

Global Research Report **The changing research landscape of the Middle East, North Africa and Turkey**

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Introduction

The global research landscape has changed seismically over the last four decades. In the 1980s, the trans-Atlantic research axis accounted for 75-80% of all academic research journal publications indexed in the then Science Citation Index (SCI)™. The next 20 years saw a changing research picture: emerging competencies with new economic strength in Latin America, unprecedented growth in investment in the Asia-Pacific and a broadening renaissance across the Middle East, North Africa and Turkey (MENAT).

Our 2011 Global Research Report on the Middle East opened with a foreword from the late Egyptian-American chemistry Nobelist Ahmed Zewail who drew attention to the surprising underperformance of Middle East countries in research, despite their history of deep commitment to knowledge and learning. He noted the need for enhanced investment in human capital, reform to allow freedom of thought and the development of exemplar centers of excellence to lead and to exhibit research achievements.

The United Nations Educational, Scientific and Cultural Organization (UNESCO) (2015) pointed out that the 1990 commitment by Arab states to raise gross expenditure on research and development (GERD) to 1% had not been met by any 25 years later. The United Kingdom's Royal Society (2015) reported that Organisation of Islamic Cooperation (OIC) countries generally lack science and technology policies that could address critical issues such as food, water and energy security, as well as sustainable and equitable socioeconomic development. It noted that international scientific collaboration needs to be strengthened, public and private sector investment increased, more researchers trained, and better data collection instigated. It recommended that robust peer

review systems, merit-based academic career structures and research evaluation programs should be established to ensure that investment leads to excellence. Other commentators suggest much remains to be done: Guessoum and Osama (2015) argued for a network of universities to promote broader, more open education and advancement based on meritocracy; Siddiqi et al. (2016) reported that investment has risen but that inconsistent, short-term policies remain a problem; and Forster (2018) argued that reform in support of intellectual and academic freedom is neither widespread nor adequate.

This year's report updates our picture of progress and development for a slightly wider region including North Africa. Our view of research in the Middle East, North Africa and Turkey is being enhanced by new developments led by the Egyptian Knowledge Bank, the Scientific and Technological Research Council of Turkey (TUBITAK) and the Islamic World Science Citation Center (ISC) in Iran. Funded by the Egyptian government and launched in 2020, the Arabic Citation Index (ARCI)™ provides access to bibliographic information and citations to scientific journals from more than 400 expertly curated Arabic journals. By bridging the gap between local scientific output and global impact, the benefits of the ARCI are substantial.

It will provide access to local scholarly content, helping researchers to collaborate with a wider audience on national, regional and international research efforts. It will also extend the Arabic academic footprint on the global scientific map by enhancing visibility of research published in Arabic scientific journals.

In Iran, Jafar Mehrad and Mohammad Ghane (Shiraz University), working with the Ministry of Science, Research and Technology, have led the development post-2002 of the ISC which aims to provide an evaluation of Iranian scientific journals based on scientometric indicators and principles used in the Web of Science™. ISC now covers 1,825 Iranian peer reviewed journals, which extends to 3,400 titles with journals published in OIC nations. More than one million records, covering more than 40 million references and one million citations, have been indexed in ISC. About 54% are English language journals, 38% are Farsi journals and 8% are Arabic (Mehrad and Ghane, 2021). In Turkey, TUBITAK's development of a Turkish Citation Index will extend and enhance the global impact of this regional research.

These important developments, from MENAT countries leading in the regional research renaissance, confirm the value of national indexes as an important regional supplement to the international citation indexes such as the Web of Science. A more complete picture of the research output of each country is provided and local research evaluation systems can enjoy more inclusive assessment of work absent from international citation indexing (Jin and Wang, 1999).

The MENAT research base

This report describes regional and national research activity for 19 countries in the Middle East, North Africa and Turkey (MENAT), spread from Morocco in the west to Iran in the east. The countries in this region present a very wide range of capacity in both human and financial resources, which means that ‘regional’ analysis can be only partially informative.

It is also necessary to look at the profiles and trajectories of the individual countries and their

interactions (Janavi et al., 2020). Proximity need not constrain global relationships but shared climate, history, culture and socio-economic perspectives do influence the costs and benefits of research collaboration.

Table 1 summarizes the size, in terms of population and productivity, of MENAT countries and their output, in terms of published academic journal papers, and scales this output against their economy. MENAT national publication output varies from around

1,000 papers over five years up to more than 100,000. Output per GDP (GERD is not available for many of these countries) varies 20-fold and output per capita (again, specific researcher data are not always available) ranges 100-fold from Israel to Yemen. Conflict in some of these countries will have disrupted all normal university and research activity and their data will not reflect their innate research and innovation potential. Despite these conflicts, there is a wealth of research activity.

Table 1: Population size, gross domestic product (GDP) and publication output of 19 countries in the Middle East, North Africa and Turkey.

	(1) Population	(2) GDP	(3) Output	GDP/ capita	Output/ GDP	Output/ capita
Algeria	43,053	169,988	18,121	3.95	0.11	0.42
Bahrain	1,641	38,574	1,235	23.51	0.03	0.75
Egypt	100,388	303,175	66,058	3.02	0.22	0.66
Iran	82,913	445,345	188,163	5.37	0.42	2.27
Iraq	39,309	234,094	9,247	5.96	0.04	0.24
Israel	9,053	395,099	74,605	43.64	0.19	8.24
Jordan	10,101	43,744	9,674	4.33	0.22	0.96
Kuwait	4,207	134,761	4,976	32.03	0.04	1.18
Lebanon	6,856	53,367	9,116	7.78	0.17	1.33
Libya	6,777	52,076	1,237	7.68	0.02	0.18
Morocco	36,472	118,725	12,200	3.26	0.10	0.33
Oman	4,975	76,983	4,729	15.47	0.06	0.95
Qatar	2,832	183,466	12,482	64.78	0.07	4.41
Saudi Arabia	34,269	792,967	80,552	23.14	0.10	2.35
Syria	17,070	40,405	1,269	2.37	0.03	0.07
Tunisia	11,695	38,798	23,046	3.32	0.59	1.97
Turkey	83,430	754,412	157,579	9.04	0.21	1.89
U.A.E	9,771	421,142	16,540	43.10	0.04	1.69
Yemen	29,162	27,591	1,511	0.95	0.05	0.05

(1) World Bank, '000s (2018)
 (2) World Bank and OECD National Accounts data files, current US\$ millions (2018)
 (3) Journal articles and reviews indexed in the Web of Science (2015-2019)

