KLSC
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Kuwait Life Sciences

Middle East Science Report

Foreword

My favorite story about the ancient Arab **House of Wisdom** (***Bayt Al Hikma***) which was built during the lifetime of the **Caliph Haroun Al Rasheed** and located in the world's most famous circle city, Baghdad – mankind's first millennium capital of human culture and scientific endeavor, was how the Caliph himself use to reward authors and translators from every corner of the world with the weight of their books in gold. Mind you, these were usually very heavy leather bounded books.

The establishment of the House of Wisdom as one of history's first centers of scientific excellence helped usher in the Islamic Golden Age. This House of Wisdom for all the world would go on to achieve continued global recognition under Haroun's son, **Capilh al-Ma'mun** , who is credited with its formal institution.

From the 8th century to the 15th century AD, starting just a little over 150 years from the death of the Prophet Mohammad Peace Be Upon Him (PBUH), Islamic, Arab and Middle Eastern scientists and polymaths (including both Persian and Turkish scholars) propelled to new heights the fields of astronomy, algebra and mathematics, cartography and geography, alchemy and chemistry, anatomy and medicine, zoology and ethology (animal behavior).

For close to 800 years, scientific legends including **Hunayn ibn Ishaq** (*Johannitius*), **Al Razzi** (*Rhazeus*), **Al Zahrawi** (*Abulcasis*), **Ibn Sina** (*Avicenna*), **Ibn Zuhr** (*Avenzoar*)**, and Ibn Rushd** (*Averroes*) to name just a few, would work openly as part of a scientific community, educating both Middle Eastern and Western nations in their chosen field of specialization. It was a cross cultural exchange of culture ideals and scientific enlightenment. Indeed, Ibn Sina's groundbreaking book, ***Al-Qanoon Fil Tibb*** ("The Canon of Avicenna"), published in the late 10th century AD, would go on to be the standard textbook of medicine for the next 700 years. Another important book, ***Al Muqaddimah*** *("The Prolegomena") by* **'Abd al-Rahman Ibn Muhammad Ibn Khaldun al-Hadrami of Tunis,** commonly known as **Ibn Khaldun**, laid down the foundations of different fields of knowledge, in particular the science of civilization *(Al-'Umran)* with significant contributions to economics including production, supply and demand, cost and consumption, and utility, providing notable inspiration to the so-called "Father of Economics," **Adam Smith** whose great works were published some three hundred and seventy years after Ibn Khaldun's passing.

Today, the state of Middle Eastern scientific thought has reached its nadir. This 100 page plus report over 10 sections was produced via a combined 1,000 plus man-hours. It is a humble jeu d'esprit to help return our region on a path towards zenith. We have profiled 57 institutions that have funded, supported and published close to 1,500 significant scientific papers and registered over 30,000 unique patents. However, the region is still lagging both international best practices and closer regional best practices. The Middle East boasts only a mere

two Nobel Science Prizes. My alma mater, **Columbia University**, has 61 (and a total of 82 if we include Nobel prizes in Peace, Literature and Economics).

On a more positive note, we managed to interview 20 of the brightest minds from across the Middle East and North Africa (MENA) region and it is our personal belief that brighter days for science in the Middle East are surely ahead, for these accomplished minds and their collective wisdom, is sure to inspire a new generation of MENA scientists, polymaths, scholars and technology entrepreneurs. This is acutely represented by the Global Top 10 Ranking in Science and Mathematics education achieved by the United Arab Emirates in the most recent report by the World Economic Forum (WEF). Another important recent development are the multibillion dollar education endowments of many Saudi Universities, including the world's sixth richest, **King Abdulla University of Science and Technology** ($20 billion), **King Saud University** ($2.7 billion) and **King Abdul Aziz University** ($1 billion).

Unfortunately, these are the only three institutions in the region that publically announce the size of their endowments. Indeed, more transparency is needed across the region, not just in terms of the size of economic investment into science, research and education, but more importantly, more transparency is needed on the outcome of these large investments. The Caliph Haroun Al Rasheed and his sons had public libraries full of books; what do today's a contemporary patron of scientific thought have to show? Postmodern architectural buildings and fat faculty salaries are a great start, but we hope to see increased focus on the actual science itself, for the simple sake of scientific advancement, for the sake of wisdom.

Perhaps one of the greatest lasting legacies of our Middle Eastern scientific forefathers is that there are 165 stars and various star systems named in Arabic (see Appendix at the end of the report for a full and detailed list). From the expansive *as-Saḥābat uṣ-Ṣaghirah* or "small cloud" also known today as the **Andromeda Galaxy**, which was first catalogued by **Al-Sufi** in his ***Book of Fixed Stars***, to the giant *Bint ul-Jawzā',* better known today as **Betelgeuse,** the brightest start in our nights sky. Young Middle Eastern minds need but only look up to the night's sky to find continued inspiration from these tremendous contributions of our region to science.

Sincerely,

Dr. Mussaad M. Al-Razouki (*Arrizacamus*)

Principal Author – Middle East Science Report
Chief Business Development Officer
Kuwait Life Sciences Company (*KLSC*)

This report is dedicated to.....

The Middle East Science Report is dedicated in loving memory to Prof. Ahmed Zewail, the Middle East and North Africa (MENA) region's first Nobel Science Prize winner (Chemistry in 1999). And Prof. Aziz Sancar of Turkey, Nobel prize winner for Chemistry in 2015.

Ahmed Hassan Zewail (*Zewaileus*) Born: February 26, 1946 Died: August 2, 2016) was an Egyptian-American scientist, known as the "father of femtochemistry." Ahmed Zewail was born in Damanhur, Egypt, and grew up in Alexandria. His father worked as a bicycle and motorbike fitter before becoming a government official. After studying at the University in Alexandria, Zewail moved to the US to undertake his PhD at the University of Pennsylvania in Philadelphia. After some time spent working at the University of California, Berkeley, Zewail transferred to the California Institute of Technology in Pasadena in 1976, where he continues to work in his chosen scientific field. He was awarded the 1999 Nobel Prize in Chemistry for his work on femtochemistry ("for his studies of the transition states of chemical reactions using femtosecond spectroscopy" **Field:** chemical kinetics, physical chemistry) and became the first ever Arab to win a Nobel Prize in a scientific field.

Aziz Sancar (***Binsancar***) was born on 8th September 1946 in Savur in southeast Turkey to a lower middle class family. His parents had no formal education but considered education important for their children. Sancar studied at Istanbul University and at the University of Texas, Dallas, where he received his doctorate in 1977. He is currently a professor at the University Of North Carolina School Of Medicine, Chapel Hill. Aziz Sancar is married to Gwen Boles Sancar who also is a professor in biochemistry and biophysics. He was awarded the 2015 Nobel Prize in Chemistry for his work on Mechanisms of DNA Repair by Photolyase and Excision Nuclease.

Acknowledgement

We would like to thank the entire leadership team at Kuwait Life Sciences Company for their unvarnished support and we would also like to especially thank the guest contributors from across the world, representing a total of ten different metropolitan areas, who contributed their thoughts as well as their valuable time in reviewing the final product. Their detailed profiles have been included at the end of the report but we find it important to mention them by name here at the start. To honor these contributors, we have provided them with Latinized epithets in the style of the European Renaissances' appreciation for Middle Eastern scholarship.

Name (*Latinization*)	Position	Organization/Institution	City, Country
Dr. Ali Al Sanousi (*Azzanousi*)	Executive Chief Medical Information Officer	Hamad Medical Corporation	Doha, Qatar
Dr. Bader Alzaid Altraiji (*Azzaidulturaji*)	CEO	YIACO Medical Company	Kuwait City, Kuwait
Dr. Bahareh Azizi (*Bintazizi*)	Consultant	Kuwait Foundation for the Advancement of Sciences (KFAS)	Kuwait City, Kuwait
Prof. Fahd Al-Mulla (*Ammula*)	Founder and CEO	Genatak	Kuwait City, Kuwait
Prof. Hasan Al-Nashash (*Annashashi*)	Professor of Electrical and Biomedical Engineering	American University of Sharjah	Sharjah, UAE
Prof. Hayat Sindi (*Bintulsindi*)	Founder	i2institute	Jeddah, Saudi Arabia
Joe W. Henein (*Avihenein*)	President & CEO	NewBridge Pharmaceuticals	Dubai, UAE
Majid F Alghaslan *(Aqqaslaneus)*	CEO	Dimensional	Riyadh, Saudi Arabia
Dr. Malek El Husseini *(Ahusaini)*	Operating Partner	Qatar First Bank	Doha, Qatar
Dr. Manar Al Moneef, MD *(Ammoneef)*	Chief Growth Officer, MENA	General Electric	Riyadh, Saudi Arabia
Dr. Mohamed Gad *(Gadeus)*	Health Economist	Global Health and Development Group	London, UK
Mustafa Ergen *(Ergenus)*	Chief Technology Advisor	Türk Telekom / Koç University	Istanbul, Turkey
Najati Ali-Hasan *(Avihasan)*	Partner	Anchor Consulting	Dubai, UAE
Dr. Riad Hartani *(Avihartani)*	Partner	Xona Partners, Inc	Algiers, Algeria
Dr. Saba Alzabin *(Azzabin)*	Sr. Scientist	University of Oxford and Epistem Ltd	London, UK
Dr. Sameer Al Zanki *(Azzanki)*	Director of Science and Technology	Kuwait Institute for Scientific	Kuwait City, Kuwait
Dr. Shadi Abu-Hayyeh *(Avuhayya)*	Assistant Director	Department for International Trade, British Government	London, UK
Prof. Syed Mohamed Aljunid *(Ajunaidus)*	Professor of Economics, Policy and Management	Kuwait University	Kuala Lumpur, Malaysia
Valentina Qussisiya *(Bintqussiya)*	CEO	Abdul Hameed Shoman Foundation	Amman, Jordan
Zeina Ali Siam *(Alisiam)*	PhD Candidate, Health Systems	Harvard University	Boston, USA

What's in a Name?

A short comment on the name of the report. Similar to the popular temptation to confine all the works of the 8th to 15th century AD to only Arab or Islamic scholars, we have decided to name the report the "Middle East Science Report" to captivate the collective works of both contemporary Persian and Turkish schools of scholarship. In a similar fashion to the Caliph Haroun Al Rasheed, we accepted contributions of knowledge and opinion from both Western born or Western based scholars with a strong affinity for the Middle East and North Africa region.

For the purposes of this report and primarily due to the limited availability of both primary and secondary data sources, the list of MENA countries includes: Algeria, Bahrain, Egypt, Iran, Iraq, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, Turkey, the United Arab Emirates and Yemen. In many graphs Israel, the UK and USA have been also presented as regional and international comparisons and benchmarks.

We also use the term Middle East and MENA interchangeably but expect the coverage to be synonymous. In future editions, we hope to increase the scope of study to include scholarly works from, the Indian Subcontinent, South East Asia and Sub-Saharan Africa to produce a more expansive Muslim Science Report.

This is only the beginning.

Contents

Introduction

The Middle East and North Africa (MENA) region encompasses significant cultural similarities as well as highly distinct political and economic systems with a heterogeneous social fabric. Its people share a commonality of language, history and religion but their societies are at variance in terms of natural wealth, governance, currency, traditions and socio-economic systems.

It is an area of historical importance, as it is the birthplace of the world's three Abrahamic monotheistic religions. For centuries, the region was a hub of groundbreaking science. MENA as always been an area of strategic importance from the days of the earliest of empires until today, owing to its location and a wealth of subterranean natural resources, essentially in the form of oil, natural gas and phosphate. The MENA region produces over 30 million bbpl or barrels of oil per day (about two thirds of which comes from the GCC and the vast majority from the MENA OPEC members – see Table of Global Oil Production in the Appendix). This represents almost 1/3 of global oil output. The region is also home to over 1/3 of the world's known gas reserves are held in this region, mostly in the peninsula of Qatar, and more than half of the world's phosphate reserves are held in Morocco alone, which is of particular importance to our planet's plant based organisms.

In light of recent international economic uncertainty and growing populism, Middle Eastern countries will have no choice but to stimulate Science, Technology and Innovation (STI) together with the education sector to mitigate global economic risk factors including population health, food, clean (fresh) water and energy security. MENA countries can also learn from the remarkable socioeconomic progress of countries such as Japan, Brazil, China, Korea and Malaysia, due in part to the development of STI related sectors

MENA governments that are dependent on both oil exports scientific/technology imports are continuously calling for the development of Knowledge Economies. But what does that actually mean? More on the development of the Middle Eastern Knowledge Economy can be found in the final section of the report.

Indeed, a wide range of recent positive MENA initiatives hitch STI to socio-economic development, more often in the field of energy. Examples are the revival of the Zewail City of Science and Technology project in Egypt, Masdar in Abu Dhabi, the Kuwait Foundation for the Advancement of Sciences (KFAS) and the establishment of the Emirates Institution for Advanced Science and Technology (EIAST) to operate Earth observation satellites – each acting as their own bright star in their own respective country, many with regional aspirations.

