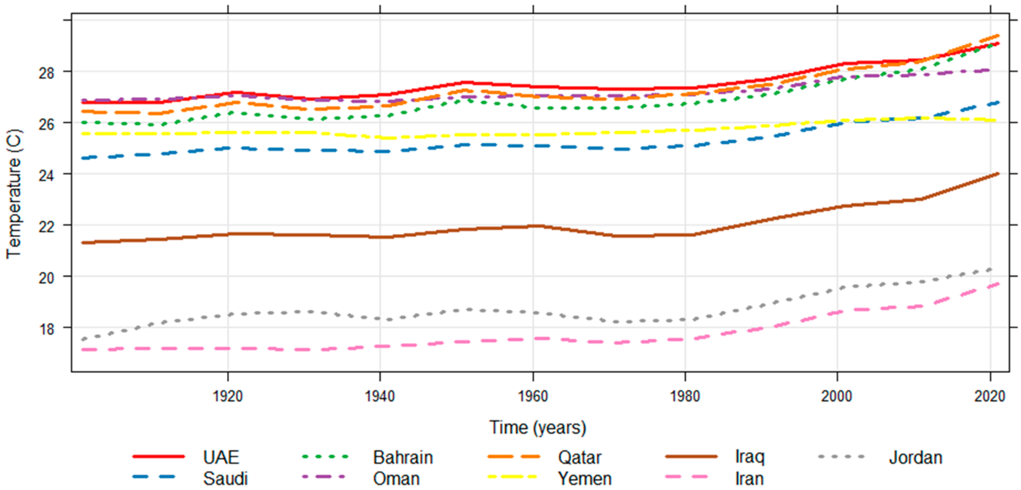
Several studies investigated the climatic changes in the APNR in the last few decades. For example, [50] studied the regional climatology of the APNR over 30 years (1986–2015) by analysing the basic climatological patterns and found the climate of the APNR is characterized by significant spatial and temporal variations, due to its complex topography and the large-scale atmospheric circulation. Ref. [52] investigated the impact of climate change on sea surface temperature across the APNR over the past four decades, with a prediction for the end of the 21st century. Their results showed that the highest warming occurred during the summer seasons and the lowest warming during the winter and fall seasons [52]. Refs. [55,56] studied climate change impacts on the Middle East and found that the APNR might experience increased precipitation, contrary to the findings for the rest of the Middle East region. The APNR region will also be subject to an increased number of extreme temperature days such as the other Middle Eastern regions [55,56].

Figure 3a,b show the decadal changes in temperature and precipitation in the APNR. The studied parameters are extracted from the database of the climate research unit at the University of East Anglia in the UK, available at https://www.uea.ac.uk/groups-and-centres/climatic-research-uni (accessed on 6 February 2023).

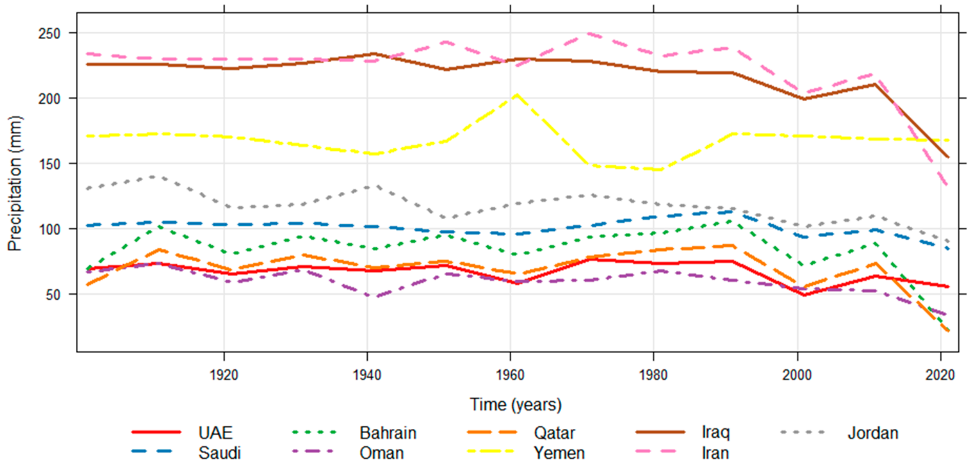
The ascending and descending trend in the average decadal temperature and precipitation, respectively, represent global warming and climate change in the region. It can be seen that the APNR countries have experienced almost the same warming trend in the recent century. However, Iran and Iraq faced a significant decrease in rainfall over the past decade. Country-specific information on climate and climate change impacts is provided in the subsections below.

3.1.1. United Arab Emirates (UAE)

The UAE is categorized into four bio-climatic regions: Abu Dhabi, Al Ain, Sharjah and Dubai [57], which were attributed to their different climatic conditions and soil/vegetation associations. Ref. [57] predicted negligible change to mean temperatures in the four bio-climatic regions until 2030, except for the region of Dubai, where an increasing trend is expected. However, the results of his study predicted increasing trends in maximum temperatures in the northeastern emirates of Dubai and Sharjah and a higher occurrence of extreme temperatures in the emirate of Abu Dhabi and Al Ain. Another study showed that significant increasing trends were observed in extreme temperatures and rainfall parameters in the northern and southern regions of the UAE except the Al Ain region [58]. Most of UAE's major cities fall on the coastline. Therefore, the increasing trend in extreme rainfall [59] places the UAE at an increased risk from flash floods, despite an overall reduction in precipitation and an increase in water deficits [60]. Flash floods are a phenomenon common in arid regions that presents a potential hazard to life, and the social and economic status of the country [58].



(**a**)



(**b**)

Figure 3. Decadal variation in (**a**) temperature and (**b**) precipitation of the APNR for 1901–2021.

3.1.2. Saudi Arabia

Saudi Arabia is the largest country in the APNR both in size and population. Refs. [41,51] investigated the temperature variability over Saudi Arabia for the period 1978–2010 and its association with global climate indices. The results showed that temperature variability was highest in winter and lowest in summer, with an indication of a warming phase that started in the late 1990s in addition to lower precipitation rates [41,51]. Ref. [61] concluded that the Makkah region in Saudi Arabia is suffering from a considerable warming temperature trend. Moreover, Ref. [62] investigated the trends in the maximum and minimum temperatures observed in four different climatic zones of Saudi Arabia. Despite finding a significant increase in annual temperature in all regions, the rise in minimum temperatures was more significant than the rise in maximum temperature, indicating a narrower temperature range and fewer cold days [62]. According to a recent study analysing long-term temperature trends and maximum temperature events between 1979 and 2019, Saudi Arabia has experienced warming at a rate 50% higher than the rest of the Northern Hemisphere landmass, with the recent decade (2010–2019) being the warmest on record [63]. A wide body of research has confirmed an upward warming trend in maximum temperatures in Saudi Arabia in recent decades [64–68].

3.1.3. Western Coastal Regions of Iran and Southern Iraq Regions

The impacts of climate change have been observed in Iran over the last 50 years. The main impacts are manifested in changes in sea level, increasing temperatures and declining precipitation rates [45,69–72]. The annual mean temperature has significantly increased by around 0.3 °C/decade throughout the whole country, while annual precipitation has significantly decreased by −7 mm/decade [73]. The impacts of climate change on water resources have been highlighted in several studies, indicating potential growing water deficits [74–76]. With respect to the southern region of Iran (the area of interest in this review), there has been growing evidence of increasing trends in temperatures and evapotranspiration as an indication of a warming climate [77].

In Iraq, the consequences of climate change are manifested in changes in weather patterns and rise in sea level [45]. Increased temperatures and reduced precipitation trigger other environmental burdens including drought, desertification and sandstorms [45]. Climate change effects are particularly threatening to Iraq's southern regions as rising sea levels pose a threat to Iraq's port and coastline and the southern part of the Tigris- Euphrates delta [45].

3.1.4. Other Countries including Jordan, Oman, Kuwait, Qatar and Yemen

Ref. [78] simulated the future climate conditions in Jordan and predicted an increase in annual mean temperature and a decrease in water availability in the Jordan River area. Ref. [35] investigated the impact of climate change and land use change on water resources and food security in Jordan. The results indicated an increased annual temperature and decreased rainfall, exacerbating the problem of water scarcity and food insecurity. Ref. [38] investigated the impact of climate change on water resources in the Mujib basin, central Jordan, using different climate scenarios. In a recent study, Ref. [79] forecasted an increasing temperature trend and decreasing precipitation trend in Jordan. The results show that the increase in minimum temperature will exceed the increase in maximum temperature.

In Qatar, Ref. [80] examined the temperature trend for 30 years (1983–2012); the results indicate a warming trend, an increase in the number of hot nights and days and a reduction in the number of cool nights and days. Another finding, consistent with similar studies in the region, is that minimum temperatures exhibited a higher rate of warming than maximum temperatures [80].

In Oman, an earlier climate change study indicated a clear gap in knowledge and requirement for future research to quantify and assess the impact of climate change in the country [81]. Ref. [82] investigated current and future patterns of temperature and rainfall and observed that Oman will experience increased minimum temperature and decreased precipitation, as the highest impact of climate change. In a recent study, Ref. [83] shows that the mean air temperature in Oman has been increasing at a rate of 0.039 °C per year since 1980.

