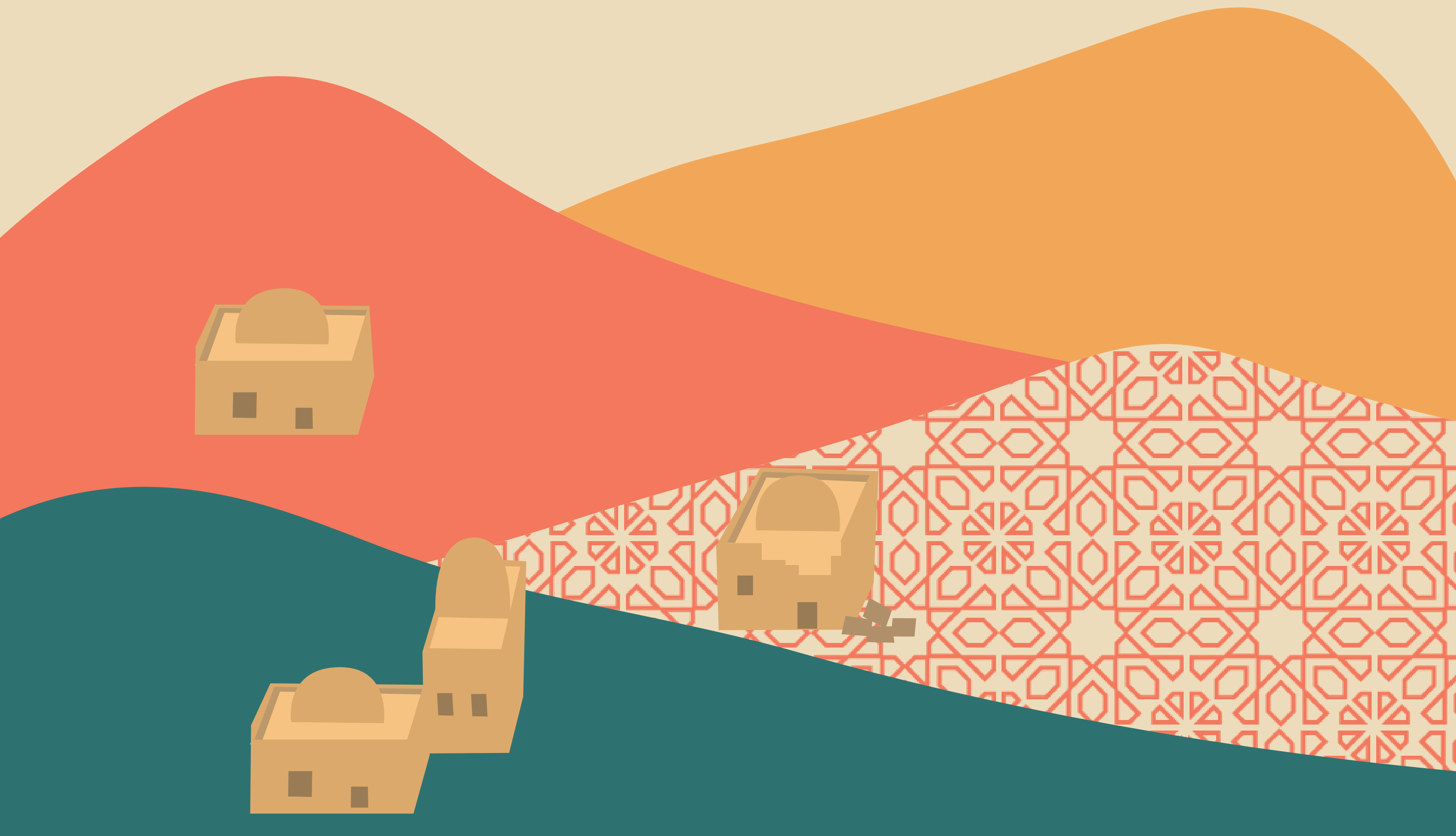
United Nations Development Programme

THE IMPACT OF COVID-19 ON ARAB COUNTRIES: WHAT CAN WE “SEE”?



RBAS WORKING PAPERS SERIES

Acknowledgements

This paper has been prepared by Giorgia Giovannetti, Velia Bigi and Elena Perra under the overall guidance and coordination of Vito Intini. We are grateful to Cesar Serra from the International Monetary Fund (IMF), and Nadine Abdelraouf, Shireen Al-Azzawi, Firas Gharaibeh, Walid Merouani and Anna Vitkova from UNDP for their review and comments.

This paper was finalized in Q1 2021 and reflects the situation up until that time.

The paper has been produced thanks to funding from the Government of Japan in support of the League of Arab States (LAS)-Japan-UNDP joint policy dialogue.

The designations employed and the presentation of material on the maps of this paper do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations or UNDP concerning the legal status of any country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries.

UNDP is the leading United Nations organization fighting to end the injustice of poverty, inequality, and climate change. Working with our broad network of experts and partners in 170 countries, we help nations to build integrated, lasting solutions for people and planet.
Learn more at undp.org or follow the organization at @UNDP.

Disclaimer

The views expressed in this publication are those of the author(s) and do not necessarily represent those of the United Nations, including UNDP, or the UN Member States.

Copyright © [2021]

All rights reserved. No part of this publication may be reproduced, stored in retrieval systems or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without prior permission of UNDP.

Table of contents

Abstract

The pervasiveness of the COVID-19 crisis has called for an immediate, multifaceted response. Although COVID-19 is not the first pandemic in human history, its disruptive nature and extremely fast transmission rate have made it unique in many ways. Countries have tackled the COVID-19 emergency with different strategies, either by simply relying on the civic sense of its citizens, or by imposing more stringent measures that range from mobility restrictions to curfews and lockdowns. Arab countries are among those that have employed precautionary measures to tackle the spread of COVID-19, acting in advance to avoid the dramatic consequences of the virus. By exploiting new and unprocessed publicly available data sets, this paper provides a real-time analysis of the economic and environmental consequences of the measures undertaken to tackle the spread of the COVID-19 pandemic. The empirical focus is on a selected group of countries in the Arab region illustrative of the socio-dynamics of the area, for which the paper aims to “visualize” the regions that have been most negatively affected by the contagion containment measures in near-real time. Recently released data from NASA and the European Space Agency (ESA), namely real-time night lights (NTLs) and tropospheric nitrogen dioxide (NO_2), are cleaned and elaborated to map the registered drop in luminosity and emissions during the COVID-19 containment period. Although the reduction in atmospheric NO_2 should be regarded positively, as a significant reduction in air pollution, the similar drop registered in NTLs could be considered an alarming sign of the contemporaneous economic slowdown. An examination of correlations between NO_2, mobility trends and oil prices shows how these indicators are significantly interconnected. Finally, elasticities of gross domestic product (GDP) to NTLs are calculated to make projections of GDP loss, which are then compared with those reported by official institutions. We forecast serious economic losses for all Arab countries, generally in line with official projections. The analyses highlight the potential role of satellite data in providing useful and timely information for decision makers during crises.

Keywords:

COVID-19, night lights, tropospheric nitrogen dioxide, geographic information system

1. Introduction

The COVID-19 virus officially emerged in Wuhan, China, in December 2019. Since then, as it swept across most of the world, on 11 March 2020, World Health Organization (WHO) Director General Dr. Tedros Adhanom Ghebreyesus was forced to declare the outbreak a global pandemic (WHO, 2020a). The announcement was accompanied by calls for "urgent and aggressive" action by governments, which face two main challenges: controlling contagion on the one hand, and finding a balance between protecting citizens' health and minimizing the unforeseen negative economic consequences of shutting down all main economic activities, on the other (BBC News, 2020).

Arab countries appear to have implemented strict precautionary provisions, which have helped control the spread of the virus. Unlike Europe and the United States, Middle Eastern countries have benefited from a younger average population (people within the age ranges of 0–24 and 24–64 represent approximately 95 percent of the population (McKee and others, 2017)), making them less likely to be negatively affected by the virus.[1] However, despite relatively low mortality rates, most governments in the region worry about other potential effects of the virus (Bowen, 2020). Even in places not overturned by conflicts or full-scale wars, the potential negative economic and social effects, which may deepen "crisis-points", are a cause for concern (Bowen, 2020). Indeed, while the pandemic should be seen primarily as an urgent global health crisis, indirect economic damages are reaching alarming levels and have raised the economic implications to priority status (McKee and Stuckler, 2020).

1 Scientific studies have shown that the mortality rate of COVID-19 is 10–27 percent for people aged 84 and over, 3–11 percent for people aged 65–84 years, and less than 1 percent for people aged 20–54 years (Centers for Disease Control and Prevention, 2020).

Nevertheless, it is difficult to collect reliable real-time data to estimate the economic impact of COVID-19. Coronavirus has already seriously struck the Arab region with interrelated shocks: the first, "pure" COVID-19-related shock happened when the virus appeared in China, due to the close economic relations between the two regions and the breakdown of supply chain mechanisms, with subsequent loss of jobs; the second was due to the collapse of oil prices and oil demand (partially related to the economic slowdown caused by COVID-19), and the third hit the tourism sector (Yahya and others, 2020), which for some of the countries in the region, is a crucial source of income.

The lack of real-time and high-frequency data is a serious impediment to understanding the severity of the COVID-19 crisis and to targeting those whose have been most affected by its economic consequences. In this context, alternative data sources may represent a second-best information tool able to give immediate insights into how to tackle the emergency phase. Satellite data, social media and remotely sensed data are therefore an excellent option to obtain quantitative and reliable information in real time (Jean and others, 2016). This is why tech giants like Google and Apple have released daily data on mobility to actively help combat COVID-19 (Apple, 2020; Google, 2020). When inspecting the potential of these data, it is important to note that they have not required any specific investment to be processed, since they are collected as simple by-products of other services that are already active. Past data on mobility trends can then easily be compared with current data to analyse the effects of containment measures. Similarly, the data retrieved via more traditional satellite data such as night lights (NTLs) and tropospheric nitrogen dioxide (hereafter, NO_2) are effective instruments, and already widely implemented by the scientific community (Henderson, Storeygard and Weil, 2012; Elvidge and others, 1997; Gibson, Li and Boe-Gibson, 2014; Sutton and Costanza, 2002; Doll, Muller and Elvidge, 2000; Lamsal and others, 2015).

This paper investigates the negative effects of COVID-19 in Arab countries using innovative high-frequency data. It includes:

- A brief overview of the measures undertaken to contain the virus and the economic response of the countries studied. The use of mobility data from Google and Apple should be considered a benchmark to evaluate the effectiveness of action taken by governments,

- An inquiry into the negative effects of the contagion containment measures on the economy, using the drop in emitted luminosity (NTLs) and the reduction in NO_2 presence in the atmosphere as proxy (Henderson, Storeygard and Weil, 2012). This framework allows the regions that have been most negatively affected by the contagion containment measures to be observed in real time, and may offer policymakers significant insight enabling them to implement cost-effective targeted policies to help mitigate economic damages caused by coronavirus. While this may stop the dispersion of valuable and scarce economic resources, it may also prevent already fragile territories from becoming hotbeds of conflict and social tension. The elaboration of these scientific real-time data is one of the main contributions of this paper. Integrating indicators, data and disciplines is paramount in a technologically driven society in which socio-economic events are increasingly connected with environmental, atmospheric and biological phenomena. Beyond analysis of the implications of COVID-19, the study focuses on the use of these innovative tools. Indeed, it is paramount that researchers in different fields recognize the importance of integrating methods and data to obtain evidence-based policy guidelines,

- An investigation on the potential correlation among the collapse of oil prices in the region, the drop in NO_2 emissions and mobility trends data,

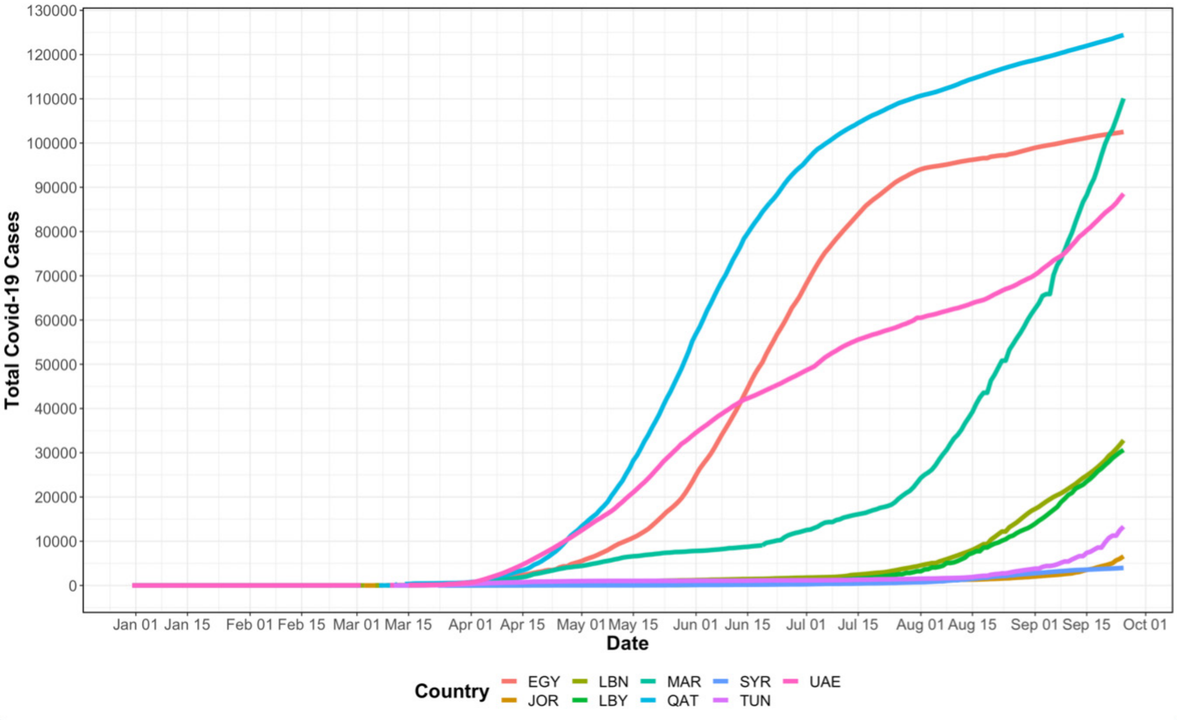
- A macroeconomic framework to assess the economic damages of the lockdown in terms of gross domestic product (GDP), exploiting the estimated elasticities of GDP to variation in NTLs, retrieved from Giovannetti and Perra (2020), to provide alternative measurements of GDP loss. By extrapolating GDP loss from reduction in NTLs, different scenarios have been provided for each country, with slightly different projections regarding those released by the International Monetary Fund (IMF) and the World Bank.

It concludes with some policy implications, with a focus on tourist areas, providing insights for policymakers so that they can implement discretional economic and social policies which consider the peculiarities of the hardest hit areas. The appendix includes selected additional graphs and maps.

2. Mobility trends

In Arab countries, the outbreak has been expanding westwards since the end of January 2020 (see Figure 1). The very first case of COVID-19 was registered in the United Arab Emirates (UAE) on 29 January (WHO, 2020m), and on 15 February, Egypt was the first African country and the second of the WHO Eastern Mediterranean Region countries to report cases (WHO, 2020a).

Figure 1. Evolution of active COVID-19 cases in selected Arab countries



Source: Ritchie and others (2020). A similar graph showing the total number of deaths per million is contained in the appendix.

In the following 15 days, all countries confirmed cases—Lebanon (22 February; WHO, 2020b); Kuwait (24 February; WHO, 2020c); Bahrain, Iraq and Oman (25 February; WHO, 2020d); Algeria (26 February; WHO, 2020e); Qatar (1 March; WHO, 2020f); Jordan, Morocco, United Arab Emirates and Tunisia (3 March; WHO, 2020g)—with the exception of the fragile States of the region which confirmed COVID-19 cases much later, namely the Syrian Arab Republic (23 March; WHO, 2020h), Libya (25 March; WHO, 2020i) and Yemen (11 April; WHO, 2020j). This analysis will focus on a selection of representative countries belonging to three categories: Gulf countries (UAE and Qatar), middle-income countries (Jordan, Egypt, Morocco and Tunisia) and fragile countries (Syria, Lebanon and Libya).

Each country adopted containment and control measures according to development of the pandemic and transmission within their borders (see also Arezki and others, 2020).[2] In Figure 2, areas shaded in grey represent the periods during which containment measures were in place. The mobility data were sourced from Apple and Google Maps; Google measures mobility by referring to mobile phone locations, while Apple bases its estimates on its users' searches for directions to specific destinations. Together, they create an overview on daily population movements with great temporal and spatial detail (Apple, 2020; Google, 2020).[3] Figure 2 shows that Lebanon (Houssari, 2020) and Qatar (Qatar, Government Communication Office, 2020) enforced lockdowns between 13 and 15 March (data range 1); they were followed by Jordan (Abdullah II ibn Al Hussein, 2020) and Morocco (Morocco, Interior Ministry, 2020) which enforced lockdowns between 18 and 19 March (data range 2). Within 22–24 March (data range 3), Egypt (Egypt, State Information Service, 2020), Libya (Al Arabiya, 2020b), Syria (United Nations Population Fund, 2020) and UAE (Salman, 2020) opted for curfew measures (with the exception of the city of Dubai in the UAE), while Tunisia (Guetat, 2020) chose to enforce a total lockdown. Regardless of the type of measure imposed, the effects on people's movement were remarkable (see Figure 2 and Table 1). Looking at mobility data released by Google and Apple, it is indeed possible to detect a net and substantial decrease in daily commuting after the announcement of restrictions to social movements, compared with the baseline period.[4]

2 A comprehensive archive of governments' responses to the pandemic can be found at www.bsg.ox.ac.uk/research/research-projects/coronavirus-government-response-tracker.

3 For information on the construction of such indicators, visit: www.ubdc.ac.uk/news-media/2020/may/apples-and-pears-comparing-google-and-apple-mobility-data/.

4 The Google baseline is the mean value for the period from 3 January to 6 February 2020; the Apple baseline is 13 January 2020.

Figure 2. Mobility trends in 2020 based on Google and Apple data (7-day moving average)

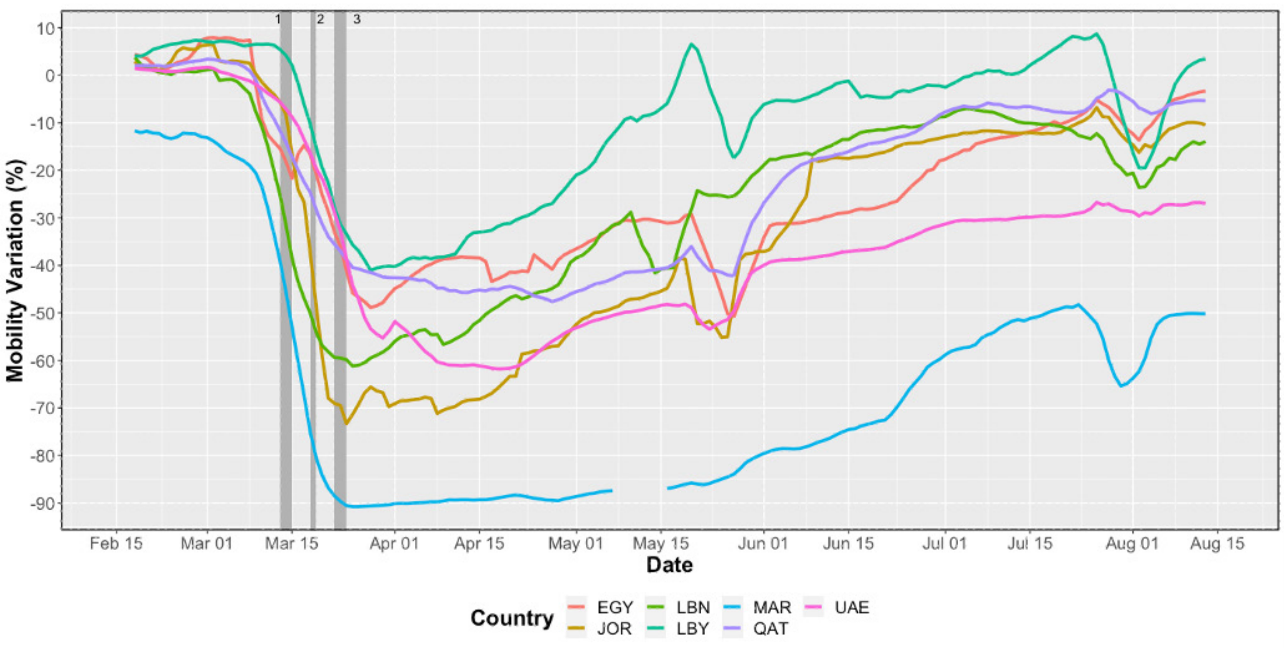


Table 1. Disaggregated mobility trends variation as at 15 May 2020

	Location	Restrictive measure	Retail & recreation (%)	Grocery & pharmacy (%)	Parks (%)	Transit station (%)	Workplaces (%)
Middle-income countries	Jordan	Lockdown	-63.3	-41.4	-53.9	-86.9	-59.3
	Egypt	Curfew	-56.0	-12.6	-42.8	-51.1	-32.8
	Morocco	Lockdown	-	-	-	-	-
	Tunisia	Lockdown	-	-	-	-	-
Gulf countries	Qatar	Lockdown	-52.7	-25.1	-41.5	-52.7	-32.3
	UAE	Lockdown	-58.6	-28.2	-68.8	-71.0	-46.0
Fragile countries	Lebanon	Lockdown	-57.5	-28.4	-34.2	-71.7	-49.0
	Syria	Curfew	-	-	-	-	-
	Libya	Curfew	-37.8	-14.1	-20.2	-41.7	-25.9

Downward trends are recorded for all categories (‘Retail & recreation’, ‘Grocery & pharmacy’, ‘Parks’, ‘Transit station’ and ‘Workplaces’) without distinction (see Table 1). Categories of necessary movement like ‘Grocery & pharmacy’ and ‘Workplaces’ are reduced to the essential (-12 to -40 percent and -25 to -60 percent respectively) while non-necessary movement categories like ‘Parks’ have seen a sharp decrease (-35 to -69 percent). As a result, movement through transit nodes have also decreased dramatically (-40 to -90 percent). As Figure 2 shows, mobility trends detected in Morocco, for which only Apple data have been released,[5] were higher in the pre-lockdown period compared with other countries. This is because Apple mobility trend data cumulates all categories of movement, including residential, into two different groups, namely driving and walking movements. These have experienced a marked decrease of 82 percent and 85 percent, respectively. The fluctuating troughs correspond to weekdays and holidays or other events (e.g. on 12 March in Egypt, all main activities were closed due to inclement weather; Al Arabiya, 2020a).