Presently, a significant portion of the MENA region is in turmoil. Syria, Iraq, Libya and Yemen are considered by many to be failed states emblazoned by bloody civil struggles, causing untold damage to human life, physical infrastructure and perhaps most importantly, a lost generation of intellectual development. Fifteen million people have fled their homes, many to fragile or economically strapped countries such as Jordan, Lebanon, Djibouti and Tunisia, giving rise to the largest global refugee crisis since World War II. The current turmoil in Yemen has set that country's development back several decades. Blockades and repeated cycles of violence have made Gaza's unemployment rate the highest in the world and with Gross Domestic Product at only 40% of its potential [1]. The relatively stable oil exporters, such as Algeria, Iran and the GCC, are grappling with low oil prices alongside chronic youth unemployment and undiversified economies. On a positive note, political developments in Kuwait, Tunisia, Morocco, and Jordan indicate that citizens are increasingly engaging in policymaking [2].

There remains, however, much to be done in terms of the development of STI related policies and sectors which is an important first step that MENA governments must take to foster the growth of the so-called Knowledge Economy focused on novel technologies rather than hydrocarbon resources.

It is time to focus more so on the potential of people walking the ground, rather than what is treasured underneath.

Section I: Socio-Economic Status

We have profiled 18 countries in the MENA region, inhabited by approximately half a billion people (Refer: Table-1) of which around 54 million people (including a sizeable foreign labour force) live in the six GCC countries, representing around 10% of the MENA population and considered by many to be the region's growth engine, both in terms of population growth (from both natural birth rate and immigration) and in terms of economic development.

Indicator	Total population (in thousands)							CAGR
Time	2010	2011	2012	2013	2014	2015	2016	%
Country								
Algeria	36,036	36,717	37,439	38,186	38,934	39,667	40,376	1.91%
Bahrain	1,261	1,306	1,334	1,349	1,362	1,377	1,397	1.72%
Egypt	82,041	83,788	85,661	87,614	89,580	91,508	93,384	2.18%
Iran	74,253	75,184	76,157	77,152	78,144	79,109	80,043	1.26%
Iraq	30,868	31,868	32,958	34,107	35,273	36,423	37,548	3.32%
Jordan	6,518	6,760	6,994	7,215	7,416	7,595	7,748	2.92%
Kuwait	3,059	3,239	3,420	3,594	3,753	3,892	4,007	4.60%
Lebanon	4,337	4,592	4,924	5,287	5,612	5,851	5,988	5.52%
Libya	6,266	6,289	6,283	6,266	6,259	6,278	6,330	0.17%
Morocco	32,108	32,532	32,984	33,453	33,921	34,378	34,817	1.36%
Oman	2,944	3,210	3,545	3,907	4,236	4,491	4,654	7.93%
Qatar	1,766	1,905	2,016	2,101	2,172	2,235	2,291	4.44%
Saudi Arabia	28,091	28,788	29,496	30,201	30,887	31,540	32,158	2.28%
Syria	20,721	20,501	19,979	19,323	18,772	18,502	18,564	-1.82%
Tunisia	10,639	10,759	10,881	11,006	11,130	11,254	11,375	1.12%
Turkey	72,310	73,517	74,849	76,224	77,524	78,666	79,622	1.62%
UAE	8,329	8,735	8,953	9,040	9,086	9,157	9,267	1.79%
Yemen	23,592	24,235	24,883	25,533	26,184	26,832	27,478	2.57%
MENA Total	445,140	453,925	462,756	471,558	480,245	488,755	497,047	1.86%
Israel	7,420	7,563	7,695	7,818	7,939	8,064	8,192	1.66%
UK and NI	62,717	63,165	63,574	63,956	64,331	64,716	65,111	0.63%
USA	309,876	312,390	314,799	317,136	319,449	321,774	324,119	0.75%

Table-1, Source: UNESCO Statistics

Population growth as Compounded Annual Growth Rate (CAGR) %

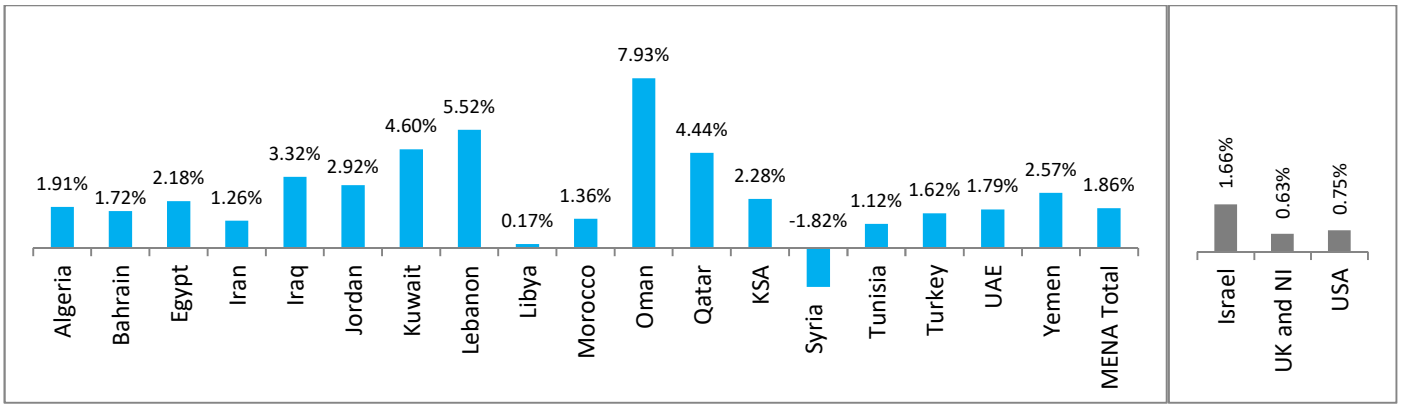

Chart-1, Source: UNESCO Statistics

The Gross Domestic Product (GDP) of MENA is calculated (Refer Table-2) at 3.5 billion USD (2015) with a Compound Annual Growth Rate (CAGR) of 2.06%, which significantly trails international best practices and regional comparisons such as the UK (3.46%), USA (3.70%) and Israel (4.79%). On a more positive note both the CAGR (2010 to 2015) and overall value of GDP for 9 out of 18 MENA countries is actually higher than Israel, UK and USA (Refer: Chart-2). It is important to note that the six (most small population) nations of the Gulf Cooperation Council contribute to over 40% of total MENA GDP.

Indicator	GDP (in million current US$)						CAGR %
Time	2010	2011	2012	2013	2014	2015	2010 - 2015
Country							
Algeria	161,207	200,013	209,047	209,704	213,518	166,839	0.69%
Bahrain	25,713	29,044	30,756	32,898	33,851	32,221	4.62%
Egypt	218,888	236,002	276,353	286,011	301,499	330,779	8.61%
Iran	467,790	592,038	587,209	511,621	425,326	N/A	-1.89%
Iraq	138,517	185,750	218,001	232,497	223,508	168,607	4.01%
Jordan	26,425	28,840	30,937	33,594	35,827	37,517	7.26%
Kuwait	115,419	154,028	174,070	174,161	163,612	112,812	-0.46%
Lebanon	38,010	40,079	43,205	44,352	45,731	47,103	4.38%
Libya	74,773	34,699	81,905	65,504	41,143	29,153	-17.17%
Morocco	93,217	101,370	98,266	107,235	110,009	100,360	1.49%
Oman	58,641	67,938	76,341	78,183	81,797	70,255	3.68%
Qatar	125,122	169,805	190,290	201,885	210,109	166,908	5.93%
Saudi Arabia	526,811	669,507	733,956	744,336	753,831	646,002	4.16%
Syria	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tunisia	44,051	45,811	45,044	46,256	47,603	43,015	-0.47%
Turkey	731,168	774,754	788,863	823,243	798,797	718,221	-0.36%
UAE	286,049	348,526	373,430	387,192	399,451	370,293	5.30%
Yemen	30,907	31,079	32,075	35,955	N/A	N/A	3.07%
MENA	3,162,711	3,709,282	3,989,750	4,014,626	3,885,614	3,501,363	2.06%
Israel	234,322	261,764	259,614	292,408	305,675	296,075	4.79%
UK and NI	2,403,504	2,594,905	2,630,473	2,712,296	2,990,201	2,848,755	3.46%
USA	14,964,372	15,517,926	16,155,255	16,663,160	17,348,072	17,946,996	3.70%

Table-2, Source: UNESCO Statistics, N/A-Data not available

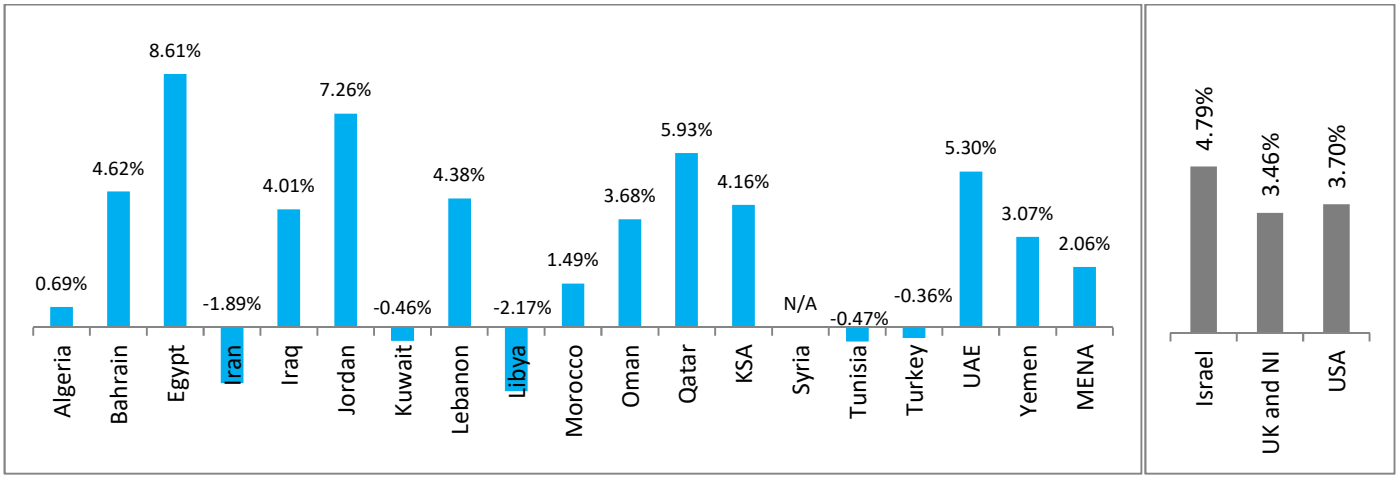

Chart-2, Source: UNESCO Statistics

Section II: The Importance of Higher Education in Science

The current link between Middle Eastern universities and industry is weak to non-existent when compared to international best practices. This weak-link is further exacerbated by populations focused on consumerism and feeble academic research requirements at many of MENA's universities and STI related institutions. The symbiotic relationship between academia and industry has a profound implication on the scientific status quo of a country - it can be a potent tool for building an institutional research capacity – in addition to forming the central pillars of a national strategy that empowers the transfer of knowledge and technology from universities to corporate organizations, which in turn can help to boost innovation and the competitiveness of both companies and the nations they are domiciled in, as well as (eventually) the entire economic system itself.

To foster a true Knowledge Economy, nations need to focus on nurturing special higher education programs that provide critical scientific skills training, improved science and technology teaching standards, which will then prepare the graduates of tomorrow for careers in scientific research and technology development. The production of employable graduates and promoting all ways of learning including distance and open learning must be a core tenant of MENA state policy.

Thankfully, both Qatar and Saudi Arabia have seen phenomenal growth in the volume of scientific publications over the past decade. Saudi Arabia now counts two universities [3], among the world's top 500. Many other countries in the MENA region have made grandiose plans to reduce their dependence on foreign workers by developing technical and vocational education with equal opportunities across the fathomous gender gap.

University Science Programs

University education in science has significantly grown across the MENA region; both in terms of quantity and quality, since the end of the World War II. There are ~500 universities in MENA countries, with almost half of all universities offering programs in science. We have profiled 50 of the region's top universities at the end of the report as well as seven other non-degree offering instructions focused on fostering scientific thought and technology development. According to the report's calculations, there are ~220 science universities located in MENA region, with an average of 13 universities per country (Refer Chart-3) translating to an average of one university per 2.23 million of population. Bahrain (0.36 million), Qatar (0.76 million) and Oman (0.93 million) have the best population allocation per science university. Approximately 50% of these science universities are located in three countries with Turkey (62), Iran (35) and Saudi Arabia (30) registering the most number of scientific universities. Moreover, Algeria, Egypt,

Iran, Morocco, Saudi Arabia and Turkey have a higher population per science university rate than the MENA average, with the rest of the MENA countries greatly falling below.