Currently climate change is also being witnessed in Kuwait, with projections for rising maximum average summertime temperatures of 1–3 °C by 2050 [84]. Temperature differences in Kuwait were observed between urban and non-urban areas due to heat island effects [85]. Interestingly, daytime and night time variations in urban heat islands were indicated, being cooling during the daytime and heating at night time [85].

3.2. Climate-Change-Related Extreme Weather Conditions

In this section, we review the corresponding literature that studied climate-change-related extreme weather conditions in the APNR.

3.2.1. Extreme Temperature

The reviewed literature frequently highlights that extreme temperature events (heatwaves) are one of the most serious effects of climate change in the APNR. Heatwaves significantly impact human morbidity, mortality and quality of life in the Middle East and North Africa (MENA) region [86]. The Arabian desert, in particular, is expected to be a climate change hotspot, increasingly exposing its residents to very extreme temperatures in the summers. Ref. [87] concludes that climate warming in the MENA region is much stronger in summer than in winter, especially in the desert regions where summers are already hot and dry. Climate change has led to the increased frequency of hot days and nights, higher extreme temperature values, fewer cold days and shorter cold spell durations [88].

3.2.2. Dust Storms

Dust storms throughout Saharan Africa, the Middle East and Asia are estimated to place more than 200–5000 million tons of mineral dust into the Earth's atmosphere each year [89]. The APNR is one of the largest sources of desert dust in the Middle East and is characterized by arid conditions and large beds of sand dunes [90]. The region is also characterized by frequent synoptic pressure gradients [91] and strong Monsoon winds during the spring and summer seasons (March–September). This leads to the formation of dust storms [92–94], sometimes coupled with intensive rainfalls that are responsible for the wet deposition of suspended dust over the region [90,95]. Dust storms cause significant disturbances in the radiation-energy balance of the earth's atmospheric system, causing either atmospheric heating or cooling [6]. The construction of river dams amidst a warming climate have further enhanced desertification in the APNR, especially in semi-arid and arid regions that cover almost a third of the APNR [96].

Dust originating from these regions is dispersed across oceans and sometimes globally. The mineral and chemical compositions in addition to the constituting biological agents (e.g., fungi, bacteria and viruses) may have adverse effects on human health and quality of life [97,98]. Ref. [99] found that $PM_{2.5}$ in desert dust has a lower oxidative potential and is less harmful to health than that produced by combustion. This might be particularly important for congested, industrially active, desert regions such as many countries of the APNR.

In the APNR, Shamal events occur throughout the year and have substantial effects upon society, the economy, transportation and the natural environment [49,100,101]. Several studies focus on Shamal events and its effect on various meteorological parameters and its relation to climate change. Ref. [49] found that Shamal events, although not always a direct cause of dust storms, were directly correlated with dust storms. They were found to cause abrupt changes in meteorological parameters such as increasing wind speeds, increasing temperatures during summer and decreasing temperatures during winter, and reducing humidity.

Other regional studies have attempted to quantify the radiative effects of dust in the APNR by investigating the relationships between dust Aerosol Optical Depth (AOD) and meteorological parameters such as precipitation, temperature, pressure and wind speed [91,102,103]. Their results indicate that dust event formation is better related to precipitation in the late cold season and early warm season (March and April), while temperature is related more to AOD in the late warm season (August and September) [91]. Ref. [103] investigated the impact of dust storms on radiation fluxes and climate characteristics within the APNR region. They found that the main dust sources are the river valleys of the lower Tigris and Euphrates in Iraq; areas from Kuwait, Iran and the UAE; and the basin of the Arabian desert (which includes the Rub' al Khali, An Nafud and Ad Dahna). Dust sources were also identified along the western coast of the APNR. Their empirical findings show a negative correlation between dust formation over high dust concentration regions and surface temperature. This might indicate a cooling meteorological response to dust radiative forcing. Similar studies conducted in the region also observed the dust aerosol cooling effect [104,105]. Ref. [6] highlighted the significant impact of dust and dust events on visibility. Visibility can be used as a proxy for air pollution but is also important for health, safety and the economy; lowered visibility increases the likelihood of vehicle accidents [106]. However, no significant trend in long-term visibility was observed in Saudi Arabia [107].

Changes in dust characteristics over the past few decades could constitute a possible indicator of climate change in the region [90]. In the UAE, Ref. [92] investigated the long-term natural and anthropogenic aerosol characteristics for 2006–2015 and found an increase of 4.32% in AOD in recent years. This was attributed to increasing the activity of the anthropogenic emission sources. Some studies have modelled the radiative effects and formation patterns of dust in the region with a primary focus on the contribution of natural dust and rarely mention the impact of anthropogenic dust [104,108–110]. Increased dust under anthropogenic climate change conditions in the APNR leads to a consideration of what proportion of dust can be natural or anthropogenic. As evident from the literature, a proper contribution of anthropogenic activities to APNR dust emissions has not been sufficiently determined, mainly due to the lack of proper dust characterization [98]. On a global scale, Ref. [111] estimates that anthropogenic dust accounts for 25% of global dust emissions. Ref. [100] highlights that dust forecasting in the APNR is still a challenging aspect of research and requires further investigation.

3.3. Air Pollution and Climate Change Interactions

In a review of air pollution in MENA, Ref. [112] categorized air emissions into health-related and climate-related emissions. Particulate matter and gaseous pollutants were identified as the major pollutants causing detrimental health effects in the whole Middle East and North African regions [112]. Specifically for the APNR, NO_2, SO_2 and CO_2 have received considerable attention during recent decades due to unprecedented economic growth and infrastructure development [5]. Other pollution sources in MENA include desalination plants, the energy sector and cement production. Overall, the situation is no different in general in the APNR, except for the additional presence of sandstorms that facilitate pollution and fine particle transport [99]. Air pollution might be exacerbated in some rich, oil-producing countries as a result of excessive use of governmentally subsidized energy, major infrastructure projects, fossil fuel burning, water desalination and heavy traffic [113].

Climate and air quality are intricately connected, whereby many sources of air pollutants are also sources of CO_2, other GHGs and/or short-lived climate forcers (SLCFs) [114]. A schematic picture of the likely interactions between the air pollutants and climate forcers is represented in Figure 3. The interaction of climate change with air pollution in a desert environment is represented in Figure 4. Climate is expected to degrade air quality in many regions by changing air pollution meteorology (dilution and ventilation) and precipitation and by triggering amplifying responses in atmospheric chemistry [115]. This will mainly impact the shape distribution and extreme episodes of tropospheric O_3 and fine particulate matter, which are influenced by changes in precipitation and ventilation due to changes in weather patterns. Additionally, climate change influences air pollution by altering the frequency, severity, and duration of heatwaves, air stagnation events, and other meteorology conducive to the accumulation of heatwaves [116]. A recent literature review in 2020, by Gallagher and Holloway, presented evidence that GHG reduction has synergistic benefits of decreasing air pollution and protecting public health [117]. They note that "compared to other aspects of climate and energy policy evaluation, however, there are still relatively few of these co-benefits analyses". This is particularly important in the APNR due to the strong links between climate change, desert dust and air pollution.

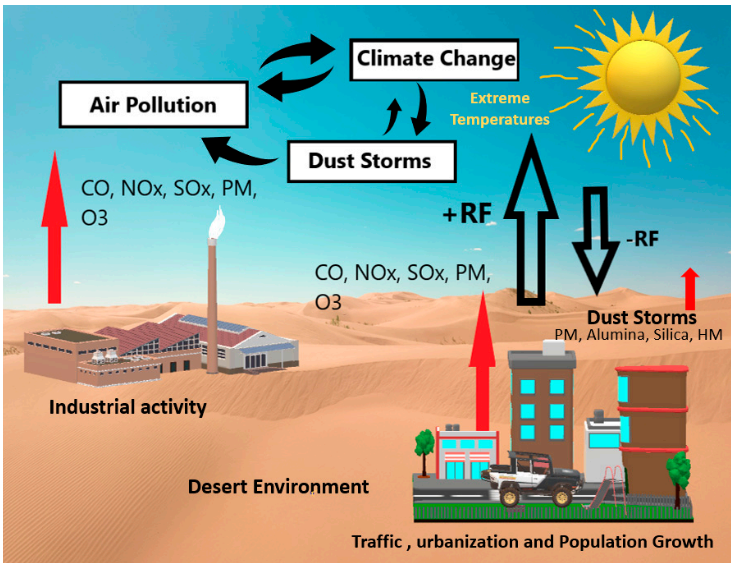


Figure 4. A schematic picture of climate change and air pollution interactions in a desert regions.

3.4. Health Impact of Desert Dust, Air Pollution and Climate Change

3.4.1. Health Impact of Air Pollution and Desert Dust

The WHO states that "From smog hanging over cities to smoke inside the home, air pollution poses a major threat to health and climate across the globe." [118]. Air pollution accounts for an estimated 7 million premature deaths per year, with 4 million attributed to indoor air pollution. Air pollution has been classified as a leading cause of death and disability worldwide due to heart disease, stroke, COPD, cancer and pneumonia [118]. Evidence regarding the linkage between air pollution to a specific diseases, such as cardiovascular, respiratory diseases and cancers has been produced at the national, regional, and global levels [119–123]. In addition to its effects upon physical health, recently, short-term exposure to air pollution has been linked to short-term cognitive decline [124] and longer-term neurodegenerative diseases [125].