Regional trends

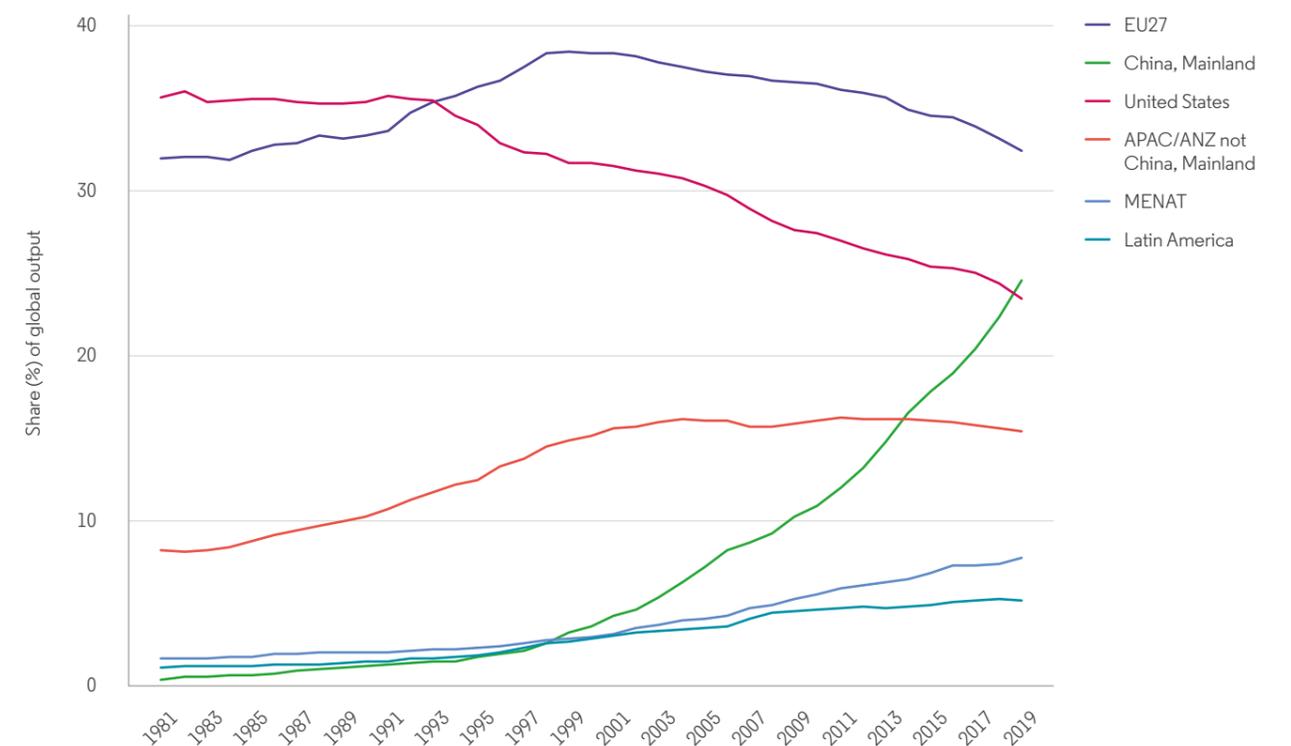
Research output is best tracked in terms of journal articles and reviews (the primary media for original academic research, which we refer to as ‘papers’). Our data refer to 20,000 leading journals indexed in the Web of Science. Collective regional publication output for MENAT has grown over the last four decades from 7,665 papers in 1981 to more than 150,000 papers in 2019. This 20-fold absolute growth can also be seen against the background of expanding global output as more countries invested in research as a key part of economic policy.

The expansion of research publication in MENAT represents a growth from 2% to 8% of global share. This is a four-fold

relative increase in a highly competitive environment where researchers struggle for publication in leading international journals. By comparison, the EU27, Latin America and Asia-Pacific (excluding Mainland China*) all saw a recent decrease in their world publication share, especially in the second part of the period. The United States saw a particularly large drop from around 37% to 24% of world share. These regions were all affected by the exceptional trajectory of Mainland China, which expanded from less than 1% of world publications in 1981 to more than 25% in 2019. MENAT's relative expansion is therefore to be acknowledged as a significant positive mark of its growing engagement with the global research network. (Figure 1)

The absolute growth of output (the count of papers) driving this increased share has been steep. A significant part of the rise is driven by international collaboration, which is increasing globally as more countries realize the benefits of sharing the costs of significant scientific and social challenges. For the MENAT countries, about 55% of total publication output is authored by researchers with addresses in just one country. The other 45% has co-author partners in MENAT (about 5%) or in other countries outside the region. This balance can be compared with Western Europe where typically 65% of publication output now has international co-authors, and such collaboration usually accounts for some of the highest impact and most influential work.

Figure 1: Change in annual regional or national publication output as a percentage of all journal articles and reviews indexed globally in the Web of Science.



*Web of Science data for Mainland China includes Hong Kong and Macau

Publication by country

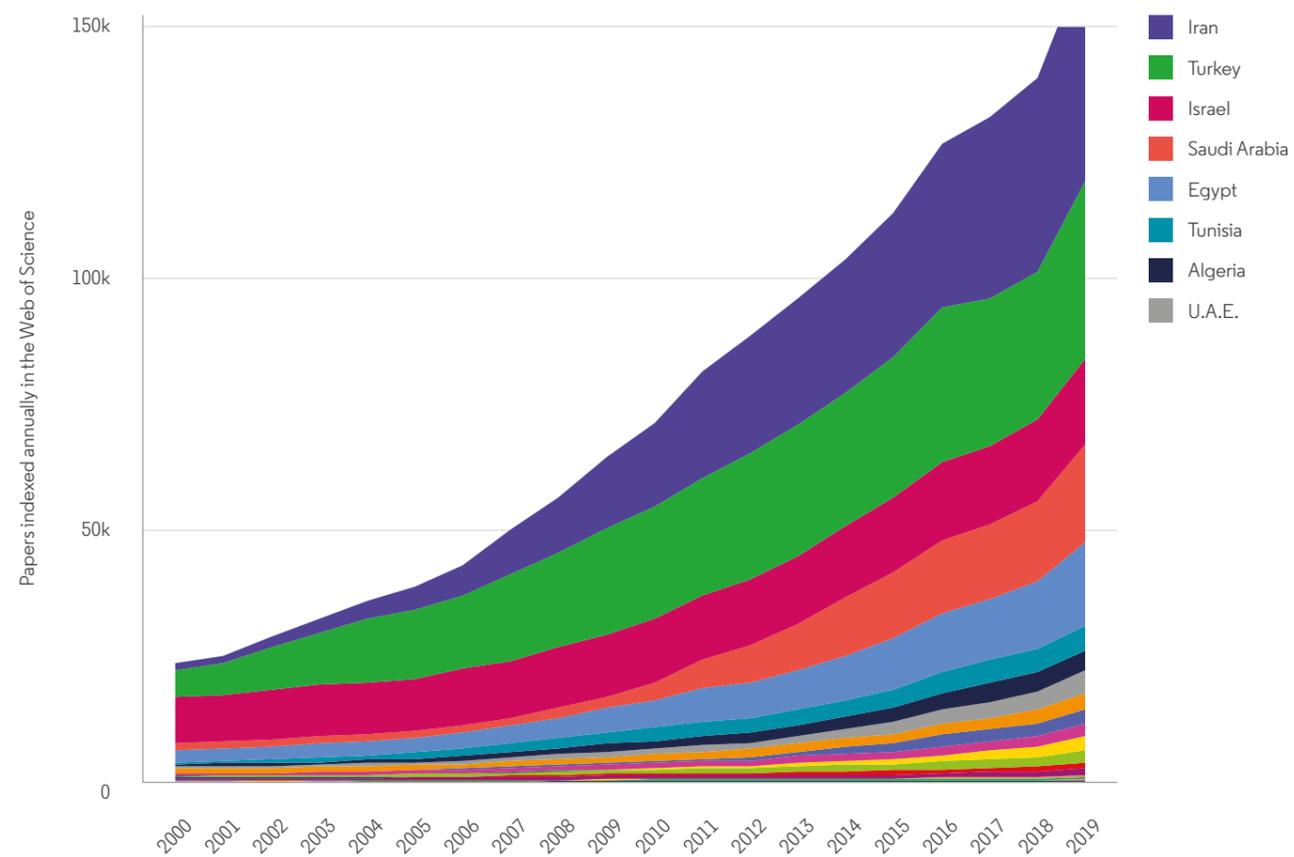
National growth trends are shown in a stacked chart (Figure 2). In agreement with Cavacini (2016) we find that six countries (Iran, Turkey, Israel, Saudi Arabia, Egypt and Tunisia) dominate this picture and account for more than 80% of total regional publications.