5 Apple data have been standardized for the purpose of comparison with Google data.


1
016317

3. Satellite data analysis: Night lights and tropospheric nitrogen dioxide emissions

The lockdowns imposed by governments due to the COVID-19 pandemic have manifested their effects in trade disruption, job losses, disruption of business confidence and degradation of job-rich sectors such as tourism. Moreover, the collapse of oil prices and the relative slowing of global demand have further exacerbated the negative economic and social situation in the region (Middle East and Central Asia Department, IMF, 2020; IMF, 2020c). These simultaneous shocks may not only sharply slow economic activities, with severe repercussions in terms of macroeconomic instability, but may also fuel social dissatisfaction, creating fertile ground for public unrest and multiplying conflict across the region (Yousef and others, 2020; Center for Strategic & International Studies, 2020). The uncertainty regarding duration of the shocks and the complicated policy response may amplify the fragilities of the poorest and most unstable countries in the region, establishing a new vicious circle of poverty and fragility (London School of Economics and Political Science, 2020).

Addressing the urgency of the COVID-19 crisis calls for researchers to employ new digital tools. The Day/Night Band (DNB) sensor of the Visible Infra-red Imaging Radiometer Suite (VIIRS) is a valuable tool for extrapolating global daily measurements of nocturnal visible and near-infra-red lights, which can be used as effective proxies for economic activity (Henderson, Storeygard and Weil, 2012). The sensor represents a new generation of quality NTL products that allow for better monitoring of nighttime phenomena, giving new insights for application studies (Levin and others, 2020). Equally, the European Space Agency (ESA) has recently released a new environmental air-quality data set, collected through Sentinel-5P satellite using TROPOMI (a tropospheric monitoring instrument) (Goddard Earth Sciences Data and Information Services

Center, 2019). This chapter contains high-quality pixel-based estimates of NTLs and tropospheric dioxide data corresponding to the last week of January 2020 and the official dates of lockdown or containment measures for each country.[6] To build a holistic picture of the economic damages caused by the measures, these data were mapped for each country to show the change from pre- to post-lockdown/containment measures, both in terms of NTLs and NO_2. The estimated drop in NTLs should be interpreted as a reduction in economic activities due to the fading of luminosity emitted by urban settlements, gas flares and fires (Croft, 1978). Indeed, NTLs ought to be seen as a good substitute for mapping socio-economic outcomes. Similarly, nitrogen dioxide (NO_2), a trace-gas toxic component, may be considered a valuable proxy for human activities, since it is the result of anthropogenic events and natural processes, such fossil fuel combustion from vehicles and power plants, and also lighting and soil processes (Ogen, 2020; Doll, Muller and Elvidge, 2000). The use of these alternative data sources is usually associated with countries with a weak statistical and administrative system—namely developing countries—which cannot rely on swift, solid and trustworthy data.[7] Nevertheless, given the urgency of the COVID-19 crisis, these innovative data sources may prove valuable for analysing the situation and geographically mapping the worst-hit areas.

This study covers the period from the pre-COVID-19 outbreak (January 2020) to the immediate aftermath of the lockdown/containment measures (this differs for each country). Mobility data from Google and Apple (Figure 2) have been used to ensure the accuracy of the selected dates.

Spatial data on NO_2 concentration in the atmosphere is derived from Sentinel-5P TROPOMI, which was launched on 13 October 2017, and programmed by the European Commission under the “Copernicus” programme (TROPOMI, 2017).[8] Sentinel-5P TROPOMI provides a high spatial resolution data set (5.5 km x 3.5 km at nadir), measuring air pollution in the atmosphere on a near-global scale.[9] NO_2 is an ozone precursor found near the surface which derives from fires, industrial sources, transport, and stationary sources such as power plants. The application of trace gases data in the academic literature ranges from the detection of pollution over time and the analysis of increased NO_2 emissions (Lamsal and others, 2008; Lamsal and others, 2010; Duncan and others, 2016), to health (Geddes and others, 2016; Anenberg and others, 2018). This atmospheric data can also record sudden variation in trace gases trends due to causes such as social unrest, natural disasters, economic recessions and policy changes. From NASA’s Black Marble nighttime lights products suite (VNP46), high-quality daily nighttime NTLs available at a resolution of 742 m, have been employed. The VIIRS DNB on-board the Suomi National Polar-orbiting Partnership (NPP) provides NTLs at a resolution of 500 m from January 2012 to the present (Wu and Wang, 2019; Wang and others, 2018; Li and others, 2019).[10] NASA’s Black Marble nighttime products suite (VNP46) utilizes all “high-quality, cloud-free, atmospheric-, terrain-, vegetation-, snow-, lunar-, and stray light corrected radiances to estimate daily NTLs and other intrinsic surface optical properties” (Wang and others, 2018). Processed versions of these data have been widely used in the scientific literature to study urban socio-economic dynamics and natural disasters.[11]

These data have been collected and cleaned at each country-level analysis, using the administrative areas derived from GADM (available at https://gadm.org/index.html) as geographical reference units. The data have then been combined with the information retrieved from the Open Street Map (retrieved from www.geofabrik.de/) and Landscan (Oak Ridge National Laboratory, 2019). Data on specific points of interest have been gathered from Open Street Map, including information regarding the location of cities (with a population of over 100,000 people), towns (with a population of between 10,000 and 100,000 people) and suburbs, which are areas defined as peripheral to towns or cities. Meanwhile, Landscan provided a global population distribution at a resolution of 1 km (approximately 30’’ x 30’’), enabling a highly detailed analysis.

6 When satellite images were unavailable or of insufficient quality, data were retrieved for the closest date available.

7 NTLs are a good proxy for reflecting investments in physical capital and infrastructure, but they are less capable of representing the value generated by the service sectors. This is why NTLs are usually more adequate for reflecting the economy of developing countries rather than developed countries, whose service sector represents one of the main pillars of their economy.

8 It has been designed to last seven years. The synergy of TROPOMI and VIIRS/OMPS is designed to be able to give additional information on aerosols and clouds, producing better output results. It represents the evolution of the Ozone Monitoring Instrument (OMI) launched on 15 July 2004. However, from 2007, the OMI registered an anomaly which grew until 2012, at which point nearly 50 percent of the data captured were altered.

9 Pixel size (near nadir) is around 7 x 3.5 km^2 for all spectral bands.

10 These data represent significant improvements with respect to those provided by the Defence Meteorological Satellite Program’s Operational Line-scan System Visible Near-Infra-red Band (DMSP/OLS VNIB), which provides NTLs from 1992 to 2013. Indeed, the spatial resolution of the DMSP is lower (around 2.7km compared with 742 m of the VIIRS). Moreover, VIIRS satellites appear to better capture even weaker lights at nights, compared to the DMSP (Wu and Wang, 2019).

11 In this study, nighttime radiance products have been cleaned of atmospheric disturbances and moon illumination fractions for the period of the analysis, since at the time, the already processed versions of these data were not available.

This study focuses on two different levels of analysis: the first concerns the relative drop in NTLs and NO_2 recorded from January to March for the most populated places, using as proxy the cities and towns found on Open Street Map (these are represented by coloured dots to make them stand out; see Figures 3–37). Points of interest are presented in choropleth maps, in which darker shading implies higher variation in NO_2 (measured in μmolm[2]) and NTLs (measured in nWcm-2sr-1). The maps also show the recorded variation in luminosity and NO_2 emissions at the lowest administrative level available. These quantities have been weighted by population density so that they are easily comparable (Rose and others, 2019). Thus, these maps simultaneously show which are the worst hit areas and whether densely populated places have been more affected by containment measures, as would be expected *a priori*. This first specification reinforces the fact that these instruments are an optimal tool for measuring urban agglomeration and socio-economic dynamics at a granular level. The second level of analysis concerns the percentage variation recorded in NTLs and NO_2 at the national level, providing a benchmark for comparison of aggregate remotely sensed statistics with localized ones.

In the following chapter, the results categorize countries into: i) oil-importing middle-income countries, ii) Gulf countries, and iii) fragile countries.

4. Oil-importing middle-income countries

Egypt, Jordan, Morocco and Tunisia are a heterogeneous group of countries in terms of political systems and economic and sociocultural aspects. Nevertheless, they are among the Arab countries whose tourist sector has become increasingly important in the last few decades, representing one of the main budget items in their national GDP. Due to its intrinsic connection with the globalized movement of people and goods, the tourism industry has been one of the sectors most affected by the COVID-19 supply shock.

The measures undertaken by governments of the region in the wake of the crisis were similar: curfews, self-isolation, stringent restrictions on social gatherings, precautionary sanitation, raising of public awareness, and public updates on the number of cases (Mezran and others, 2020). In the following sections, middle-income Arab countries are analysed individually to understand subnational determinants and consequences of the COVID-19-induced economic and social disruptions.

4.1 Tunisia

Tunisia is among the countries that have enforced the strictest anti-contagion measures. Aware of the fragility of the health care system and the serious potential economic repercussions generated by the spread of the disease, on 23 March 2020, president Kais Saided enforced a lockdown, deploying the army. However, although the measures undertaken by the Tunisian authorities seem to have dampened the escalation of contagion,[12] the socio-economic consequences appear to be even "more damaging to Tunisia than the virus itself" (Cherif, 2020).

Figure 3–6 show how the anti-contagion measures are already having an effect, with a drastic change in both NO_2 (Figure 3 and Figure 4) and NTLs (Figure 5 and Figure 6).

From Figure 3 and Figure 4 the strong reduction in NO_2 emissions recorded seems to be consistent and severe across the whole country, with an average NO_2 emission reduction of 29.77 percent. The only territories that have not been affected are the Tataouine Governorate and the surrounding areas. This is plausible given the predominance of the Sahara Desert and the lack of population and productive activities. In terms of luminosity, the more severely hit districts are those belonging to the Governorates of Medenine in the south-east, and Kasserine, Sidi Bouzid and Gasfa in the mid- and north-west of the country. The drop recorded in these areas is 8–10 percent, while the Tunisian average is around 2–3 percent. However, once the weighted variation of luminosity is taken into account, the most fragile areas turn out to be the capital, Tunis, and other important cities such as Kasserine, and Sousse, a strategic port and commercial hub (see Figure 5).

Moreover, it is interesting to observe how the places most severely damaged by the lockdown seem to be the main destinations of the conventional tourist itineraries. Given that the tourism sector is the second-largest contributor to the Tunisian economy (immediately after agriculture), its complete shutdown may have devastating consequences in terms of economic and social recovery. Indeed, the recent figures updated by the IMF foreshadow a GDP contraction of around 4.3 percent in 2020 due to the impact of COVID-19 (IMF, 2020a). The tourism sector has been devastated by the pandemic, with an estimated revenue loss of approximately US$1.4 billion and more than 400,000 people facing the possibility of losing their jobs (Amara, 2020).

As with many other countries affected by the virus, Tunisia will have to face numerous socio-economic challenges in the near future. The current crisis has exacerbated the government's shortcomings and the fragility of Tunisian institutions (Brown, Brechenmacher and Carothers, 2020). Moreover, its economic and social climate threatens its management of the crisis. Tunisia already has an unemployment rate of 15.51 percent (34.81 percent for people aged 15–24; Statista, 2020), while the informal economy consists of about 53 percent of the total Tunisian population (International Labour Office, 2018). This means that a significant portion of the Tunisian population is already deprived of job security, social protection and social guarantees. The repercussions of coronavirus, though still difficult to estimate with precision, may only deepen the vulnerability of the more fragile sections of society.

12 As of 24 August, 2,818 COVID-19 cases have been officially recorded, while deaths total 49 (Worldometer, 2020).

Figure 3. Nitrogen dioxide weighted variation (blue bar) and nitrogen dioxide drop in populated places in Tunisia (red bar)

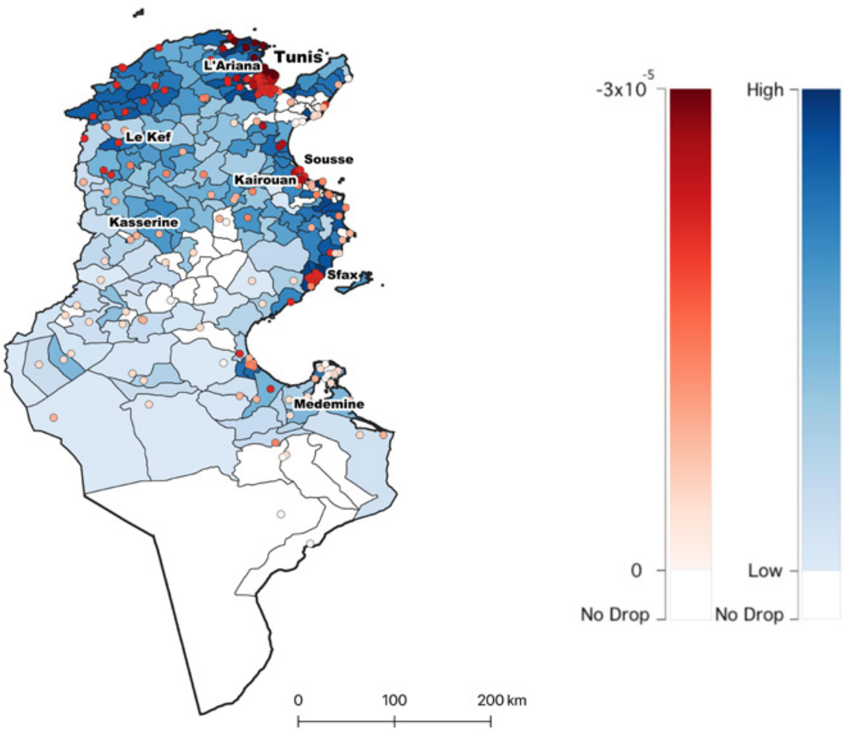


Figure 4. Nitrogen dioxide variation in Tunisia

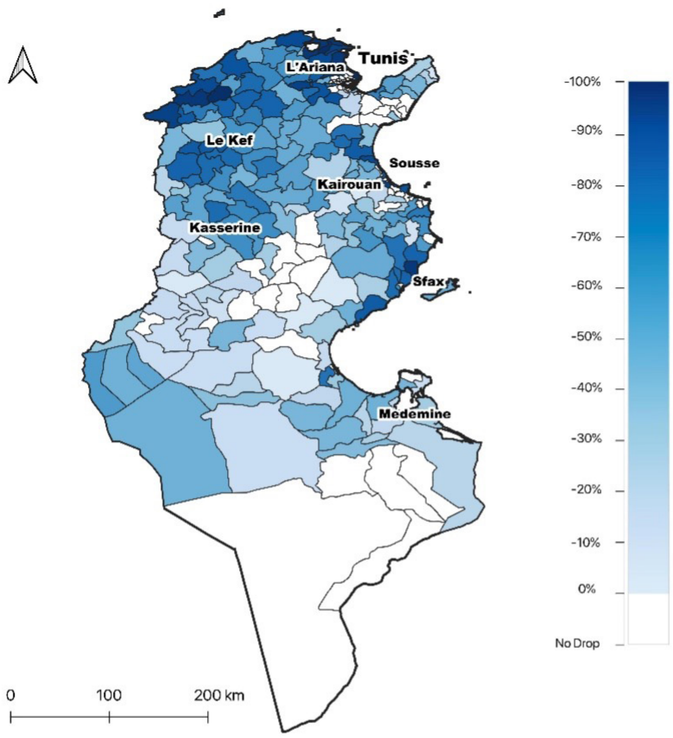


Figure 5. Weighted variation in night lights (black bar) and drop in night lights in populated places in Tunisia (red bar)

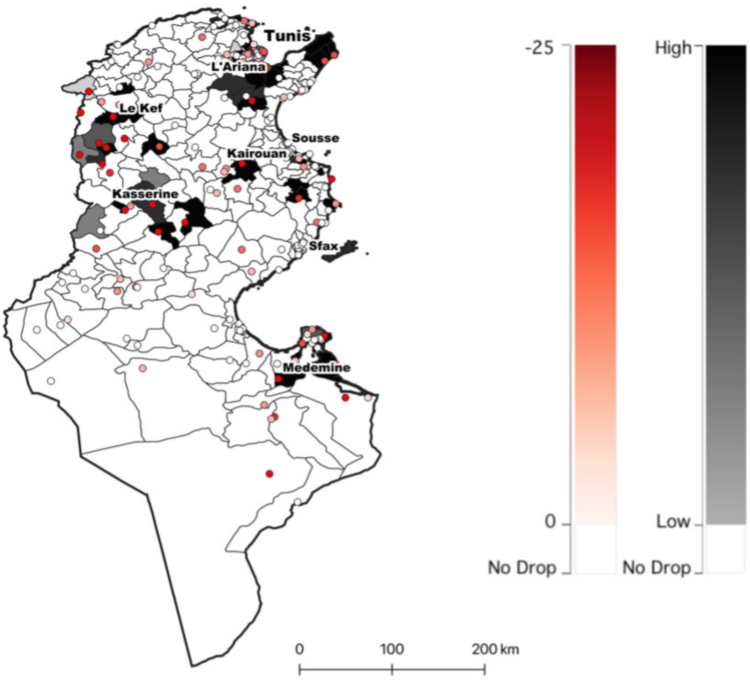
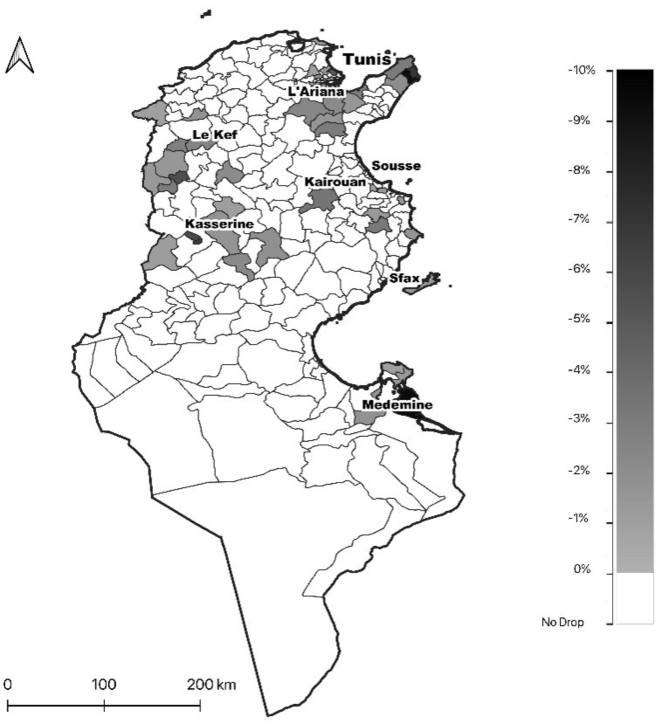


Figure 6. Variation in night lights in Tunisia



4.2 Jordan

Jordan enforced lockdown measures and a curfew with strict restrictions on movement on 18 March. The measures implemented have contained the virus as cases remain limited[13] to geographical and time-limited clusters (WHO, 2020k). Jordan’s economy is mainly devoted to the tertiary sector, with a robust services sector, especially tourism (World Bank, 2020c) which accounts for 10 percent of GDP (Shdeifat, 2006). According to a survey on the impact of COVID-19 on households in Jordan, almost half of respondents (43.2 percent) said they had lost all their work, albeit sometimes only temporarily (UNDP, 2020c).

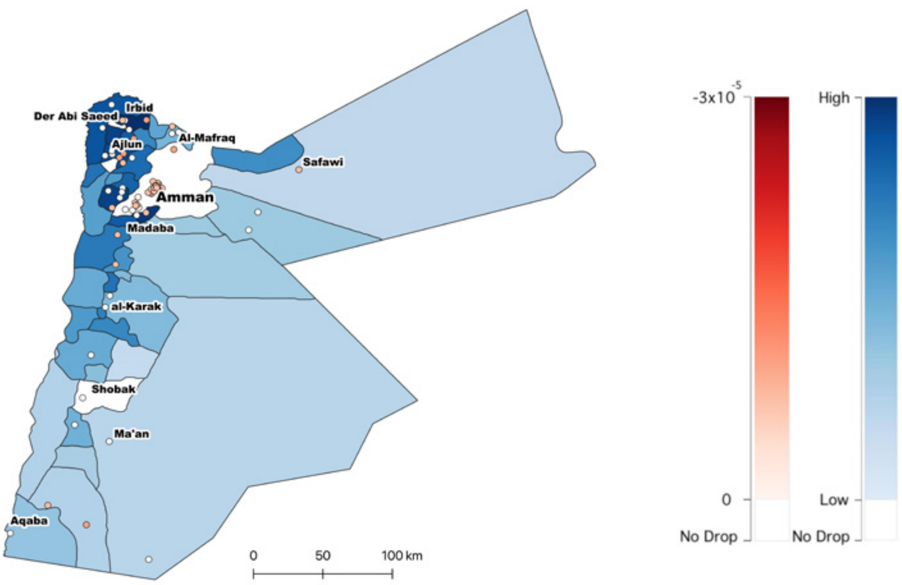
Considering the country’s low saving capacity, which was the case even before the outbreak (Kamar and Selim, 2020), the estimated revenue loss, together with the interruption of reception of remittances from abroad (which represent 10 percent of its national GDP; World Bank, 2020f)), have had a detrimental effect on the fulfilment of basic needs.

Public finances are also burdened by a long-lasting refugee crisis. To mitigate the economic and human impact of COVID-19, the IMF approved a 48-month arrangement under the Extended Fund Facility (EFF) with Jordan for US$1.3 billion (IMF, 2020b) while the World Bank approved a US$20 million COVID-19 Emergency Response project (World Bank, 2020h).