Desert dust causes respiratory diseases, cardiovascular diseases, cardiopulmonary diseases and mental health issues. Indirectly, it can cause injuries and, in many cases, death from transport accidents related to poor visibility [97,126]. Many studies worldwide looked into the health-related impacts of anthropogenically generated PM, while little research considered the health impact of naturally generated desert dust PM [127]. Similarly, in the APNR, research related to the health effects of desert dust is scarce. In addition to serious illness, sandstorm episodes can also lead to general discomfort and irritation and are correlated with coughs, runny nose, eye irritation, headache and sleep apnoea, as indicated by a study conducted in Saudi Arabia [23].

Some of the major cities in the APNR are listed among the world's worst with respect to PM_{10} concentrations. The average daily concentration could reach up to 280 ug/m^3 in the APNR [126]. Riyadh in Saudi Arabia is ranked 7th and Bahrain is ranked 11th in terms of the highest PM_{10} concentrations [128]. Moreover, the level of PM_{10} was more than 5 to 6 folds higher than the WHO limits in Kuwait, while the level could reach 10 fold higher in the UAE [129]. Saudi Arabia and Qatar also exceed the WHO recommendations in their reported PM_{10} concentrations [129]. It is noted that the WHO air-quality recommendations became more stringent in 2021, so exceedances of the WHO recommendations will likely now be more common. Western areas in Iran show significant exposure to dust-related air pollutants, particularly PM_{10} during middle eastern dust events from the Arabian Peninsula, Jordan, Iraq, Syria, and Kuwait, leading to an excess of hospital admissions for Chronic Obstructive Pulmonary Disease (COPD) and an excess of respiratory mortality [28,130]. Within Kuwait, the correlation between the occurrence of respiratory and cardiovascular diseases and dust storms indicated that PM_{10} concentrations were significantly correlated with bronchial asthma, acute lower respiratory tract infection and acute upper respiratory tract infection with correlation coefficient (r) values of 0.292, 0.737 and 0.839, respectively. Moreover, PM10-associated respiratory and cardiovascular mortality rates were 0.62 per 10,000 persons [131]. Ref. [131] provides good evidence of the consistent relationship between dust storm events, PM_{10} concentration levels and respiratory diseases.

Within the APNR region, PM pollution is a serious environmental and health concern, mainly due to the desert environment but also due to the elevated $PM_{2.5}$ generated from anthropogenic sources. The Arab Forum for Environment and Development 2017 report indicated that the UAE has one the world's highest levels of pollution with regard to fine particulate matter ($PM_{2.5}$) [12]. In Kuwait, elevated levels of $PM_{2.5}$ particularly during rush hours, weekends and summer were associated with high excess premature mortality for ischemic heart diseases and stroke [132]. Air pollution ranks 8 out of 19 in 'leading risks' to health in Saudi Arabia [133].

Poor air quality has been linked to an increased risk of mortality in the UAE [134], Kuwait [135] and Iran [136]. Ref. [136] found that elevated PM_{10} and SO_2 increased total and cardiovascular mortality, hospital admissions due to respiratory and cardiovascular diseases, COPD and acute myocardial infarction. Outdoor air pollution is the leading source of environmental-linked mortality in the UAE, followed by indoor air pollution and occupational exposures [134]. Ref. [137] investigated the impact of air pollution on adolescents between the ages of 13 and 20 years from nine different regions within the UAE. Their results revealed that geographical regions and proximity to industrial areas can be predictors of asthma [137]. Another epidemiology study in the UAE indicated that at least 13% of children, particularly those of Emirati descent, in the UAE suffer from asthma, with the main causes attributed to indoor and outdoor environmental factors [138]. The location of the residence, the concentration of outdoor pollution and indoor ventilation all impact indoor pollution, with outdoor pollutants infiltrating into indoor spaces. Significant positive associations between household SO_2 and hydrogen sulphide (H_2S) concentrations and doctor-diagnosed asthma were identified [139]. An Iran-based study revealed a positive association between elevated pollution levels and abortion, premature delivery and stillbirth [140].

3.4.2. Health Impacts of Climate Change

As highlighted in the Lancet Countdown report, "changing climate has already produced considerable shifts in the underlying social and environmental determinants of health at the global level" [141]. The most affected areas are clean air (as discussed in the previous section), safe drinking water, sufficient food and secure shelter [142]. With respect to human symptoms of climate change, 2020 indicators presented the "most worrying outlook" since the Lancet Countdown was first published [141]. The WHO predicted a devastating 250,000 additional climate-change-related deaths per year, between 2030 and 2050, from extreme heat, vector-borne and water-borne diseases, and natural disasters. Vulnerable populations will be the most impacted, which is reflected in rising morbidity and mortality rates: 53.7% increase in heat-related mortality in people older than 65 years in the last 20 years [141]. This also includes people living in coastal areas and megacities.

Climate Change has been referred to as a "game changer" in the APNR, for which Ref. [44] argues that the health sector warrants emergency health preparedness in response to the threat. Within the APNR, the threat to human health is consistently related to heat stress from elevated extreme temperature [86], reduction in air quality, increase in vector-borne and water-borne diseases, and increase in natural disasters associated with climatological hazards [42,143]. Climate change can also lead to increased humidity, which increases the potential for heat stress by reducing the body's ability to perspire [24].

Our review highlights the variable health impacts of climate change in APNR countries. In the UAE, for example, climate change is found to impact people in urban areas more than in rural areas. This is attributed to the heat island effect that exacerbates ground ozone pollution and worsens air quality [144]. Indirectly, climate change is also expected to increase vector-borne diseases and generally increase the spread of infectious diseases [144]. Increases in mortality and morbidity due to heat stress are also found to especially impact coastal areas within the APNR region and vulnerable groups, particularly people aged above 65 years old [86,145]. Ref. [146] examines the social vulnerabilities of populations living in the coastal area of the APNR and predicts future drought severities due to reduced rainfall and flood caused by climate-change-based rising sea levels. Other factors such as political instability in certain states of the APNR can also impact social vulnerability and hence magnify the effects of climate change and air pollution upon health. It has been suggested that climate change has exacerbated the crisis of the health sector of politically unstable Yemen by increasing susceptibility to vector-borne disease, increasing heat stress and impacting water supply by reducing levels of rainfall [147].

Studying the past, present and future social vulnerabilities of communities is critical to comprehend how exposure, sensitivity and adaptive capacities have evolved over time, which might be useful to enhance the opportunity for future mitigative and climate change resilient capacities [146].

3.4.3. Combined Health Impacts of Air Pollution and Climate Change

Studies that analyse the synergistic impact of air quality and climate change are not as abundant as studies that segregate the individual impacts. However, a number of international studies have emphasized the importance of analysing the interactions between climate change and air pollution synergistically to assess their impact upon human health [115,120,148–150]. Table 1 shows a summary of the health impacts of air pollution and climate change, as well as their combined health impact.

Table 1. Summary of the health impacts of air pollution, climate change and their combined health impacts; see for example Refs. [42,86,115,120].

Environmental Condition	Health Impact
Air Pollution and desert dust	Respiratory illness (including asthma, COPD and lung cancers). Cardiovascular disease (including heart disease and stroke). Mental and cognitive health issues and cognitive decline. Maternal health (including premature delivery and stillbirth).
Climate Change	Heat-stress and heat-related mortality. Increase spread of infectious disease, including vector-borne diseases.
Combined	Exacerbation of respiratory and cardiovascular disease.

From the human health perspective, the frequency and amplitude of dust activity is a very important factor and is found to depend on three main factors: anthropogenic modification of desert surfaces, natural climatic variability (e.g., in the El Niño Southern Oscillation or the North Atlantic Oscillation), and changes in climate brought about by global warming [20]. As such, it is critical to study the impact of climate change on the frequency of dust activity in the region to realize actual harm to human health.

The current environmental burden of disease from climate change is considered low risk in several countries in the region [133,134,151], notably compared to the high health risk involved with outdoor and indoor pollution, towards which most of the research is being diverted. Based on the search criteria for this review, only one study conducted in Qatar was found in the region and considers the combined health impact of climate change and air pollution. Similar to other countries in the region, Qatar faces a rising risk of health-related problems due to poor air quality stemming from natural and anthropogenic sources [24]. Ref. [24] discussed the impact of changing weather patterns that emerged from climate change on air pollution and consequently human health in Qatar. The results of the study highlighted the association of increased temperature to rising ground-level ozone and particulate matter concentrations, which are associated with cardiovascular and respiratory diseases.

This review of environmental health studies in these regions indicates a scarcity of epidemiological research that investigates the combined impact of air pollution and climate change. Air pollution impacts on health have been studied more rigorously due to its direct impact on human health. At the international level, researchers, scientists, medical professionals and politicians have started to become increasingly interested in the combined impact of climate change and air pollution on health [117,120,122,123,152–155]. Understanding the interaction of climate change and air pollution and their synergistic impacts on human health is vital for effective mitigation and adaptation strategies, raising awareness and effective policy implementation.