Growth for research economies that were well established before 2000 has been more modest whereas others have seen a more significant

expansion in their research activity and published output. Relative growth should also be considered. Israel doubled its output over the period since 2000 whereas Iran has seen an outstanding and more than 30-fold growth. Moed (2016) commented that Iran had become by “2015 by far the leading country in the Persian Gulf”. Tunisia (now almost 10 times its 2000 volume), Turkey and Egypt (both seven times) have also seen substantial growth and there is similar expansion

among the smaller countries. Saudi Arabia’s numbers grew more rapidly but there has been commentary that at least some of that expansion is attributable to non-Saudi researchers who are attached to Saudi institutions and list them as affiliations (Bhattacharjee, 2011). Another stand-out growth profile deserving mention is that of Iraq where publication output remains small but has increased more than 50-fold under the most challenging circumstances.

Figure 2: Trajectory of rising output among MENAT countries (2000-2019), shown as stacked volume (the apparent total for summed countries in region exceeds actual deduplicated total in Figure 2 because of collaboration between countries).



Although a small number of the 19 countries appear to dominate this analysis, that dominance is in fact less marked than it was in the past. This can be seen by looking at the tree-map diagrams comparing two five-year periods (Figure 3).

The relative expansion and diversification amongst the smaller economies is a shift that may be as important as overall growth. Despite the long historical traditions

of learning and scholarship in the region, some of these countries have started from a low base with poor infrastructure and a less strongly embedded recent profile of academic publication. The spread of research and knowledge capacity across all the regional members, and the associated enhancement of tertiary education that comes from a rich knowledge base, will be repaid in workforce and technology capability and in significant improvement in the quality of life.

Iran: emerging strength and impact

Iran has now surpassed Israel and Turkey as the largest producer among MENAT countries. Its world share of the Web of Science literature, just 0.2% in 2000, reached 2.3% by 2019. Iranians increasingly partner with colleagues abroad, despite external sanctions (Farhadi, 2015). A nation whose scientific research was in retreat is now increasingly networked with a tally of internationally co-authored papers rising through 35%. Overall Category Normalized Citation Impact (CNCI) reached world level in 2018, was 7% above world in 2019 and stands at 17% ahead of this by 2020.

Rising impact derives not only from more international collaboration but also via publication in more influential journals. During 2015-2019, Iran cut its share of papers published in low-impact titles by 30% and increased papers in top quartile – typically Anglophone – journals by the same. This is a considerable achievement for Iranian researchers who are non-native English writers (Maniati and Jalilifar, 2018).

Iranian science policymakers, administrators and scientists face many challenges. Economic sanctions mean shortages of supplies, travel to conferences has been limited and foreign publications are often unobtainable (Butler, 2019; Kokabisaghi et al 2019). In highly competitive, rapidly expanding countries, including Iran as well as others, some examples of scientific misconduct have surfaced and provoked concern. To classic examples of fabrication, falsification and plagiarism were added new behaviors such as fake peer review and fictional affiliations (Szomszor and Quaderi, 2020). To their credit, Iranian scientists themselves have published urgent calls to address misconduct through better education and institutional policies (Didari and Abdollahi, 2018; Kamali et al, 2020; Mousavi and Abdollahi, 2020; Rahimi and Abadi, 2019; and Rezaee-Zavareh et al 2016).

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Figure 3: Tree-map to show the relative volume of published output indexed in the Web of Science for countries in the MENAT region in two five-year periods.

Figure 3a: 2000-2004

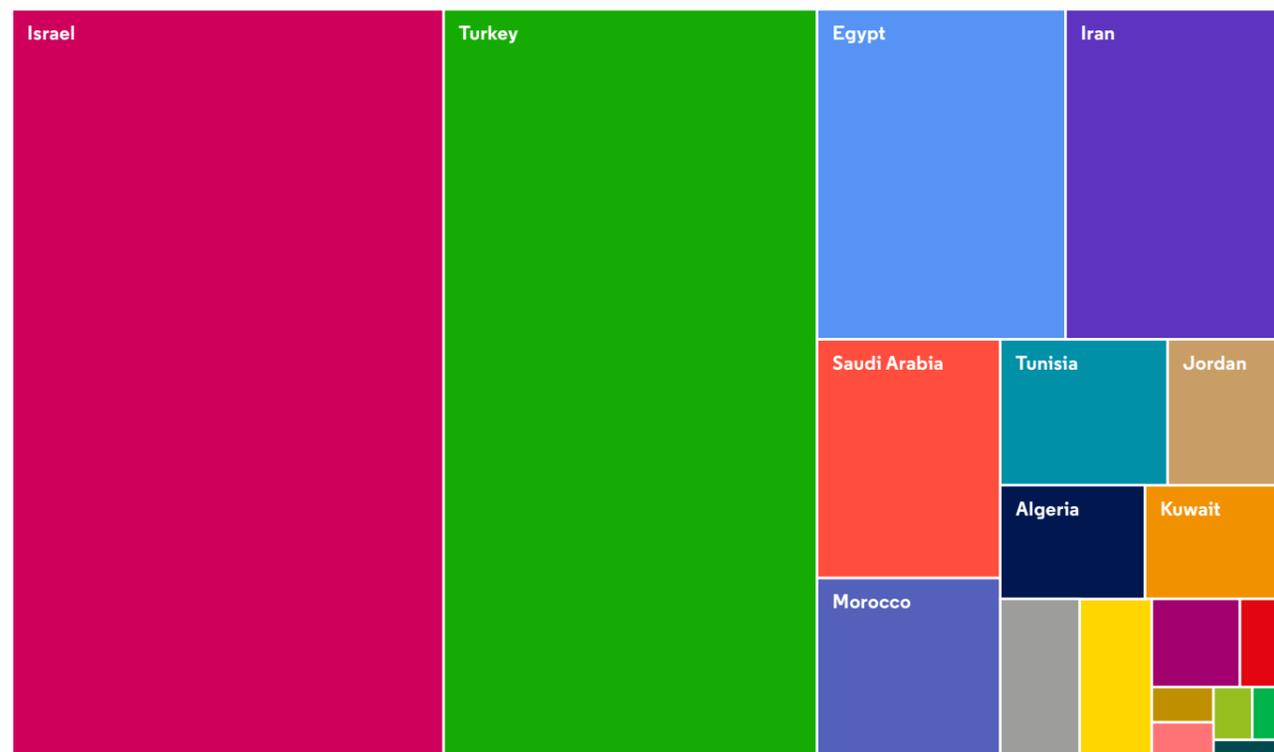
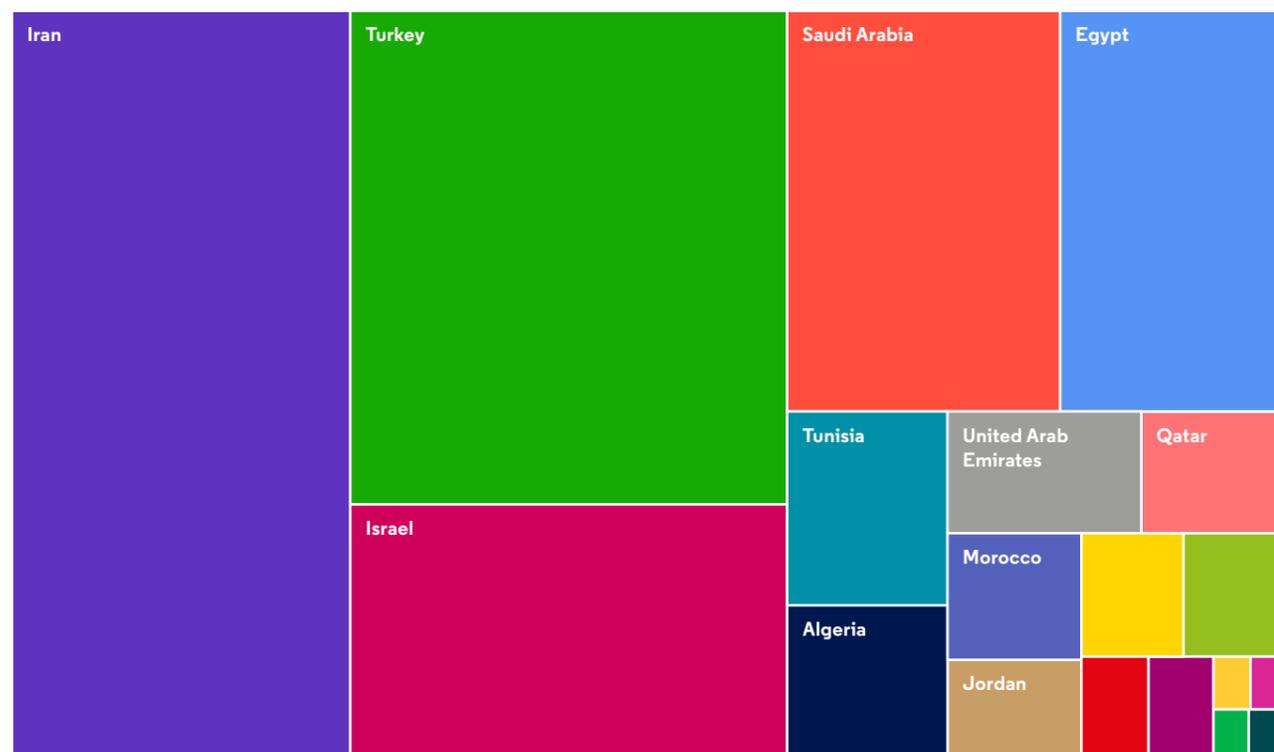