As the pandemic reached its peak, NO_2 underwent a mean negative drop of 42 percent and a countrywide mean variation of -16 percent (see Figure 8). The weighted variation shows how the worst impacted areas are found in western Jordan, which borders with Israel and the State of Palestine. All the major tourist attractions and tourist industry facilities are condensed within this strip, according to Open Street Map data.[14] However, based on population distribution in terms of NO_2 emissions, the worst-hit provinces are found in the north, where the majority of refugee camps are located (see Figure 7).[15] Management of refugees under the pressure of COVID-19 is a further burden for the Jordan authorities, who face a lack of resources and the sanitary precarity of high-density refugee slums (Carpi, 2020).

Negative variation in NTLs were only detected in the peripheral provinces of Shoabak, Mafraq, Aqaba and Ma’an (see Figure 10). The registered drop in NTLs seem not to involve the main cities' centres, but rather the areas surrounding the major tourist hubs, like Petra, Crusader Castle Montreal and Wadi Rum (see Figure 9 and 10).

Figure 7. Nitrogen dioxide weighted variation (blue bar) and nitrogen dioxide drop in populated places (red bar) in Jordan



13 Currently, 1,609 cases have been confirmed (Worldometer, 2020).

14 Maps of the locations of the main tourism facilities are provided on request.

15 See Figure 11.2 in the appendix.

Figure 8. Nitrogen dioxide variation in Jordan

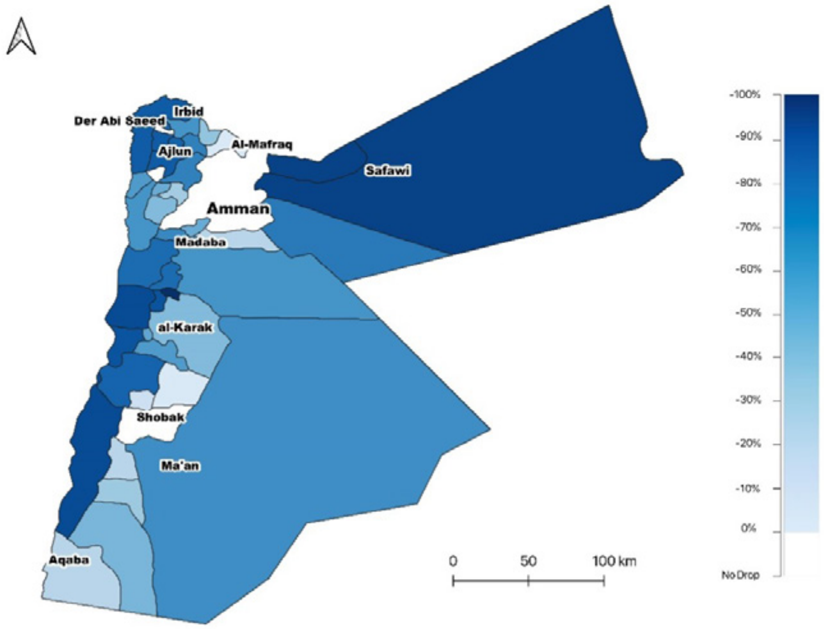


Figure 9. Weighted variation in night lights (black bar) and drop in night lights in populated places (red bar) in Jordan

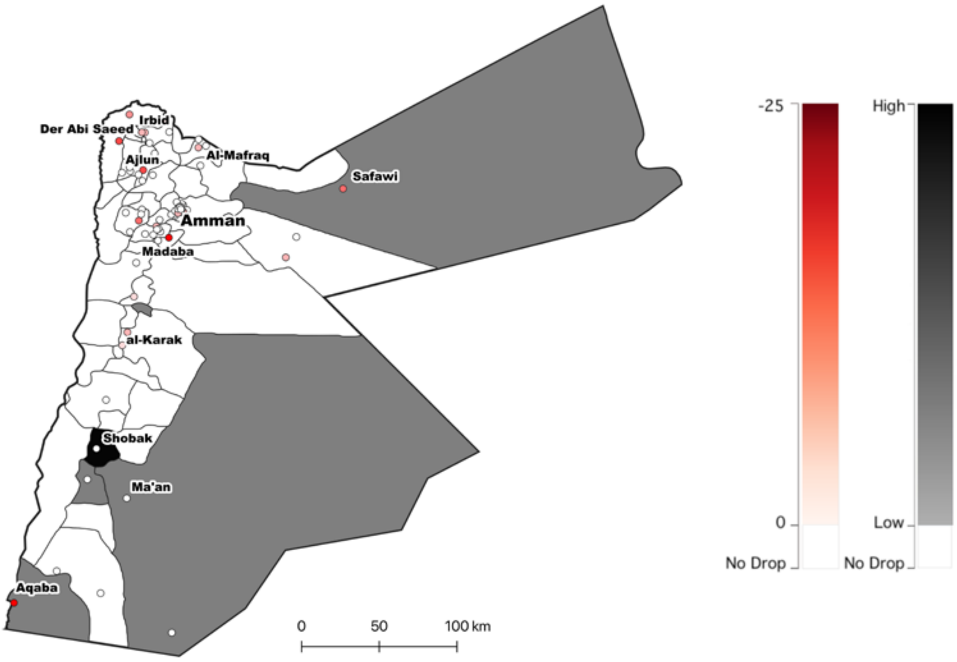
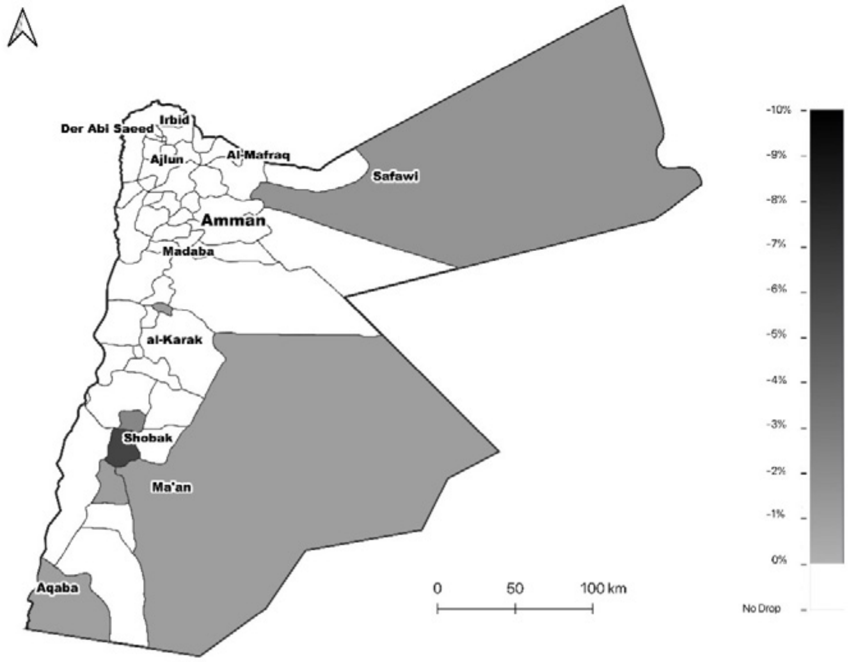


Figure 10. Variation in night lights in Jordan



4.3 Egypt

Egypt is the most populous country in the Arab region, with a population of over 100 million that is growing at 1.94 percent per year and mostly concentrated in high-density city centres, particularly along the River Nile and in the surrounding areas of Cairo. In response to COVID-19, the Egyptian authorities were forced to shut down schools, universities, airports and social gathering hubs, imposing a curfew between 8pm and 6am which was enforced by police patrols (Organisation for Economic Co-operation and Development [OECD], 2020a). Despite delays in the implementation of the anti-contagion measures, Egypt is among the countries that have experienced the highest recorded drop in terms of NO_2 emissions, with an estimated average drop of 55.74 percent. The reduction in luminosity registered, meanwhile, appears less evident, at around 3–4 percent. However, although the country has undergone a generalized reduction in both luminosity and emissions, the areas that have been worst-hit are those that follow the course of the Nile, namely the population centres. Similar to Tunisia and Morocco, tourist hotspots in particular have been most impacted by the crisis.[16]

The coronavirus pandemic arrived at the beginning of the tourist season, nullifying the tourism sector's revenue expectations before the season had even begun (Ardovini, 2020). The updated government figures foreshadow a monthly revenue loss of US$1 billion from tourism, which corresponds to approximately US$12.5 billion in a year, or 12 percent of GDP (OECD, 2020a). This number appears even more dramatic in view of the fact that the collapse of the tourism industry will affect at least 1.4 million people (10 percent of Egyptian employees) (OECD, 2020a). Together with the decline in tourism revenue, Egypt, which is the fifth-largest recipient of remittances in the world (10 percent of GDP), will face a severe drop in Egyptian expatriates, especially those who work in the Gulf countries (recent estimates expect a decrease of US$2.3 billion for the period of April–June 2020 (Abdo, 2020)).

16 These are tourist destinations that had already been severely damaged by the turmoil caused by the Arab Spring revolution of 2011.

4.4 Morocco

After the first case of COVID-19 was confirmed on 2 March 2020, Moroccan authorities implemented an immediate response to limit the spread of disease. Morocco enforced a strict lockdown on 20 March to curb infections and mitigate potential repercussions on the health care system. There is a great deal of concern about the stability of the health system, considered “decadent” and inadequate to cope with this widespread health emergency (Laaroussi, 2020; Arezki and others, 2020). Moreover, there is general mistrust in the government’s ability to manage the pandemic and its consequences, despite the precautionary measures undertaken (Cimini and Chalfaouat, 2020).

The economic impact of the closure of all activities has brought large strategic Moroccan sectors to their knees. COVID-19 was immediately felt by the Moroccan economy given the tight relations between Rabat and China, in particular concerning raw materials and production components which are fundamental for the electronic industry supply chain (Martini, 2020). This is reflected by the dramatic and immediate reduction in NO_2. NO_2 emissions have seen a generalized and significant drop throughout Morocco, averaging 39.28 percent. Unsurprisingly, the weighted variation seems to have been more extreme and concentrated in the main cities of Rabat, Tangier, Casablanca and Marrakesh.

The perceived drop in NTLs appears less drastic in respect to that of Tunisia. On average, they have decreased by around 1 percent, though in some areas the registered drop is up to 6.3 percent. The most affected places, however, remain the major population centres and Morocco’s major tourist destinations. The tourism sector, which, before the crisis, provided around 500,000 direct jobs, has been immediately hit by COVID-19. Restaurants, hotels and tourists’ facilities in particular will face a 25-percent revenue drop by the end of 2020 (OECD, 2020b), while overall, the tourism sector will lose an estimated US$3.4 billion (Alaoui, 2020). However, similar to Tunisia, the confinement measures’ deepest effects will be felt by the informal sector, which constitutes a key source of income for the Moroccan economy (up to 40 percent of employment is informal in the non-agricultural sector; IMF, 2019). For a large portion of the Moroccan population, the informal job market—tourism, transportation and retail in particular—is their only viable source of income. The pandemic may trigger the descent of millions of Moroccans into poverty (UNDP, 2020a).

Estimates of GDP growth for Morocco, of around 3.5 percent, were revised to -3.7 percent (OECD, 2020b; IMF, 2020c). The negative economic implications of COVID-19 may generate substantial social and economic problems, worsening social inequality and laying the foundations for potential turmoil. The socio-political consequences may be serious, especially in the suburbs of the biggest cities, which seem to be the most severely hit by the lockdown.

5. Fragile countries

The Middle East has long been the scene of clashes, conflicts and turmoil, making the region one of the most turbulent areas in the international panorama (Cordesman, 2018). In a region already crippled by a social and political crisis, COVID-19 may be considered an additional detonator. Although the number of cases seems to be under control, this may be due to lack of tracking and limited health monitoring. Despite a younger population and warmer climate, which in some contexts seem to have alleviated the spread of the virus, COVID-19 has rapidly multiplied in the region, threatening the "millions of people inhabiting overcrowded and unsanitary refugee camps" in particular (Bianco and others, 2020).

5.1 Lebanon

The timing of the outbreak was terrible given the socio-political and economic situation of Lebanon (United Nations Office for the Coordination of Humanitarian Affairs, 2020). Its announcement of debt default, on 9 March, was immediately followed by confirmation of the country's first COVID-19 case. Given the current situation, Lebanon faces a triple fiscal, banking and currency crisis, a protracted refugee crisis, a question of political legitimacy and the weight of the repercussions of the spread of the virus (Yahya and others , 2020) in addition to other shocks such as the Beirut Port blast, which took place on 4th August 2020. Mass protests and demonstrations against the government's actions, corruption, sectarian political system and fiscal policies were already ongoing since October 2019. Before the onset of COVID-19, the World Bank estimated that poverty could rise up to 50 percent, depending on the economic situation. The country is also plagued by youth unemployment, which is equally estimated to be on the rise (World Bank, 2019). The situation is complicated by additional factors: an inflation surge driven by the country's currency crisis has caused an uptick in the price of essential goods such as food and medicines; national debt is up to 170 percent of GDP, compounding the destabilizing effects of sweeping inequality, which sees the 55 percent of GDP in the hands of the top decile of the population (Yahya and others, 2020).

The imposition of a partial curfew on 26 March to limit the spread of the virus is already having an effect, causing a drastic drop in the NO_2 emissions, by -17.77 percent, as shown in Figure 13. However, Figure 11 shows that the drop has been more drastic in big population centres. Tripoli and Sour in particular have seen the biggest reduction in NO_2 emissions, while Beirut has seen the most drastic drop in terms of NTLs, as shown in Figure 13. The average decrease in NTLs luminosity is 4.78 percent (see Figure 18), and is concentrated in the coastal, most densely populated area.

Figure 11. Nitrogen dioxide weighted variation (blue bar) and nitrogen dioxide drop in populated places (red bar) in Lebanon

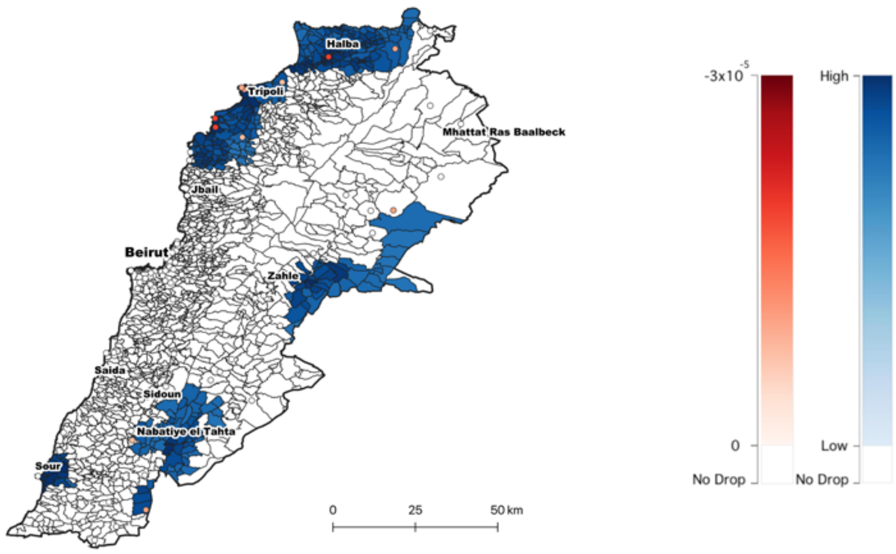


Figure 12. Nitrogen dioxide variation in Lebanon

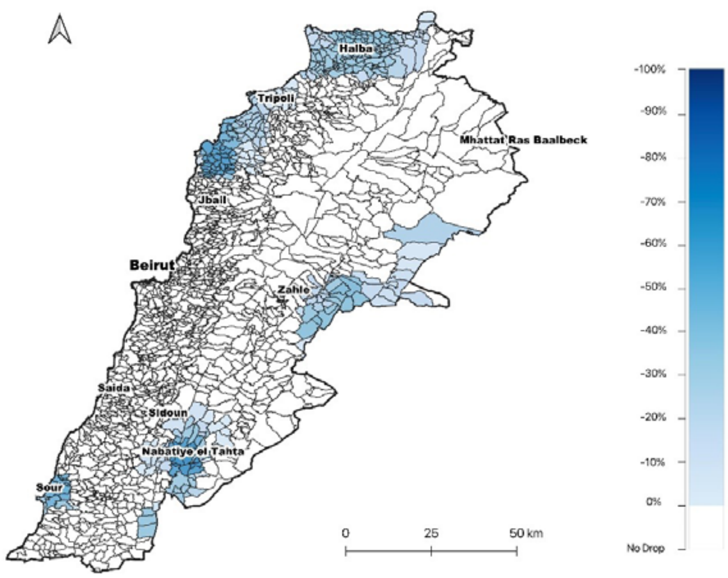


Figure 13. Weighted variation in night lights (black bar) and drop in night lights in populated places (red bar) in Lebanon

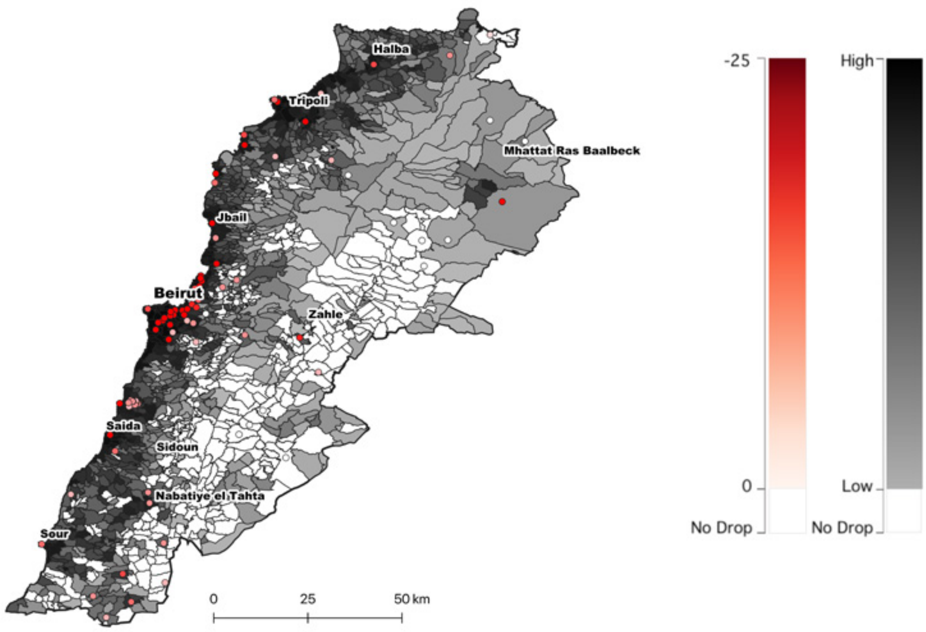
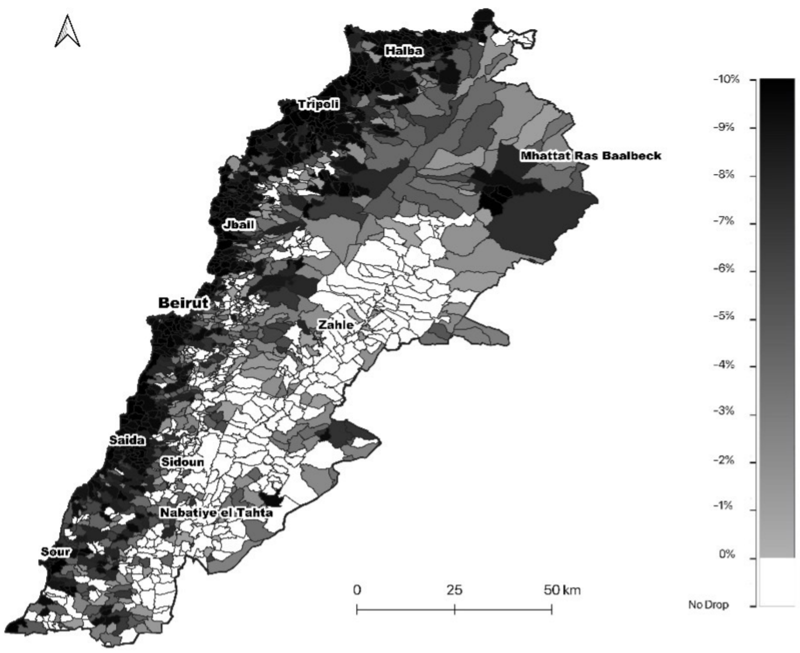


Figure 14. Variation in night lights in Lebanon



5.2 Libya

Libya is facing a complex and delicate crisis: the escalation of an armed conflict, the collapse of its health care system, its isolation from humanitarian organizations, the multiplication of factions aligned with the Tripoli-based Government of National Accord (GNA) and Haftar's Libyan Arab Armed Forces (LAAF) concentrated in the east of the country (Badi, 2020).

Despite the COVID-19 warning issued by WHO and the cease-fire invoked by the United Nations, the conflict continues to escalate, with one of the Khadra General Hospitals in Tripoli severely damaged after a rocket attack by the Haftar's forces (Aljazeera, 2020). Civilian infrastructures were systematically damaged, creating shortages in basic services such as water and electricity access. WHO declared Libya a high-risk country in terms of contagion (Piscitelli, 2020).

On 17 April 2020, the GNA imposed a 24-hour curfew for 10 days. However, it is implausible to attribute the short-term reduction in NO_2 emissions and NTLs luminosity solely to anti-contagion policies given that the country has been fully immersed in a civil war since 2011.

Although the relative drop should not be ascribed to coronavirus containment measures *per se*, the numbers could help identify the most fragile areas which coincide with high population concentrations.

The registered drop in NO_2 and NTLs are -43.87 percent and -1.05 percent, respectively (see Figure 16 and Figure 18). However, when weighting the decrease by population density (see Figure 15 and Figure 17), the results remain coherent with the unweighted maps, but they highlight how the major Libyan cities are suffering from additional pressure, compared with the rest of the country. The most dramatically affected areas are the capital, Tripoli, followed by Misrata, Sirte and Benghazi, confirming *a priori* expectations.