4. Discussion, Gap Analysis and Conclusions

For thousands of years, the people in the APNR have been exposed to changes in meteorology and the challenges of climate variability. These challenges have been overcome by adapting their survival strategies [156]. In current decades, temperatures are reaching ever higher and are expected to continue to rise for the foreseeable future, thus bringing new challenges. This review aims to answer six questions, stated earlier in the Introduction section.

In response to the first question, climate change and air pollution are already impacting daily lives in the APNR. Climate change is causing increased mean, minimum and maximum temperatures; higher frequencies of extreme temperature episodes; reduced precipitation; and rising sea levels. Global climate actions and policies need to be rapidly put in place to reduce the extent of extreme warming in the APNR. The strong linkage between climate change and air pollution is highlighted through numerous studies in the region (question 3). The impact of climate change upon meteorology can also impact air pollutant concentrations. This is of particular importance for the APNR, as it can affect dust storm activity, make dust storm events more extreme and affect their frequency and duration. The effect of dust storms upon the local climate, via reflection of incoming solar radiation and other mechanisms, is currently under research in the region and requires further research. Further research is also required on the characterization of APNR dust to distinguish between natural and anthropogenic dust and their relevant impacts upon climate and human health (question 6).

In response to the fourth question, the review shows that climate change and air pollution are impacting human health in the region. Human health, specifically respiratory and cardiovascular health, has also been impacted by rising levels of pollution and extreme dust events. There have been significant investments in health care infrastructure by many of the APNR governments in the past 25 years; nevertheless, the region is faced with a large disease burden that includes communicable and non-communicable diseases (NCDs), mental health issues and accidental injuries [157]. Over the next century, the expected increases in population, urbanization and economic development within the APNR have the potential to increase air pollution emissions. The potentially increasing impacts of climate change and air pollution will further add to the burden of NCDs within the APNR.

This review highlights the scarcity of comprehensive, quantitative and analytical studies that investigate the synergistic health impacts of climate change and pollution. This can be considered one of the main limitations of previous studies. Environmental health studies in the region focus on the health impacts of air pollution, mainly from NO_2, O_3 and anthropogenic PM [56,135,136,158–160]. Despite some mention in the literature of the impact of climate change on rising sea levels and potential floods, climate change is rarely perceived as a direct threat to human health. Climate change is primarily viewed as a climatic phenomenon that might have a significant impact on the ecosystem, water availability and liveability due to increased episodes of heatwaves during the summer and alterations in rainfall patterns [40,161–163].

The academic reporting on the impacts of air pollution and climate change on health in the APNR has grown significantly over the past decade. Despite this overall increase, this review shows that research strength and depth are not consistent across the region, leading to potential imbalances in knowledge (question 5).

Worldwide, the publication of original research on health and climate change has increased by a factor of eight from 2007 to 2019 [141]. This academic research is crucial in raising awareness. The 2017 Report of the Arab Forum for Environment and Development revealed a clear deficiency in the APNR region in the impact of environmental research on policy implementation. The report explains that, to enhance environmental research to an impactful and effective degree, there needs to be enabling conditions, stimulating work environments and potential links to policy. Some suggested improvements include enhancing the research budget allocation; creating centres of excellence; improving publication mechanisms for research institutions; and strengthening research collaboration among countries in the region and with other centres worldwide, particularly in the area of climate change and policy [12].

Author Contributions: H.A. reviewed the literature and wrote the initial draft. O.G. helped with the literature review and paper editing. F.D.P. acquired the funding, was the supervisor and generated the final draft of the paper. All authors have read and agreed to the published version of the manuscript.

Funding: H.A. is funded by the Ministry of Education, UAE, for her PhD program. Funding for F.D.P. was from the UK Natural Environment Research Council NERC (NE/V002449/1).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: Thanks to the Ministry of Education, UAE, for supporting climate change and air pollution research.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Schmidt-Traub, G.; Kroll, C.; Teksoz, K.; Durand-Delacre, D.; Sachs, J.D. National baselines for the Sustainable Development Goals assessed in the SDG Index and Dashboards. *Nat. Geosci.* **2017**, *10*, 547–555. [CrossRef]
2. World Atlas. Arabian Peninsula Countries. Available online: https://www.worldatlas.com/peninsulas/arabian-peninsula.html (accessed on 14 November 2022).
3. Olabemiwo, F.; Danmaliki, G.; Oyehan, T.; Tawabini, B. Forecasting CO_2 emissions in the Persian Gulf States. *Glob. J. Environ. Sci. Manag.* **2017**, *3*, 1–10.
4. WPR. World Population Review: Arabian Peninsula Countries 2021. Available online: https://worldpopulationreview.com/country-rankings/arabian-peninsula-countries (accessed on 5 January 2023).
5. Farahat, A. Air pollution in the Arabian Peninsula (Saudi Arabia, the United Arab Emirates, Kuwait, Qatar, Bahrain, and Oman): Causes, effects, and aerosol categorization. *Arab. J. Geosci.* **2016**, *9*, 196. [CrossRef]
6. Alam, K.; Trautmann, T.; Blaschke, T.; Subhan, F. Changes in aerosol optical properties due to dust storms in the Middle East and Southwest Asia. *Remote Sens. Environ.* **2014**, *143*, 216–227. [CrossRef]
7. Zhang, Q.; Jiang, X.; Tong, D.; Davis, S.J.; Zhao, H.; Geng, G.; Feng, T.; Zheng, B.; Lu, Z.; Streets, D.G.; et al. Transboundary health impacts of transported global air pollution and international trade. *Nature* **2017**, *543*, 705–709. [CrossRef]
8. Shokoohi, Z.; Dehbidi, N.K.; Tarazkar, M.H. Energy intensity, economic growth and environmental quality in populous Middle East countries. *Energy* **2022**, *239*, 122164. [CrossRef]
9. IPCC. 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*; Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Eds.; IPCC: Geneva, Switzerland, 2021.
10. IPCC. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Core Writing Team, Pachauri, R.K., Meyer, L.A., Eds.; IPCC: Geneva, Switzerland, 2014; p. 151.
11. Economist, T. *Pocket World in Figures 2021*, 2021 ed; Profile: London, UK, 2020; p. 256.
12. AEFD. *Arab Environment in 10 Years. Annual Report of Arab Forum for Environment and Development, 2017*; Technical Publications: Beirut, Lebanon, 2017.
13. Borowski, P.; Patuk, I. Environmental, social and economic factors in sustainable development with food, energy and eco-space aspect security. *Present Environ. Sustain. Dev.* **2021**, *15*, 153–169. [CrossRef]