Figure 3b: 2015-2019



Tracking research priorities: MENAT's involvement in sustainable development

The United Nation's Sustainable Development Goals (SDGs) provide a useful shared agenda to consider a country or a region's contribution to global research. The Institute for Scientific Information (ISI)TM has developed a map of global research around the SDGs and this can be used to visualize MENAT activity against that world background. In some areas, MENAT countries are contributing to the global effort on health and climate and in other areas there are regional sustainability priorities.

Figure 4 shows the global map using the methodology described in our April 2019 report 'Navigating the Structure of Research on Sustainable Development Goals' and an updated dataset (including publications up to January 2021). Topic maps like these for SDGs are created across all research disciplines and provide an important tool for identifying the hottest areas of research. They can also help to identify where an organization

or region is making the greatest contribution and where it has gaps in its portfolio. Our 2019 report identified 'Health and Healthcare' and 'Environment, Agriculture and Sustainability' as the two primary focuses in the SDG network. There is a clear separation on the map between these two major areas (left and right respectively) that are bridged by topics such as (9) Sanitation and clean water and (22) Air pollution.

There are 819 SDG topics that were identified (the largest are colored in the map) from analysing 57,361 papers relevant to SDGs and indexed in the Web of Science from 1997, but most of these were published in the last five years. MENAT researchers published at least one paper in 253 topics (31%), but only 77 topics have 10 or more MENAT papers. There are 12 SDG topics where MENAT has 50 or more papers.

Figure 5 highlights the papers with a MENAT author showing topics with concentrated activity as well as the

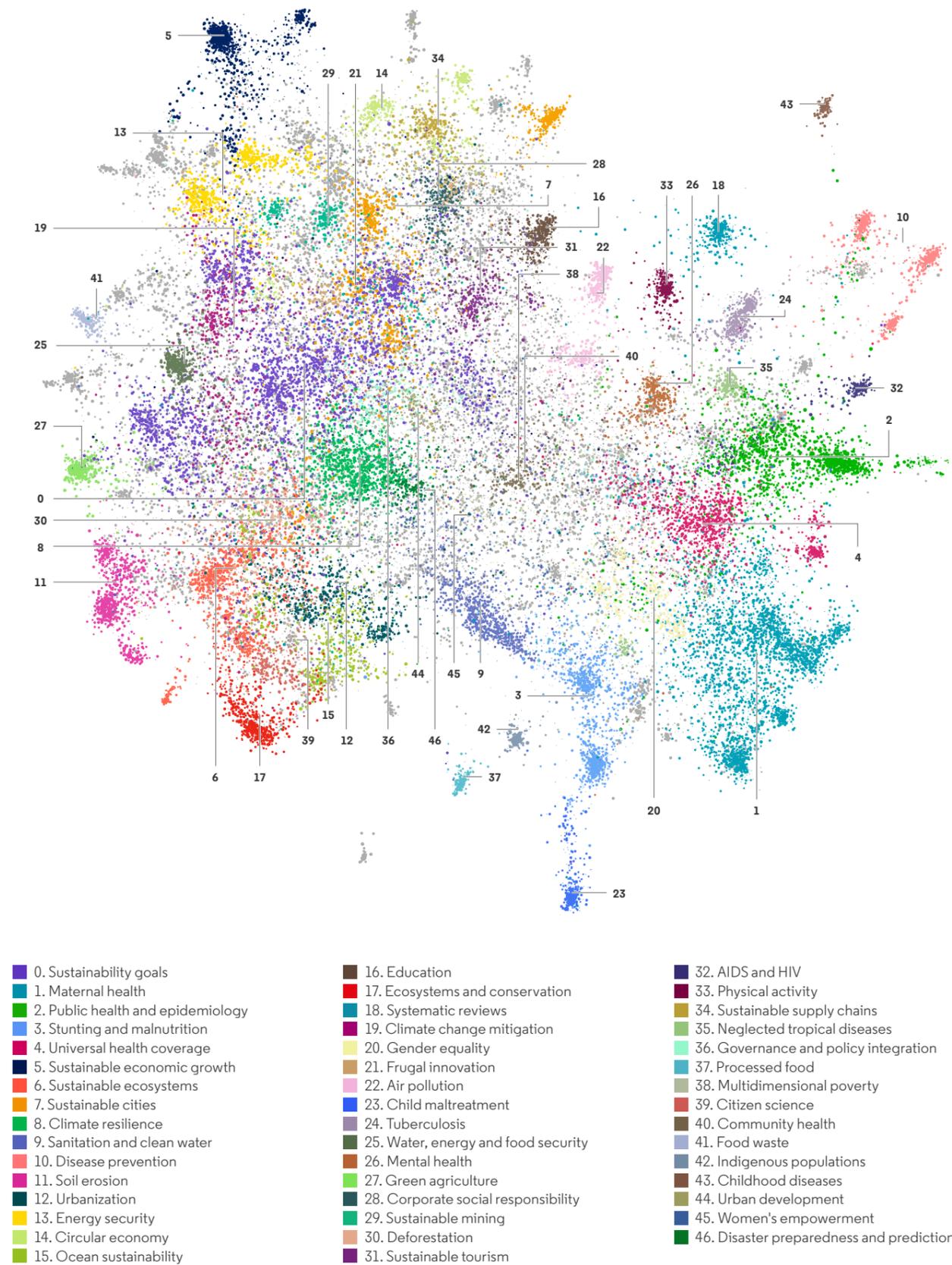
general spread of participation. For most of the MENAT countries, topic (2) Public health and epidemiology is the most frequent topic for publication and accounts for more than one-quarter of each country's SDG-related papers. The clear exception is Turkey which has more than one-quarter of its papers in (5) Sustainable economic growth, making two-thirds of the MENAT papers and co-authoring almost 20% of global papers in that topic. It also dominates a second energy topic on biogas.

The topics vary in the number of papers that they include, so total count is not always the best index of contribution. The share of world is also important. Using that perspective, topic (11) Soil erosion is then a clearly hot topic where MENAT co-authors 20% of world papers, although two-thirds of these are authored by just one country: Iran.