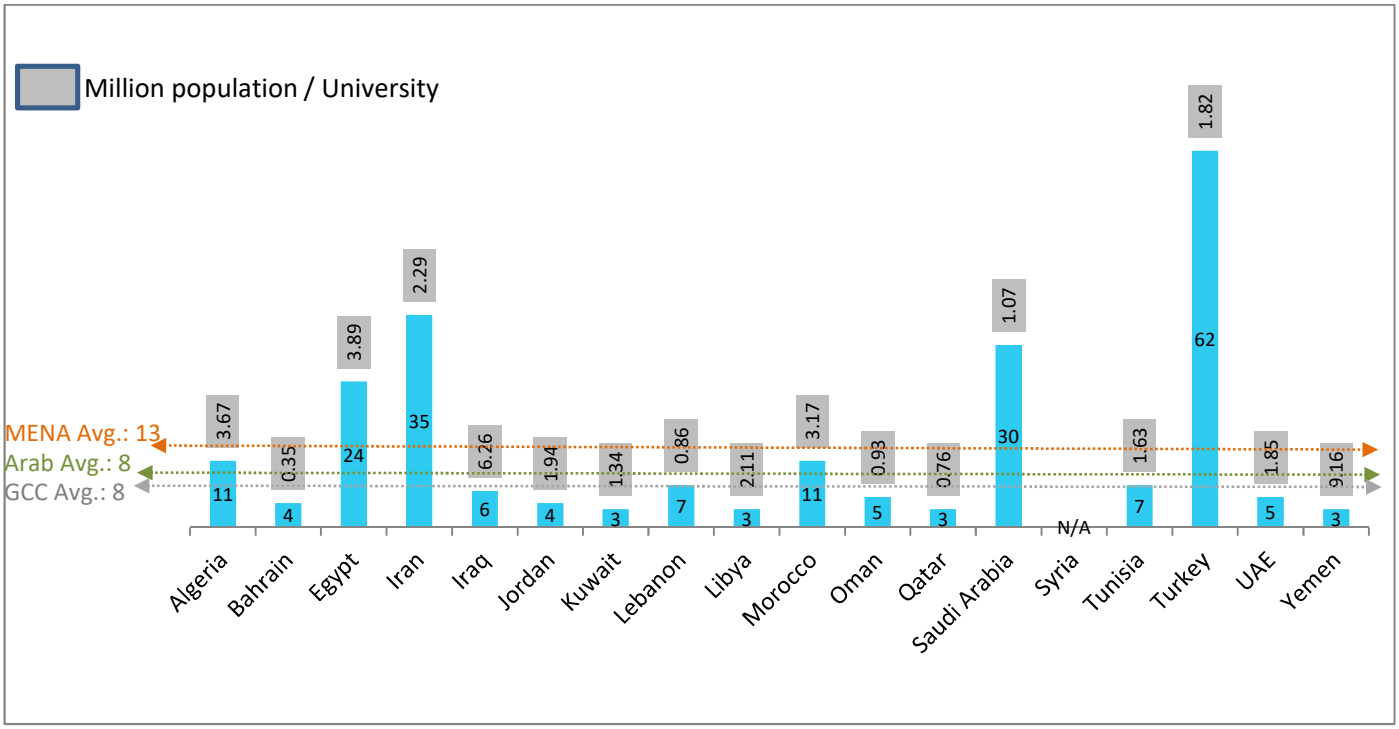

Chart-3, Source: Nature Index, QS ranking.

Tertiary Education Graduates

There are approximately three million tertiary educated (university) graduates matriculating out of the MENA region each year across all fields of study, which represents 0.6% of the total population, a population that is heavily youthful and is considered by many to be the youngest population in the world.

Young men and women in the MENA region are facing the highest youth unemployment levels in the world and express lower levels of trust in government than their parents. Since young people 15-29 years old exceed 30% of the working-age population in most MENA countries, governments urgently need to develop and implement strategies focused on fully engaging youth in the economy, society and scientific thought leadership.

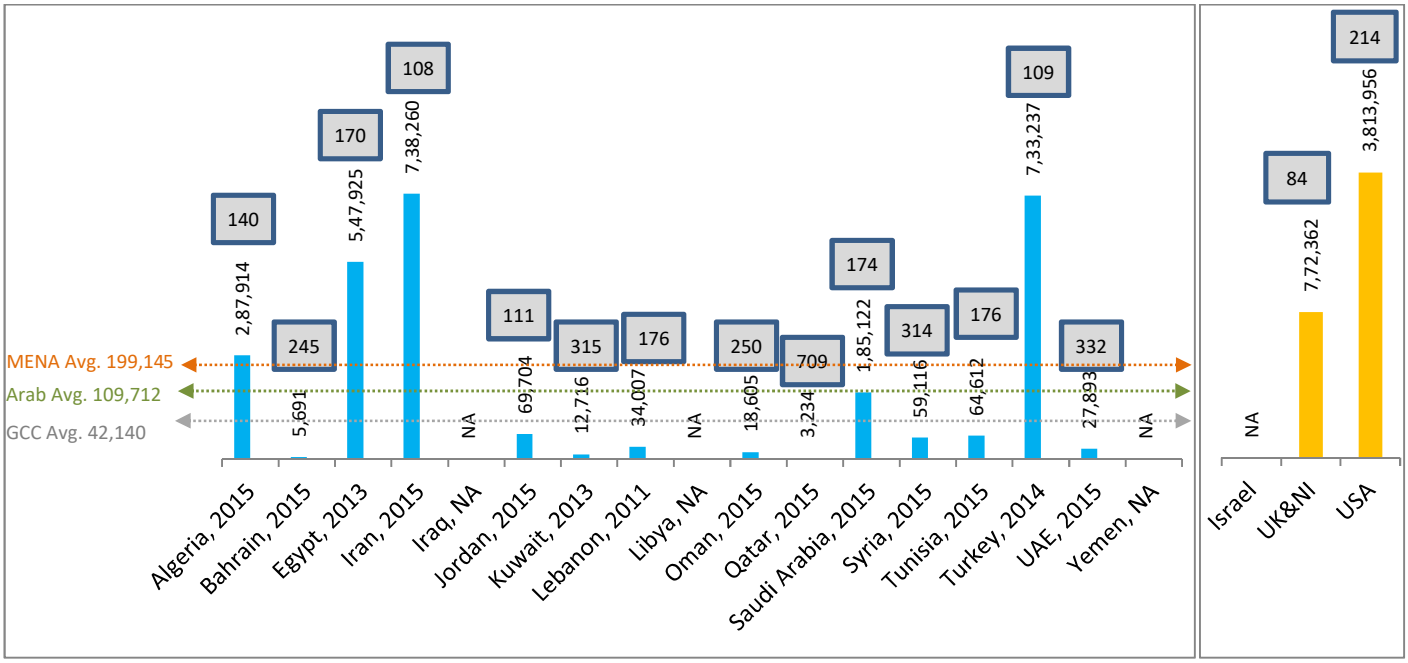

Chart-4, Source: UNESCO Statistics, NA-Data Not Available

On average, the total annual MENA tertiary graduation output is calculated as 199,145 (Refer; Chart-4) number of university graduates per country (across all fields of study). Qatar produces the smallest total number of graduates (3,234) whereas Iran produces the highest number of graduates (738,260). Furthermore, the calculated average for population per graduates for MENA with 163 peoples per graduate. This means that out of every 163 people in MENA, only one is a university graduate. Both Iran (108) and Turkey (109), although lower than the UK (84) are higher than the USA (214). Unfortunately all GCC countries (except KSA-174) produce less university graduates per capita higher than the US and UK.

Graduates from International Standard Classification of Education (ISCED) 8 Programmes in Tertiary Education

According to KLSC calculations, the MENA region producues ~22,000 ISCED graduates annually. Egypt, Iran and Turkey account for over 3/4 of these graudates. The MENA average for ISCED graduates is 1,371 per country (Refer:Chart-5) and when totalled (21,940), represents less than the total number of ISCED graduated in the UK and less than 1/3 the total number of ISCED graduates from the USA.

The ISCED classification was adopted by the UNESCO General Conference at its 36th session in November 2011. Initially developed by UNESCO in the 1970s, and first revised in 1997, the ISCED classification serves as an instrument to compile and present education statistics both nationally and internationally. The framework is occasionally updated in order to better capture new developments in education systems worldwide.

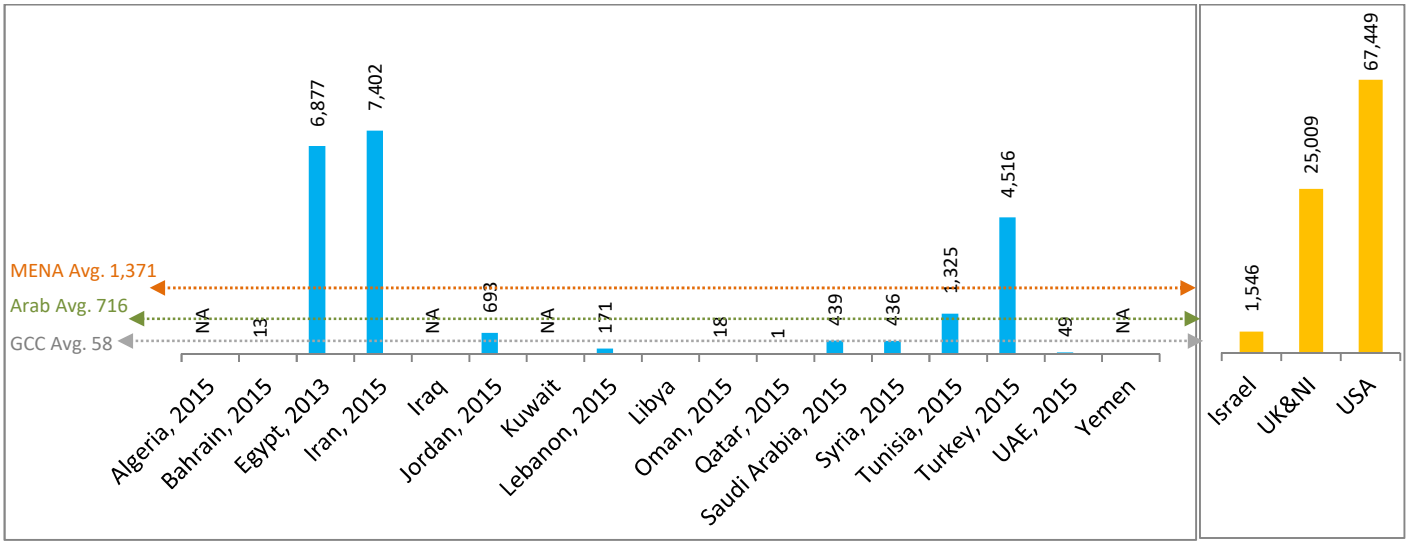

Chart-5, Source: UNESCO Statistics, NA-Data Not Available

Tertiary Education Enrollment (TEE) Rate-Ranking

When it comes to the region's global ranking vis- à -vis Tertiary Education Enrollment (TEE) data [4], the average ranking of MENA is 74 out of 138 (Refer; Chart-6). Turkey (17th), Iran (33rd), and Saudi Arabia (44th) are the highest ranked MENA countries in terms of the number of students enrolled in tertiary education. All MENA countries, with the exception of Turkey, rank below Israel with the vast majority (10/18) ranking in the bottom half globally and a further five ranking in the bottom third of the world. Furthermore, the Arab average is half that of Israel and the total number of GCC TEE (520) is still below all other Middle Eastern countries with the exception of Lebanon and those without any data.

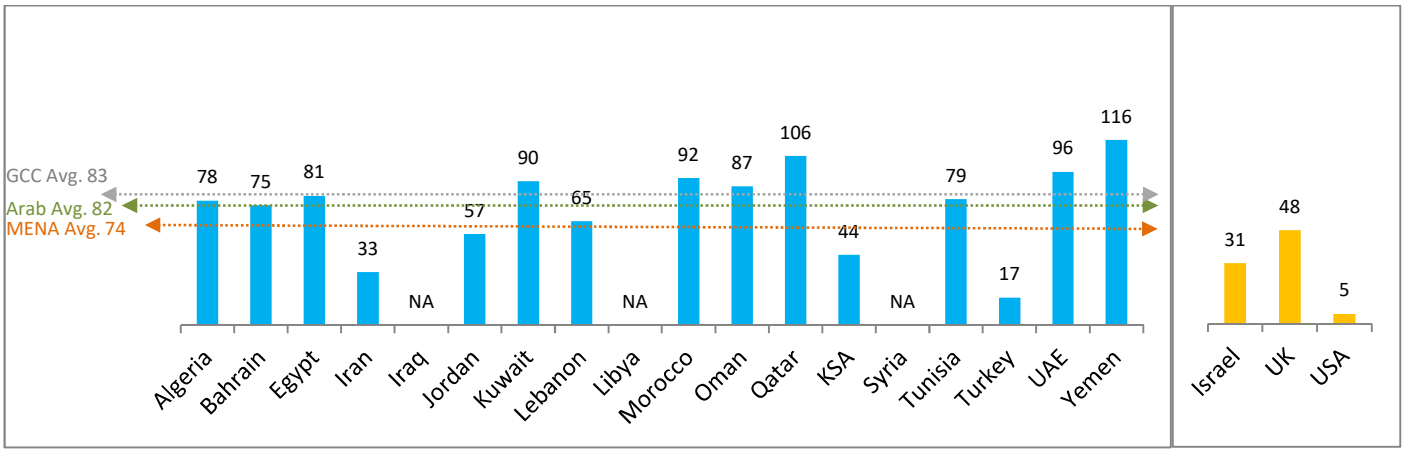

Chart-6, Source: WEF Report-2016, NA-Data Not Available

University-Industry Collaboration in R&D - Ranking

The global ranking of University-Industry Collaboration in R&D shows the average ranking of MENA to be 78 out of 138 (Refer:Chart-7.0). Qatar (10th), the UAE (25th) and Jordan (38th) are the highest ranked MENA countries. Unfortunately once again the vast majority of countries (10/18) ranked within the bottom third of the world with a further seven ranking within the bottom 15% globally.