14. Elahi, E.; Khalid, Z.; Zhang, Z. Understanding farmers' intention and willingness to install renewable energy technology: A solution to reduce the environmental emissions of agriculture. *Appl. Energy* **2022**, *309*, 118459. [CrossRef]
15. UNFCC. NDC Registry. Available online: https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx (accessed on 12 November 2021).
16. Zhu, L.; Hao, Y.; Lu, Z.-N.; Wu, H.; Ran, Q. Do economic activities cause air pollution? Evidence from China's major cities. *Sustain. Cities Soc.* **2019**, *49*, 101593. [CrossRef]
17. CDC. Air Pollutants. Available online: https://www.cdc.gov/air/pollutants.htm (accessed on 12 December 2021).
18. WHO. Ambient (Outdoor) Air Pollution. Available online: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health (accessed on 21 November 2022).
19. WHO. Newsroom: Spotlight: How Air Pollution Is Destroying Our Health. Available online: https://www.who.int/news-room/spotlight/how-air-pollution-is-destroying-our-health (accessed on 28 June 2021).
20. Goudie, A.S. Desert dust and human health disorders. *Environ. Int.* **2014**, *63*, 101–113. [CrossRef]
21. Willis, H.H.; MacDonald Gibson, J.; Shih, R.A.; Geschwind, S.; Olmstead, S.; Hu, J.; Curtright, A.E.; Cecchine, G.; Moore, M. Prioritizing Environmental Health Risks in the UAE. *Risk Anal.* **2010**, *30*, 1842–1856. [CrossRef]
22. Gibson, J.M.; Farah, Z.S. Environmental risks to public health in the United Arab Emirates: A quantitative assessment and strategic plan. *Environ. Health Perspect.* **2012**, *120*, 681–686. [CrossRef]
23. Meo, S.A.; Al-Kheraiji, M.F.A.; AlFaraj, Z.F.; abdulaziz Alwehaibi, N.; Aldereihim, A.A. Respiratory and general health complaints in subjects exposed to sandstorm at Riyadh, Saudi Arabia. *Pak. J. Med. Sci.* **2013**, *29*, 642. [CrossRef]
24. Teather, K.; Hogan, N.; Critchley, K.; Gibson, M.; Craig, S.; Hill, J. Examining the links between air quality, climate change and respiratory health in Qatar. *Avicenna* **2013**, *2013*, 9. [CrossRef]
25. El-Zein, A.; Jabbour, S.; Tekce, B.; Zurayk, H.; Nuwayhid, I.; Khawaja, M.; Tell, T.; Mooji, Y.A.; De-Jong, J.; Yassin, N.; et al. Health and ecological sustainability in the Arab world: A matter of survival. *Lancet* **2014**, *383*, 458–476. [CrossRef]
26. Elachola, H.; Memish, Z.A. Oil prices, climate change—Health challenges in Saudi Arabia. *Lancet* **2016**, *387*, 827–829. [CrossRef]
27. Khanjani, N. The effects of climate change on human health in Iran. *Int. J. Public Health* **2016**, *3*, 38–41. [CrossRef]
28. Khaniabadi, Y.O.; Daryanoosh, S.M.; Amrane, A.; Polosa, R.; Hopke, P.K.; Goudarzi, G.; Mohammadi, M.J.; Sicard, P.; Armin, H. Impact of Middle Eastern Dust storms on human health. *Atmos. Pollut. Res.* **2017**, *8*, 606–613. [CrossRef]
29. Snyder, H. Literature review as a research methodology: An overview and guidelines. *J. Bus. Res.* **2019**, *104*, 333–339. [CrossRef]
30. Torraco, R.J. Writing Integrative Literature Reviews: Guidelines and Examples. *Hum. Resour. Dev. Rev.* **2005**, *4*, 356–367. [CrossRef]
31. Syed, F.; Latif, M.; Al-Maashi, A.; Ghulam, A. Regional climate model RCA4 simulations of temperature and precipitation over the Arabian Peninsula: Sensitivity to CORDEX domain and lateral boundary conditions. *Clim. Dyn.* **2019**, *53*, 7045–7064. [CrossRef]
32. Hafez, Y. A Recent Study Concerning the Climatic Variability over the Kingdom Saudi Arabia for the Period 1948-2018. *J. Geosci. Environ. Prot.* **2019**, *07*, 268–289. [CrossRef]
33. Onol, B.; Semazzi, F. Regional impact on climate change on water resources over Eastern Mediterranean: Euphrates-Tigris Basin. In Proceedings of the 18th Conference on Climate Variability and Change, the 86th AMS Meeting, Atlanta, GA, USA, 29 January–2 February 2006.
34. Sowers, J.; Vengosh, A.; Weinthal, E. Climate change, water resources, and the politics of adaptation in the Middle East and North Africa. *Clim. Chang.* **2011**, *104*, 599–627. [CrossRef]
35. Al-Bakri, J.T.; Salahat, M.; Suleiman, A.; Suifan, M.; Hamdan, M.R.; Khresat, S.; Kandakji, T. Impact of climate and land use changes on water and food security in jordan: Implications for transcending "the tragedy of the commons". *Sustainability* **2013**, *5*, 724–748. [CrossRef]
36. Gleick, P. Water, Drought, Climate Change, and Conflict in Syria. *Weather Clim. Soc.* **2014**, *6*, 331–340. [CrossRef]
37. Ibrahim, B. Climate change effects on agriculture and water resources availability in Syria. In *Implementing Adaptation Strategies by Legal, Economic and Planning Instruments on Climate Change*; Springer: Berlin, Germany, 2014; pp. 305–313.
38. Abu-Allaban, M.; El-Naqa, A.; Jaber, M.; Hammouri, N. Water scarcity impact of climate change in semi-arid regions: A case study in Mujib basin, Jordan. *Arab. J. Geosci.* **2015**, *8*, 951–959. [CrossRef]
39. DeNicola, E.; Aburizaiza, O.S.; Siddique, A.; Khwaja, H.; Carpenter, D.O. Climate change and water scarcity: The case of Saudi Arabia. *Ann. Glob. Health* **2015**, *81*, 342–353. [CrossRef]
40. Tarawneh, Q.Y.; Chowdhury, S. Trends of climate change in Saudi Arabia: Implications on water resources. *Climate* **2018**, *6*, 8. [CrossRef]
41. Almazroui, M. Temperature Variability over Saudi Arabia and its Association with Global Climate Indices. *J. King Abdulaziz Univ. Meteorol. Environ. Arid Land Agric. Sci.* **2012**, *23*, 85–108. [CrossRef]
42. Elasha, B.O. Mapping of climate change threats and human development impacts in the Arab region. *UNDP Arab Dev. Rep. –Res. Pap. Ser. UNDP Reg. Bur. Arab States* **2010**, *1*, 13–31.
43. Elahi, E.; Khalid, Z.; Tauni, M.Z.; Zhang, H.; Lirong, X. Extreme weather events risk to crop-production and the adaptation of innovative management strategies to mitigate the risk: A retrospective survey of rural Punjab, Pakistan. *Technovation* **2022**, *117*, 102255. [CrossRef]
44. Al-Maamary, H.M.S.; Kazem, H.A.; Chaichan, M.T. Climate change: The game changer in the Gulf Cooperation Council Region. *Renew. Sustain. Energy Rev.* **2017**, *76*, 555–576. [CrossRef]

45. Adamo, N.; Al-Ansari, N.; Sissakian, V.K.; Knutsson, S.; Laue, J. Climate Change: Consequences on Iraq's Environment. *J. Earth Sci. Geotech. Eng.* **2018**, *8*, 43–58.
46. Al-Saidi, M. Cooperation or competition? State environmental relations and the SDGs agenda in the Gulf Cooperation Council (GCC) region. *Environ. Dev.* **2021**, *37*, 100581. [CrossRef]
47. Scheffran, J.; Battaglini, A. Climate and conflicts: The security risks of global warming. *Reg. Environ. Chang.* **2011**, *11*, S27–S39. [CrossRef]
48. Brauch, H.G. Policy responses to climate change in the Mediterranean and MENA region during the anthropocene. In *Climate Change, Human Security and Violent Conflict*; Springer: Berlin, Germany, 2012; pp. 719–794.
49. Al Senafi, F.; Anis, A. Shamals and climate variability in the Northern Arabian/Persian Gulf from 1973 to 2012. *Int. J. Climatol.* **2015**, *35*, 4509–4528. [CrossRef]
50. Patlakas, P.; Stathopoulos, C.; Flocas, H.; Kalogeri, C.; Kallos, G. Regional climatic features of the Arabian Peninsula. *Atmosphere* **2019**, *10*, 220. [CrossRef]
51. Almazroui, M.; Nazrul Islam, M.; Athar, H.; Jones, P.; Rahman, M.A. Recent climate change in the Arabian Peninsula: Annual rainfall and temperature analysis of Saudi Arabia for 1978–2009. *Int. J. Climatol.* **2012**, *32*, 953–966. [CrossRef]
52. Noori, R.; Tian, F.; Berndtsson, R.; Abbasi, M.R.; Naseh, M.V.; Modabberi, A.; Soltani, A.; Kløve, B. Recent and future trends in sea surface temperature across the Persian Gulf and Gulf of Oman. *PLoS ONE* **2019**, *14*, e0212790. [CrossRef]
53. Naderi Beni, A.; Marriner, N.; Sharifi, A.; Azizpour, J.; Kabiri, K.; Djamali, M.; Kirman, A. Climate change: A driver of future conflicts in the Persian Gulf Region? *Heliyon* **2021**, *7*, e06288. [CrossRef]
54. Vaughan, G.O.; Al-Mansoori, N.; Burt, J.A. Chapter 1—The Arabian Gulf. In *World Seas: An Environmental Evaluation (Second Edition)*; Sheppard, C., Ed.; Academic Press: Cambridge, MA, USA, 2019; pp. 1–23.
55. Lelieveld, J.; Hadjinicolaou, P.; Kostopoulou, E.; Chenoweth, J.; El Maayar, M.; Giannakopoulos, C.; Hannides, C.; Lange, M.A.; Tanarhte, M.; Tyrlis, E.; et al. Climate change and impacts in the Eastern Mediterranean and the Middle East. *Clim. Chang.* **2012**, *114*, 667–687. [CrossRef]
56. Lelieveld, J.; Hadjinicolaou, P.; Kostopoulou, E.; Giannakopoulos, C.; Pozzer, A.; Tanarhte, M.; Tyrlis, E. Model projected heat extremes and air pollution in the eastern Mediterranean and Middle East in the twenty-first century. *Reg. Environ. Chang.* **2014**, *14*, 1937–1949. [CrossRef]
57. Al Blooshi, L.; Ksiksi, T.; Gargoum, A.; Aboelenein, M. Climate Change and Environmental Awareness: A Study of Energy Consumption among the Residents of Abu Dhabi, UAE. *Perspect. Glob. Dev. Technol.* **2020**, *18*, 564–582. [CrossRef]
58. Chowdhury, R.; Mohamed, M.M.A.; Murad, A. Variability of Extreme Hydro-Climate Parameters in the North-Eastern Region of United Arab Emirates. *Procedia Eng.* **2016**, *154*, 639–644. [CrossRef]
59. Chandran, A.; Basha, G.; Ouarda, T.B.M.J. Influence of climate oscillations on temperature and precipitation over the United Arab Emirates: Influence of Climate Oscillations on Temperature and Precipitation. *Int. J. Climatol.* **2016**, *36*, 225–235. [CrossRef]
60. Ouarda, T.B.M.J.; Charron, C.; Niranjan Kumar, K.; Marpu, P.R.; Ghedira, H.; Molini, A.; Khayal, I. Evolution of the rainfall regime in the United Arab Emirates. *J. Hydrol.* **2014**, *514*, 258–270. [CrossRef]
61. Abdou, A.E.A. Temperature Trend on Makkah, Saudi Arabia. *Atmos. Clim. Sci.* **2014**, *4*, 457–481. [CrossRef]
62. Vijayan, L. Long Term Temperature Trends in Four Different Climatic Zones of Saudi Arabia. *Int. J. Appl. Sci. Technol.* **2014**, *4*, 233.
63. Odnoletkova, N.; Patzek, T.W. Data-driven analysis of climate change in Saudi Arabia: Trends in temperature extremes and human comfort indicators. *J. Appl. Meteorol. Climatol.* **2021**, *60*, 1055–1070. [CrossRef]
64. Raggad, B. Statistical assessment of changes in extreme maximum temperatures over Saudi Arabia, 1985–2014. *Theor. Appl. Climatol.* **2018**, *132*, 1217–1235. [CrossRef]
65. Almazroui, M.; Islam, M.N.; Dambul, R.; Jones, P. Trends of temperature extremes in Saudi Arabia. *Int. J. Climatol.* **2014**, *34*, 808–826. [CrossRef]
66. Nazrul Islam, M.; Almazroui, M.; Dambul, R.; Jones, P.; Alamoudi, A. Long-term changes in seasonal temperature extremes over Saudi Arabia during 1981–2010. *Int. J. Climatol.* **2015**, *35*, 1579–1592. [CrossRef]
67. Rashid, I.U.; Almazroui, M.; Saeed, S.; Atif, R.M. Analysis of extreme summer temperatures in Saudi Arabia and the association with large-scale atmospheric circulation. *Atmos. Res.* **2020**, *231*, 104659. [CrossRef]
68. Alghamdi, A.S.; Harrington, J. Synoptic climatology and sea surface temperatures teleconnections for warm season heat waves in Saudi Arabia. *Atmos. Res.* **2019**, *216*, 130–140. [CrossRef]
69. Hama, R.H.; Hamad, R.T.; Aziz, F.H. Climate change in relation to rainfall and temperature in Erbil province, Kurdistan, Iraq. In Proceedings of the Tunisian Association of Digital Geographic Information, 8th International Congers Geo Tunis, Tunis, Tunisia, 2–6 April 2014; Volume 8.
70. Azooz, A.; Talal, S. Evidence of climate change in Iraq. *J. Environ. Prot. Sustain. Dev.* **2015**, *1*, 66–73.
71. Mustafa, A. Hotspots and Climate Change Assessment in Iraq. *J. Chem. Bio. Phy. Sci. Sec. D* **2017**, *7*, 19–30.
72. Agha, O.M.M.; Şarlak, N. Spatial and temporal patterns of climate variables in Iraq. *Arab. J. Geosci.* **2016**, *9*, 302. [CrossRef]
73. Rahimi, J.; Malekian, A.; Khalili, A. Climate change impacts in Iran: Assessing our current knowledge. *Theor. Appl. Climatol.* **2019**, *135*, 545–564. [CrossRef]
74. Osman, Y.; Al-Ansari, N.; Abdellatif, M. Climate change model as a decision support tool for water resources management in northern Iraq: A case study of Greater Zab River. *J. Water Clim. Chang.* **2019**, *10*, 197–209. [CrossRef]