While topic (0) Sustainability goals has an appreciable number of papers across most countries, this is such a generic global topic that the MENAT share (3.5%) is not particularly high. Similarly, (1) Maternal health is covered by many countries and is again a smaller MENAT global share (4.6%) compared to the region's contribution to (10) Disease prevention (7.6%). Other topics with strong MENAT participation include (34) Sustainable supply chains (9.7% of papers), (7) Sustainable cities (9.3%), and (25) Water, energy and food security (9.0%).

In some areas, MENAT countries are contributing to the global effort on health and climate and in other areas there are regional sustainability priorities.

Figure 4: Global map of research relating to topics associated with United Nations Sustainable Development Goals (SDGs). Each point is a publication indexed in the Web of Science. The colors denote the topic cluster to which these papers are assigned (see key)



819

SDG topics that were identified

253

Topics where MENAT has at least one paper

12

Topics where MENAT has 50 or more papers

Figure 5: UN SDG publications with an author or co-author from the MENAT region against the background of the global map established in Figure 4.



Mobility and collaboration

The increasingly international dimensions of the MENAT regional research base are seen in the mobility of its researchers and the collaborative nature of its research activity.

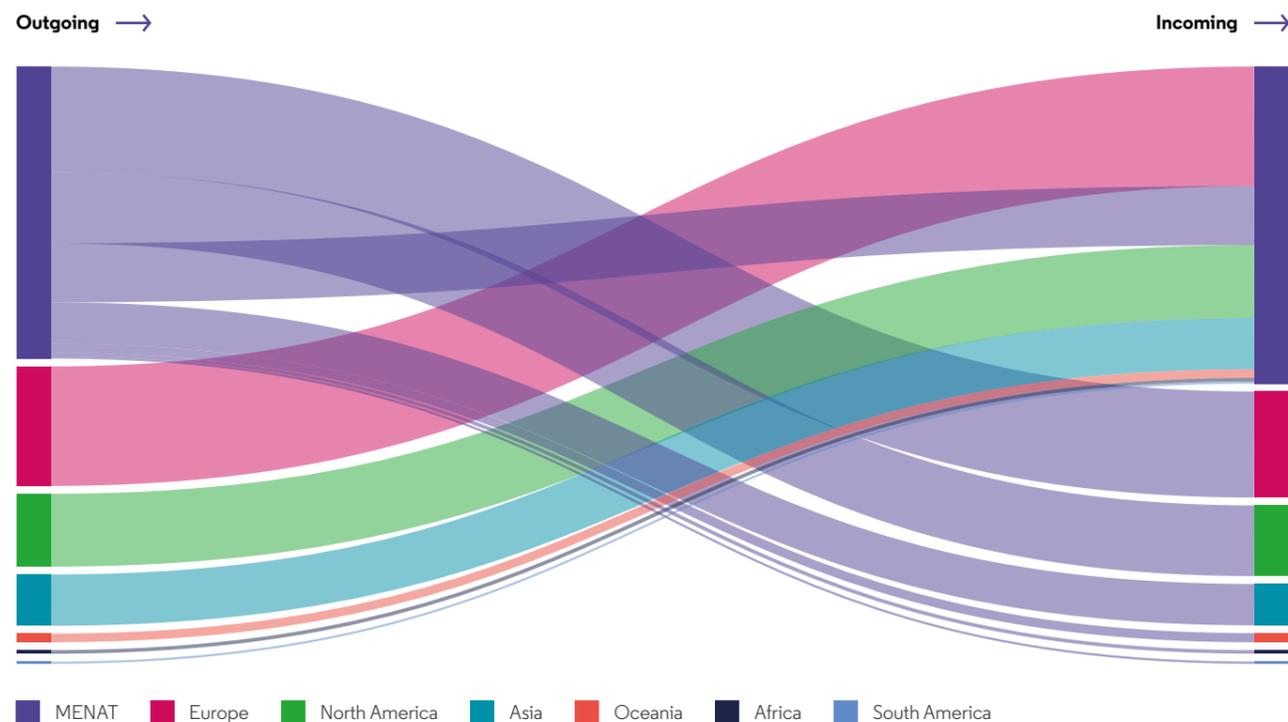
El Ouahi et al. (2020) investigated MENAT research mobility between 2008 and 2017 by exploring author affiliation in the Web of Science article records. About one in six of 22 million individual researchers identified within the region had been internationally mobile at some point in the period studied. The most frequent origins and destinations were identified to assess the influence of geographical, cultural, historical and linguistic proximities and the study indexed researchers' academic ages by scaling publishing histories. The most common academic

age group of migrant scholars was 6-to-10 years, although the average age was older (12.4 years) for both emigrant and immigrant scholars because of some long-established and mobile individuals. Immigrants were typically younger than emigrants, except for Iran, Palestine, Lebanon and Turkey. Researchers who moved to Gulf Cooperation Council (GCC) countries and to Jordan and Morocco were on average 1.5 publication years younger than emigrants from the same countries. There was a clear gender gap in scientific mobility and male researchers were the largest migrant group in MENAT countries.

As shown in Figure 6, the most common target and source region for MENAT research mobility was Europe, with North America as the second and Asia

well behind. The regional inward and outward flows were similar. At country level the United States, France, United Kingdom, Germany, Canada, Malaysia and Mainland China are frequent non-MENAT destinations and origins. However, specific channels stand out among these. France is the preferred destination for researchers from Morocco, Algeria and Tunisia and these North African countries also have other strong European ties. The United Kingdom is a frequent destination for GCC countries such as Saudi Arabia, the United Arab Emirates and Qatar. By contrast, researchers from Egypt and Jordan mostly migrate to Saudi Arabia and secondarily to the United States. Iraq and, to some extent, Iran have principal flows from and to Malaysia although sanctions clearly impact Iranian mobility (Kokabisaghi et al., 2019; Butler, 2019).

Figure 6: MENAT mobility flows at the regional level (2008-2017).



The patterns of mobility bear significant similarity to the growing network of international collaboration, and it may well be that many returning researchers are enabling their home institutions to initiate and maintain links to the out-region institutions at which they later work.

The rise in international output is necessarily accompanied by a fall in purely domestic share (domestic papers are those where there are no international co-authors: Figure 7) This analysis also draws attention to the relatively low level of regional collaboration. Since this is about 5% of total output, the lines describing the volumes of purely domestic and solely regionally collaborative output are relatively close together. Although regional collaboration appears to have increased very little as a share of total output, such collaboration was in fact

barely 1% in the 1980s and stayed that low until as recently as 2008. The increase to 5% in the last decade is an improvement, but the greater potential for regional networking remains to be realized.