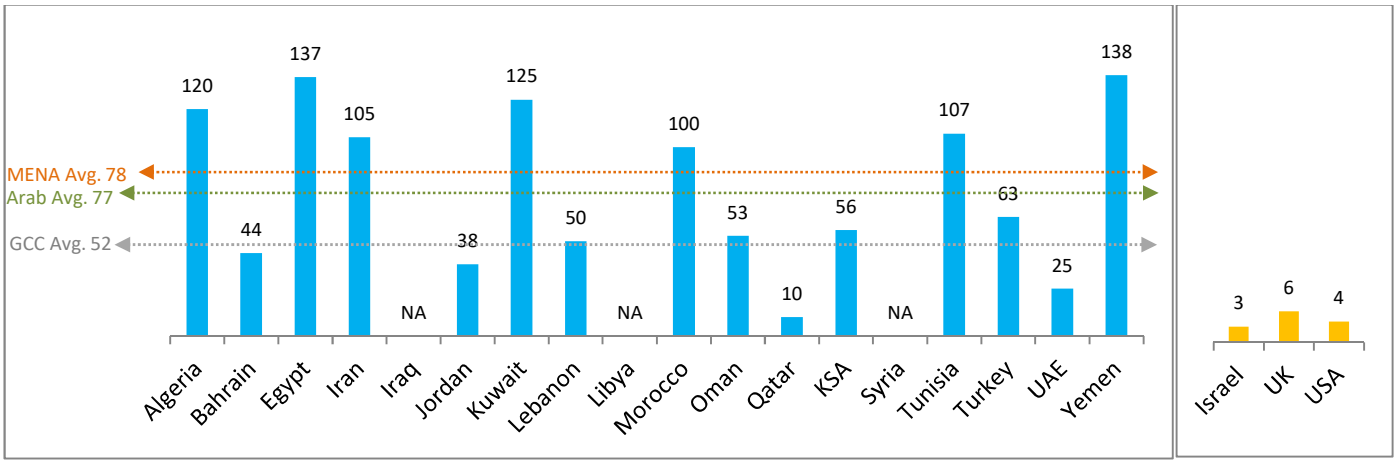

Chart-7, Source: WEF Report-2016, NA-Data Not Available

Quality of Math and Science Education - Ranking

The global ranking of Quality of Math and Science Education shows the average ranking of MENA to be 68 out of 138 (Refer:Chart-8.0). Qatar (5th), Lebanon (6th) and UAE (10th) are the highest ranked countries in MENA as well as world. With the exception of Qatar, Lebanon the UAE and Bahrain, all MENA countries rank lower than Israel, UK and USA with the vast majority (9/18) ranking in the bottom half globally and a further five ranking in the bottom third of the world.

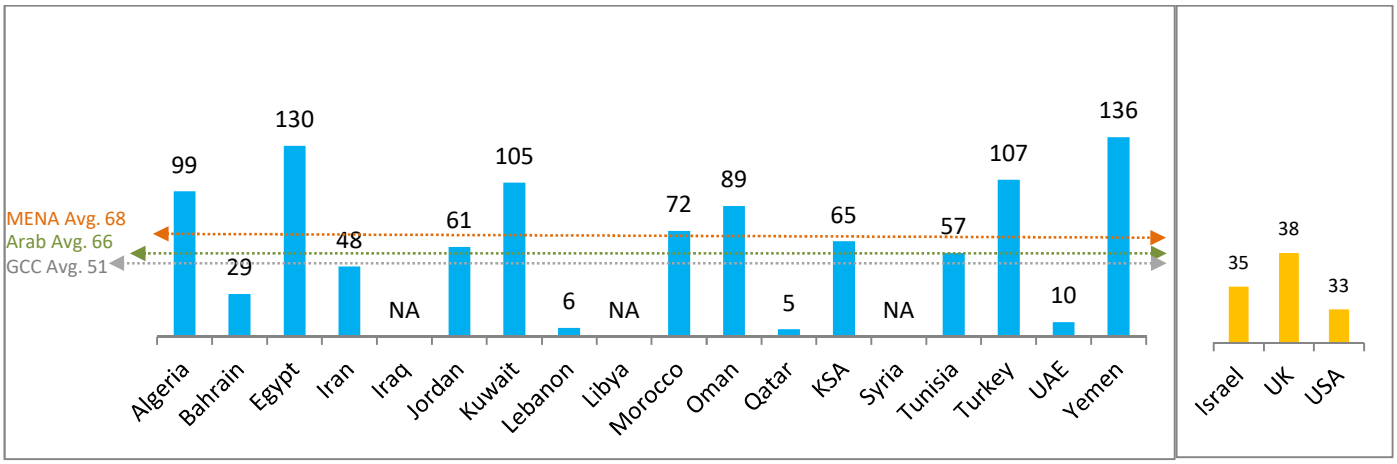

Chart-8, Source: WEF Report-2016, NA-Data Not Available

Higher Education and Training - Ranking

The global ranking of Higher Education and Training shows the average ranking of MENA to be 77 out of 138 (Refer: Chart-9). The average ranking for MENA region is performs slightly better than the Arab average (80) however the GCC average is significantly better (61). Qatar (30th), UAE (34th) and Bahrain (44th) are highest ranking MENA countries. Once again, all countries in MENA region rank below Israel the UK and the USA, with 7 out of 18 countries ranked bottom third of world.

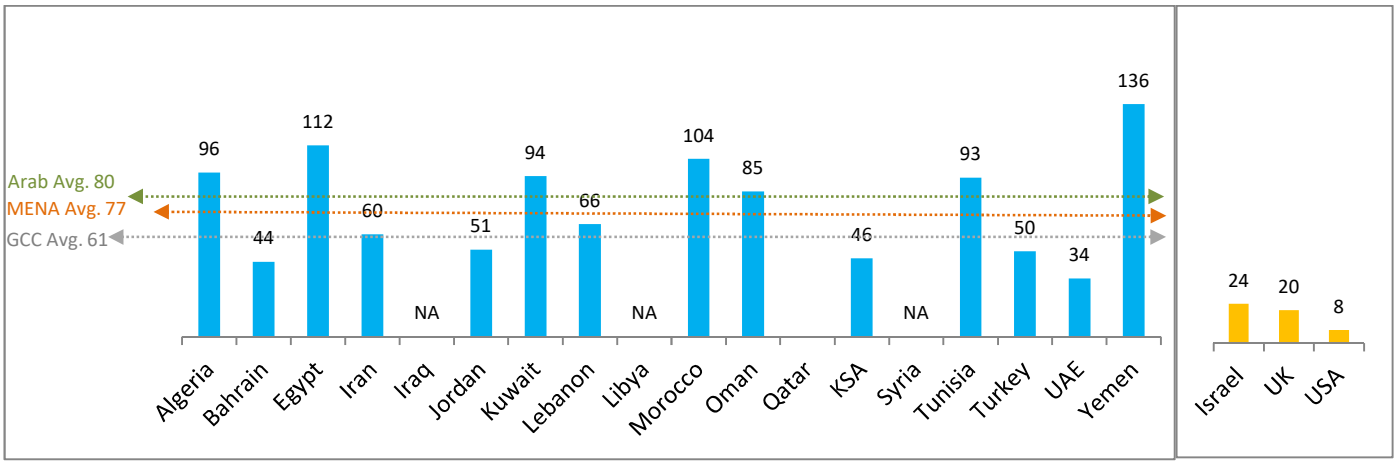

Chart-9, Source: WEF Report-2016, NA-Data Not Available

Section III: The Arab Science Spring – Science and Technology Innovation (STI) in MENA

Scientific and technological innovation is considered by many as the transformation of an idea into a new or improved product that is subsequently introduced into the market, into a new or improved operational process used in industry and commerce, or into a new approach to a social service. The word "innovation" can have different meanings in different contexts and the one chosen will depend on the particular objectives of measurement or analysis. For the purposes of this report, we define innovation as:

"Any new scientific ideation and/or implemented engineering excellence that empowers the application of novel solutions that either meets new requirements, unarticulated needs, or existing market needs in a more efficient manor thus creating added value for society."

Unlike most regions of the developed world, the MENA region is rich in both human and natural resources. However, what many of its countries lack is a powerful, poignant and precise cultural and scientific transformation to reach worldwide recognition in education, research and economic productivity. Thankfully, there are several vanguard institutions leading the charge towards creating a positive impact, kindling hope for a successful 'science spring' [5] (for more information on these institutions see Sections VII and VIII)

The MENA region must continue to spearhead a strategy to harness science, technology and innovation for both economic and social development by improving science education, upgrading and reforming universities, building research capacity and encouraging international cooperation [6] and collaboration. A great example is the King Abdullah University of Science and Technology (KAUST), a flagship institution inaugurated during the reign of the late Custodian of the Two Holy Mosques, has helped usher in a fresh era of scientific discovery in the Middle East, thanks in part to its newfangled facilities and generous 20 bn USD endowment, the highest in the region and the sixth highest in the world. Another flattering flagship for the MENA region is Masdar of Abu Dhabi, the region's top oasis of thought leadership in renewable energy, which has attracted powerful partners to the Emirati desert including companies like Credit Suisse and Siemens as cornerstone backers of the US $250 million Masdar Clean Tech Fund. Six leading research institutions, including Imperial College, RWTH Aachen University, DLR (German Aerospace Center), University of Waterloo, Columbia University and the Tokyo Institute of Technology are all part of the Masdar Research Network [7]. The United Arab Emirates is investing heavily in space technologies with 5.4 billion USD [8] committed to sending a UAE Mars Mission by 2021 to coincide with the 50th anniversary of the founding of the UAE. Morocco and Saudi Arabia are investing in

development of solar energy [9]. Egypt, Morocco and Tunisia have initiated wind energy [10]. These are some examples of the rapidly changing context for STI in MENA.

According to most recent World Economic Forum (WEF) report, the MENA average for 'Innovation' ranking is 77 (again out of a total 138) (Refer: Chart-10). Qatar (18th), UAE (25th) and KSA (42nd) are the highest ranking nations in MENA. Unfortunately none of the MENA countries rank above with Israel, the USA and the UK with half of the MENA countries ranking in bottom half globally and further six countries ranking in bottom third of world.

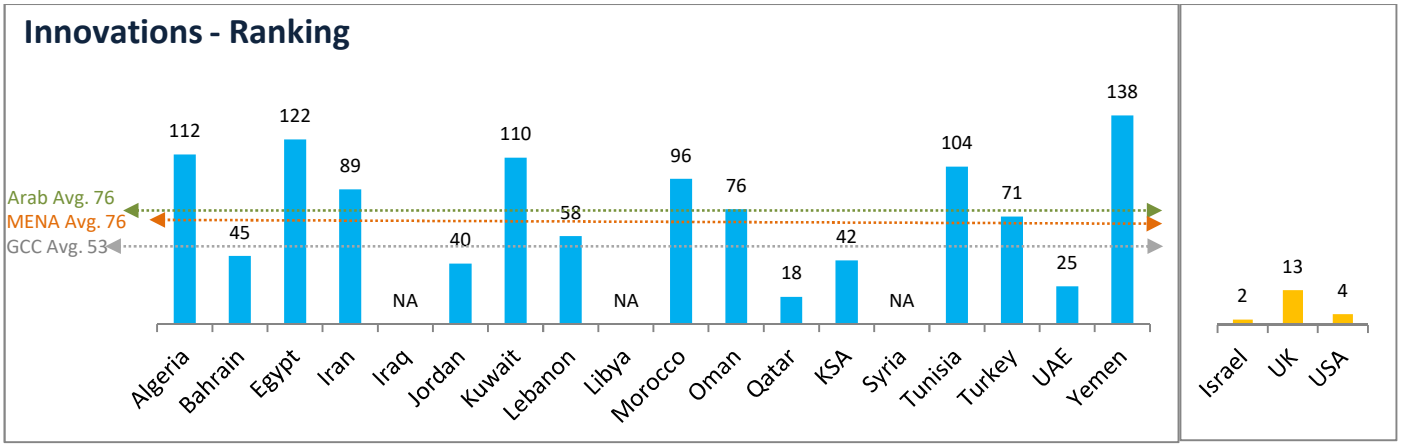

Chart-10, Source: WEF Report-2016, NA-Data Not Available

Innovation Ranking vs. Oil Production Ranking

A crude comparison of global rankings of Oil Production, KSA (2nd globally), Iraq (4th), UAE (8th), Kuwait (9th) are ranked (Refer: Chart-11 and see Appendix) in terms of global crude oil production in 2015 [11]. As the chart below shows, the higher the oil production, typically, the lower the innovation.