75. Abbas, N.; Wasimi, S.A.; Al-Ansari, N. Impacts of climate change on water resources in Diyala River Basin, Iraq. *J. Civ. Eng. Archit.* **2016**, *10*, 1059–1074.
76. Abbas, N.; Wasimi, S.A.; Al-Ansari, N. Impacts of climate change on water resources of Greater Zab and Lesser Zab Basins, Iraq, using soil and water assessment tool model. *Int. J. Environ. Chem. Ecol. Geol. Geophys. Eng.* **2017**, *11*, 823–829.
77. Dinpashoh, Y.; Jahanbakhsh-Asl, S.; Rasouli, A.A.; Foroughi, M.; Singh, V.P. Impact of climate change on potential evapotranspiration (case study: West and NW of Iran). *Theor. Appl. Climatol.* **2019**, *136*, 185–201. [CrossRef]
78. Smiatek, G.; Kunstmann, H.; Heckl, A. High-resolution climate change simulations for the Jordan River area. *J. Geophys. Res. Atmos.* **2011**, *116*, D16. [CrossRef]
79. Abdulla, F. 21st Century Climate Change Projections of Precipitation and Temperature in Jordan. *Procedia Manuf.* **2020**, *44*, 197–204. [CrossRef]
80. Cheng, W.L.; Saleem, A.; Sadr, R. Recent warming trend in the coastal region of Qatar. *Theor. Appl. Climatol.* **2017**, *128*, 193–205. [CrossRef]
81. Ahmed, M.; Choudri, B.S. Climate change in Oman: Current knowledge and way forward. *Educ. Bus. Soc. Contemp. Middle East. Issues* **2012**, *5*, 228–236. [CrossRef]
82. Al-Charaabi, Y.; Al-Yahyai, S. Projection of future changes in rainfall and temperature patterns in Oman. *J. Earth Sci. Clim. Chang.* **2013**, *4*, 1–8.
83. Marzouk, O.A. Assessment of global warming in Al Buraimi, sultanate of Oman based on statistical analysis of NASA POWER data over 39 years, and testing the reliability of NASA POWER against meteorological measurements. *Heliyon* **2021**, *7*, e06625. [CrossRef]
84. Alsarraf, H. Projected climate change over Kuwait simulated using a WRF high resolution regional climate model. *Int. J. Glob. Warm.* **2020**, *26*, 1867. [CrossRef]
85. Alahmad, B.; Tomasso, L.P.; Al-Hemoud, A.; James, P.; Koutrakis, P. Spatial distribution of land surface temperatures in Kuwait: Urban heat and cool Islands. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2993. [CrossRef]
86. Ahmadalipour, A.; Moradkhani, H. Escalating heat-stress mortality risk due to global warming in the Middle East and North Africa (MENA). *Environ. Int.* **2018**, *117*, 215–225. [CrossRef]
87. Lelieveld, J.; Proestos, Y.; Hadjinicolaou, P.; Tanarhte, M.; Tyrlis, E.; Zittis, G. Strongly increasing heat extremes in the Middle East and North Africa (MENA) in the 21st century. *Clim. Chang.* **2016**, *137*, 245–260. [CrossRef]
88. Donat, M.G.; Peterson, T.C.; Brunet, M.; King, A.D.; Almazroui, M.; Kolli, R.K.; Boucherf, D.; Al-Mulla, A.Y.; Nour, A.Y.; Aly, A.A.; et al. Changes in extreme temperature and precipitation in the Arab region: Long-term trends and variability related to ENSO and NAO. *Int. J. Climatol.* **2014**, *34*, 581–592. [CrossRef]
89. Rezazadeh, M.; Irannejad, P.; Shao, Y. Climatology of the Middle East dust events. *Aeolian Res.* **2013**, *10*, 103–109. [CrossRef]
90. Hamza, W.; Enan, M.R.; Al-Hassini, H.; Stuut, J.-B.; de-Beer, D. Dust storms over the Arabian Gulf: A possible indicator of climate changes consequences. *Aquat. Ecosyst. Health Manag.* **2011**, *14*, 260–268. [CrossRef]
91. Namdari, S.; Karimi, N.; Sorooshian, A.; Mohammadi, G.; Sehatkashani, S. Impacts of climate and synoptic fluctuations on dust storm activity over the Middle East. *Atmos. Environ.* **2018**, *173*, 265–276. [CrossRef]
92. Abuelgasim, A.; Farahat, A. Effect of dust loadings, meteorological conditions, and local emissions on aerosol mixing and loading variability over highly urbanized semiarid countries: United Arab Emirates case study. *J. Atmos. Sol.-Terr. Phys.* **2020**, *199*, 105215. [CrossRef]
93. Beegum, S.N.; Gherboudj, I.; Chaouch, N.; Temimi, M.; Ghedira, H. Simulation and analysis of synoptic scale dust storms over the Arabian Peninsula. *Atmos. Res.* **2018**, *199*, 62–81. [CrossRef]
94. Rashki, A.; Arjmand, M.; Kaskaoutis, D.G. Assessment of dust activity and dust-plume pathways over Jazmurian Basin, southeast Iran. *Aeolian Res.* **2017**, *24*, 145–160. [CrossRef]
95. Rashki, A.; Kaskaoutis, D.G.; Mofidi, A.; Minvielle, F.; Chiapello, I.; Legrand, M.; Dumka, U.C.; Francois, P. Effects of Monsoon, Shamal and Levar winds on dust accumulation over the Arabian Sea during summer—The July 2016 case. *Aeolian Res.* **2019**, *36*, 27–44. [CrossRef]
96. Francis, D.; Chaboureau, J.-P.; Nelli, N.; Cuesta, J.; Alshamsi, N.; Temimi, M.; Pauluis, O.; Xue, L. Summertime dust storms over the Arabian Peninsula and impacts on radiation, circulation, cloud development and rain. *Atmos. Res.* **2021**, *250*, 105364. [CrossRef]
97. Soleimani, Z.; Teymouri, P.; Darvishi Boloorani, A.; Mesdaghinia, A.; Middleton, N.; Griffin, D.W. An overview of bioaerosol load and health impacts associated with dust storms: A focus on the Middle East. *Atmos. Environ.* **2020**, *223*, 117187. [CrossRef]
98. Middleton, N.J. Desert dust hazards: A global review. *Aeolian Res.* **2017**, *24*, 53–63. [CrossRef]
99. Fussell, J.C.; Kelly, F.J. Mechanisms underlying the health effects of desert sand dust. *Environ. Int.* **2021**, *157*, 106790. [CrossRef]
100. Karami, S.; Hamzeh, N.H.; Alam, K.; Noori, F.; Saadat Abadi, A.R. Spatio-temporal and synoptic changes in dust at the three islands in the Persian Gulf region. *J. Atmos. Sol.-Terr. Phys.* **2021**, *214*, 105539. [CrossRef]
101. Aboobacker, V.M.; Samiksha, S.V.; Veerasingam, S.; Al-Ansari, E.M.A.S.; Vethamony, P. Role of shamal and easterly winds on the wave characteristics off Qatar, central Arabian Gulf. *Ocean Eng.* **2021**, *236*, 109457. [CrossRef]
102. Osipov, S.; Stenchikov, G.; Brindley, H.; Banks, J. Diurnal cycle of the dust instantaneous direct radiative forcing over the Arabian Peninsula. *Atmos. Chem. Phys.* **2015**, *15*, 9537–9553. [CrossRef]