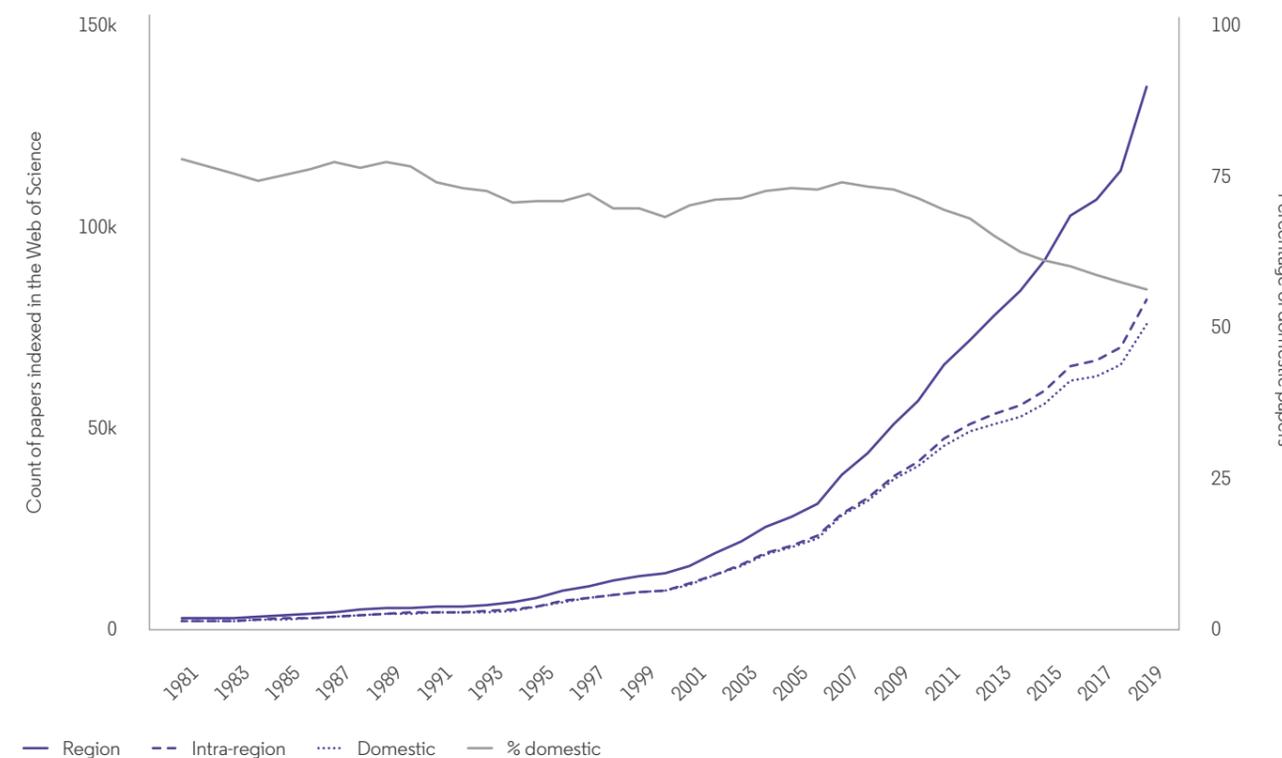
The major collaborative foci for MENAT countries are similar to the targets for mobile researchers: the research area in Western Europe; leading Anglophone research economies in North America and Australasia; and a network across Asia. This is a remarkably diverse spread of partnerships.

Five large research economies are particularly prominent in collaboration outside the MENAT region. The most frequent partner is the United States, which has been a co-author on about 8-10% of regional papers throughout the period. The United Kingdom has increased its

collaboration from around 3% to 5.2% of regional papers and Germany is also now a frequent partner across many countries. France was a frequent collaborator, appearing as a co-author on 7% or more of regional papers before 2000, but is now co-authoring less than 5%. France also differs from the other European Union (EU) nations in its concentrated engagement with the North African countries rather than the MENAT region more generally, a remnant of its colonial history.

8-10%
of papers co-authored with the United States

Figure 7: MENAT regional publication growth, showing the balance of output that is international, regional and domestic (all author addresses from one country).



However, the greatest change has been collaboration with Mainland China, whose researchers co-authored fewer than 100 papers per year before 2000 but in 2019 co-authored 6,800 papers: almost 5% of regional output and more than the regional collaboration between MENAT countries. The interface between MENAT and both South and East Asia and Asia-Pacific is quite marked as Moed (2016) noted. It is an intriguing reflection of the extent to which the world's wider research balance has shifted. MENAT collaboration with Malaysia, for example, is remarkably high despite the distance. (Table 2)

While the MENAT collaboration network is improving there is a great deal of opportunity for increased regional engagement. The message on regional collaboration suggested by Figure 7 is confirmed by the detailed data in Table 2. The collaboration between Egypt and Saudi Arabia (15,878 papers) stands out as the most concentrated interface in the table – and this was also the greatest concentration of researcher exchange in the region – but many of the other regional pairings are smaller than the collaboration tallies between these countries and partners outside the region. The 2,804 papers that Turkey shares with Saudi Arabia is fewer than it

shares with the EU countries in the table and with Canada as well as the United States and Mainland China.

This table shows all collaborative papers. A significant number of the collaborations between countries in the MENAT region are in fact highly multi-authored papers involving not only several regional partners and many countries out of region. If we restrict the analysis to purely bilateral collaboration, with no third country, then Turkey and Egypt shared just 90 papers of the overall 1,548 on which they both have co-authors during 2015-2019, whereas Egypt shared 198 bilateral papers with Australia.

Table 2: The numbers of papers shared by the six largest MENAT economies (by research output). Data are shown for those international partners that co-authored 10,000 or more MENAT articles and reviews (2015-2019) published in journals indexed in the Web of Science.

Regional total		Iran	Turkey	Saudi Arabia	Israel	Egypt	Tunisia
188,162	Iran		3,171	1,616	219	1,278	236
157,578	Turkey	3,171		2,804	1,436	1,548	369
80,550	Saudi Arabia	1,616	2,804		369	15,878	2,660
78,605	Israel	219	1,436	369		259	113
66,057	Egypt	1,278	1,548	15,878	259		423
23,046	Tunisia	236	369	2,660	113	423	
33,050	France	2,864	4,605	3,428	4,968	2,118	6,975
32,705	U.K.	4,989	6,643	6,227	6,626	3,755	588
28,108	Germany	4,591	6,307	4,159	8,022	4,374	649
21,308	Italy	4,443	5,507	2,891	5,332	2,233	1,266
16,935	Spain	3,066	4,274	2,790	3,760	1,961	1,548
10,880	Netherlands	1,856	3,369	1,482	3,391	742	187
75,764	U.S.	12,018	13,904	12,812	20,289	8,085	866
21,750	Canada	5,590	2,837	3,837	4,219	2,507	643
16,463	Australia	4,673	2,491	3,798	3,013	1,340	264
25,158	China, Mainland	4,065	4,060	9,216	3,758	3,866	414
15,883	India	2,434	2,562	7,388	1,734	2,201	359
12,041	Pakistan	1,564	2,358	7,464	193	1,531	197
11,431	Malaysia	3,746	1,684	3,714	693	1,414	147
10,202	Japan	1,376	2,171	2,099	2,143	2,807	246
9,282	South Korea	2,347	1,958	3,061	1,031	2,016	165

The impact of MENAT research

The impact, or influence, of research publications is conventionally indexed by the number of times that they are subsequently cited by later work.

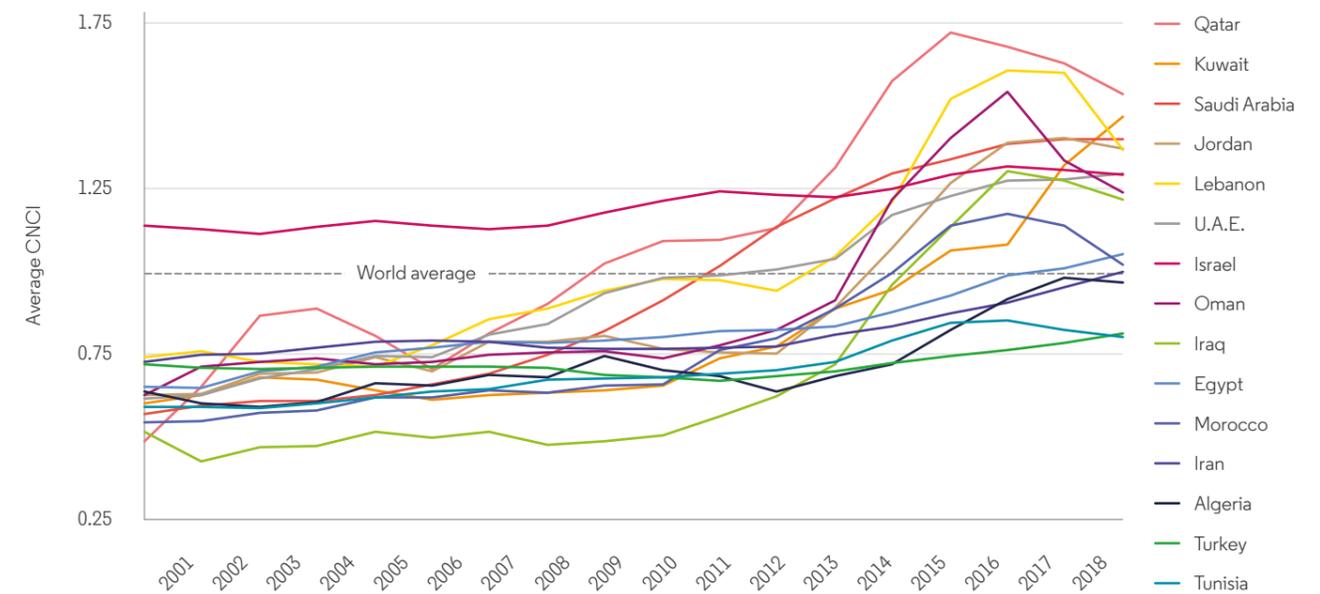
Papers that are cited frequently are associated with researchers and institutions that are generally considered by peer review to have more exceptional research achievements and performance.