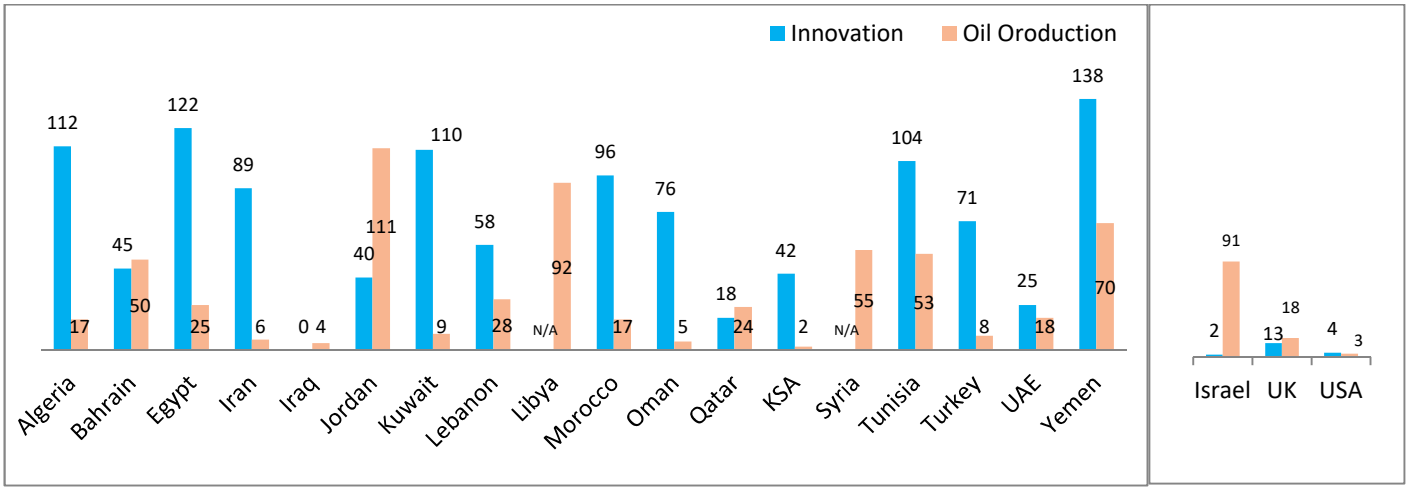

Chart-11, Source: WEF Report-2016, NA-Data Not Available

The MENA STI Strategy

An STI strategy for MENA must focus on improving science education in universities, enhancing scientific research capacity, increasing financial support for research and development and fostering regional and international scientific and educational cooperation.

An online science and technology observatory should be established to monitor the science and technology scene in most of the MENA countries and highlight shortcomings in implementation.

This observatory should include a portal for research, development and innovation activities and projects, a database of technological centers and universities, a directory of MENA scientists, technologists, educationists and policy-makers, science and technology indicators, and information on conferences, symposiums and workshops in the MENA region.

The strategy proposes setting up a network of science centers of excellence in the MENA countries to promote interactive approaches, excellence and innovation.

The network will use selected outstanding technological institutions and research centers associated with universities in MENA region as regional hubs to facilitate cooperation through joint research projects, and to promote high-level training.

The strategy urges MENA countries to increase financial support for research and development from the present 0.3% of gross domestic product to 3%, with the private sector contributing 30% to 40% [12].

This could be made possibly by creating a pan MENA fund for science and technology development, which could be supported by new financial mechanisms such as taxes and customs, according to the aforementioned strategy.

The STI strategy must focus on national and pan-Arab higher education and research initiatives in approximately 13 priority areas including biotechnology, life sciences, nanotechnology, information technology, clean water, food, agriculture technology and fishery, space, energy, desert sciences, the environment, and renewable energy.

The strategy also calls for greater mobility of scientists within the region and cooperation with international science, technology, innovation and higher education organizations.

Geopolitical Events Reshaping Science in MENA

The past five years have witnessed major geopolitical changes with significant implications for science and technology in the Middle East. These include but are certainly not limited to the Arab Spring of 2011; the US nuclear deal with Iran in 2015 [13] and the creation of the Association of Southeast Asian Nations (ASEAN) Economic Community in 2015 [14].

At first sight, many of these developments have little to do with science and technology but their indirect impact has often been significant. In Egypt, for instance, there has been a radical change in STI policy since the Arab Spring. The new government considers the pursuit of the elusive Knowledge Economy as the best way to harness an effective growth engine. The constitution adopted in 2014 mandates the state to allocate 1% of GDP to research and development (R&D) and stipulates that the 'state guarantees the freedom of scientific research and encourages its institutions as a means towards achieving national sovereignty and building a knowledge economy that supports researchers and inventors.' It is a good start, but 1% is nowhere near enough.

In Tunisia, there has been greater academic freedom in the past year and scientists have been developing closer international ties; Libya, on the other hand, is confronted with ongoing militant insurgency, offering little hope of a rapid revival of science and technology. Syria is in the throes of a civil war. Porous political borders resulting from the political upheaval of the Arab Spring.

Environmental Crises Raising Expectations of Science

Environmental crises, whether natural or human-made, have also influenced STI policy and governance in the past five years. The shockwaves from the Fukushima nuclear disaster in March 2011 carried far beyond Japan's shores. The disaster prompted Germany to commit to phasing out nuclear energy by 2020 and fostered debate in other countries on the risks of nuclear energy. All GCC countries have indefinitely mothballed their sojourned attempts at developing the so-called 'nuclear program for peaceful purposes.'

Public Research Budgets: A Converging, Yet Contrasting Picture

The past five years have seen a converging trend: disengagement in R&D by the public sector in many high-income countries (Australia, Canada, USA, etc.) and a growing investment in R&D on the part of lower income countries. There is a growing recognition in the MENA region and beyond that the development of modern infrastructure (hospitals, roads, railways, etc.) and the achievement of economic diversification and industrialization will necessitate a first step towards greater investment in STI, including the constitution of a critical mass of skilled workers.

Section IV: Gross Domestic Expenditure on R&D (GERD)

Geographically, the distribution of investment in knowledge across the world and especially within the Middle East remains unequal. The North America region still dominates globally, with 28.4% of world investment in R&D, in which USA alone consist 26.4%. China has recently moved into second place with 20.4% on the heels of its impressive economic miracle or perhaps vice versa, ahead of a pre-exit EU (19%) and (a shrinking in terms of overall population) Japan (10%). The rest of the world represents 67% of the global population but just a mere 23% of global investment in R&D, of this the MENA region represents 2.30% [15] GERD encompasses both public and private investment in R&D.

The share of GERD performed by the business enterprise sector (BERD) tends to be higher in economies with a greater focus on technology-based competitiveness in manufacturing, as reflected in their higher BERD/GDP ratio. Among the larger economies for which adequate primary and secondary data sources are readily available, the BERD/GDP intensity has risen noticeably in only a handful of countries including the Republic of Korea and China and, to a lesser extent, in Germany, the USA, Turkey and Poland. At best, it has remained stable in Japan and the UK and receded in Canada and South Africa while almost practically non-existent across the MENA region.

In 2013, world GERD amounted to Purchasing Power Parity (PPP) $1,478 billion, compared to only PPP $1,132 billion in 2007. This was less than the 47% increase recorded over the previous period (2002–2007) but it is a significant increase nevertheless. Moreover, this rise took place during a time of a global economic crisis in a post Lehman brother's world. As GERD increased much faster than global GDP, this perhaps in turn caused global R&D strength to climb from 1.57% (2007) to 1.70% (2013) of GDP [16].

Unfortunately, GERD has remained low in most of the MENA countries, especially in the oil-rich economies where high GDP makes it hard to increase GERD from a mathematical perspective, not to mention the willingness of both local governments and private national champions to invest heavily in R&D.

The average GERD/GDP of MENA region is 0.3% (Refer: Chart-12). The average for Arab (0.27%) region is below than MENA and above then GCC (0.25%).) Turkey (1.01%), Morocco (0.71%) and UAE (0.70) are highest GERD as percentage countries in MENA region. Unfortunately all the MENA countries GERD/GDP below than Israel (4.11%) and UK (1.70%).

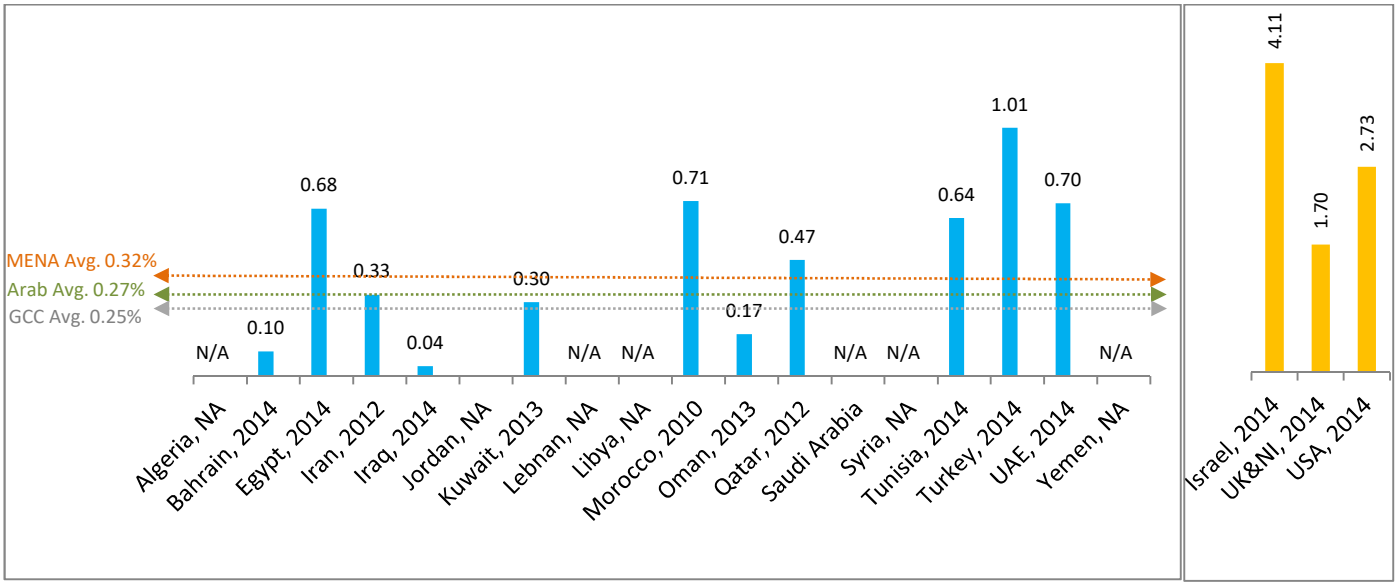

Chart-12, Source: UNESCO Statistics, NA-Data Not Available

Quality of Scientific Research Institutions - Ranking

According to the most recent WEF report, Global Ranking for Quality of Scientific Research, the average ranking of MENA is 86 out of 138 (Refer; Chart-13). Qatar (14th), UAE (27th) and Jordan (57th) are the highest ranking countries in MENA region in terms of quality of scientific research institutions. But yet again, all of the MENA countries rank below Israel (3rd), the UK (2nd) and the USA (5th) with vast majority of countries (11/18) ranking in bottom half globally, and a further nine countries ranking in bottom third of the world. The average ranking for MENA and Arab countries were similar (86th) with the GCC average (64th) only slightly better.

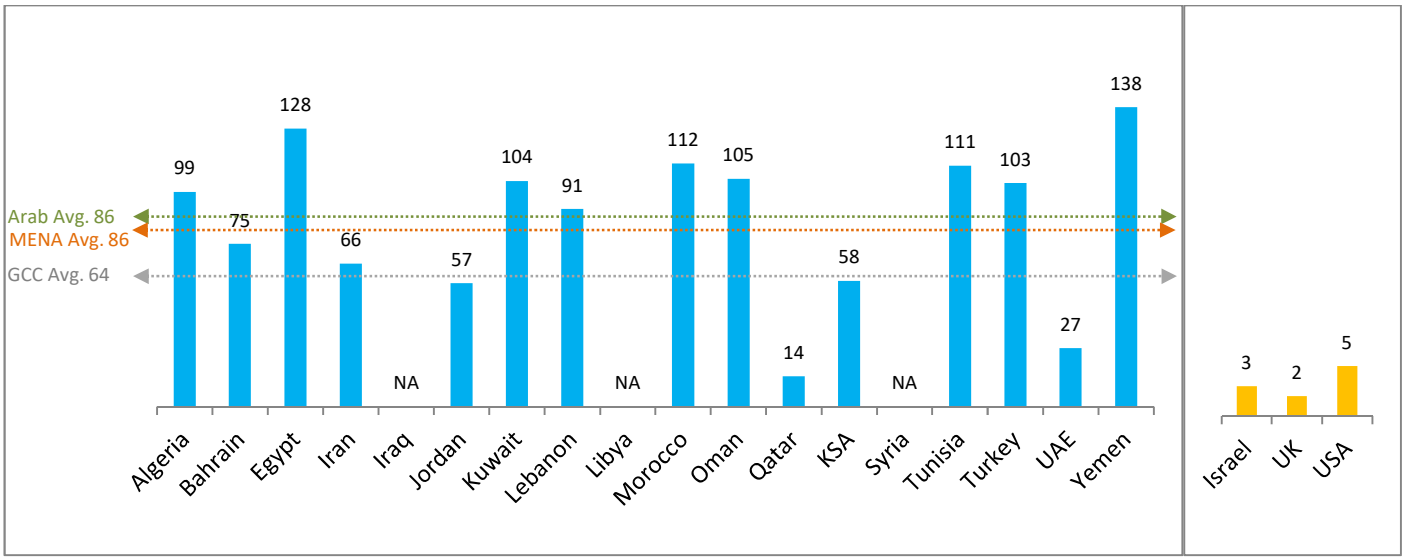

Chart-13, Source: WEF Report-2016, NA-Data Not Available

Corporate Spending on R&D - Ranking

The global ranking for corporate spending on R&D according to the most recent WEF report indicates that the average ranking of MENA is 82 out of 138 (Refer; Chart-14). Qatar (11th), UAE (22nd) and KSA (48th) are the highest ranking countries in MENA region in terms of corporate spending on R&D. All countries in MENA region except Qatar (11th), rank below the UK (17th), Israel (3rd) and the USA (2nd) with most of the countries (10/18) ranking in bottom half globally and a further six countries ranking in bottom third of the world.