103. Prakash, P.J.; Stenchikov, G.; Kalenderski, S.; Osipov, S.; Bangalath, H. The impact of dust storms on the Arabian Peninsula and the Red Sea. *Atmos. Chem. Phys. Discuss.* **2014**, *14*, 199–222. [CrossRef]
104. Kalenderski, S.; Stenchikov, G.; Zhao, C. Modeling a typical winter-time dust event over the Arabian Peninsula and the Red Sea. *Atmos. Chem. Phys.* **2013**, *13*, 1999–2014. [CrossRef]
105. Islam, M.N.; Almazroui, M. Direct effects and feedback of desert dust on the climate of the Arabian Peninsula during the wet season: A regional climate model study. *Clim. Dyn.* **2012**, *39*, 2239–2250. [CrossRef]
106. Singh, A.; Bloss, W.J.; Pope, F.D. 60 years of UK visibility measurements: Impact of meteorology and atmospheric pollutants on visibility. *Atmos. Chem. Phys.* **2017**, *17*, 2085–2101. [CrossRef]
107. Maghrabi, A.H. Long-Term Visibility Trends in the Riyadh Megacity, Central Arabian Peninsula and Their Possible Link to Solar Activity. *Am. J. Clim. Chang.* **2021**, *10*, 282–299. [CrossRef]
108. Yu, Y.; Notaro, M.; Liu, Z.; Wang, F.; Alkolibi, F.; Fadda, E.; Bakhrjy, F. Climatic controls on the interannual to decadal variability in Saudi Arabian dust activity: Toward the development of a seasonal dust prediction model. *J. Geophys. Res. Atmos.* **2015**, *120*, 1739–1758. [CrossRef]
109. Fountoukis, C.; Ackermann, L.; Ayoub, M.A.; Gladich, I.; Hoehn, R.D.; Skillern, A. Impact of atmospheric dust emission schemes on dust production and concentration over the Arabian Peninsula. *Model. Earth Syst. Environ.* **2016**, *2*, 1–6. [CrossRef]
110. Kontos, S.; Liora, N.; Giannaros, C.; Kakosimos, K.; Poupkou, A.; Melas, D. Modeling natural dust emissions in the central Middle East: Parameterizations and sensitivity. *Atmos. Environ.* **2018**, *190*, 294–307. [CrossRef]
111. Ginoux, P.; Prospero, J.M.; Gill, T.E.; Hsu, N.C.; Zhao, M. Global-scale attribution of anthropogenic and natural dust sources and their emission rates based on MODIS Deep Blue aerosol products. *Rev. Geophys.* **2012**, 50. [CrossRef]
112. Abbass, R.A.; Kumar, P.; El-Gendy, A. An overview of monitoring and reduction strategies for health and climate change related emissions in the Middle East and North Africa region. *Atmos. Environ.* **2018**, *175*, 33–43. [CrossRef]
113. Lin, Y.-C.; Li, Y.-C.; Amesho, K.T.T.; Chou, F.-C.; Cheng, P.-C. Filterable PM2.5, Metallic Elements, and Organic Carbon Emissions from the Exhausts of Diesel Vehicles. *Aerosol Air Qual. Res.* **2020**, *20*, 1319–1328. [CrossRef]
114. Colette, A.; Réal, E.; Schucht, S.; López-Aparicio, S.; Eerens, H.; Peek, K.; Ruyssenaars, P.; Guerreiro, C. Joint Actions for Air Quality and Climate Mitigation in Europe. 2015. Available online: http://acm.eionet.europa.eu/reports/ETCACM_TP_2015_7_SLCPActionPlans (accessed on 14 April 2022).
115. Fiore, A.M.; Naik, V.; Leibensperger, E.M. Air Quality and Climate Connections. *J. Air Waste Manag. Assoc.* **2015**, *65*, 645–685. [CrossRef]
116. Hong, C.; Zhang, Q.; Zhang, Y.; Davis, S.J.; Tong, D.; Zheng, Y.; Liu, Z.; Guan, D.; He, K.; Schellnhuber, H.J. Impacts of climate change on future air quality and human health in China. *Proc. Natl. Acad. Sci. USA* **2019**, *116*, 17193–17200. [CrossRef]
117. Gallagher, C.L.; Holloway, T. Integrating Air Quality and Public Health Benefits in U.S. Decarbonization Strategies. *Front. Public Health* **2020**, *8*, 563358. [CrossRef]
118. WHO. Health Topics: Ambient Air Pollution. Available online: https://www.who.int/health-topics/air-pollution#tab=tab_2 (accessed on 21 November 2022).
119. WHO. *Ambient Air Pollution: A Global Assessment of Exposure and Burden of Disease*; WHO: Geneva, Switzerland, 2016; p. 121.
120. Dionisio, K.L.; Nolte, C.G.; Spero, T.L.; Graham, S.; Caraway, N.; Foley, K.M.; Isaacs, K.K. Characterizing the impact of projected changes in climate and air quality on human exposures to ozone. *J. Expo. Sci. Environ. Epidemiol.* **2017**, *27*, 260–270. [CrossRef]
121. Wilson, A.; Reich, B.J.; Nolte, C.G.; Spero, T.L.; Hubbell, B.; Rappold, A.G. Climate change impacts on projections of excess mortality at 2030 using spatially varying ozone–temperature risk surfaces. *J. Expo. Sci. Environ. Epidemiol.* **2017**, *27*, 118–124. [CrossRef]
122. Schraufnagel, D.E. Global Alliance against Chronic Respiratory Diseases symposium on air pollution: Overview and highlights. *Chin. Med. J.* **2020**, *133*, 1546–1551. [CrossRef]
123. Nassikas, N. Ozone-related asthma emergency department visits in the US in a warming climate. *Environ. Res.* **2020**, *183*, 109206. [CrossRef]
124. Shehab, M.A.; Pope, F.D. Effects of short-term exposure to particulate matter air pollution on cognitive performance. *Sci. Rep.* **2019**, *9*, 8237. [CrossRef]
125. Castellani, B.; Bartington, S.; Wistow, J.; Heckels, N.; Ellison, A.; Van Tongeren, M.; Arnold, S.R.; Barbrook-Johnson, P.; Bicket, M.; Pope, F.D.; et al. Mitigating the impact of air pollution on dementia and brain health: Setting the policy agenda. *Environ. Res.* **2022**, *215*, 114362. [CrossRef]
126. Goudie, A.S. Dust Storms and Human Health. In *Extreme Weather Events and Human Health: International Case Studies*; Akhtar, R., Ed.; Springer International Publishing: Cham, Switzerland, 2020; pp. 13–24.
127. de Longueville, F.; Ozer, P.; Doumbia, S.; Henry, S. Desert dust impacts on human health: An alarming worldwide reality and a need for studies in West Africa. *Int. J. Biometeorol.* **2013**, *57*, 1–19. [CrossRef]
128. WHO. *Urban Air Pollution Database*; WHO: Geneva, Switzerland, 2016.
129. Omidvarborna, H.; Baawain, M.; Al-Mamun, A. Ambient air quality and exposure assessment study of the Gulf Cooperation Council countries: A critical review. *Sci. Total Environ.* **2018**, *636*, 437–448. [CrossRef]
130. Khaniabadi, Y.O.; Fanelli, R.; De Marco, A.; Daryanoosh, S.M.; Kloog, I.; Hopke, P.K.; Conti, G.O.; Ferrante, M.; Mohammadi, M.J.; Babaei, A.A.; et al. Hospital admissions in Iran for cardiovascular and respiratory diseases attributed to the Middle Eastern Dust storms. *Environ. Sci. Pollut. Res.* **2017**, *24*, 16860–16868. [CrossRef]