Figure 15. Nitrogen dioxide weighted variation (blue bar) and nitrogen dioxide drop in populated places (red bar) in Libya

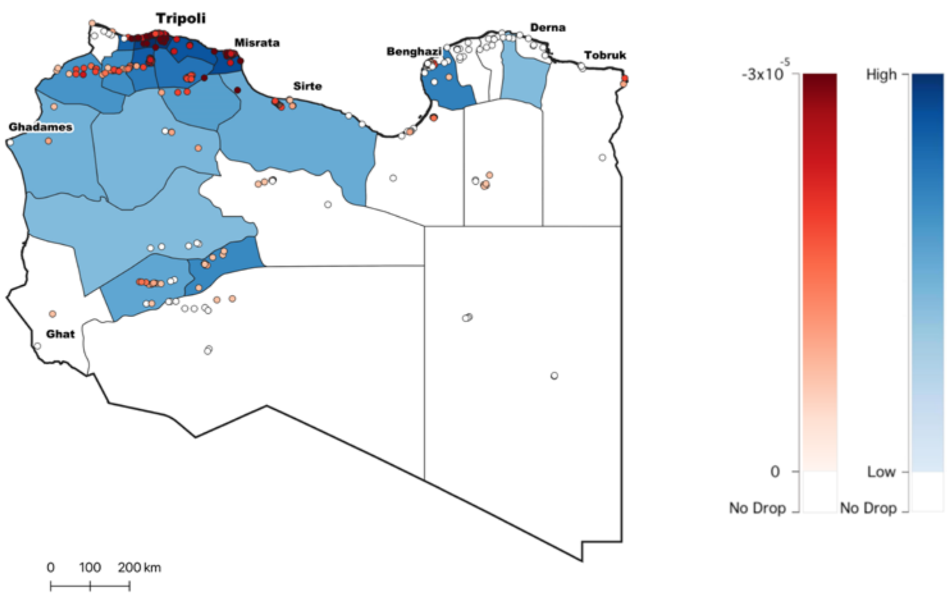


Figure 16. Nitrogen dioxide variation in Libya

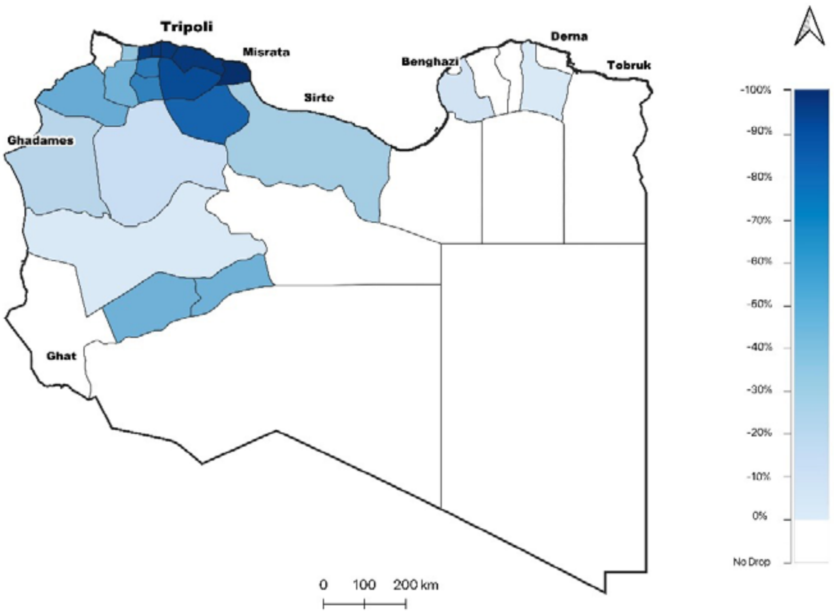


Figure 17. Weighted variation in night lights (black bar) and drop in night lights in populated places (red bar) in Libya

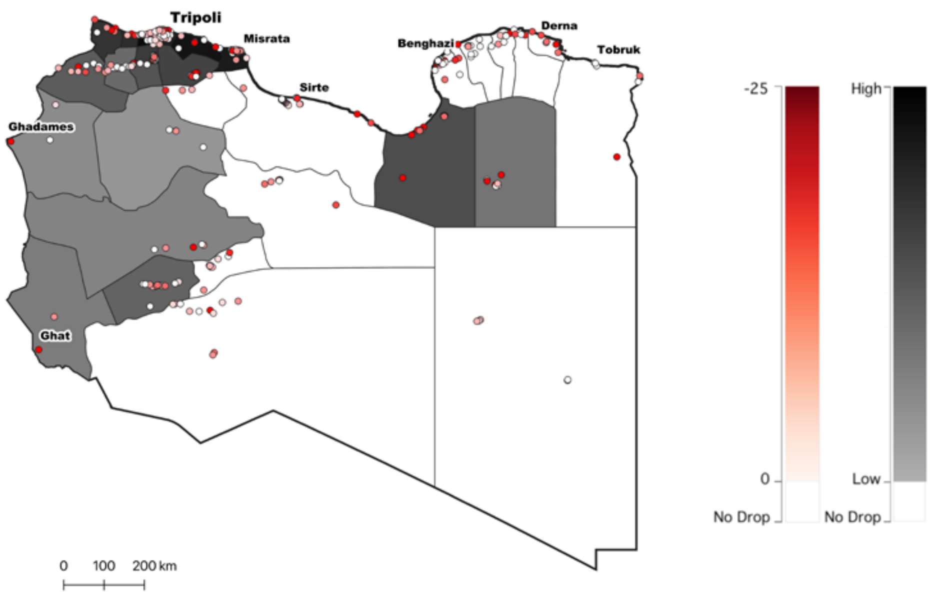
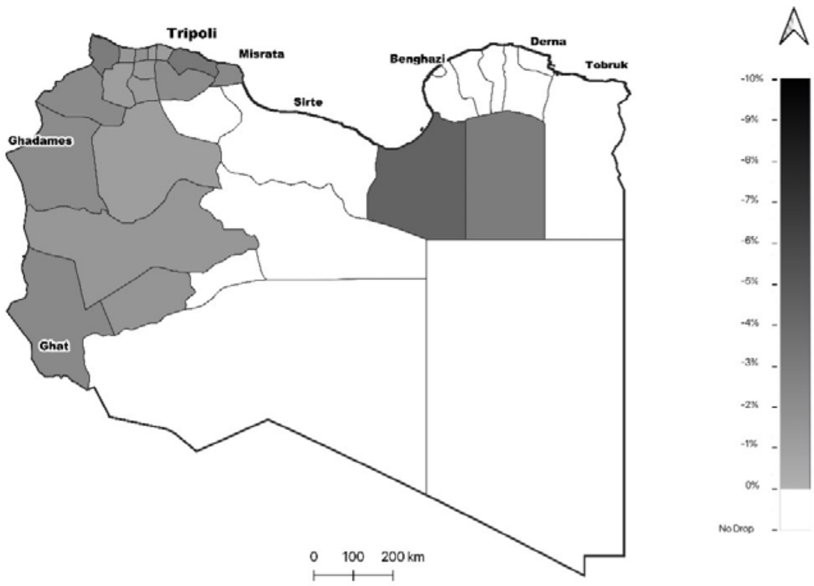


Figure 18. Variation in night lights in Libya



5.3 Syria

Syria is facing its tenth year of protracted civil war, which makes the country tremendously unsuited to control the spread of COVID-19 on its territory.

The health care system, public infrastructure and access to essential services have been seriously compromised by the compounded attacks of multiple armies and international actors operating on the Syrian territory since 2011 (Asseburg and others, 2020). Around 70 percent of the previously employed health care workers have fled the country since the onset of the civil war, weakening the capacity of an already low-standard public health care sector (Tsurkov and Jukhadar, 2020).

The war has also resulted in an alarming number of internally displaced people (around 6 million), who, by definition, do not have access to basic services such as water, electricity, health care and sanitation. Given all this, the pandemic was able to wreak havoc on an already devastated society, where around 80 percent of the population lives below the poverty line (United Nations Children's Fund, 2020). Similar to Libya, the measured drop of NO_2 and NTLs should not be attributed solely to the imposition of the curfew on 25 March, but as the result of a combination of forces.

NO_2 has dropped by an average of 58 percent, while NTLs have decreased on average by 3.59 percent (see Figure 20–22). It is clear from Figure 19 and Figure 21, how the most affected areas are those concentrated on the coast, which hosts most of the main population centres.

Figure 19. Nitrogen dioxide weighted variation (blue bar) and nitrogen dioxide drop in populated places (red bar) in Syria

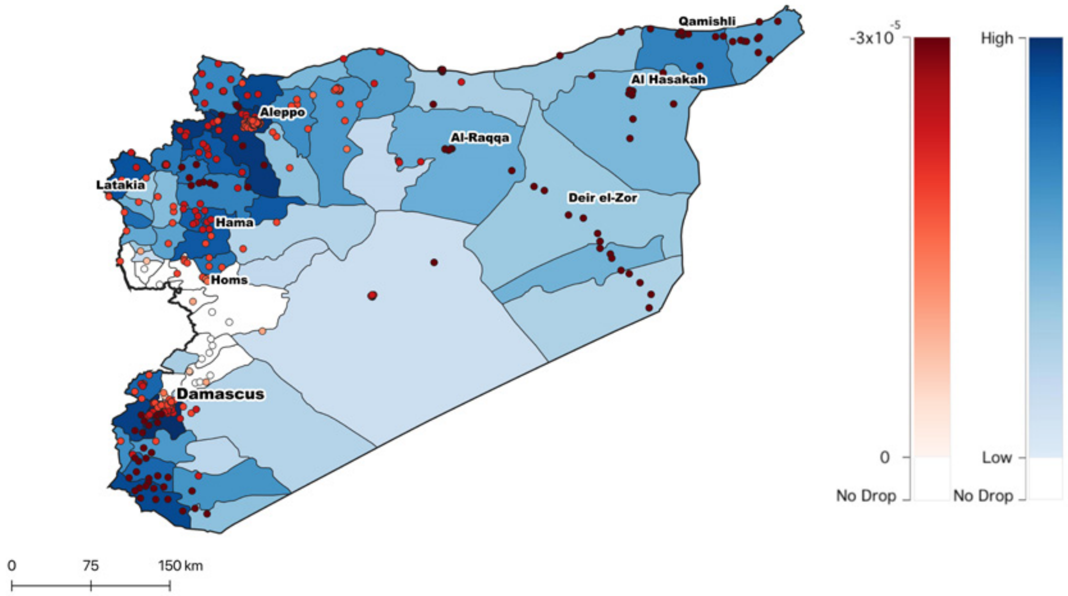


Figure 20. Nitrogen dioxide variation in Syria

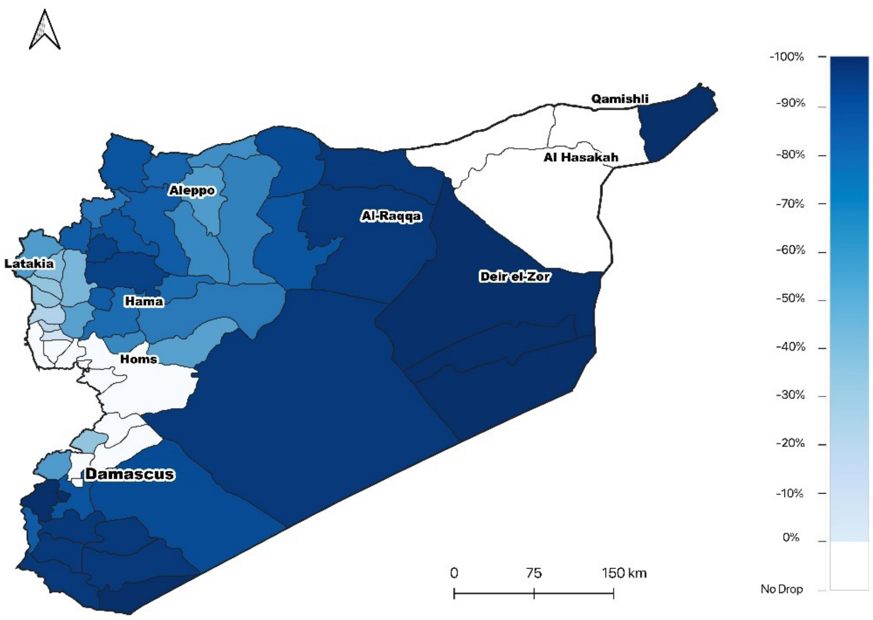


Figure 21. Weighted variation in night lights (black bar) and drop in night lights in populated places (red bar) in Syria

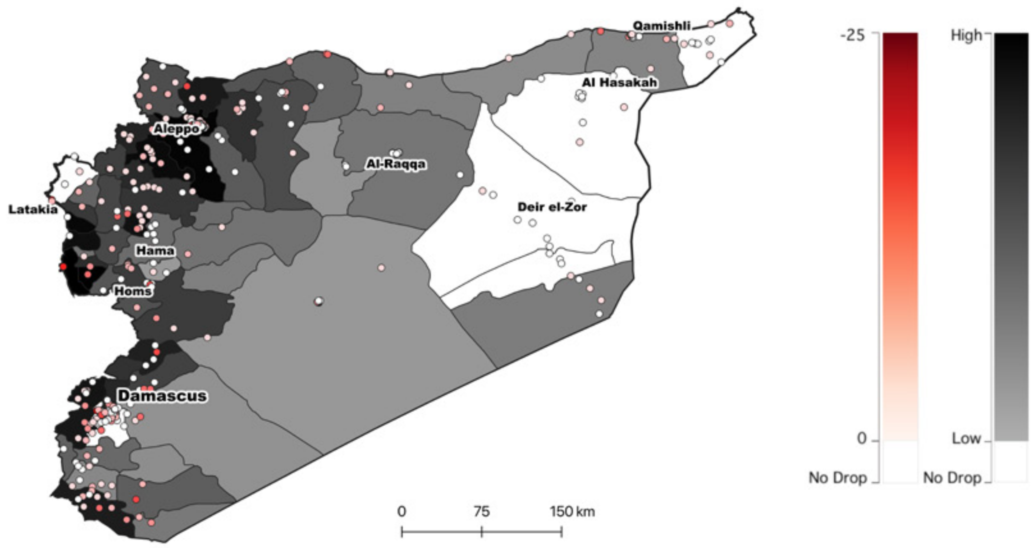
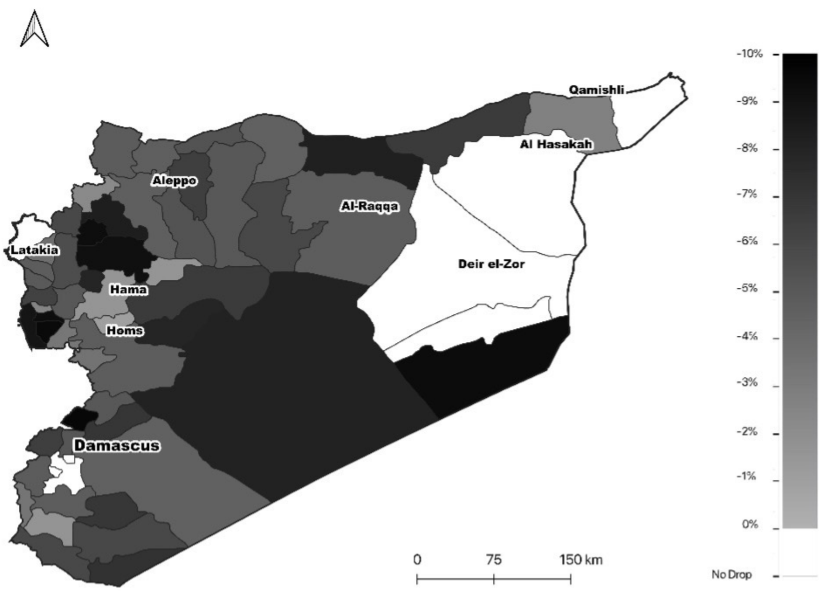


Figure 22. Variation in night lights in Syria



6. Gulf countries

6.1 United Arab Emirates and Qatar

Gulf countries suffered from the double burden of the costs of the pandemic and the oil price crisis. UAE and Qatar are the Arab countries most impacted by COVID-19 (67,282 and 117,266 cases respectively; Worldometer, 2020). Moreover, as major oil exporters (eighth largest oil producer and world's leading exporter of liquefied natural gas, respectively; Nordea, 2020a; Nordea, 2020b) the collapse of oil demand has forced them to revise growth trajectories, with downward estimates exceeding 10 percent of GDP in most countries (IMF, 2020c). To mitigate the socio-economic consequences of this, several Arab states announced measures. UAE in particular announced a US$27 billion stimulus—including water and electricity subsidies for citizens and commercial and industrial activities—to boost the economy. Similarly, Qatar announced a US$23 billion package to support the private sector and provide financial and economic incentives (UNDP, 2020b).

Over the first 10 days of March 2020, UAE started to adopt containment measures targeting people entering the country. As the pandemic worsened, stricter measures were implemented, progressing from restrictions on public gatherings (16 March) to closure of nonessential businesses (23 March), until a partial lockdown was announced, lasting for 10 days (26 March–4 April). In Qatar, measures to stop the virus entering the country (international movement restrictions) were rapidly followed by lockdown measures on 13 March (Qatar, Government Communication Office, 2020). Their effect on businesses was evident for both countries. In UAE, NO_2 emissions have dropped by nearly half throughout the country (see Figure 24). In Qatar, NO_2 emissions decreased by approximately -27 percent on average, with peaks in the south (see Figure 26). In terms of variation in NTLs, Dubai in UAE (see Figure 28) and the municipalities of Dukhan and Mesaieed in Qatar, in the black regions (see Figure 30) are the most affected. In fact, as the world has slowed down, the export of goods and services from these countries, particularly oil products, has greatly reduced. In 2018, the share of export in GDP was about 94 percent for UAE and 54 percent for Qatar. In UAE, a successful economic diversification policy led to a reduction in the proportion of oil-derived GDP to 30 percent (Organization of the Petroleum Exporting Countries, 2020), while the tertiary sector now contributes 52.5 percent of GDP, employing nearly three quarters of the workforce (73 percent; Nordea, 2020b). Dubai is a big contributor given its popularity as a tourist attraction. Conversely, Qatar is highly dependent on the oil and gas sectors. Moreover, both UAE and Qatar are preparing big international events. In UAE, Dubai's World Expo 2020 was postponed to 2021. Qatar, meanwhile, is trying to complete FIFA-related infrastructure ready for 2022 while coping with reduced investment capacity and social distancing, and respecting migrant workers' human rights (World Bank, 2020d; Qatar, 2020; Business & Human Rights Resource Centre, 2020; Amnesty International, 2020). Coronavirus hotspots were indeed identified in the old industrial area of Doha, where mainly migrant workers live in densely populated districts (Middle East Eye, 2020).

However, the uncertainty of COVID-19 was expected to have a significant impact on the success of these events both in terms of the completion of infrastructure and visitor attendance. Since the area is largely characterized by desert, it is more interesting to look at NO_2 and NTLs variation at the municipal level, where the changes actually took place. In UAE, all the main inhabited places have been hit by a drop in NO_2 and NTLs (see Figure 23 and Figure 27). However, drops in NTLs are fewer and smaller compared to NO_2, meaning that the shutdown of a limited number of businesses had a greater impact on NO_2 emissions.

In Abu Dhabi, there was no drop detected in terms of NTLs at the regional level, but there was a drop in NO_2. This area includes the country's main oil reservoirs which are accountable for enormous combustion processes (Morad and others, 2012). In Qatar, the main populated places are found around Doha, and have registered a change in terms of both NO_2 emissions and NTLs (see Figure 25 and Figure 29). Moreover, high variations are detected in Al Wakrah and Al Jumayliyah municipalities. These two municipalities are oil and gas refinery hubs and are linked by kilometres of pipelines. In fact, the whole of the south has been hit by a drop in NO_2.