This is not a good guide to individual publications, which may be outliers, but has been shown to work well for sufficiently large samples. Because citation counts rise over time at rates that are field dependent, the observed counts are 'normalized' by calculating the ratio to an expected value, which for Web of Science data is taken to be the average citation count for all papers published in the same year in

the same journal subject category (CNCI: world average is 1.0).

Looking back to 2000, the average national CNCI for all MENAT countries except Israel was in the band between 0.5 and 0.75 of world average. Every country in the region has improved its CNCI since then and 15 of the 19 countries now have an average 2019 CNCI above world average.

Figure 8: Trends in annual average CNCI (three-year running averages from 2000-2002 to 2017-2019) for the 15 countries in the MENAT region that published more than 1,000 papers in 2019.



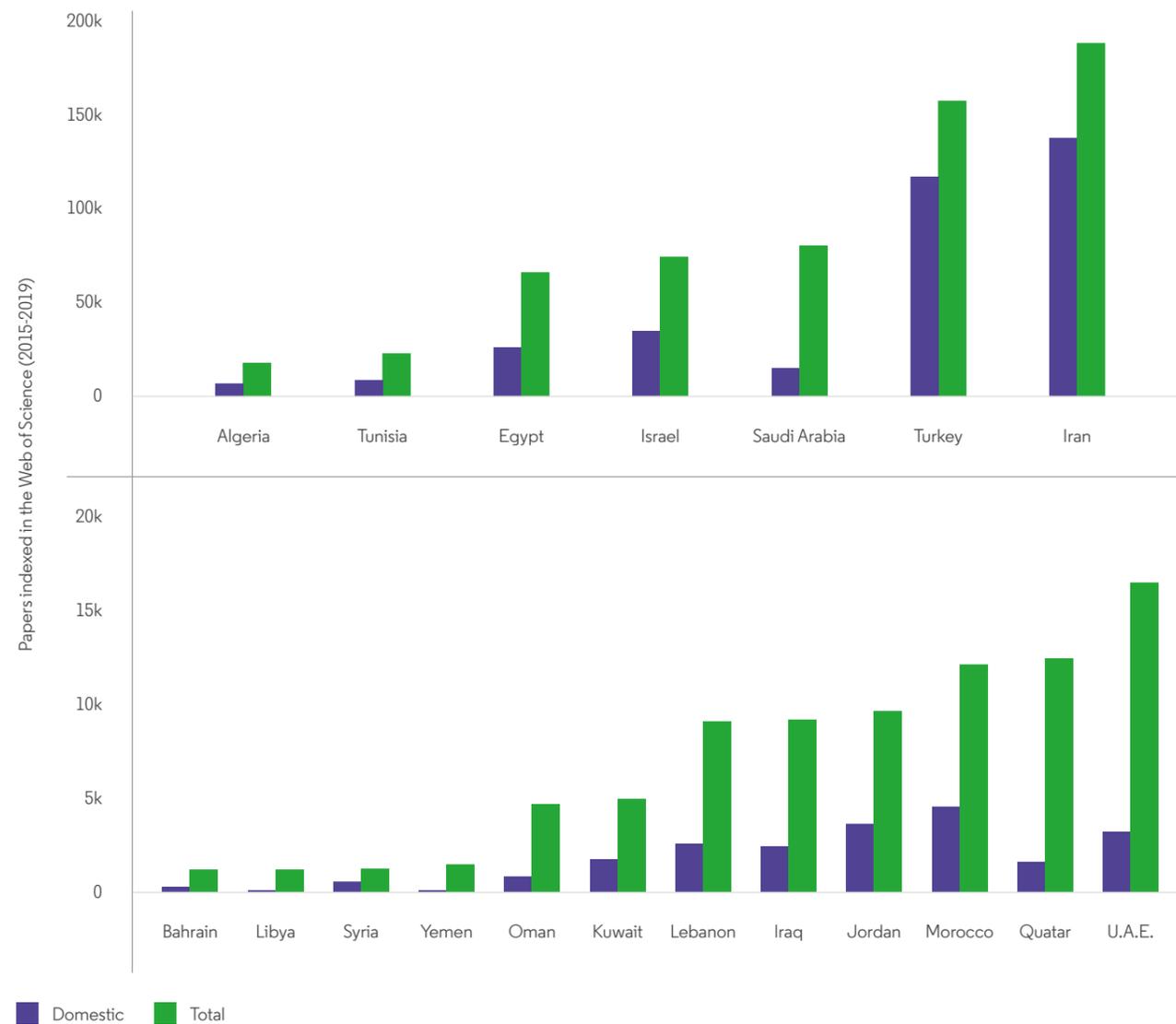
Some individual national lines have erratic spikes, especially in recent years. These are often associated with countries with smaller portfolios where an internationally collaborative paper that attracts high early citations stands out from others published in the same year and 'boosts' the annual average. That boost may disappear as data accumulate but it is a warning that simple averages only reveal part of the story about research performance. For this reason, Figure 8 shows only those countries

with more than 1,000 papers published in 2019 (omitting Bahrain, Libya, Syria and Yemen) and uses three-year running averages rather than single-year point metrics.

The overall regional trend is clearly upwards. Impact will be influenced both by internal development and by growing international collaboration. Although international collaboration is generally lower in MENAT (45%) than in Western Europe (65%) it varies a great deal. Iran and Turkey both publish

many papers but only 25% have international co-authors. Egypt, where CNCI is above world average and exceeds Iran and Turkey, has 60% international collaboration, Tunisia has 65% and Saudi Arabia has 80% despite being the third-largest research economy. Generally, high international collaboration is typical of smaller research producers (here including Yemen, Libya, Oman, Qatar and Bahrain) which are engaged in research but have yet fully to develop their domestic infrastructure (Figure 9).

Figure 9: Comparison between the total numbers of papers published by researchers in MENAT countries (2015-2019) and the numbers of papers that were domestic (with no co-author outside the country).



There is in fact a significant correlation for 2017-2019 between higher average CNCI and high average internal co-authorship. Internationally collaborative papers have, on average, higher impact than purely domestic papers, partly because collaboration implies an endeavour to solve major challenges not amenable to a solo effort but also because the paper reaches a wider audience. However, the consequence of having 80% internationally collaborative output is that gross national CNCI is likely to be

well above that of underlying domestic CNCI. In the MENAT data, this means that the impact of research for Iran and Turkey is a clear index of their national performance whereas for the smaller nations and for Saudi Arabia we would want to look in more detail at their domestic and collaborative components to gain a complete picture (Potter et al., 2020).