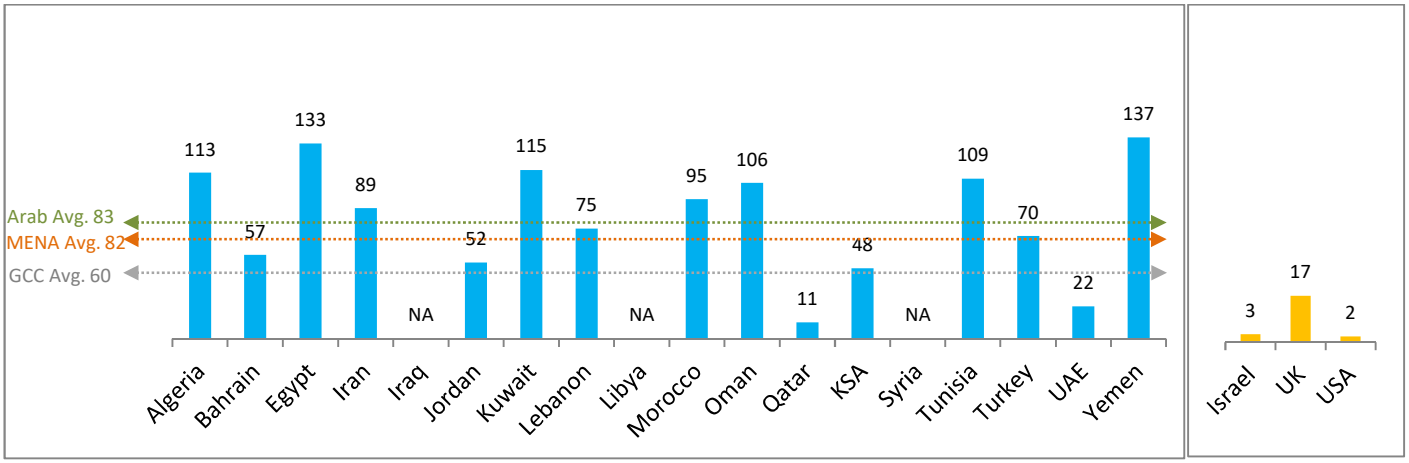

Chart-14, Source: WEF Report-2016, NA-Data Not Available

Trends in Human Capital & Research

The global human capital and research ranking is based on key indicators (Refer: Table-3) such as education, tertiary education and research & development [17].

MENA Human Capital and Research Index-2016	Country Name	Algeria	Bahrain	Egypt	Iran	Iraq	Jordan	Kuwait	Lebanon	Libya	Morocco	Oman	Qatar	Saudi Arabia	Syria	Tunisia	Turkey	United Arab Emirates	Yemen	Israel	United Kingdom	United States of America
Indicator Ranking																						
Human capital and research		79	68	82	48	n/a	86	72	76	129	61	52	59	32	n/a	45	43	41	111	16	7	14
Education		60	80	56	89	n/a	109	72	107	n/a	64	92	98	49	n/a	55	57	76	106	45	28	39
Expenditure on education		73	106	85	98	n/a	n/a	86	108	n/a	40	76	91	45	n/a	23	103	n/a	65	33	31	43
Govemment expenditure on education per pupil, secondary		n/a	n/a	n/a	74	n/a	85	48	109	n/a	10	55	98	66	n/a	35	n/a	65	95	79	47	44
School life expectancy		56	n/a	72	52	n/a	80	75	86	n/a	89	64	73	29	n/a	53	24	n/a	108	31	10	20
Assessment in reading, mathematics, and science		n/a	n/a	n/a	n/a	n/a	54	n/a	n/a	n/a	n/a	n/a	60	n/a	n/a	56	40	38	n/a	36	17	25
Pupil-teacher ratio, secondary		n/a	26	43	76	n/a	n/a	9	10	n/a	n/a	n/a	29	34	n/a	54	84	52	72	24	71	62
Tertiary education		64	34	103	4	n/a	57	37	38	n/a	36	5	13	28	n/a	14	49	20	106	73	6	50
Tertiary enrolment		73	70	77	31	n/a	55	84	60	n/a	85	81	97	41	n/a	74	16	89	106	29	45	5
Graduates in science and engineering		15	59	97	2	n/a	78	20	34	n/a	4	1	16	18	n/a	3	49	51	n/a	n/a	29	85
Tertiary inbound mobility		86	11	69	97	n/a	19	n/a	21	n/a	65	51	1	33	n/a	67	79	1	35	77	6	41
Research and development (R&D)		115	67	52	63	n/a	64	84	48	115	72	83	71	33	n/a	66	38	37	115	3	10	5
Researchers		n/a	n/a	54	53	n/a	n/a	79	n/a	n/a	48	80	57	n/a	n/a	42	45	n/a	n/a	1	17	21
Gross expenditure on R&D (GERD)		n/a	n/a	51	74	n/a	65	77	n/a	n/a	47	93	63	106	n/a	50	35	48	n/a	2	21	10
Global R&D companies, average expenditure top 3		45	45	45	45	n/a	45	45	45	n/a	45	45	45	25	n/a	45	36	41	45	19	7	2
QS university ranking average score top 3 universities		73	59	46	54	n/a	58	68	44	73	73	62	61	30	n/a	73	39	40	73	22	2	1

Table-3, Source: GII Report-2016, n/a-Data Not Available

The average ranking of human capital & research for MENA is 77 out of 130 (Refer: Chart-15). Saudi Arabia (32nd), the UAE (41st) and Turkey (43rd) are the highest ranking countries in MENA region. Once again, all MENA countries rank below best practices with the vast majority of countries (9/18) ranking in bottom half globally.

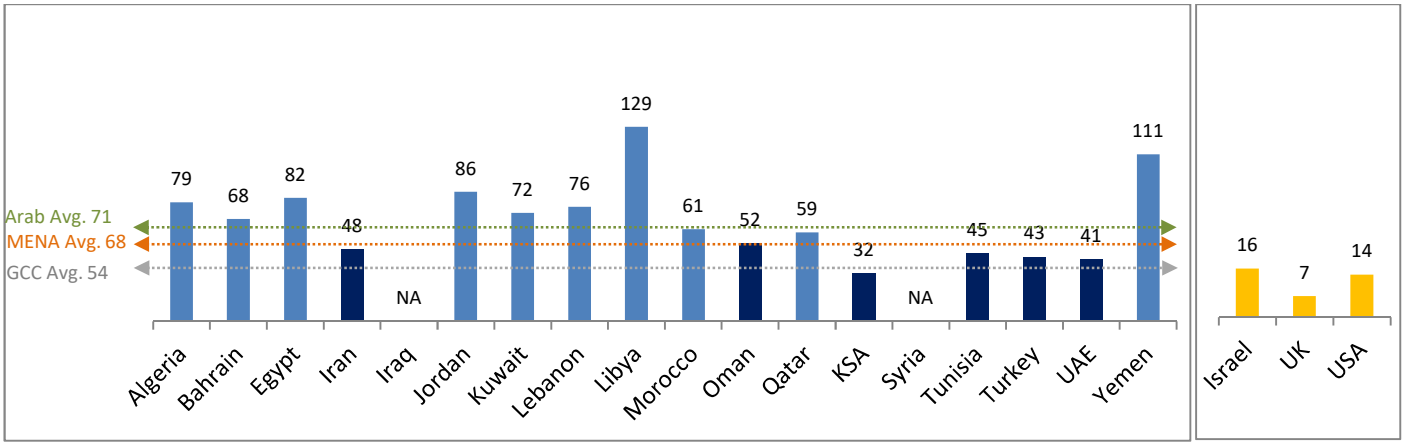

Chart-15, Source: GII Report-2016, NA-Data Not Available

Trends in Business Sophistication

The business sophistication ranking is based on indicators (Refer: Table-4) such as knowledge workers, innovation linkage and knowledge absorption.

MENA Business Sophistication Index-2016	Country Name	Algeria	Bahrain	Egypt	Iran	Iraq	Jordan	Kuwait	Lebanon	Libya	Morocco	Oman	Qatar	Saudi Arabia	Syria	Tunisia	Turkey	United Arab Emirates	Yemen	Israel	United Kingdom	United States of America
Indicator Ranking																						
Business sophistication		118	59	122	111	n/a	116	127	63	127	125	124	78	66	n/a	107	86	24	128	6	14	11
Knowledge workers		112	n/a	109	102	n/a	127	126	55	n/a	113	117	110	73	n/a	85	83	25	119	18	16	10
Employment in knowledge-intensive services		79	n/a	31	81	n/a	n/a	n/a	44	n/a	98	n/a	75	48	n/a	67	71	32	n/a	7	8	26
Firms offering formal training		85	n/a	92	n/a	n/a	94	n/a	65	n/a	66	n/a	n/a	n/a	n/a	60	61	n/a	88	82	n/a	n/a
GERD performed by business enterprise		n/a	n/a	64	61	n/a	n/a	n/a	n/a	n/a	49	71	59	n/a	n/a	n/a	36	33	n/a	1	20	10
GERD financed by business enterprise		n/a	n/a	73	49	n/a	n/a	85	n/a	n/a	52	58	60	n/a	n/a	65	20	4	n/a	43	25	9
Females employed with advanced degrees		79	n/a	77	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	78	76	n/a	n/a	72	n/a	n/a	3	18	n/a
Innovation linkages		92	15	105	65	n/a	48	94	76	122	118	80	32	35	n/a	110	93	5	128	3	8	19
University/industry research collaboration		122	84	120	94	n/a	51	98	108	124	90	67	8	37	n/a	107	59	21	n/a	7	4	2
State of cluster development		99	26	31	76	n/a	30	57	65	124	86	74	8	20	n/a	91	50	1	n/a	29	7	2
GERD financed by abroad		n/a	n/a	98	n/a	n/a	n/a	86	n/a	n/a	81	99	77	n/a	n/a	71	87	n/a	n/a	5	24	70
Joint venture/strategic alliance deals		n/a	3	27	n/a	n/a	36	15	38	n/a	71	10	8	26	n/a	n/a	56	9	n/a	22	11	17
Patent families filed in at least two offices		110	82	100	113	n/a	67	99	74	n/a	102	108	54	59	n/a	107	39	68	105	8	16	13
Knowledge absorption		104	112	118	125	n/a	57	126	71	n/a	120	123	73	102	n/a	103	72	85	128	16	33	12
Intellectual property payments		76	n/a	63	86	n/a	n/a	n/a	88	n/a	82	n/a	n/a	n/a	n/a	104	72	n/a	106	53	27	12
High-tech imports		43	97	67	109	n/a	94	105	110	n/a	n/a	116	118	78	n/a	55	49	89	103	33	23	9
ICT services imports		108	111	82	85	n/a	n/a	100	27	n/a	93	116	10	77	n/a	102	118	n/a	107	52	33	44
Foreign direct investment, net inflows		108	61	85	115	n/a	30	117	21	n/a	52	100	114	98	n/a	78	89	67	126	72	92	104
Research talent in business enterprise		n/a	n/a	71	60	n/a	n/a	n/a	n/a	n/a	67	56	46	n/a	n/a	n/a	26	n/a	n/a	1	33	5

Table-4, Source: GII Report-2016, n/a-Data Not Available

The average ranking of business sophistication for MENA is 99 out of 130 (Refer: Chart-16), UAE (24th), Bahrain (59th) and Lebanon (63rd) are highest ranking countries in MENA region. All of the MENA countries rank below Israel (6th) and UK (14th) with vast majority of countries (12/18) ranking in bottom half globally and further ten countries ranking bottom third of world. In terms of regional average ranking, GCC (80th) ranked highest than Arab and MENA (99tth).