Figure 23. Nitrogen dioxide weighted variation (blue bar) and nitrogen dioxide drop in populated places (red bar) in United Arab Emirates

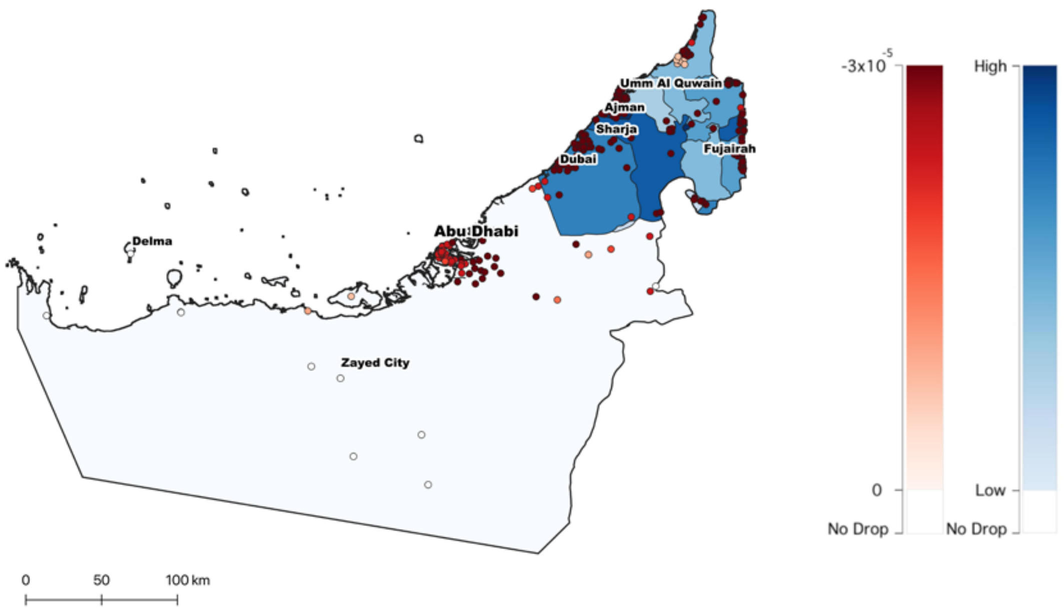


Figure 24. Nitrogen dioxide variation in United Arab Emirates

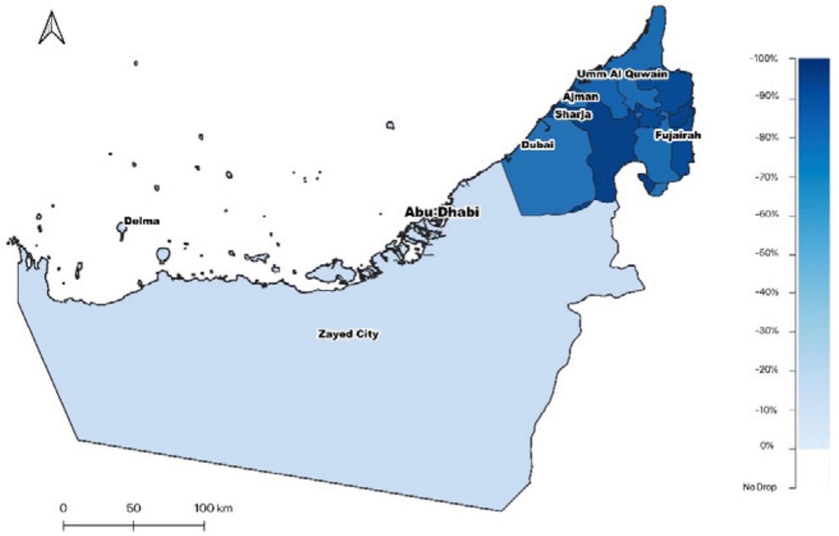


Figure 25. Nitrogen dioxide weighted variation (blue bar) and nitrogen dioxide drop in populated places (red bar) in Qatar

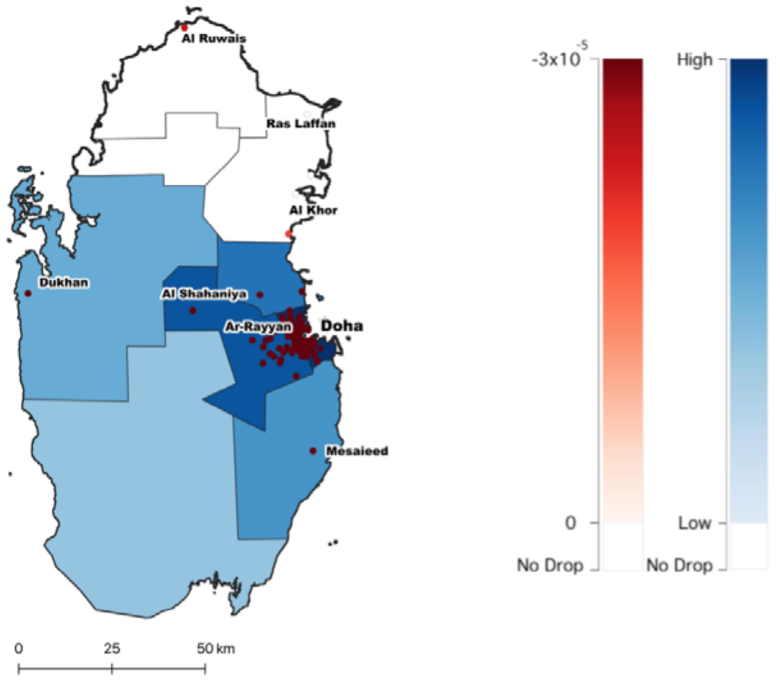


Figure 26. Nitrogen dioxide variation in Qatar

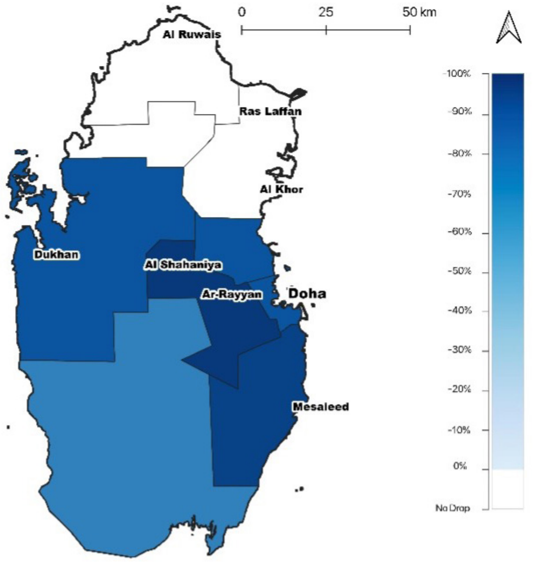


Figure 27. Weighted variation in night lights (black bar) and drop in night lights in populated places (red bar) in United Arab Emirates

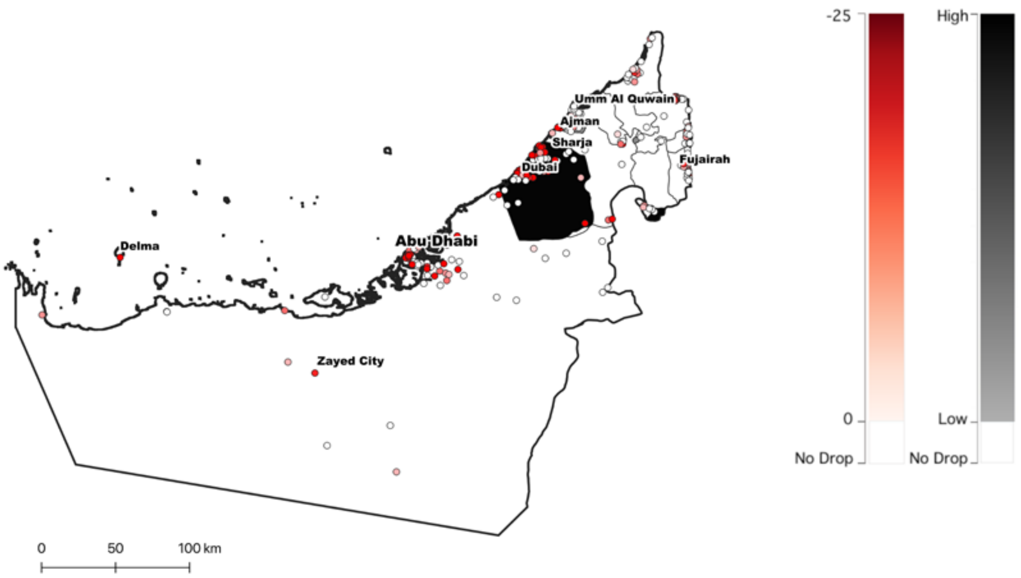


Figure 28. Variation in night lights in United Arab Emirates

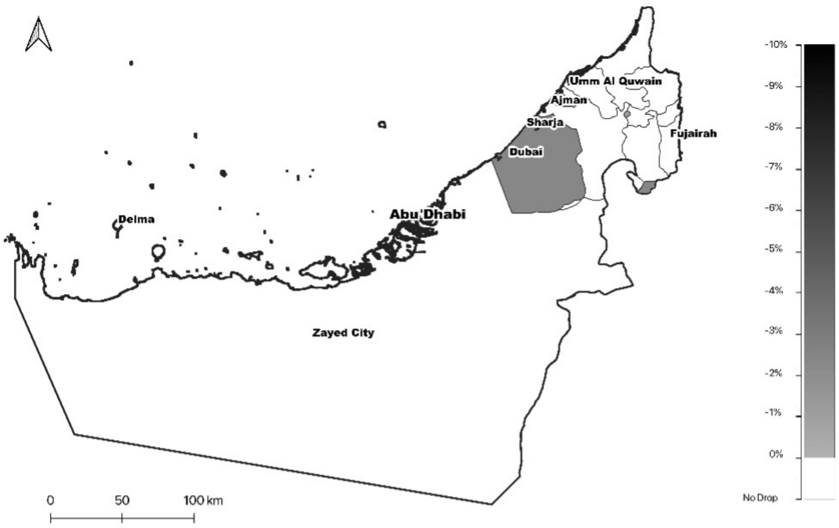


Figure 29. Weighted variation in night lights (black bar) and drop in night lights in populated places (red bar) in Qatar

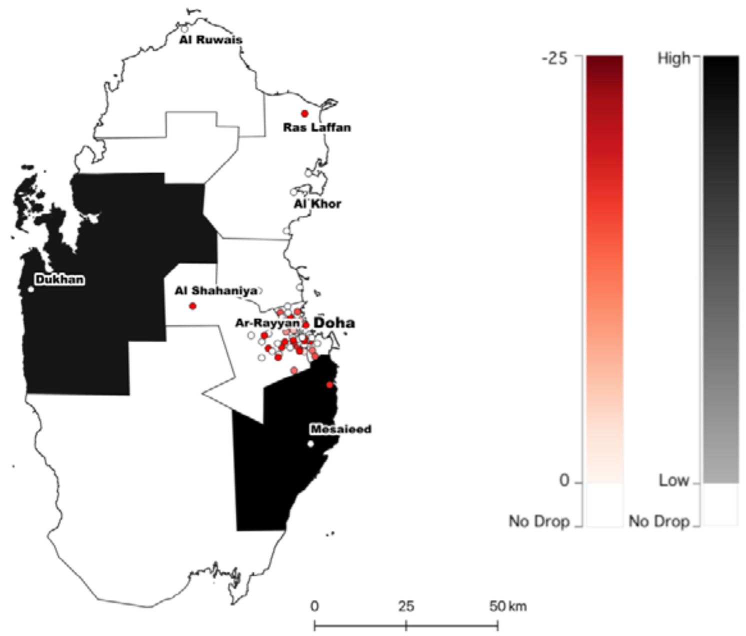
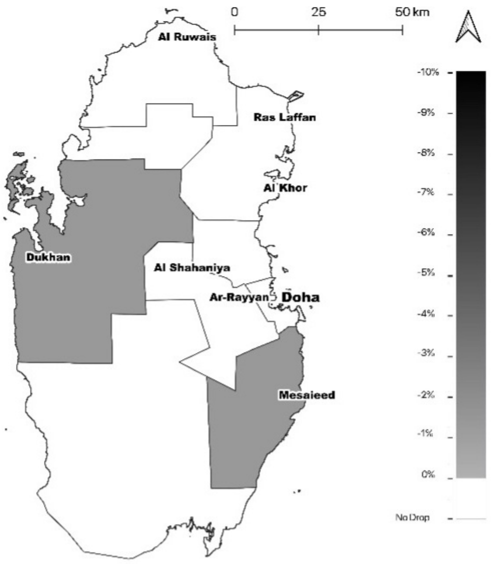


Figure 30. Variation in night lights in Qatar



7. Cross-country comparison of results

Table 2 shows that fragile countries have experienced the biggest drop in terms of NTLs. It also shows that the registered reduction in luminosity is generally one order of magnitude smaller than the one observed for NO_2. This is consistent with *a priori* expectations, since NTLs are particularly apt to capture variation in activities that cover manufacturing and infrastructure investments. Luminosity emitted by households is likely not to have been affected by the containment measures, especially in large urban agglomerations. On the contrary, the use of NO_2 emissions as a proxy of economic activity is also connected with the measurement of reduction in transportation, which is one of the sectors most heavily affected by lockdown and curfews. As such, these proxies of economic activity are suited for analysis of two different issues: NTLs are useful for observing regional level development and unequally distributed spatial shocks to manufacturing and investments, while NO_2 emissions reflect spatial trends in mobility and may be employed for microlevel analyses of policies aimed at tracking or improving transportation flows.

Table 2. Results for night lights (NTLs) and nitrogen dioxide (NO_2) for the period of restriction enforcement for each country (January–March 2020)[17]

	Location	Restrictive measure	NTL drop (%)	NO_2 drop (%)
Middle-income countries	Jordan	Lockdown	-0.98	-42.61
	Egypt	Curfew	-3.52	-55.74
	Morocco	Lockdown	-1.002	-39.20
	Tunisia	Lockdown	-1.35	-37.56
Gulf countries	Qatar	Lockdown	-0.57	-62.47
	UAE	Curfew	-0.83	-52.94
Fragile countries	Lebanon	Lockdown	-4.78	-17.77
	Syria	Curfew	-3.59	-58.62
	Libya	Curfew	-1.05	-43.87

17 Estimates have only been calculated for regions that have experienced a drop in NTLs and NO_2.

8. Correlations with economic factors: Oil prices, mobility and nitrogen dioxide

8.1 Oil prices

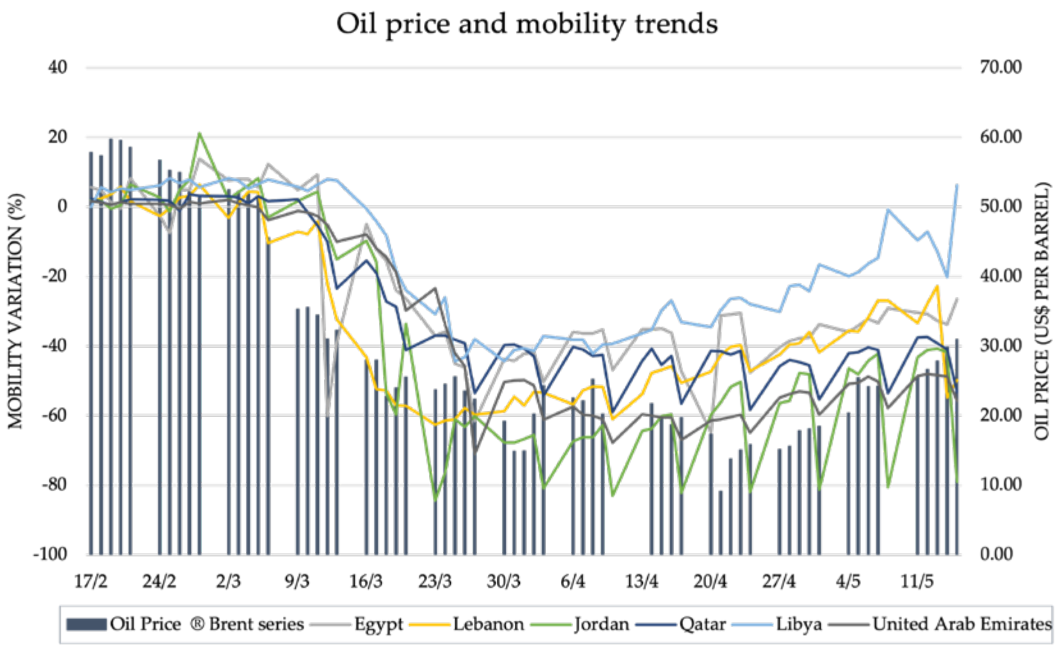
Arezki and Nguyen (2020) and UNDP (2020c) warned that at the outset, Arab countries were facing a dual shock due to the COVID-19 pandemic and the abrupt drop in oil prices[18] (see Figure 31 and Figure 33 for the Brent series oil price). The collapse of oil prices was so critical that the West Texas Intermediate price for crude oil (used as a reference for the American market) turned negative for the first time in history (Walker, 2020). At the same time, the Brent price for crude oil reached its lowest at US$9.12 per barrel (Federal Reserve Bank of St. Louis, 2020).

At the beginning of the pandemic, oil demand dropped dramatically as containment measures enforced the suspension of workplace attendance, the prohibition of gatherings (including at places of worship), restriction of travel, the suspensions of flights, the closure of ports and the partial blockage of productive activities. These

18 Data on crude oil prices (Brent – Europe, dollars per barrel, daily, not seasonally adjusted) were retrieved from the Federal Reserve Bank of St. Louis (2020) and accessed on 5 June 2020, for those countries for which mobility data were available.

containment measures and the subsequent oil price war have triggered an uninterrupted decline in oil prices, with a registered net oil revenue loss of around US$11 billion from January to mid-March (United Nations Economic and Social Commission for Western Asia [UNESCWA], 2020). Leading exporters, members of the Organization of the Petroleum Exporting Countries and other producers such as Russia agreed to cut production to balance oil prices in the international market. This was positively received by markets and oil prices increased afterwards. The impact of coronavirus on both oil prices and mobility trends,[19] a proxy for the forced confinement of people, is shown in Figure 31 and Figure 32. From these figures, a clearly positive correlation can be observed, as the mobility slowdown from mid- February to mid-March 2020 followed the decline rate of oil prices (UNESCWA, 2020).

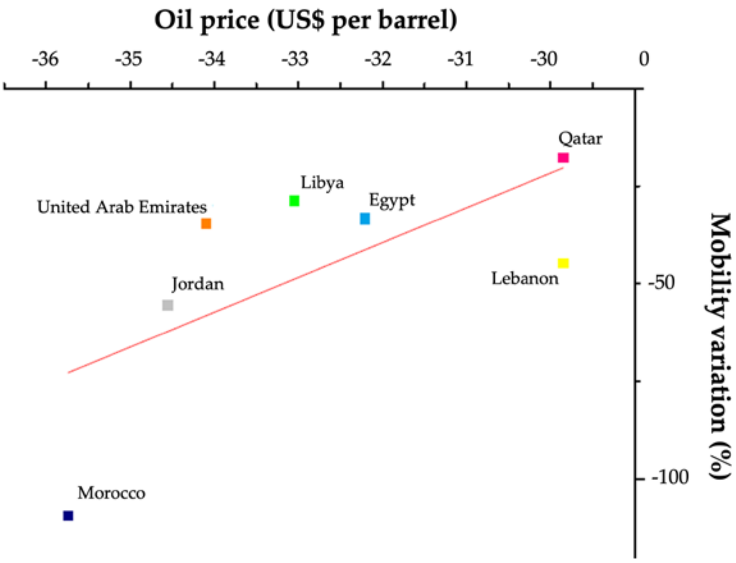
Figure 31. Oil price and mobility trends in the first half of 2020



The estimated losses in oil revenue for oil exporters in the Arab region range from US$10.7 billion to around US$38 billion, compared with a potential gain of US$0.49 billion to US$1.76 billion for oil importers, depending on oil price scenarios. The estimated net loss for the entire region thus ranges from US$10.2 billion to US$36.3 billion, dwarfing the positive supply shock to importers, and potentially limiting the capacity of Gulf countries to provide financial assistance to the entire region (UNESCWA, 2020).

19 Data on crude oil prices (Brent – Europe, dollars per barrel, daily, not seasonally adjusted) were retrieved from the Federal Reserve Bank of St. Louis (2020) and accessed on 5 June 202018, for those countries for which mobility data were available.

Figure 32. Correlation between oil price variation and mobility variation



To assess whether the drop in oil price has had an impact on the productivity of the countries analysed, this study explores the possibility of a correlation between oil price trends and NO_2 variation[20] according to the periods of containment measures.

Figure 33. Oil price trends and NO_2 variation

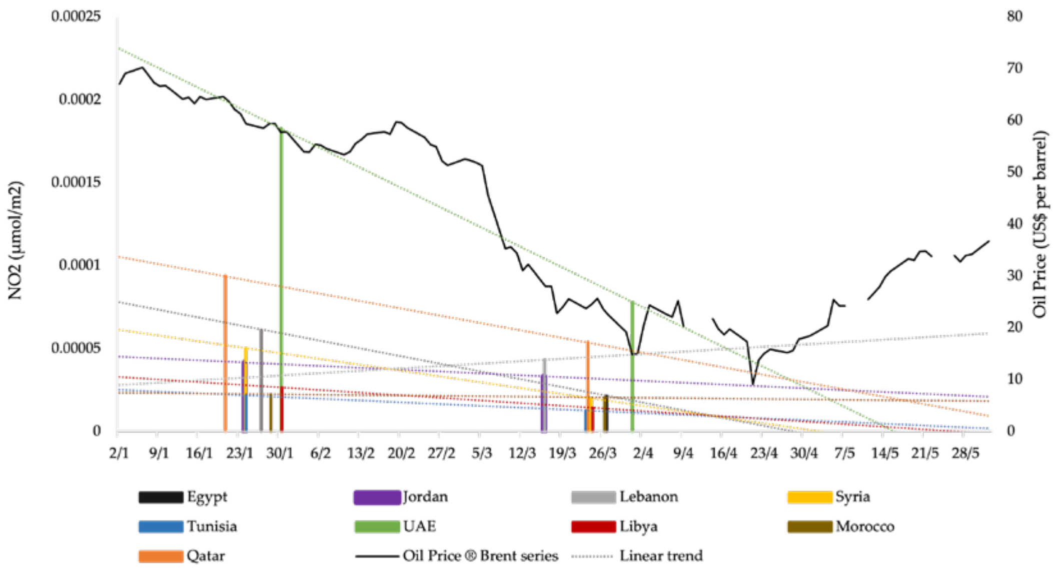
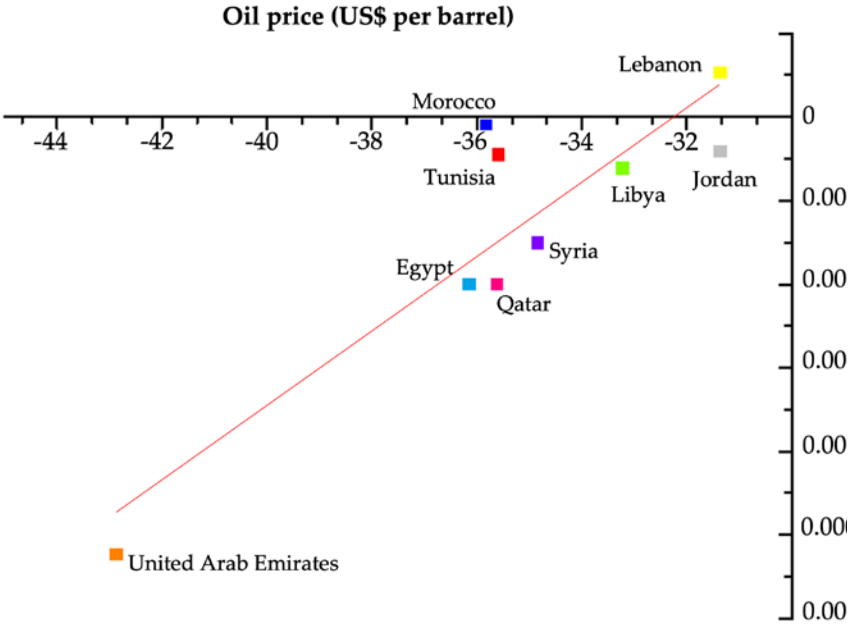


Figure 33 reveals a downward trend in oil price and mean cumulated NO_2 for each country detected by the satellite data, except for Lebanon. Oil exporters UAE, Libya and Qatar in particular, as well as Syria and Egypt, show a

20 This study will not explore the correlation between oil price trends and NTLs as it is difficult to analyse the drop in radiance solely in production activities.

marked reduction in NO_2. This correlation is reinforced when observing Figure 34, which shows a positive linear trend between the two variables; this means that the countries with the greatest NO_2 variation were also facing the highest oil price variation during enforcement of the containment measures.