This is important because a simple view of the CNCI trends (Figure 8) might suggest that the larger research

producers (including Turkey, Iran, Egypt, Tunisia, Algeria and Morocco) were performing less well than the regional average whereas the correct analysis would take note of the smaller international contribution to the research capacity of those countries. If we take Saudi Arabia as an example, its average CNCI for 119,184 papers published during 2010-2019 was 1.31, but when we look at the 24,723 papers (20.7% of the total) that had solely domestic authorship then the average CNCI drops to 0.74.

Main focus areas for largest research economies

The overall research strengths of the MENAT countries have been rooted in their research related to industry and applied science. Their portfolio is diversifying as their capacity grows, as Sotudeh (2012) and Siddiqi et al. (2016) have reported, and this is enhanced by the growth across countries because each has its own specialisms.

The data reported in Table 3 show the categories in which the six countries publishing the greatest numbers of

papers have a relatively high proportion of the overall global output indexed in the Web of Science. This, rather than paper count, is used as an indicator of specialism because some research categories are innately bigger than others. It is the variance between countries that points to their areas of particular focus.

Iran is clearly specialized in physical and technological sciences: it has 2.2% of global publications overall but 8% of

global output in Petroleum engineering and more than 5% in eight other engineering-related areas. Turkey, by contrast, has a particular focus on specialist areas of medical science. Egypt has a mix of research in medical science and in agriculture and environment. This links to the focus on agriculture in Tunisia, which also prioritizes some technologies, but not those prioritized by Iran and Saudi Arabia. Israel's portfolio is quite different to all these.

Table 3: The 10 research journal categories in which the six MENAT economies with the greatest research output have a high share (%) of papers indexed in the Web of Science (2015-2019) compared to global publication counts in that category (text highlights: bold against name is overall global share; purple = technology; crimson = medicine; green = agriculture).

Iran	2.17	Turkey	1.82	Egypt	0.76
Engineering, petroleum	8.07	Folklore	14.6	Andrology	3.30
Materials, composites	7.02	Andrology	7.23	Chemistry, medicinal	2.60
Thermodynamics	6.64	Textiles science	6.54	Anatomy morphology	2.21
Mechanics	6.21	Emergency medicine	5.41	Dairy animal science	2.12
Engineering, geological	6.01	Otorhinolaryngology	4.76	Microscopy	2.01
Engineering, civil	5.98	Area studies	4.66	Pharmacy	1.92
Materials characteriz'n	5.97	Ophthalmology	4.62	Veterinary sciences	1.70
Andrology	5.62	Anatomy morphology	4.62	Entomology	1.70
Engin'ng, mechanical	5.56	Oral surgery medicine	4.61	Parasitology	1.70
Quantum technology	5.09	Obstetrics gynecology	4.39	Chemistry, organic	1.67
Saudi Arabia	0.93	Israel	0.92	Tunisia	0.27
Mathematics, applied	2.37	Social work	3.34	Automation control	0.98
Oral surgery medicine	2.21	Psychoanalysis	3.30	Textiles science	0.92
Telecommunications	2.20	Religion	3.29	Agricultural engin'ng	0.84
Engineering, petroleum	2.18	Archaeology	3.26	Business finance	0.80
Thermodynamics	2.16	Logic	3.24	Mathematics, applied	0.74
Information systems	2.05	Area studies	3.20	Agronomy	0.73
Mathematics	1.91	Psychology, social	2.81	Mathematics	0.73
Maths, interdisciplinary	1.88	Asian studies	2.62	Condensed matter	0.70
Artificial intelligence	1.88	Education, special	2.53	Chemistry, applied	0.68
Chemistry, medicinal	1.87	Obstetrics gynecology	2.49	Engin'ng, manufact'ng	0.64

Prospective view and reference back to 2011

The analysis in our 2011 report presented a complex picture, and the contrasts across the region today remain very marked. There had been very rapid growth for some nations, notably Turkey and Iran, but we have to note now that despite welcome and significant development and what is outstanding relative growth across the wider group of economies (Figure 1) there are still low levels of research activity and output elsewhere (Table 1, Figure 2 and see Cavacini, 2016). The qualifying note is, of course, that disruption – often external – in those states has wholly undermined their societal and economic ambitions.

Output in 2015-2019 is much more diverse than in the past (Figure 3) and there are some important differences in portfolios between countries (Table 3) that point to the opportunity for complementarity in specialisms and strengths. The overall impact of countries' research is rising (Figure 8) and Egypt has achieved rising impact at scale, although the profile for the smaller countries is clearly boosted by their international collaboration building on a small domestic research base.

The MENAT research network remains fragmented yet it contains lighthouses of excellence in a stormy sea. Although there is diversity of output and rising impact, a regional network of collaborative endeavor remains unrealized (Table 2), yet such a network could improve competitiveness between the region and the rest of the world by focusing on shared needs and priorities. It is true that there is still insufficient capacity in some countries to engage even locally and that levels of collaboration are, for most of the region, below those that are now common in Europe and Asia. Nonetheless, shared interests and shared challenges would surely provide a powerful incentive and enable significant mutual benefits to be realized.

It is difficult, and perhaps unnecessary, to provide any simple summary of the current state of the research environment across such a complex region as the Middle East, North Africa and Turkey. Institutional growth and development will surely transform the emerging strengths of the last decade into a new reality. But it is important to reiterate a message that was spelled out in the reports discussed in the introduction to this report: it is essential that the region should not only deliver top-end research but also create more robust educational and social transformation through human resource capacity. How widespread that change becomes and how it translates into different research fields will be an interesting narrative to follow. Given the MENAT region's rich human capacity and available resources, as well as the clear evidence of improvement presented here, one may hope to see further advances in science and technology for the region in the future.

Does the OIC provide a parent for a new agency to deliver this? Hassan et al. (2015) argue that OIC states have yet to come up with short- and long-term research and development plans to progress and compete with the rest of the world, and that international collaboration to enable this lacks sufficient status. However, Currie-Alder et al. (2018) note that, although MENAT countries have increased competitive research funds, evaluation criteria privilege collaboration with distant partners and connect with global, not regional, networks.

Several studies have shown the benefits of international mobility for scientific training and innovation. Many successful programs supporting scientific mobility are available such as Erasmus, Marie Skłodowska-Curie, China Scholarship Council and the Science Without Borders program. These programs are essential to stimulate early-career researcher development. Under the aegis of the OIC, the Islamic World Educational,

Scientific and Cultural Organization launched an educational exchange program aimed at student mobility among member states in July 2019. This is a promising step as the MENAT region needs such programs and mechanisms to increase scientific mobility through the provision of a common structure and basic support to local researchers.

Comparison between the OIC and the EU might seem invidious but is not inappropriate given the extensive collaboration between MENAT and European Research Area (ERA) countries. Figure 1 showed that, in an era of Mainland China's unprecedented research expansion, the EU27 has maintained its world share more effectively than the United States. The EU's absolute publication volume has grown from a 1981 figure similar to that of MENAT's today (157,000) to four times that in 2019 (665,000). If MENAT is to achieve similar growth, then it too will need a new level of research organization and collaboration.

We echo a suggestion made by the Royal Society (2015) that pooling resources from OIC nations, and related regional economies, would more effectively meet the economic and societal challenges they face. Collaboration within the region as well as with the rest of the world will also enhance the quality of scientific research, accelerate access to new markets and allow the financial costs of research to be shared. This could be mediated by a joint funding organization, supported by all and linked to national budget capacity, led by outstanding scientists from across the region, staffed by an international secretariat and with transparent peer review of the highest international standards. This would do much to advance the region, power up its unquestionable talent and capacity and visibly rebuild the international reputation of Islamic, Arab, Persian and Turkish learning and scholarship that sustained the Western world for centuries.

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