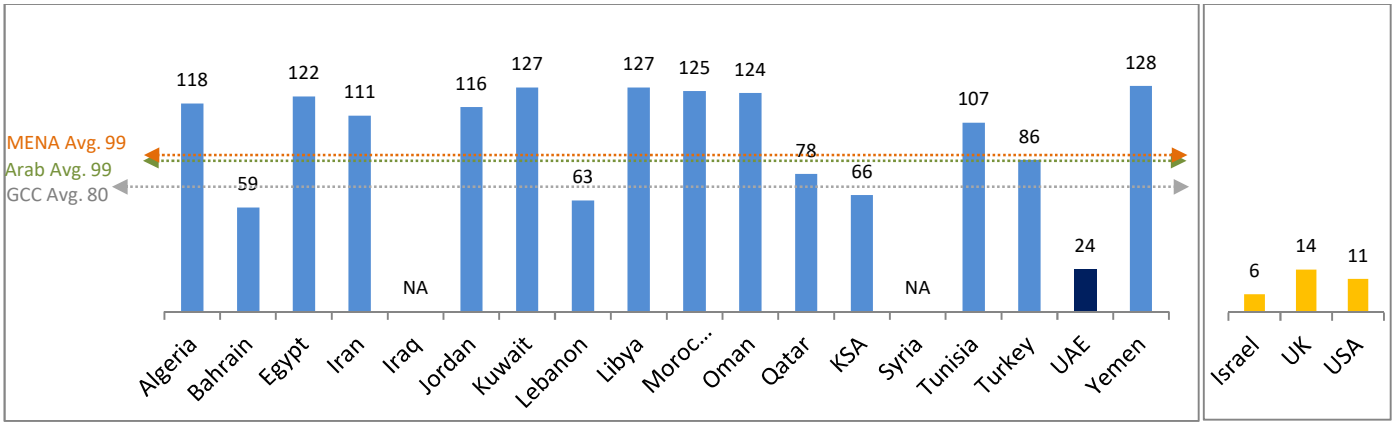

Chart-16, Source: GII Report-2016, NA-Data Not Available

Trends in Knowledge and Technology Output

The knowledge and technology outputs ranking is based on indicators (Refer: Table-5) such as knowledge creation and knowledge diffusion.

MENA Knowledge and Technology Outout Index-2016	Country Name	Algeria	Bahrain	Egypt	Iran	Iraq	Jordan	Kuwait	Lebanon	Libya	Morocco	Oman	Qatar	Saudi Arabia	Syria	Tunisia	Turkey	United Arab Emirates	Yemen	Israel	United Kingdom	United States of America
Indicator Ranking																						
Knowledge and technology outputs		100	61	94	65	n/a	79	51	74	129	72	95	88	75	n/a	89	45	86	124	12	9	4
Knowledge creation		104	124	70	26	n/a	60	107	55	n/a	78	113	108	66	n/a	56	35	102	127	10	9	5
Patent applications by origin		94	102	68	14	n/a	75	118	n/a	n/a	58	119	116	70	n/a	61	33	108	88	29	16	6
PCT international applications by origin		91	64	74	n/a	n/a	n/a	n/a	n/a	n/a	57	88	73	n/a	n/a	69	30	58	n/a	7	18	14
Utility model applications by origin		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	11	n/a	62	n/a	n/a	n/a
Scientific and technical publications		101	116	66	37	n/a	48	115	53	n/a	85	104	94	73	n/a	26	44	106	114	10	14	38
Citable documents H index		82	115	48	41	n/a	77	79	65	n/a	68	89	99	51	n/a	73	36	72	119	15	1	1
Knowledge diffusion		120	33	91	127	n/a	64	8	47	129	52	70	44	98	n/a	122	81	53	108	14	34	12
Intellectual property receipts		96	n/a	29	83	n/a	n/a	n/a	59	n/a	91	n/a	n/a	n/a	n/a	49	n/a	n/a	25	22	11	1
High-tech exports		119	93	89	72	n/a	78	117	98	n/a	n/a	76	121	109	n/a	39	62	111	116	16	23	26
ICT services exports		106	20	55	115	n/a	n/a	16	32	n/a	27	114	102	120	n/a	56	116	n/a	19	7	39	71
Foreign direct investment, net outflows		106	17	80	n/a	n/a	85	9	22	n/a	63	35	16	56	n/a	n/a	50	54	n/a	41	116	31

Table-5, Source: GII Report-2016, n/a-Data Not Available

The average ranking of business sophistication for MENA is 83 out of 130 (Refer: Chart-17). The UAE (45th), Kuwait (51st) and Bahrain (61st) are the highest ranking countries in MENA. Again all MENA countries rank below Israel (12th) , the UK (9th) and the USA (4th) with vast majority of countries (13/18) ranking in bottom half globally and further five countries ranking bottom third of world. In terms of regional average ranking, GCC (76th) ranked slightly higher than the Arab average (87th).

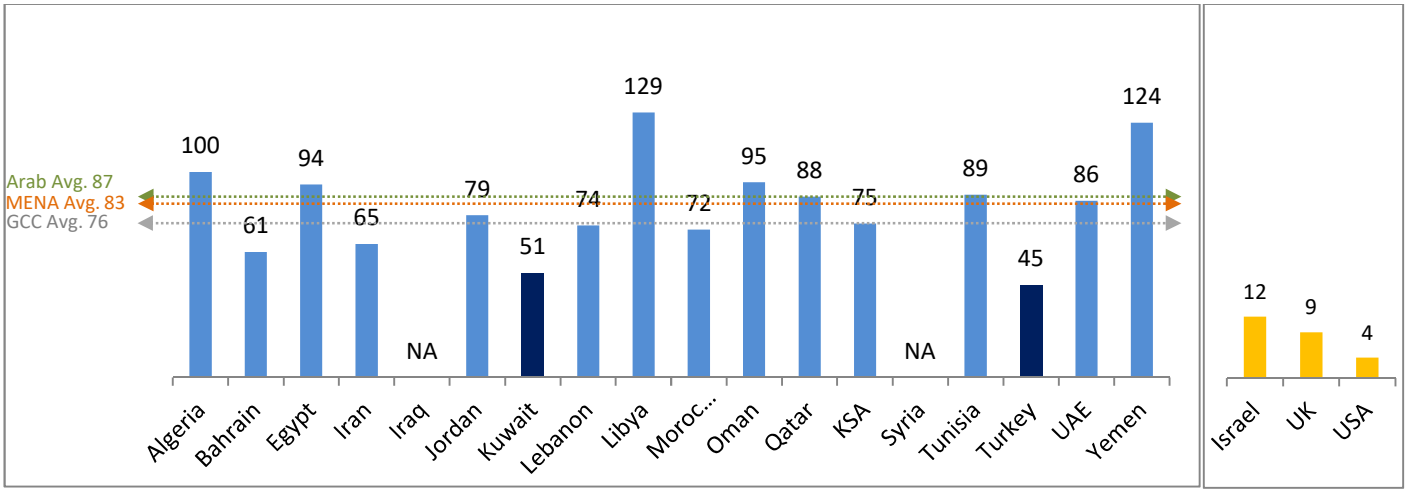

Chart-17, Source: GII Report-2016, NA-Data Not Available

Trends in Creative Output

The creative outputs ranking is based on indicators (Refer: Table-6) such as intangible assets, Trademark application class count by origin and Industrial designs by origin. The average ranking of creative output for MENA is 76 out of 130 (Refer: Chart-18). Turkey (31st), Saudi Arabia (47th) and Qatar (49th) are the highest ranking countries in MENA region. Again, all of the MENA countries rank below Israel (16th), the USA (14th) and the UK (7th) with vast majority of countries (10/18) ranking in bottom half globally and further four countries ranking bottom third of world. In terms of regional average ranking, the GCC (64th) ranked slightly above both the MENA (76th) and Arab (80th) averages.

MENA Creative output Index-2016	Country Name	Algeria	Bahrain	Egypt	Iran	Iraq	Jordan	Kuwait	Lebanon	Libya	Morocco	Oman	Qatar	Saudi Arabia	Syria	Tunisia	Turkey	United Arab Emirates	Yemen	Israel	United Kingdom	United States of America
Indicator Ranking																						
Creative outputs		122	74	97	75	n/a	78	64	51	112	67	79	49	47	n/a	81	31	70	125	26	3	13
Intangible assets		122	91	100	55	n/a	82	50	71	124	36	46	25	31	n/a	85	5	56	125	34	9	45
Trademark application class count by origin		100	103	91	n/a	n/a	64	n/a	n/a	n/a	36	n/a	105	n/a	n/a	n/a	4	96	82	90	42	78
Industrial designs by origin		57	99	n/a	20	n/a	97	n/a	n/a	n/a	8	n/a	n/a	103	n/a	58	1	102	100	n/a	n/a	62

Table-6, Source: GII Report-2016, n/a-Data Not Available

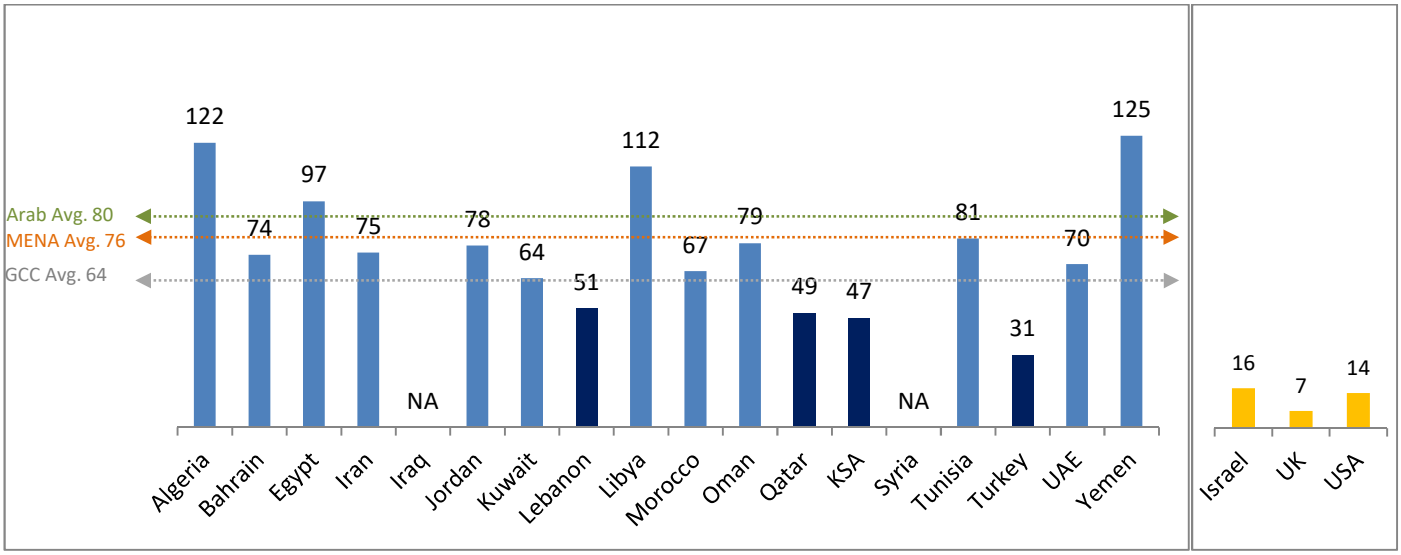

Chart-18, Source: GII Report-2016, NA-Data Not Available

Section V: Research Articles and Journal Publication in MENA

According to the Nature Index [18], the total article/journal publications are 1,486. The average article publication rate per country for MENA is 87 (Refer: Chart-19). KSA (481), Turkey (368), and Iran (180) publish the most articles in MENA region with five MENA countries publishing fewer than 10 internationally renowned 10 articles per year. Israel (1,238) publishes almost as many articles as the entire MENA region combined.