Figure 34. Variation in oil price and tropospheric nitrogen dioxide



9. Estimates of gross domestic product loss through night lights and comparison with official projections for 2020

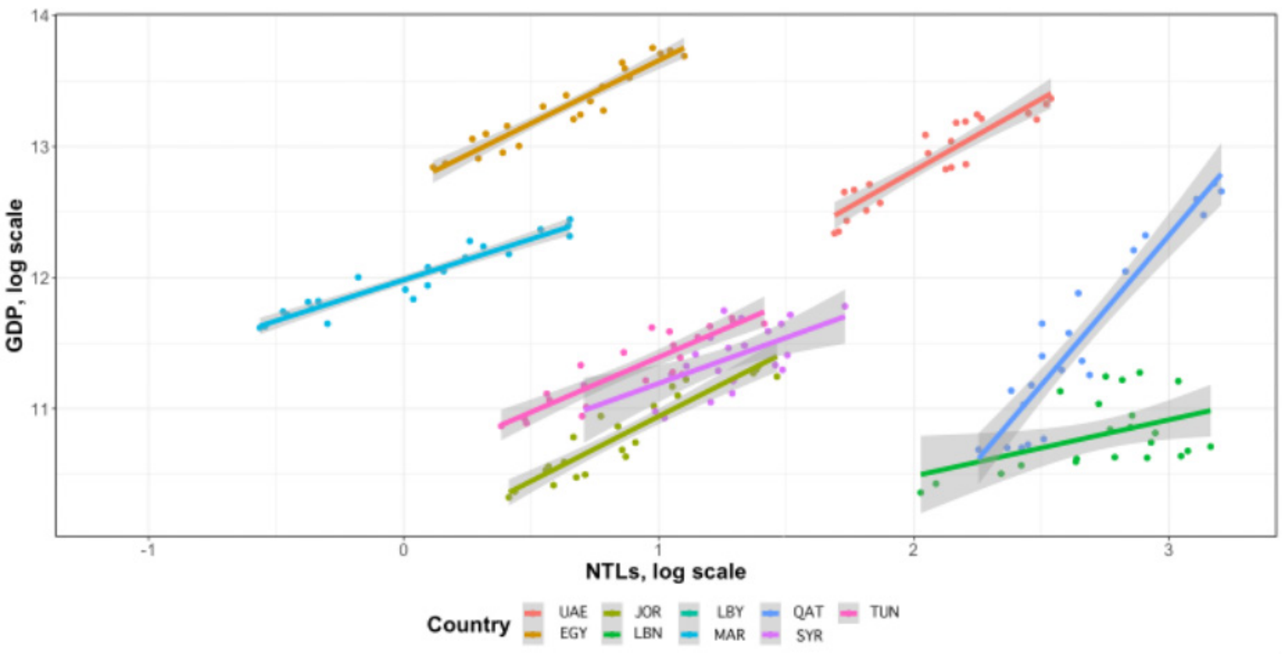
Estimates of GDP loss are paramount to understand the magnitude of the crisis in monetary terms and build a solid plan for a resilient recovery. However, the forecasts provided by international organizations on the potential drop in GDP experienced by countries due to COVID-19 necessarily had a degree of uncertainty. This is due to difficulties in evaluating the effects of the pandemic on the different economic, social and geo-political plans and their interconnected outcomes.

In the last two decades, data from outer space have been increasingly used to produce alternative measures of GDP, which allow for different evaluations of multifaceted phenomena, and testing of the accuracy of official projections. The availability of these tools of the digital millennium has allowed economists to construct various proxies of macroeconomic indicators that cover periods and regions for which GDP data may not be available or reliable (due to natural disasters and war, for example). The main advantages of these new techniques relate to the possibility of overcoming problems of accessibility and danger, by relying on near real-time information.

The urgency of the pandemic has heightened the importance of these indicators. This section specifically explores the usefulness of using NTLs as proxies for tracking short-term fluctuations in economic growth. It has already been affirmed in the academic literature (Henderson, Storeygard and Weil, 2012) that there is a strong correlation between changes in emitted luminosity and GDP growth (see Figure 35). Although detection of observable NTLs may be subject to measurement errors, NTLs may nonetheless provide insight about the intensity of the crisis. Indeed, the strict restrictions imposed by countries in the region, as shown in the previous chapter, has been clearly detected both in terms of reduction in luminosity and in pollution emissions.

This section expands on the existing literature related to remotely sensed measurements of GDP, using the insights offered by Henderson, Storeygard and Weil (2012)'s cross-country analysis of a selected panel of Arab countries (World Bank, 2020e).[21] This study uses the variation in NTLs over time as a proxy of GDP to measure the elasticity of GDP to NTLs for this sample. Then, using these estimated elasticities, the study constructs upper and lower bounds of the drop in GDP for the selected countries. Finally, Table 3 compares the GDP drop measured by this process with the scenarios envisaged by the IMF (2020c) and the World Bank (2020i).

Figure 35. Correlation between gross domestic product and night lights



21 With the exception of Malta and Israel, which have not been included for their intrinsic economic and geo-political differences from the region.

As proposed by Henderson, Storeygard and Weil (2012), the empirical strategy adopted estimates coefficients which measure the responsiveness of GDP variation to change in NTLs (World Bank, 2020e).[22] An alternative specification using the 2014–2019 database on NTLs can be found in the appendix, Table A.5. Data from 1992–2013 was used due to the availability of a longer panel with more observations. The coefficients of the elasticities have been obtained from the following regression:

$$GDP_{it} = \alpha + \beta_1 NightLights_{it} + \beta_2 X_{it} + \lambda_t + \delta_i + \varepsilon_{it}$$

where GDP_{it} is the natural logarithm of the GDP per capita for each country i in year t, $NightLights_{it}$ is the natural logarithm of the average digital number extracted from National Oceanic and Atmospheric Administration (NOAA; 2013), for country i in year t, X_{it} is a vector of covariates, namely population density and electricity consumption per capita (World Bank, 2020a), for country i in year t, λ_t are year-specific fixed effects (FE), δ_i are country-specific FE, and ε_{it} is a stochastic error term. The FE method has been employed due to time-invariant unobserved heterogeneity, which could alter the estimated elasticities; it also deals with potential measurement problems, due to the variation over time of the sensitivity of satellite sensor settings, which may alter the comparisons of raw digital numbers of pixel luminosity. The results of the estimated elasticities have been reported for each group of countries in the appendix. The elasticities used in the analysis (highlighted in bold in the appendix, Table A.1) are those which correspond to estimated elasticities between GDP and NTLs for Arab countries.

Thus, the estimated GDP decrease has been extrapolated by multiplying the estimated elasticities, $\hat{\varepsilon}$, of GDP to NTLs, in each different specification, by the registered drop in NTLs, as in Giovannetti and Perra (2020):[23]

$$GDP_{LOSS} = \hat{\varepsilon} * NTL_{RAW}$$

This procedure allows for comparison of the estimated decrease in GDP with the that reported by the official projections of GDP loss provided by the IMF and the World Bank. These alternative measures of GDP may be considered tools to link spatial information with economic parameters, offering a different perspective on each country's economic outlook.

Table 3[24] presents three different scenarios based on the regressions employed for the econometric estimation of the elasticities of GDP to NTLs. These scenarios provide estimations of GDP loss for the whole of 2020, by assuming that the January–March decrease continues over the entire year.[25] Scenario 1 corresponds to an OLS regression of GDP on NTLs, Scenario 2 represents an FE specification with the addition of the squared relation between GDP and NTLs, which captures possible non-linearities, while Scenario 3 is an FE regression of GDP on NTL per capita. The observational GDP decrease for the two months under investigation is reported in brackets, while the 'Range' column reports the GDP decrease interval from the three scenarios considered.[26] The assumption of constant trends is extremely strong and to some extent optimistic, thus the results must be interpreted with a degree of caution. Indeed, compared to the official estimates of the IMF and the World Bank, the upper and lower bound of the estimated projections of the 'Range' column appear to be slightly less negative, though consistent. This may be due to the fact that the time span of the analysis is too short to take into consideration the domino effects generated by the lockdown measures on the economy as a whole. In particular, they are not able to consider the economic repercussions due to the slowdown of the global values chain, the global recessions and the rise in debt levels experienced by these already fiscally constrained economies.

22 The NTLs used in this analysis were sourced from the National Oceanic and Atmospheric Administration (NOAA; 2013). This data set covers satellite observations of the spectral bands of the Earth at night for the period 1992–2013. Three types of satellite images are produced for each year: average visible lights, cloud-free lights and stable lights. Stable lights were used in this analysis,. Stable lights images are geo-referenced 1 km x 1 km grid cells on the Earth's surface and each pixel is coded from 0 to 63, according to the luminosity emitted. Then, following Henderson, Storeygard and Weil (2012), average pixel luminosity was aggregated at the country level and a variable of average luminosity was constructed as a proxy of aggregate GDP. Moreover, a variable called NTLs per capita was created by dividing the average luminosity for each country by population density. Population density was retrieved from the World Bank Development Indicators database (World Bank, 2020g). NTLs for the period 2014–2019 have not been aggregated to the panel analysis, due to inter-calibration issues between the sensor satellites (NOAA, 2020). Processed NTL images for 2020 have not yet been released by NOAA.

23 Giovannetti and Perra (2020) employ an unbalanced panel of 19 countries: Algeria; Bahrain; Djibouti; Egypt, Arab Republic; Iran, Islamic Republic; Iraq; Jordan; Kuwait; Lebanon; Libya; Morocco; Oman; Qatar; Saudi Arabia; Syrian Arab Republic; Tunisia; UAE; West Bank Gaza; Yemen, Republic. Alternative donor pool countries were employed to estimate alternative elasticities, as reported in the appendix.

24 The projections for 2020 have been calculated following this rule proportion: : datarangelockdown = x : 366 (e.g. the dates chosen for Morocco are: 28 January 2020 and 26 March 2020, which means 366/58 = 6.3. Thus, in Scenario 1: −0.305 6.3 = -1.92).

25 In the appendix, Table A.1 reports the results of elasticity estimations. Column 1 corresponds to the OLS regression; Column 2 to baseline FE regression; Column 3 is the baseline FE specification with the addition of the squared relation between GDP and NTLs, which captures possible non linearities; Column 4 and 5 are FE regressions of GDP on NTL per capita and electricity consumption per capita, respectively, and Column 6 adds an electricity consumption per capita term. The columns chosen for analysis are Column 1, Column 3 and Column 4.

26 Estimates have only been calculated for those countries that have experienced a drop in luminosity for the period of analysis.

Table 3. Estimates of the drop in gross domestic product using calibrated elasticities

		Estimates using calibrated elasticities				Official estimates	
	Country	Scenario 1	Scenario 2	Scenario 3	Range (annual %)	IMF (annual %)	World Bank (annual %)
Middle-income countries	Jordan	-2.1 (-0.3)	-2 (-0.29)	-2.8 (-0.4)	-2.8/-2	-3.7	-3.5
	Morocco	-1.92 (-0.305)	-1.87 (-0.297)	-2.6 (-0.405)	-2.6 /-1.9	-3.7	-4
	Tunisia	-2.54 (-0.41)	-2.48 (-0.4)	-3.41 (-0.55)	-3.4 / -2.5	-4.3	-4
Gulf countries	Qatar	-1.14 (-0.17)	-1.13 (-0.16)	-1.54 (-0.23)	-1.5 / -1.1	-4.3	-3.5
	UAE	-1.53 (-0.26)	-1.48 (-0.24)	-2.04 (-0.34)	-2 /-1.5	-3.5	-4.5
Fragile countries	Lebanon	-10.28 (-1.46)	-9.99 (-1.42)	-13.6 (-1.93)	-13.6 /-10	-12	-10.9
	Syria	-6.65 (-1.09)	-6.47 (-1.06)	-8.84 (-1.459	-8.8 /-6.5	..	..
	Libya	-2.2 (-0.32)	-2.1 (-0.31)	-2.92 (-0.43)	-2.9 /-2	-58.7	..

Sources: IMF (2020c) and the World Bank (2020i).

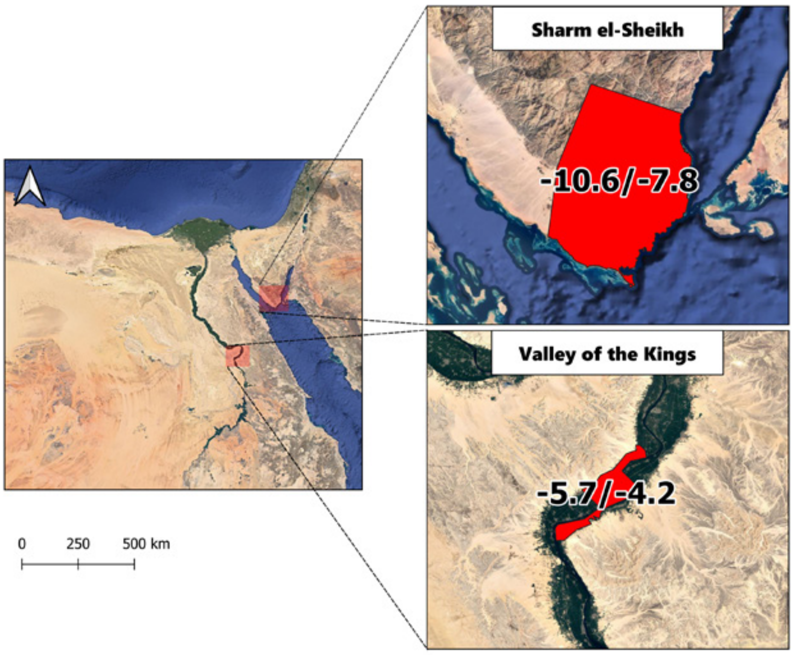
Notwithstanding the rapid fiscal response coupled with liquidity injections by the central banks, which have acted well as macroeconomic stabilizers, the rise in debt may threaten a reliable growth path. Another reason for the less pessimistic estimates of GDP may be that NTLs properly reflect investments in physical capital and infrastructure, whereas they are less able to capture the value added by other types of industries, such as the services sector, which are equally hit by the restrictions.

However, the range in estimates of GDP drop appear to be in line with the official forecasts for most countries. The only exceptions seem to be Syria and Libya. For Syria and Libya, these discrepancies do not alter confidence in the results, since both countries are experiencing civil wars which are crucial drivers of the economic and social crisis. That said, the estimated GDP drop calculated through this process may have only captured a small fraction of the devastating effects of the conflicts. For some countries, like those relying on tourism, this is probably due to the fact that the estimation of the GDP through NTLs may be driven by the results of specific areas which have experienced a strong decrease in emitted luminosity during the lockdown period. Furthermore, the assumption of a constant trend in NTLs decrease is probably too stringent, as there is likely to be a lower bound to the possible drop in luminosity connected with a contraction in GDP. Therefore a plausible reason for the discrepancy between the IMF estimates and the contraction estimated in this paper may be the heavy reliance of the models on the decrease in NTLs observed in tourist areas, which have been severely impacted by the pandemic.

Figure 36 reports two examples of tourist areas in Egypt that were significantly affected by the lockdown measures, as shown by the GDP decrease.[27] Using these two areas as an example of the results, it is clear how Sharm el Sheikh has suffered a more dramatic decrease in GDP for the period of January–March with respect to the still-sharp decrease observed in the Valley of the Kings. This is plausible since the Sharm el-Sheik area expects seaside tourism with multiple overnight stays, as opposed to day-to-day tourism in the Valley of the Kings. Sharm el Sheikh and other tourist areas expect an increase in tourist arrivals starting from March since this is the beginning of the peak tourist season, which was delayed this year by the mobility constraints imposed due to the COVID-19 pandemic.

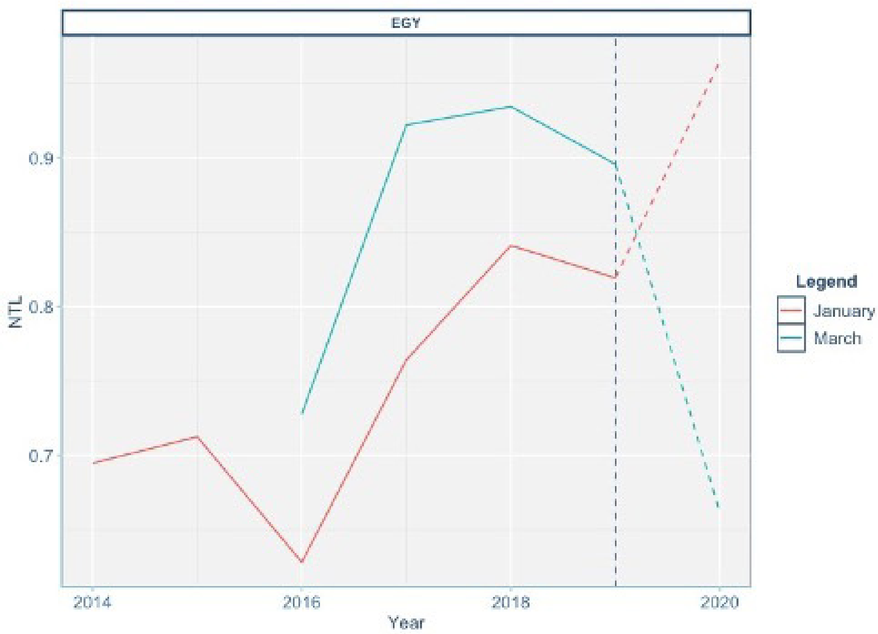
27 Maps for selected tourist areas in Tunisia, Jordan and Morocco can be found in the appendix.

Figure 36. Drop in gross domestic product recorded in selected tourist areas in Egypt



The inversion in January and March of trends in the NTLs mean is evident in Figure 37. Luminosity over the period 2014–2019 shows that the NTLs mean in March is always higher in January, while for the selected 2020 dates (pre- and post-COVID-19), the average digital number in January is significantly higher than in March. While this is expected, the result may be driven by the specific choice of period and should be interpreted with caution. Notably, 2020 data are not yet available in a monthly format and are thus not perfectly comparable to those of 2014–2019. Nonetheless, it is highly unlikely that the results are purely driven by data availability issues, since the day-to-day variability of NTLs data is insufficient to justify a drop of this significance.

Figure 37. Trends in night lights for Egypt (2014–2020)




E
T
C
LEBANESE TOURIST & TRADING CO.

10. Policy recommendations

It is still difficult to promptly quantify the actual economic impact of COVID-19 on the Arab region in real time, although estimates for 2020 were a GDP decrease of around 4.5 percent (with respect to the initially projected growth of 2.8 percent (Talbot, 2020)), with the most affected sectors being the tourism industry and the service sector.

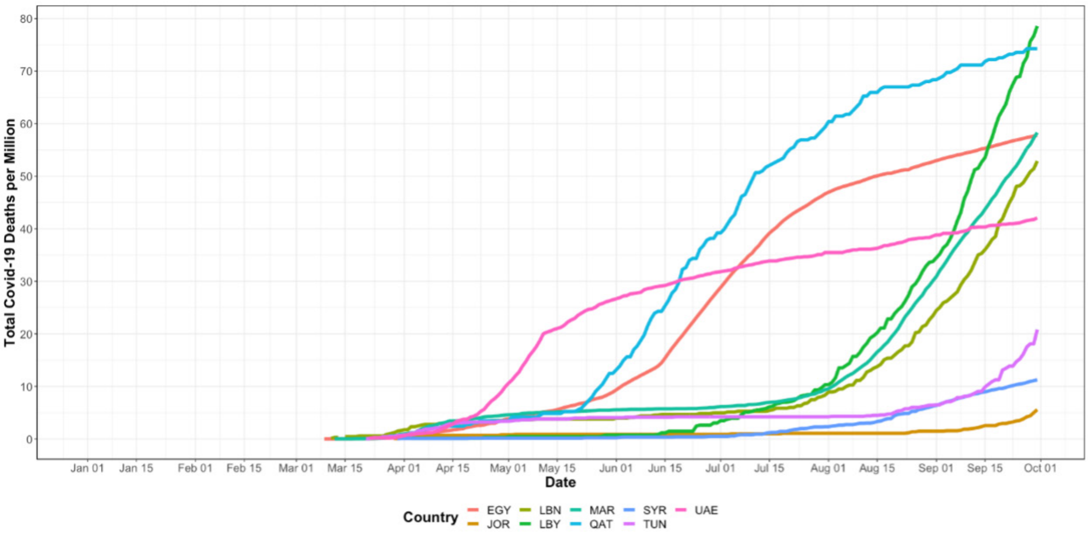
One of the main difficulties in promptly calculating the real impact of the crisis is the lack of reliable data. On the one hand, actual data about territories ravaged by war and turmoil are scattered and hard to retrieve, not to mention their dubious credibility; on the other hand, even when available, they rarely track the informal sector with sufficient granularity to inform policymakers.

Satellite observations and geographical representations of socio-economic trends may be valuable tools to analyse near real-time data to cope with the urgency of the crisis. Indeed, the United Nations have called for a "data revolution" (Independent Expert Advisory Group on a Data Revolution for Sustainable Development, 2014), which may first be enacted by combining these novel sources of information (see Jean and others, 2016) with traditional statistics. Moreover, the employment of these satellite data may give significant new insights into the creation of alternative ways of measuring economic outcomes to assess the impact of exogenous shocks. In this case, estimating GDP loss through the calibration of the elasticities of GDP variation to change in NTLs is a way of measuring the impact of COVID-19 on the region. Although the majority of these estimates of GDP are in line with those provided by the IMF and the World Bank (with Syria and Libya the only clear exceptions), these results are slightly different from the official data. Geospatial information gives further insight into the heterogenous impacts of COVID-19 on the region, calling for a differentiated policy evaluation. Evidently, even in countries such as Egypt, for which the IMF and World Bank have forecasted positive annual GDP growth, tourist areas have suffered the most from the restrictions enforced. This highlights the need for targeted and specific economic and social policies that take into consideration the heterogeneity of each country. Thus, satellite data may be helpful in identifying the areas that have been most affected.