131. Al-Hemoud, A.; Al-Dousari, A.; Al-Shatti, A.; Al-Khayat, A.; Behbehani, W.; Malak, M. Health Impact Assessment Associated with Exposure to PM10 and Dust Storms in Kuwait. *Atmosphere* **2018**, *9*, 6. [CrossRef]
132. Al-Hemoud, A.; Gasana, J.; Al-Dabbous, A.; Alajeel, A.; Al-Shatti, A.; Behbehani, W.; Malak, M. Exposure levels of air pollution (PM2.5) and associated health risk in Kuwait. *Environ. Res.* **2019**, *179*, 108730. [CrossRef]
133. Tyrovolas, S.; El Bcheraoui, C.; Alghnam, S.A.; Alhabib, K.F.; Almadi, M.A.H.; Al-Raddadi, R.M.; Bedi, N.; El Tantawi, M.; Krish, V.S.; Memish, Z.A.; et al. The burden of disease in Saudi Arabia 1990–2017: Results from the Global Burden of Disease Study 2017. *Lancet Planet. Health* **2020**, *4*, e195–e208. [CrossRef]
134. MacDonald Gibson, J.; Thomsen, J.; Launay, F.; Harder, E.; DeFelice, N. Deaths and medical visits attributable to environmental pollution in the United Arab Emirates. *PLoS ONE* **2013**, *8*, e57536. [CrossRef]
135. Achilleos, S.; Al-Ozairi, E.; Alahmad, B.; Garshick, E.; Neophytou, A.M.; Bouhamra, W.; Yassin, M.F.; Koutrakis, P. Acute effects of air pollution on mortality: A 17-year analysis in Kuwait. *Environ. Int.* **2019**, *126*, 476–483. [CrossRef]
136. Khaniabadi, Y.O.; Sicard, P.; Takdastan, A.; Hopke, P.K.; Taiwo, A.M.; Khaniabadi, F.O.; De Marco, A.; Daryanoosh, M. Mortality and morbidity due to ambient air pollution in Iran. *Clin. Epidemiol. Glob. Health* **2019**, *7*, 222–227. [CrossRef]
137. Barakat-Haddad, C.; Zhang, S.; Siddiqua, A.; Dghaim, R. Air Quality and Respiratory Health among Adolescents from the United Arab Emirates. *J. Environ. Public Health* **2015**, *2015*, 284595. [CrossRef]
138. Dalibalta, S.; Samara, F.; Qadri, H.; Adouchana, H. Potential causes of asthma in the United Arab Emirates: Drawing insights from the Arabian Gulf. *Rev. Environ. Health* **2018**, *33*, 205–212. [CrossRef]
139. Yeatts, K.B.; El-Sadig, M.; Leith, D.; Kalsbeek, W.; Al-Maskari, F.; Couper, D.; Funk, W.E.; Zoubeidi, T.; Chan, R.L.; Trent, C.B. Indoor air pollutants and health in the United Arab Emirates. *Environ. Health Perspect.* **2012**, *120*, 687–694. [CrossRef]
140. Dastoorpoor, M.; Idani, E.; Goudarzi, G.; Khanjani, N. Acute effects of air pollution on spontaneous abortion, premature delivery, and stillbirth in Ahvaz, Iran: A time-series study. *Environ. Sci. Pollut. Res. Int.* **2018**, *25*, 5447–5458. [CrossRef]
141. Watts, N.; Amann, M.; Arnell, N.; Ayeb-Karlsson, S.; Beagley, J.; Belesova, K.; Boykoff, M.; Byass, P.; Cai, W.; Campbell-Lendrum, D.; et al. The 2020 report of The Lancet Countdown on health and climate change: Responding to converging crises. *Lancet* **2021**, *397*, 129–170. [CrossRef]
142. WHO. Climate Change and Health. Available online: https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health (accessed on 21 November 2022).
143. Mousavi, A.; Ardalan, A.; Takian, A.; Ostadtaghizadeh, A.; Naddafi, K.; Bavani, A.M. Climate change and health in Iran: A narrative review. *J. Environ. Health Sci. Eng.* **2020**, *18*, 367–378. [CrossRef]
144. Salam, A. Climate Change: The Challenges for Public Health and Environmental Effects in UAE. *WIT Trans. Ecol. Environ.* **2015**, *193*, 457–466.
145. Pradhan, B.; Kjellstrom, T.; Atar, D.; Sharma, P.; Kayastha, B.; Bhandari, G.; Pradhan, P.K. Heat stress impacts on cardiac mortality in Nepali migrant workers in Qatar. *Cardiology* **2019**, *143*, 37–48. [CrossRef]
146. Mafi-Gholami, D.; Jaafari, A.; Zenner, E.K.; Nouri Kamari, A.; Tien Bui, D. Vulnerability of coastal communities to climate change: Thirty-year trend analysis and prospective prediction for the coastal regions of the Persian Gulf and Gulf of Oman. *Sci. Total Environ.* **2020**, *741*, 140305. [CrossRef]
147. Mohamed, H.; Elayah, M.; Schuplen, L. Yemen between the impact of the climate change and the ongoing Saudi-Yemen war: A real tragedy. *Anal. Rep.* **2017**. [CrossRef]
148. D'Amato, G.; Pawankar, R.; Vitale, C.; Lanza, M.; Molino, A.; Stanziola, A.; Sanduzzi, A.; Vatrella, A.; D'Amato, M. Climate Change and Air Pollution: Effects on Respiratory Allergy. *Allergy Asthma Immunol. Res.* **2016**, *8*, 391. [CrossRef]
149. Faganeli Pucer, J. Impact of changes in climate on air pollution in Slovenia between 2002 and 2017. *Environ. Pollut.* **2018**, *242*, 398–407. [CrossRef]
150. Sá, E.; Martins, H.; Ferreira, J.; Marta-Almeida, M.; Rocha, A.; Carvalho, A.; Freitas, S.; Borrego, C. Climate change and pollutant emissions impacts on air quality in 2050 over Portugal. *Atmos. Environ.* **2016**, *131*, 209–224. [CrossRef]
151. MacDonald Gibson, J. *Environmental Burden of Disease Assessment*; Environmental Science and Technology Library; Springer: Berlin, Germany, 2015; Volume 24.
152. Crimmins, A.; Balbus, J.; Gamble, J.L.; Beard, C.B.; Bell, J.E.; Dodgen, D.; Eisen, R.J.; Fann, N.; Hawkins, M.; Herring, S.C.; et al. *Executive Summary. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*; U.S. Global Change Research Program: Washington, DC, USA, 2016; p. 24.
153. Silva, R.A.; West, J.J.; Lamarque, J.-F.; Shindell, D.T.; Collins, W.J.; Faluvegi, G.; Folberth, G.A.; Horowitz, L.W.; Nagashima, T.; Naik, V.; et al. Future global mortality from changes in air pollution attributable to climate change. *Nat. Clim. Chang.* **2017**, *7*, 647–651. [CrossRef]
154. Dean, A.; Green, D. Climate change, air pollution and human health in Sydney, Australia: A review of the literature. *Environ. Res. Lett.* **2018**, *13*, 053003. [CrossRef]
155. Deng, S.-Z.; Jalaludin, B.B.; Antó, J.M.; Hess, J.J.; Huang, C.-R. Climate change, air pollution, and allergic respiratory diseases: A call to action for health professionals. *Chin. Med. J.* **2020**, *133*, 1552–1560. [CrossRef]
156. Verner, D. *Adaptation to a Changing Climate in the Arab Countries: A Case for Adaptation Governance and Leadership in Building Climate Resilience*; The World Bank: Washington, DC, USA, 2012.
157. Khoja, T.; Rawaf, S.; Qidwai, W.; Rawaf, D.; Nanji, K.; Hamad, A. Health Care in Gulf Cooperation Council Countries: A Review of Challenges and Opportunities. *Cureus* **2017**, *9*, e1586. [CrossRef]

158. Gasmi, K.; Aljalal, A.; Al-Basheer, W.; Abdulahi, M. Analysis of NOx, NO and NO_2 ambient levels in Dhahran, Saudi Arabia. *Urban Clim.* **2017**, *21*, 232–242. [CrossRef]
159. Jassim, M.S.; Coskuner, G. Assessment of spatial variations of particulate matter (PM10 and PM2.5) in Bahrain identified by air quality index (AQI). *Arab. J. Geosci.* **2017**, *10*, 19. [CrossRef]
160. Jaafari, J.; Naddafi, K.; Yunesian, M.; Nabizadeh, R.; Hassanvand, M.S.; Ghozikali, M.G.; Nazmara, S.; Shamsollahi, H.R.; Yaghmaeian, K. Study of PM10, PM2. 5, and PM1 levels in during dust storms and local air pollution events in urban and rural sites in Tehran. *Hum. Ecol. Risk Assess. Int. J.* **2018**, *24*, 482–493. [CrossRef]
161. Mahmoud, S.H.; Gan, T.Y. Impact of anthropogenic climate change and human activities on environment and ecosystem services in arid regions. *Sci. Total Environ.* **2018**, *633*, 1329–1344. [CrossRef]
162. Islam, M.; Alharthi, M.; Alam, M. The impacts of climate change on road traffic accidents in Saudi Arabia. *Climate* **2019**, *7*, 103. [CrossRef]
163. Alahmad, B.; Khraishah, H.; Shakarchi, A.F.; Albaghdadi, M.; Rajagopalan, S.; Koutrakis, P.; Jaffer, F.A. Cardiovascular Mortality and Exposure to Heat in an Inherently Hot Region: Implications for Climate Change. *Circulation* **2020**, *141*, 1271–1273. [CrossRef]