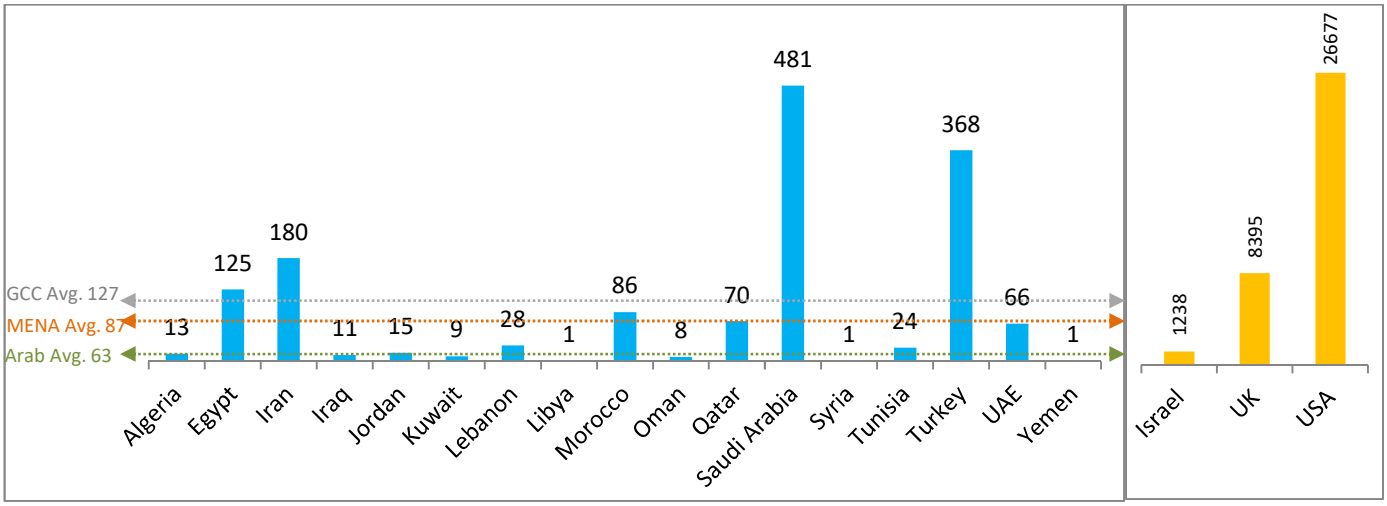

Chart-19, Source: Nature Index-2016

Articles According to Scientific Field

The Middle East produced these ~ 1500 articles (Refer: Chart-20) across different scientific field such as Chemistry, Earth & Environment, Life Sciences and Physical Sciences. Saudi Arabia produced the highest number of articles in Chemistry (242), Life Science (103) and Earth & Environment (19), whereas Turkey produced highest number (261) of articles in Physical Science. Overall MENA produces highest articles in Physical Science (53%), than Chemistry (26%), Life Science (17%) and Earth & Environment (4%).

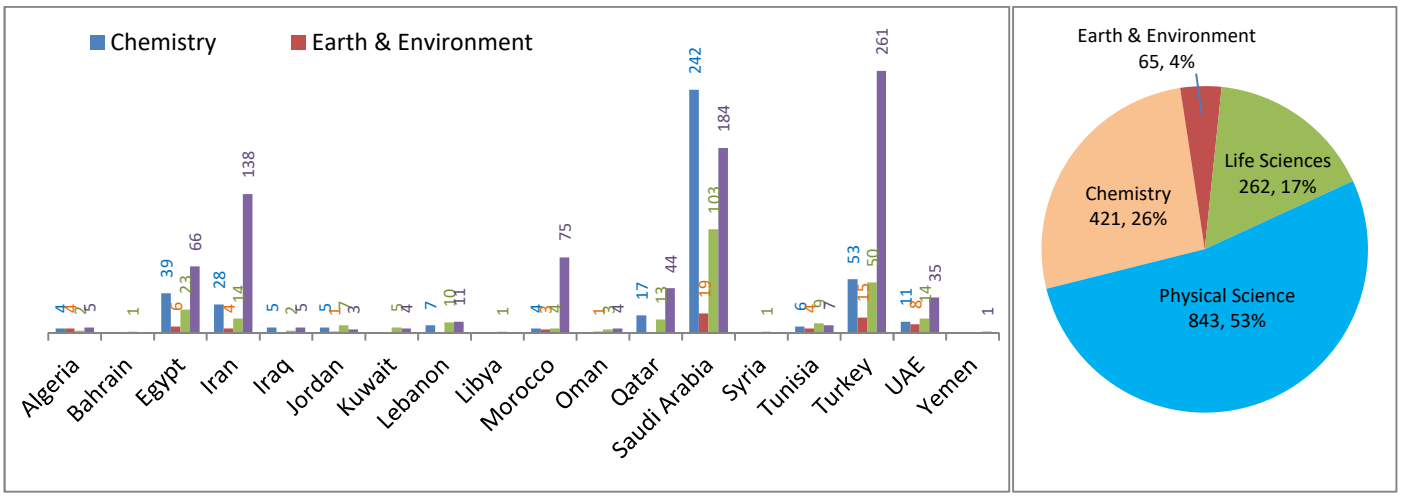

Chart-20., Source: Nature Index-2016

Section VI: Patents

A patent is a set of exclusive rights granted by law to applicants for inventions that are new, non-obvious and commercially applicable. A patent is valid for a limited period of time (generally 20 years), during which patent holders can commercially exploit their inventions on an exclusive basis. In return, applicants are obliged to disclose their inventions to the public in a manner that enables others skilled in the art to replicate the invention. The patent system is designed to encourage innovation by providing innovators with time-limited exclusive legal rights, thus enabling them to appropriate the returns from their innovative activity.

Patents registered in MENA region

The overall patents [19] registered (Refer: Chart-21) in the Middle East is calculated to be 31,037 with a MENA average is 1,724 patents per country. Iran (14,279), Turkey (5,841) and Saudi Arabia (2,436) receive the highest number of patents in the MENA region. With the exception of Iran, all MENA register patents when compared to Israel (6,908), which also receive more than half of the total patents of all Arab countries combined (10,917).

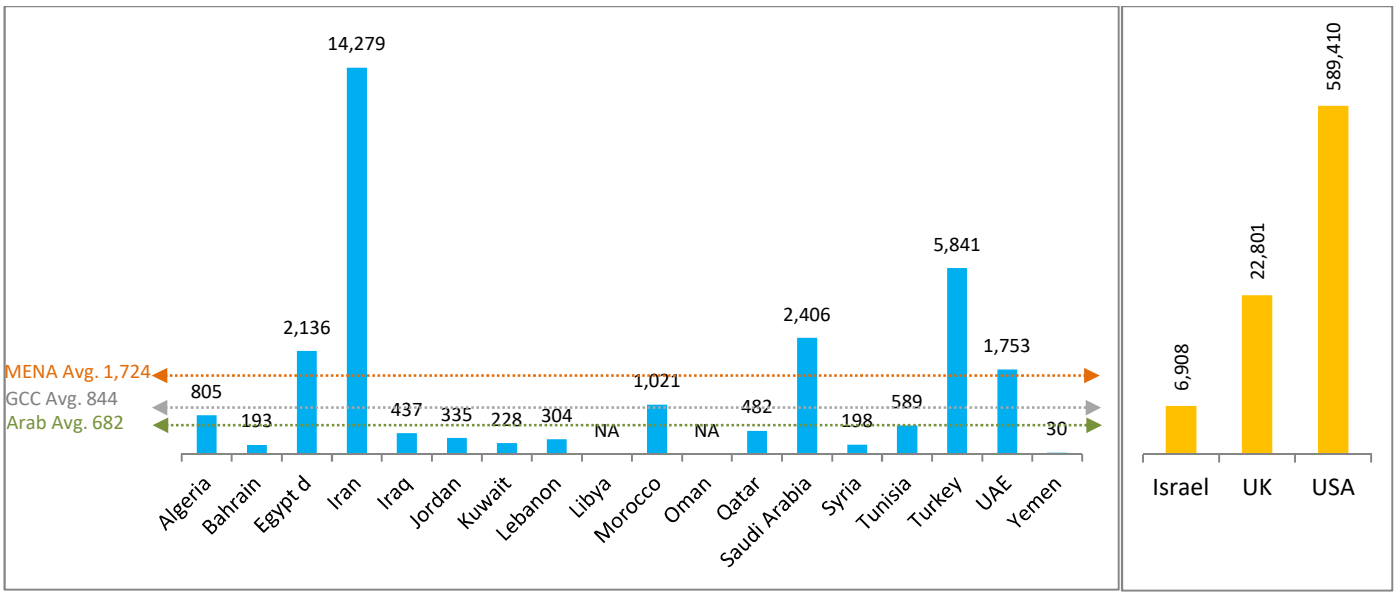

Chart-21, Source: Nature Index-2016

Patent Cooperation Treaty (PCT) international application

A patent application is filed through the WIPO-administered Patent Cooperation Treaty (PCT). It facilitates the acquisition of patent rights in a large number of jurisdictions. The PCT System simplifies the process of multiple national patent filings by reducing the requirement to file a separate application in each jurisdiction. However, the decision whether to grant patent rights remains in the hands of national and regional patent offices, and patent rights remain limited to the jurisdiction of the patent-granting authority. The PCT international application

processes starts with the international phase, are performed, and concludes with the national phase, during which a national or regional patent office decides on the patentability of an invention according to national law. The number of international PCT applications registered in the Middle East is calculated to be 1,585 with a MENA average is 88 patents per country (Refer: Chart-22). Turkey (1,010), Saudi Arabia (276) and UAE (77) have the highest number of PCT application in the region. All of the countries in MENA region have lower number of PCT applications than Israel (1,685), which is more than the entire MENA region and 3X more than all Arab countries combined (504).

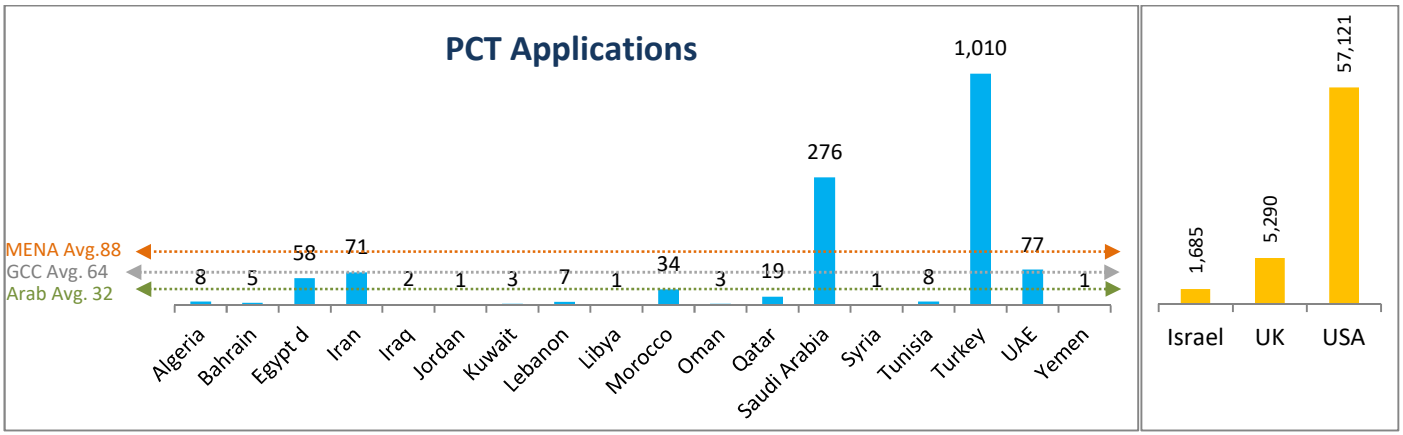

Chart-22, Source: Nature Index-2016

Comparison of Ranking (Oil Production vs. PCT Patents vs. Population)

Similar to oil production vs. innovation, the data also points to a high correlation between high levels of oil production and low levels of PCT patent applications in line with the size of the population.

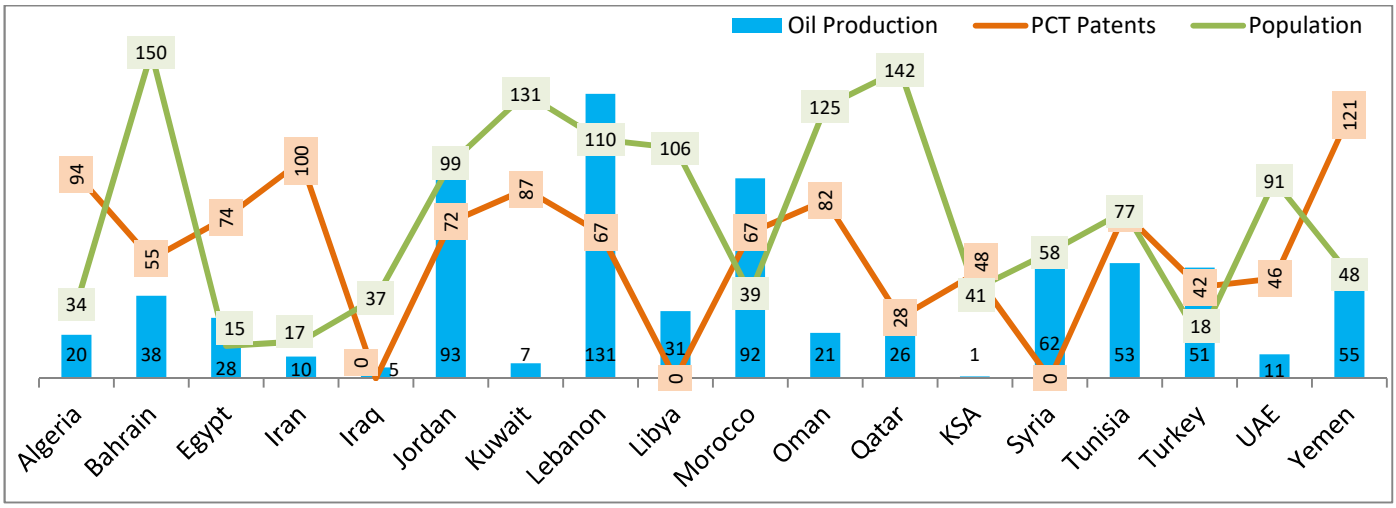

Chart-23, Source: Nature Index-2016, OPEC statistics