Coronavirus has prompted stringent restrictions to try to limit the health impact and socioeconomic damages. The discontent generated by this new crisis overlaps with prior social unrest and popular mistrust in one of the most unstable regions in the world. The post-COVID-19 scenario calls for a concerted intervention by national and regional actors to prevent the escalation of conflicts and the transfer of economic, social and health damages to the most vulnerable segments of Arab populations.

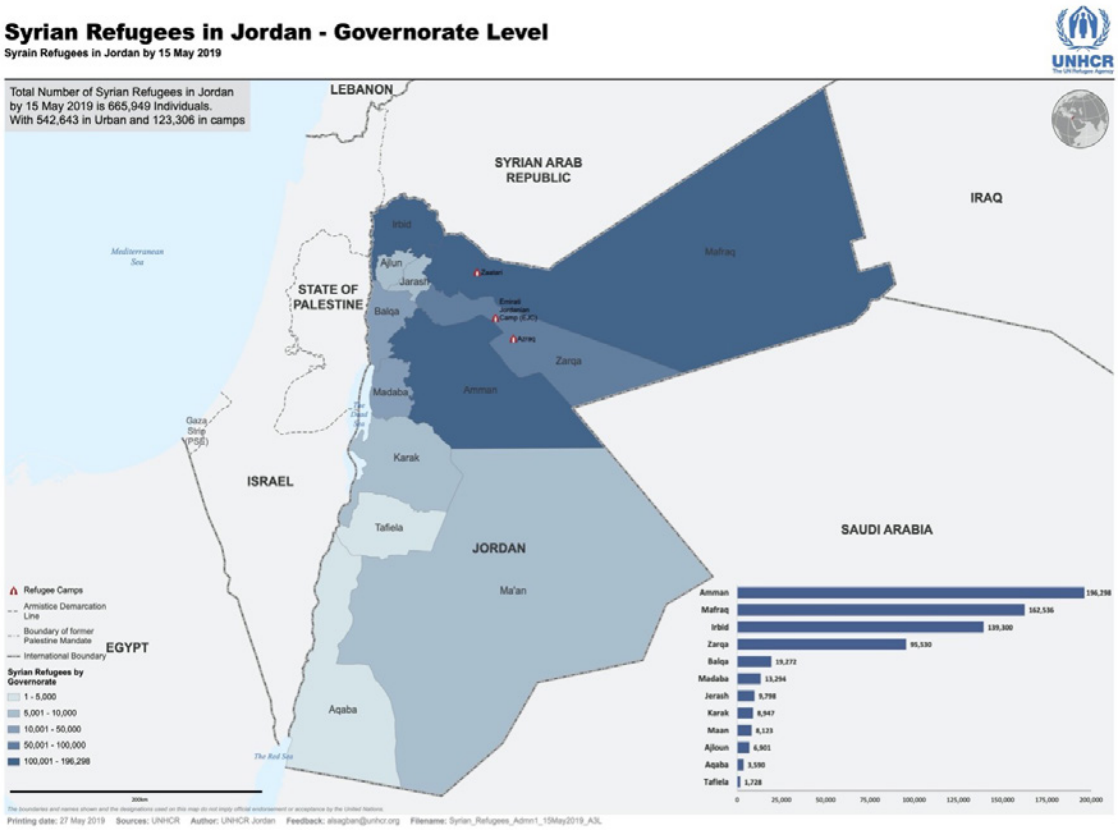
11. Appendix

Figure 38. Total deaths per million people by country



Source: Ritchie and others (2020).

Figure 39. Syrian refugees in Jordan



Source: United Nations High Commissioner for Refugees (2019).

11.1 Tables

Tables A.1–A.5 show the elasticities between GDP and NTLs for different subsamples of countries in order to obtain alternative elasticities and check the potential variability of these estimates. Following the definition of the World Bank of Arab countries, Table A.1 reports the estimated elasticities between GDP and NTLs for the period 1992–2013.[28] We also considered other definitions of Arab countries (IMF and UNDP), but even when countries such as Somalia and Sudan are included, the elasticities are similar to those obtained from the chosen sample. The World Bank definition allows for data on the largest number of countries, making it the preferred selection. The elasticities that have been applied are those reported in bold in Table A.1, particularly Scenario 1, Scenario 2 and Scenario 3. Table A.2 employs the same pool of countries as Table A.1 with the addition of Israel and Malta, using the definition of the World Bank. Table A.3 employs only the countries selected for analysis, namely: Egypt, Jordan, Tunisia, Lebanon, Libya, Morocco, Qatar, Syria and UAE. Table A.4 excludes several countries[29] from the sample in Table A.1. Finally, Table A.5 reports the estimated elasticities of GDP to NTLs for the period 2014–2019, employing only the countries selected for analysis.

Table A.1. Elasticities between gross domestic product (GDP) and night lights (NTLs) (1992–2013)

Dependent variable: GDP						
VARIABLES	OLS			Fixed effects		
	(1)	(2)	(3)	(4)	(5)	(6)
NTL	**0.305*** **	0.215*	**0.296*** **			
	(0.037)	(0.128)	(0.097)			
Squared NTL			-0.068* (0.039)			
NTL per capita				0.404***		0.459***
				(0.133)		(0.162)
Electricity per capita					0.255	-0.11
					(0.236)	(0.15)
Constant	9.337*** (0.056)					
Year FE	No	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	Yes	Yes
Observations	333	333	333	333	312	312
R2	0.171	0.037	0.109	0.300	0.081	0.312
Adjusted R2	0.169	-0.088	-0.009	0.210	-0.039	0.219

HC-Robust standard errors in parentheses
* $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

28 The countries considered are Algeria; Bahrain; Djibouti; Egypt, Arab Republic; Iran, Islamic Republic; Iraq; Jordan; Kuwait; Lebanon; Libya; Morocco; Oman; Qatar; Saudi Arabia; Syrian Arab Republic; Tunisia; United Arab Emirates; West Bank Gaza; Yemen, Republic. Malta and Israel are excluded.

29 The countries excluded are Iraq, Iran, Libya, the State of Palestine, Syria and Yemen.

Table A.2. Estimated elasticities between gross domestic product (GDP) and night lights (NTLs) (1992–2013)

Dependent variable: GDP						
VARIABLES	OLS			Fixed effects		
	(1)	(2)	(3)	(4)	(5)	(6)
NTL	0.291***	0.126	0.187*			
	(0.027)	(0.120)	(0.103)			
Squared NTL			-0.061*			
			(0.037)			
NTL per capita				0.386***		0.444***
				(0.134)		(0.161)
Electricity per capita					0.234	- 0.120
					(0.217)	(0.138)
Constant	9. 348***					
	(0.055)					
Year FE	No	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	Yes	Yes
Observations	377	377	377	377	356	356
R2	0.195	0.015	0.077	0.275	0.069	0.287
Adjusted R2	0.193	-0.102	-0.037	0.188	-0.043	0.199

HC-Robust standard errors in parentheses
* $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A.3. Elasticities between gross domestic product (GDP) and night lights (NTLs) (1992–2013)

Dependent variable: GDP						
VARIABLES	OLS			Fixed effects		
	(1)	(2)	(3)	(4)	(5)	(6)
NTL	0. 560**	0.179	0.445*			
	(0.064)	(0.216)	(0.243)			
Squared NTL			-0.106*			
			(0.060)			
NTL per capita				0. 519***		0. 322***
				(0.187)		(0.164)
Electricity per capita					0.847***	0.445***
					(0.308)	(0.093)
Constant	8.984***					
	(0.088)					
Year FE	No	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	Yes	Yes
Observations	161	161	161	161	161	161
R2	0.393	0.018	0.190	0.455	0.430	0.508

Dependent variable: GDP						
Adjusted R2	0.389	-0.200	0.003	0.335	0.304	0.395

HC-Robust standard errors in parentheses
* $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A.4. Elasticities between gross domestic product (GDP) and night lights (NTLs) that have not suffered shocks in GDP trends between 1992 and 2013

Dependent variable: GDP						
VARIABLES	OLS			Fixed effects		
	(1)	(2)	(3)	(4)	(5)	(6)
NTL	0.783***	0.086	0.389*			
	(0.060)	(0.174)	(0.223)			
Squared NTL			-0.119* (0.065)			
NTL per capita				0. 519***		0. 341***
				(0. 190)		(0.118)
Electricity per capita					0. 918**	0. 397*
					(0.383)	(0.214)
Constant	8.560*** (0.045)					
Year FE	No	Yes	Yes	Yes	Yes	Yes
Country FE	No	Yes	Yes	Yes	Yes	Yes
Observations	146	146	146	146	146	146
R2	0.573	0.005	0.245	0.549	0.503	0.579
Adjusted R2	0.570	-0.233	0.056	0.441	0.385	0.474

HC-Robust standard errors in parentheses
* $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A.5. Elasticities between gross domestic product (GDP) and night lights (NTLs) (2014–2019)

Dependent variable: GDP			
VARIABLES	OLS	Fixed effects	
	(1)	(2)	(3)
NTL	0.597*** (0.060)		
Squared NTL		0.198* (0.105)	
Electricity per capita			0. 238*** (0.075)
Constant	9.570*** (0.071)		

Dependent variable: GDP			
Year FE	No	Yes	Yes
Country FE	No	Yes	Yes
Observations	48	48	40
R2	0.722	0.158	0.336
Adjusted R2	0.716	-0.164	0.040

HC-Robust standard errors in parentheses
* $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

11.2 Maps of tourist areas

Figure 40. GDP drop recorded in selected tourist areas in Jordan

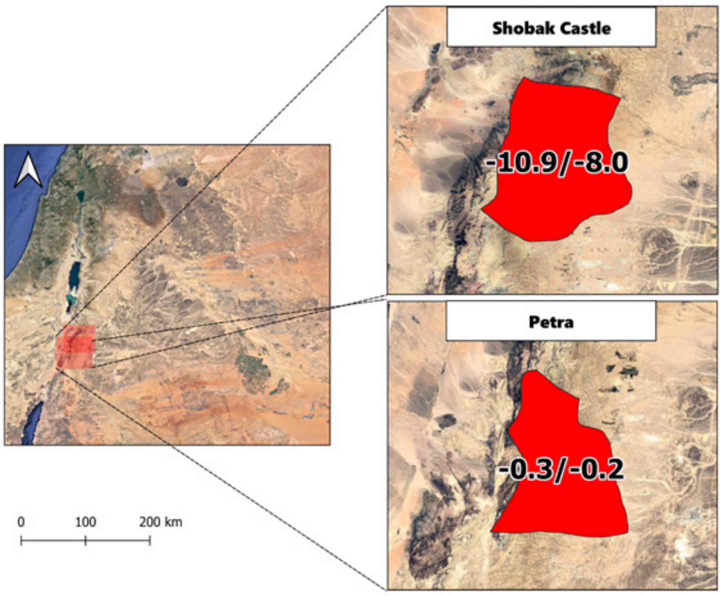


Figure 41. Drop in gross domestic product recorded in selected tourist areas in Morocco

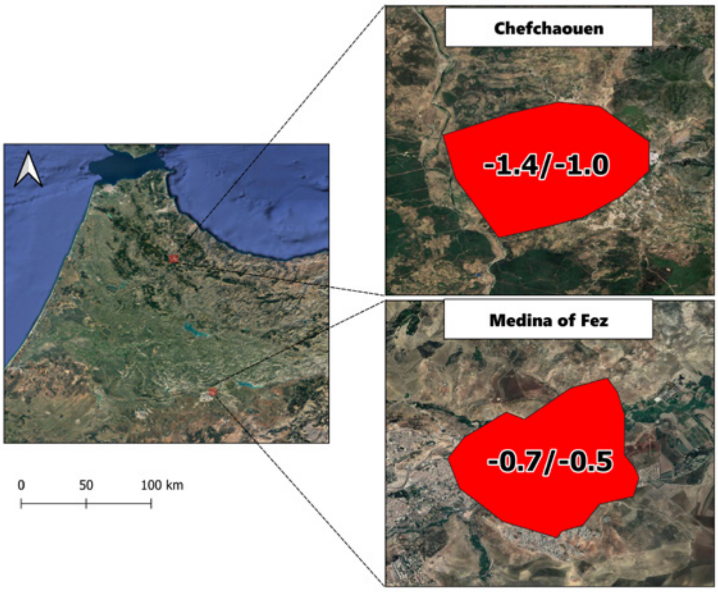
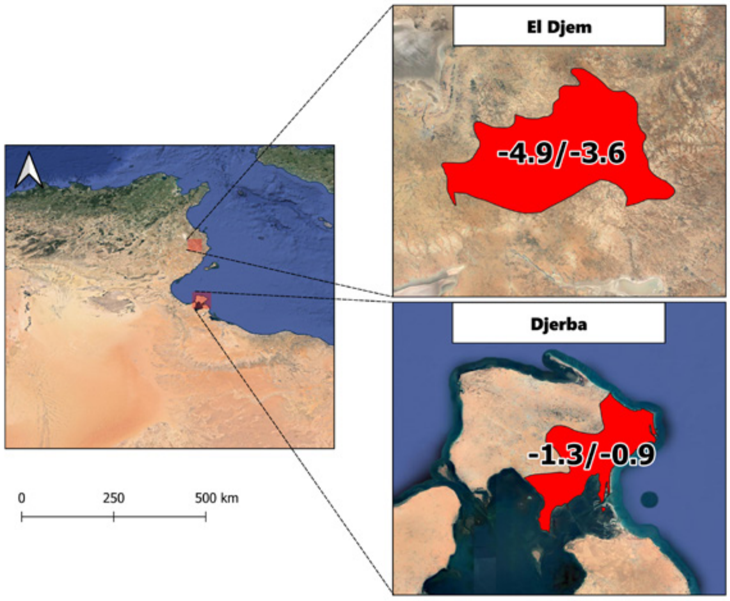


Figure 42. Drop in gross domestic product recorded in selected tourist areas in Tunisia



Bibliography

Abdo, Genieve (2020). ‘Egypt, COVID-19, and the economy: A combustible mix?’ *Brookings*, 18 May. Available at www.brookings.edu/opinions/egypt-COVID-19-and-the-economy-a-combustible-mix/. Accessed on 24 August 2020.

Abdullah II ibn Al Hussein (2020). ‘Royal Decree approves Cabinet decision to proclaim Defence Law’, 17 March. Available at https://kingabdullah.jo/en/news/royal-decree-approves-cabinet-decision-proclaim-defence-law. Accessed on 24 August 2020.

Al Arabiya (2020a). ‘Five killed as heavy rain, strong winds batter Egypt’, 13 March. Available at https://english.alarabiya.net/en/News/middle-east/2020/03/13/Five-killed-as-heavy-rain-strong-winds-batter-Egypt. Accessed on 24 August 2020.

___________ (2020b). ‘Libya’s GNA imposes curfew to combat coronavirus’, 22 March. Accessed on 24 August 2020.

Alaoui, Mohamed (2020). ‘Morocco encourages domestic tourism to mitigate COVID-19 losses’. *Arab Weekly*, 10 June. Available at https://thearabweekly.com/morocco-encourages-domestic-tourism-mitigate-COVID-19-losses. Accessed on 24 August 2020.

Aljazeera (2020). ‘UN condemns rocket attack on Tripoli hospital’, 7 April. Available at https://www.aljazeera.com/news/2020/4/7/un-condemns-rocket-attack-on-tripoli-hospital. Accessed on 23 August 2020.

Amara, Tarek (2020). ‘UPDATE 2-Tunisia tourism could lose $1.4 bln, govt seeks loan guarantee to issue bonds’. *Reuters*, 15 April. Available at www.reuters.com/article/tunisia-imf-economy/update-2-tunisia-tourism-could-lose-1-4-bln-govt-seeks-loan-guarantee-to-issue-bonds-idUSL5N2C30XR. Accessed on 23 August 2020.

Amnesty International (2020). ‘Qatar: Migrant workers in labour camps at grave risk amid COVID-19 crisis’, 20 March. Available at www.amnesty.org/en/latest/news/2020/03/qatar-migrant-workers-in-labour-camps-at-grave-risk-amid-covid19-crisis/. Accessed on 23 August 2020.

Anenberg, Susan C., and others (2018). ‘Estimates of the global burden of ambient PM2.5, ozone, and NO_2 on asthma incidence and emergency room visits’. *Environmental Health Perspectives*, vol. 126, No. 10 (October).

Apple (2020). ‘Mobility Trends Reports’. Available at https://covid19.apple.com/mobility. Accessed on 23 August 2020.

Arab News (2020). 'Qatar World Cup organizers fear coronavirus impact on 2022 football tournament’ (2020). *Arab News*, 6 May. Available at www.arabnews.com/node/1677796/sport. Accessed on 23 August 2020.

Ardovini, Lucia (2020). ‘COVID-19 in Egypt: Global pandemics in times of authoritarianism’. *Italian Institute for International and Political Studies*, 9 April. Available at www.ispionline.it/en/pubblicazione/COVID-19-egypt-global-pandemics-times-authoritarianism-25653. Accessed on 24 August 2020.

Arezki, Rabah, and Ha Nguyen (2020). ‘Coping with a Dual Shock: COVID-19 and Oil Prices’. *World Bank*, 14 April. Available at www.worldbank.org/en/region/mena/brief/coping-with-a-dual-shock-coronavirus-COVID-19-and-oil-prices. Accessed on 23 August 2020.

Arezki, Rabah, and others (2020). ‘Trading Together: Reviving Middle East and North Africa Regional Integration in the Post-Covid Era’. Washington DC: World Bank.

Asseburg, Muriel, and others (2020). ‘The COVID-19 pandemic and conflict dynamics in Syria: Neither a turning point nor an overall determinant’. *SWP Comments*, No. 21 (May).

Badi, Emadeddin (2020). ‘Coronavirus in Libya: The contagion of instability’. *Italian Institute for International and Political Studies*, 7 May. Available at www.ispionline.it/en/pubblicazione/coronavirus-libya-contagion-instability-25963. Accessed on 24 August 2020.

BBC News (2020). ‘Coronavirus confirmed as pandemic by World Health Organization’. *BBC News*, 11 March. Available at www.bbc.com/news/world-51839944. Accessed on 23 August 2020.

Bianco, Cinzia, and others (2020). 'Infected: The impact of the coronavirus on the Middle East and north Africa'. *European Council on Foreign Relations*, 19 March. Available at https://ecfr.eu/article/commentary_infected_the_impact_of_the_coronavirus_on_the_middle_east_and_no/. Accessed on 24 August 2020.

Bowen, Jeremy (2020). 'Coronavirus stokes Middle East boiling points'. *BBC News*, 4 May. Available at www.bbc.com/news/world-middle-east-52493608. Accessed on 23 August 2020.

Brown, Frances Z., Saskia Brechenmacher and Thomas Carothers (2020). 'How will the coronavirus reshape democracy and governance globally?' *Carnegie Endowment for International Peace*, 6 April. Available at https://carnegieendowment.org/2020/04/06/how-will-coronavirus-reshape-democracy-and-governance-globally-pub-81470. Accessed on 23 August 2020.

Business & Human Rights Resource Centre (2020). 'FIFA statement on worker protection from COVID-19 in Qatar', 3 April. Available at www.business-humanrights.org/en/latest-news/fifa-statement-on-worker-protection-from-COVID-19-in-qatar/. Accessed on 23 August 2020.

Carpi, Estella (2020). 'The COVID-19 among MENA refugees: A great humanitarian concern'. *Italian Institute for International and Political Studies*, 9 April. Available at www.ispionline.it/it/pubblicazione/COVID-19-among-mena-refugees-great-humanitarian-concern-25679. Accessed on 24 August 2020.

Center for Strategic & International Studies (2020). 'Economic implication of COVID-19 in the Middle East'. *Babel: Translating the Middle East*. Available at www.csis.org/podcasts/babel-translating-middle-east/economic-implication-COVID-19-middle-east. Accessed on 24 August 2020.

Centers for Disease Control and Prevention (2020). 'Severe outcomes among patients with coronavirus disease 2019 (COVID-19) – United States, February 12 – March 16, 2020'. *Morbidity and Mortality Weekly Report*, vol. 69, No. 12 (March), pp. 343–346.

Cherif, Nedra (2020). 'Covid19 in Tunisia: Beyond the health crisis, a socio-economic challenge'. *MEDirections Programme Blog*, 9 April. Available at https://blogs.eui.eu/medirections/covid19-tunisia-beyond-health-crisis-socio-economic-challenge/. Accessed on 23 August 2020.

Cimini, Giulia and Abderrahim Chalfaouat (2020). 'Coronavirus in Morocco opens possibilities for new social contracts'. *Carnegie Endowment for International Peace*, 23 April. Available at https://carnegieendowment.org/sada/81631. Accessed on 23 August 2020.

Cordesman, Anthony H. (2018). 'Stability in the Middle East: The range of short and long-term causes'. *Center for Strategic & International Studies*, 9 April. Available at www.csis.org/analysis/stability-middle-east-range-short-and-long-term-causes. Accessed on 24 August 2020.

Croft, Thomas A. (1978). 'Nighttime images of the Earth from space'. *Scientific American*, vol. 239, No. 1 (July), pp. 86–101.

Doll, Christopher N. H., Ian-Peter Muller, and Christopher D. Elvidge (2000). 'Night-time imagery as a tool for global mapping of socioeconomic parameters and greenhouse gas emissions'. *AMBIO: A Journal of the Human Environment*, vol. 29, No. 3 (May), pp. 157–162.

Duncan, Bryan N., and others (2016). 'A space-based, high-resolution view of notable changes in urban NOx pollution around the world (2005–2014)'. *Journal of Geophysical Research: Atmospheres*, vol. 121, pp. 976–996.

Earth Observations Group (2020). 'Version 1 VIIRS Day/Night Band Nighttime Lights'. Available at https://eogdata.mines.edu/download_dnb_composites.html. Accessed on 23 August 2020.

Egypt, State Information Service (2020). 'Egypt declares partial curfew for 15 days starting Wednesday' 24 March. Available at www.sis.gov.eg/Story/144199/Egypt-declares-partial-curfew-for-15-days-starting-Wednesday?lang=en-us. Accessed on 24 August 2020.

Elvidge, C. D., and others (1997). 'Relation between satellite observed visible-near infrared emissions, population, economic activity and electric power consumption'. *International Journal of Remote Sensing*, vol. 16, No. 6, pp. 1373–1379.

Federal Reserve Bank of St. Louis (2020). *FRED Economic Data*. Available at https://fred.stlouisfed.org. Accessed on 23 August 2020.

Geddes, Jeffrey A., and others (2016). 'Long-term trends worldwide in ambient NO_2 concentrations inferred from satellite observations'. *Environmental Health Perspectives*, vol. 124, No. 3 (March), pp. 281–289.

Gibson, John, Chao Li, and Geua Boe-Gibson (2014). ‘Economic growth and expansion of China’s urban land area: Evidence from administrative data and night lights, 1993–2012’. *Sustainability*, vol. 6, No. 11 (November), pp. 7850–7865.

Giovannetti, Giorgia, and Elena Perra (2020). ‘Syria in the Dark: Estimating the Economic Consequences of the Civil War through Satellite-Derived Night Lights’. Euro-Mediterranean Network for Economic Studies Working Paper, No. 29. Available at: https://emnes.org/wp-content/uploads/2020/02/emnes_wp_029_syria_in_the_dark.pdf.

Goddard Earth Sciences Data and Information Services Center (2019). ‘Sentinel-5P TROPOMI Tropospheric NO_2 1-Orbit L2 5.5km x 3.5km’. Available at https://disc.gsfc.nasa.gov/datasets/S5P_L2__NO2____HiR_1/summary?keywords=tropomi. Accessed on 24 August 2020.

Google (2020). ‘COVID-19 Community Mobility Reports: See how your community is moving around differently due to COVID-19’. Available at www.google.com/covid19/mobility/. Accessed on 23 August 2020.

Guetat, Meriem (2020). ‘Tunisia and coronavirus: The reality of a poor governance’. *Italian Institute for International and Political Studies*, 9 April. Available at www.ispionline.it/en/pubblicazione/tunisia-and-coronavirus-reality-poor-governance-25671. Accessed on 24 August 2020.

Henderson, J. Vernon, Adam Storeygard, and David N. Weil (2012). ‘Measuring economic growth from outer space’. *American Economic Review*, vol. 102, No. 2 (April), pp. 994–1028.

Houssari, Najia (2020). ‘Lebanon extends virus lockdown by two weeks’. *Arab News*, 6 May. Available at www.arabnews.com/node/1670016/middle-east. Accessed on 24 August 2020.

Independent Expert Advisory Group on a Data Revolution for Sustainable Development (2014). ‘A World that Counts: Mobilising the Data Revolution for Sustainable Development’. United Nations publication.

International Labour Office (2018). ‘Women and Men in the Informal Economy: A Statistical Picture (third edition)’. Geneva: ILO.

International Monetary Fund (2019). ‘Morocco: Selected Issues’. IMF Country Report No. 19/231.

___________ (2020a). ‘IMF executive board approves a US$745 million disbursement to Tunisia to address the COVID-19 pandemic’. Press Release No. 20/144. Available at www.imf.org/en/News/Articles/2020/04/10/pr20144-tunisia-imf-executive-board-approves-a-us-745m-disbursement-address-covid19-pandemic. Accessed on 23 August 2020.

___________ (2020b). ‘Key Questions on Jordan’. Available at www.imf.org/en/Countries/JOR/FAQ. Accessed on 24 August 2020.

___________ (2020c). ‘Regional Economic Outlook July 2020 Update: Middle East and Central Asia’. Available at www.imf.org/en/Publications/REO/MECA/Issues/2020/07/13/regional-economic-outlook-update-menap-cca.

Jean, Neal, and others (2016). ‘Combining satellite imagery and machine learning to predict poverty’. *Science*, vol. 353, No. 6301, pp. 790–794.

Kamar Bassem and Rafik Selim (2020). ‘Jordan Diagnostic 2020’. London: European Bank for Reconstruction and Development.

Laaroussi, Mohammed Issam (2020). ‘How Arab States take on coronavirus: Morocco as a case study’. *Aljazeera Centre for Studies*, 20 May. Available at https://studies.aljazeera.net/en/reports/how-arab-states-take-coronavirus-morocco-case-study. Accessed on 23 August 2020.

Lamsal, L. N., and others (2008). ‘Ground-level nitrogen dioxide concentrations inferred from the satellite-borne Ozone Monitoring Instrument’. *Journal of Geophysical Research*, vol. 113.

Lamsal, L. N., and others (2010). ‘Indirect validation of tropospheric nitrogen dioxide retrieved from the OMI satellite instrument: Insight into the seasonal variation of nitrogen oxides at northern midlatitudes’. *Journal of Geophysical Research*, vol. 115.

Lamsal, L. N., and others (2015). ‘U.S. NO_2 trends (2005–2013): EPA Air Quality System (AQS) data versus improved observations from the Ozone Monitoring Instrument (OMI)’. *Atmospheric Environment*, vol. 110, pp. 130–143.

Levin, Noam, and others (2020). ‘Remote sensing of night lights: A review and an outlook for the future’. *Remote Sensing of Environment*, vol. 237.

Li, Xi, and others (2019). 'Anisotropic characteristic of artificial light at night – Systematic investigation with VIIRS DNB multi-temporal observations'. *Remote Sensing of Environment*, vol. 233.

London School of Economics and Political Science (2020). 'Fragile states facing the COVID-19 pandemic'. Available at www.lse.ac.uk/iga/events/2020-virtual/Fragile-States-Facing-the-COVID-19-Pandemic. Accessed on 24 August 2020.

Martini, Lorena Stella (2020). 'Coronavirus in Morocco: The kingdom's forward-looking strategy'. *Italian Institute for International and Political Studies*, 9 April. Available at www.ispionline.it/it/pubblicazione/coronavirus-morocco-kingdoms-forward-looking-strategy-25647. Accessed on 24 August 2020.

Majzoub, Aya (2020). 'IMF should prioritize human rights in Lebanon loan negotiations'. *Human Rights Watch*, 22 May. Available at www.hrw.org/news/2020/05/22/imf-should-prioritize-human-rights-lebanon-loan-negotiations. Accessed on 24 August 2020.

Mezran, Karim, and others (2020). 'The coronavirus crisis highlights the unique challenges of North African countries'. *Atlantic Council*, 30 March. Available at www.atlanticcouncil.org/blogs/menasource/the-coronavirus-crisis-highlights-the-unique-challenges-of-north-african-countries. Accessed on 24 August 2020.

McKee, Martin, and David Stuckler (2020). 'If the world fails to protect the economy, COVID-19 will damage health not just now but also in the future'. *Nature Medicine*, vol. 26, pp. 640–642.

McKee, Musa, and others (2017). 'Demographic and economic material factors in the MENA region'. Middle East and North Africa Regional Architecture: Mapping geopolitical shifts, regional order and domestic transformations (MENARA) Working Paper No. 3. Rome: Istituto Affari Internazionali.

Middle East Eye (2020). 'Uncertainty reigns in Qatar worker area sealed off over coronavirus fears', 22 March. Available at www.middleeasteye.net/news/uncertainty-reigns-qatar-worker-area-sealed-over-coronavirus-fears. Accessed on 23 August 2020.

Middle East and Central Asia Department, International Monetary Fund (2020). 'Middle East and North Africa Regional Economic Outlook' [PowerPoint slides].

Morad, Sadoon, and others (2012). 'Impact of diagenesis on the spatial and temporal distribution of reservoir quality in the Jurassic Arab D and C Members, offshore Abu Dhabi oilfield, United Arab Emirates'. *GeoArabia*, vol. 17, No. 3 (July), pp. 17–56.

Morocco, Interior Ministry (2020). 'COVID-19: "State of Health Emergency" declared in Morocco as of Friday at 6:00 p.m. until further notice, Interior Ministry'. Available at www.maroc.ma/en/news/COVID-19-state-health-emergency-declared-morocco-friday-600-pm-until-further-notice-interior. Accessed on 24 August 2020.

National Oceanic and Atmospheric Administration National Centers for Environmental Information (2013). 'Version 4 DMSP-OLS Nighttime Lights Time Series'. Available at https://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html. Accessed on 23 August 2020.

Nordea (2020a). 'The economic context of Qatar'. Available at www.nordeatrade.com/no/explore-new-market/qatar/economical-context?vider_sticky=oui. Accessed on 23 August 2020.

___________ (2020b). 'The economic context of the United Arab Emirates'. Available at www.nordeatrade.com/no/explore-new-market/united-arab-emirates/economical-context. Accessed on 23 August 2020.

Oak Ridge National Laboratory (2019). 'LandScan™'. Available at https://landscan.ornl.gov/.

Ogen, Yaron (2020). 'Assessing nitrogen dioxide (NO_2) levels as a contributing factor to coronavirus (COVID-19) fatality'. *Science of The Total Environment*, vol. 726.

Organisation for Economic Co-operation and Development (2020a). 'The COVID-19 crisis in Egypt'. Tackling coronavirus (COVID-19): Contributing to a global effort. OECD.

___________ (2020b). 'The COVID-19 Crisis in Morocco'. Tackling coronavirus (COVID-19): Contributing to a global effort. OECD.

Organization of the Petroleum Exporting Countries (2020). 'UAE facts and figures'. Available at www.opec.org/opec_web/en/about_us/170.htm. Accessed on 23 August 2020.

Piscitelli, Giulio (2020). 'Conflict and COVID-19 adds up to a crisis within a crisis in Libya'. *Médecins Sans Frontieres*, 2 June. Available at www.msf.org/conflict-and-COVID-19-adds-crisis-libya. Accessed on 23 August 2020.

Qatar, Government Communication Office (2020). 'Government Communications Office statement regarding measures taken by the State of Qatar to combat Coronavirus (COVID-19)'. Available at www.gco.gov.qa/en/2020/03/12/government-communications-office-statement-regarding-measures-taken-by-the-state-of-qatar-to-combat-coronavirus-COVID-19/. Accessed on 24 August 2020.

Ritchie, Hannah, and others (2020). 'Coronavirus pandemic (COVID-19)'. *Our World in Data*. Available at https://ourworldindata.org/coronavirus.

Salman, Nour (2020). 'Local press: UAE takes tough measures to beat coronavirus'. *Emirates News Agency*, 24 March. Available at http://wam.ae/en/details/1395302832583. Accessed on 24 August 2020.

Shdeifat, Omar (2006). 'Development of methods and tools for the establishment of good environmental performance in the tourist accommodation sector in Jordan - Implementation of pilot studies'. Hashemite University.

Statista (2020). 'Tunisia: Unemployment rate from 1999 to 2019'. Available at www.statista.com/statistics/524516/unemployment-rate-in-tunisia/. Accessed on 23 August 2020.

Sutton, Paul C., and Robert Costanza (2002). 'Global estimates of market and non-market values derived from nighttime satellite imagery, land cover, and ecosystem service valuation'. *Ecological Economics*, vol. 41, No. 3, pp. 509–527.

Talbot, Valeria (2020). 'COVID-19 in MENA: Toward a shift in the regional balance of power'. *Italian Institute for International and Political Studies*, 9 April. Available at www.ispionline.it/it/pubblicazione/COVID-19-mena-toward-shift-regional-balance-power-25677. Accessed on 24 August 2020.

TROPOMI (2017). 'TROPOMI: Tropospheric Monitoring Instrument'. Available at http://www.tropomi.eu. Accessed on 24 August 2020.

Tsurkov, Elizabeth, and Qussai Jukhadar (2020). 'Ravaged by war, Syria's health care system is utterly unprepared for a pandemic'. *Middle East Institute*, 23 April. Available at www.mei.edu/publications/ravaged-war-syrias-health-care-system-utterly-unprepared-pandemic. Accessed on 23 August 2020.

United Nations Children's Fund (2020). 'Fast facts Syria crisis - March 2019'. Available at https://reliefweb.int/report/syrian-arab-republic/fast-facts-syria-crisis-march-2019. Accessed on 23 August 2020.

United Nations Development Programme (2020a). 'COVID-19: UNDP's integrated response'. UNDP.

___________ (2020b). 'Arab countries respond to COVID-19'. Available at www.arabstates.undp.org/content/rbas/en/home/coronavirus.html. Accessed on 23 August 2020.

___________ (2020c). 'Compounding Crises: Will COVID-19 and Lower Oil Prices Prompt a New Development Paradigm in the Arab Region?'. New York.

United Nations Economic and Social Commission for Western Asia (2020). 'COVID-19: Economic Cost to the Arab Region'. Policy brief. Available at www.unescwa.org/sites/www.unescwa.org/files/escwa-COVID-19-economic-cost-arab-region-en.pdf.

United Nations Office for the Coordination of Humanitarian Affairs (2020). 'Lebanon COVID-19 Emergency Appeal'. Available at https://reliefweb.int/sites/reliefweb.int/files/resources/LEA_JulyUpdate_FINAL.pdf. Accessed on 23 August 2020.

United Nations Population Fund (2020). 'Syria Country Office COVID-19 Humanitarian Response Flash Update #2 – 9th - 22nd April – 2020'.

Walker, Andrew (2020). 'US oil prices turn negative as demand dries up'. *BBC News*, 20 April. Available at https://www.bbc.co.uk/news/business-52350082. Accessed on 23 August 2020.

Wang, Zhuosen, and others (2018). 'Nasa's Black Marble Product Suite: Validation Strategy'. Paper presented at the International Geoscience and Remote Sensing Symposium, Valencia, Spain, July.

World Bank (2019). 'World Bank: Lebanon is in the Midst of Economic, Financial and Social Hardship, Situation Could Get worse', 6 November. Available at www.worldbank.org/en/news/press-release/2019/11/06/world-bank-lebanon-is-in-the-midst-of-economic-financial-and-social-hardship-situation-could-get-worse?fbclid=IwAR37pvSjI-u3P_-aPdWRmnAtgayUE0tQM-p2w0y7mmBV6smW2PqHI0DX1syM. Accessed on 24 August 2020.

___________ (2020a). 'Electricity production from renewable sources, excluding hydroelectric (kWh)'. Available at https://data.worldbank.org/indicator/EG.ELC.RNWX.KH. Accessed on 23 August 2020.

___________ (2020b). 'GDP per capita, PPP (constant 2017 international $)'. Available at https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD. Accessed on 23 August 2020.

___________ (2020c). 'Jordan's Economic Update — October 2019', 9 October. Available at https://www.worldbank.org/en/country/jordan/publication/economic-update-october-2019. Accessed on 24 August 2020.

___________ (2020d). 'MENA Economic Update: How Transparency Can Help the Middle East and North Africa', 9 April. Available at https://www.worldbank.org/en/region/mena/publication/mena-economic-update-april-2020-how-transparency-can-help-the-middle-east-and-north-africa. Accessed on 23 August 2020.

___________ (2020e). 'Middle East & North Africa'. Available at https://data.worldbank.org/country/ZQ. Accessed on 23 August 2020.

___________ (2020f). 'Personal remittances, received (% of GDP) – Jordan'. Available at https://data.worldbank.org/indicator/BX.TRF.PWKR.DT.GD.ZS?end=2018&locations=JO&start=2015&view=chart . Accessed on 24 August 2020.

___________ (2020g). 'Population density (people per sq. km of land area)'. Available at https://data.worldbank.org/indicator/EN.POP.DNST. Accessed on 23 August 2020.

___________ (2020h). 'US$20 million in Emergency Response to Help Jordan Respond to the Corona Virus Pandemic', 28 April. Available at www.worldbank.org/en/news/press-release/2020/04/28/us20-million-in-emergency-response-to-help-jordan-respond-to-the-corona-virus-pandemic. Accessed on 24 August 2020.

___________ (2020i). 'Global Economic Prospects, June 2020'. Washington, DC: World Bank.

World Health Organization (2020a). 'Coronavirus disease 2019 (COVID-19) Situation Report – 26'. WHO.

___________ (2020b). 'Coronavirus disease 2019 (COVID-19): Situation Report – 33'. WHO.

___________ (2020c). 'Coronavirus disease 2019 (COVID-19): Situation Report – 35'. WHO.

___________ (2020d). 'Coronavirus disease 2019 (COVID-19): Situation Report – 36'. WHO.

___________ (2020e). 'Coronavirus disease 2019 (COVID-19): Situation Report – 37'. WHO.

___________ (2020f). 'Coronavirus disease 2019 (COVID-19): Situation Report – 41'. WHO.

___________ (2020g). 'Coronavirus disease 2019 (COVID-19): Situation Report – 43'. WHO.

___________ (2020h). 'Coronavirus disease 2019 (COVID-19): Situation Report – 63.' WHO.

___________ (2020i). 'Coronavirus disease 2019 (COVID-19): Situation Report – 65.' WHO.

___________ (2020j). 'Coronavirus disease 2019 (COVID-19): Situation Report – 82.' WHO.

___________ (2020k). 'Coronavirus disease (COVID-19): Situation Report – 143'. WHO.

___________ (2020l). 'Coronavirus disease (COVID-19) pandemic'. Available at www.euro.who.int/en/health-topics/health-emergencies/coronavirus-COVID-19/novel-coronavirus-2019-ncov. Accessed on 23 August 2020.

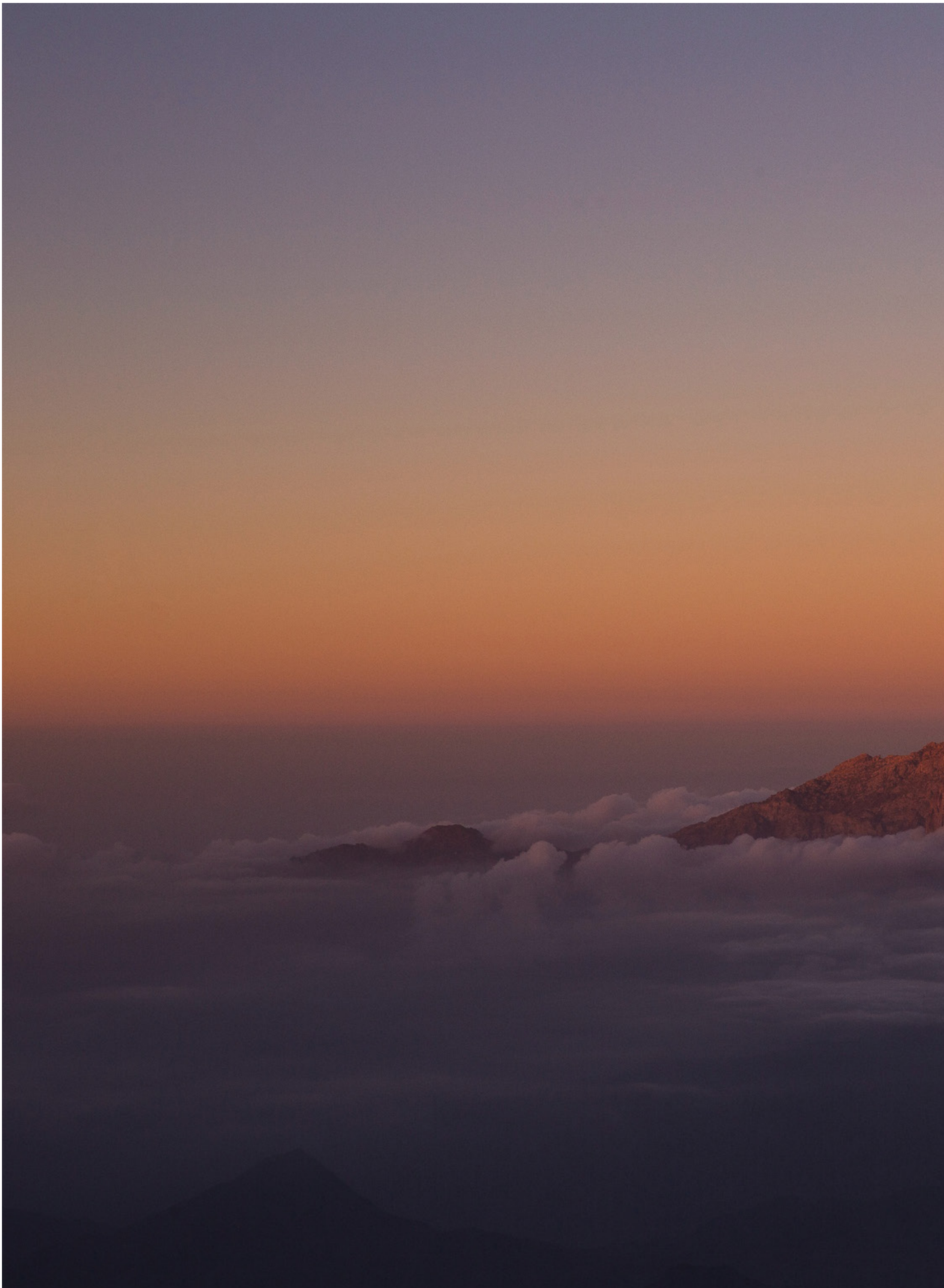
___________ (2020m). 'Novel Coronavirus (2019-nCoV): Situation Report – 9'. WHO.

Worldometer (2020). 'COVID-19 Coronavirus Pandemic: Reported Cases and Deaths by Country, Territory, or Conveyance.' Available at www.worldometers.info/coronavirus/?utm_campaign=%20. Accessed on 23 August 2020.

Wu, Kang and Wang, Xiaonan (2019). 'Aligning Pixel Values of DMSP and VIIRS Nighttime Light Images to Evaluate Urban Dynamics'. *Remote Sensing*, vol. 11, No. 12 (June).

Yahya, Maya, and others (2020). ‘The economic and security implications of COVID-19 in the Middle East’. *International Growth Centre*, 6 May. Available at www.theigc.org/event/the-economic-and-security-implications-of-COVID-19-in-the-middle-east/. Accessed on 23 August 2020.

Yousef, Tarik M., and others (2020). ‘Brookings experts on the implications of COVID-19 for the Middle East and North Africa’. *Brookings*, 26 March. Available at www.brookings.edu/opinions/brookings-experts-on-the-implications-of-COVID-19-for-the-middle-east-and-north-africa/. Accessed on 24 August 2020.



Copyright © UNDP 2021

All rights reserved

United Nations Development Programme
1 UN Plaza, New York, NY 10075, USA

U N
D P