The Arab world needs more champions of science and technology, including in the political arena, to bring about the positive change to which the region aspires.

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A computer image of office buildings to be constructed in Dubai layer by layer using three-dimensional (3D) printing technology. The furniture will also be 'printed'. See Box 17.7 for details.

Image: courtesy of Multivu.com

17 · The Arab States

Algeria, Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Palestine, Qatar, Saudi Arabia, Syria, Sudan, Tunisia, United Arab Emirates, Yemen

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INTRODUCTION

The global financial crisis has ricocheted on the region

The Arab world[1] is of strategic importance, owing to its location and wealth of oil and natural gas: 57% of the world's proven oil reserves and 28% of those for gas (AFESD *et al*, 2013).

The tremors of the global financial crises of 2008 and 2009 and the subsequent recession in most developed countries affected Arab states in a variety of ways. The oil-exporting countries of the Gulf Cooperation Council felt such tremors, most being characterized by open financial and commercial systems with high exposure to global financial markets and close association with the global commodity markets (AFESD *et al*, 2010). Not so countries such as Algeria, Libya, Sudan and Yemen, where local capital markets are not directly linked to global markets. However, as their economies also rely on oil revenue, the Brent crude price significantly affects their fiscal policy.

In, Egypt, Jordan, Lebanon, Mauritania, Morocco, Syria and Tunisia, where the banking sector is dependent on national borrowing sources, the economy was not directly affected by fluctuations in global capital markets. Such countries nevertheless felt these external economic shocks through their close association with the markets of developed countries and other major trading partners in the European Union (EU) and USA. Needless to say, their exports depend primarily on demand from the developed countries, in addition to income from tourism, remittances from expatriate workers and foreign direct investment (FDI) flows (AFESD *et al*, 2010).

The inability of most Arab countries since 2008 to address socio-economic needs effectively and ensure that their economies have kept pace with population growth has created widespread frustration. Even before the economic crisis of 2008, unemployment in the Arab world was high,[2] at around 12%. Young job seekers constitute over 40% of the region's unemployed. Today, over 30% of the population of Arab states is aged less than 15 years. As of 2013, most Arab states had achieved a gross tertiary enrolment rate of more than 30% and even above 40% for Jordan, Lebanon, Palestine and Saudi Arabia but they have failed to create the appropriate value chain of job openings required to absorb the spreading pool of graduates.

1. Although members of the League of Arab States, Djibouti and Somalia are profiled in Chapter 19 on East and Central Africa.

2. with a few exceptions, such as Kuwait, Qatar and the United Arab Emirates

The Arab region: from hope to turmoil

The so-called Arab Spring was triggered by demonstrations in Tunisia in December 2010. Popular unrest quickly spread across the region, revealing a common aspiration towards freedom, dignity and justice (ESCWA, 2014a).

Since December 2010, Arab countries have undergone extraordinary transformations, including regime change in Egypt, Libya, Tunisia and Yemen and the descent of Syria into civil war after what began as peaceful protests in the spring of 2011. Despite having elected parliaments, Jordan and Bahrain also witnessed a series of demonstrations in favour of reform in 2011. In Jordan, the protests were essentially directed against the failure of successive governments to address serious economic issues and combat unemployment. In Bahrain, demonstrations were more political in nature and, to some extent, sectarian.

In part, the upheaval in the Arab world was a reaction by technology-savvy young Arabs to decades of political stagnation and the failure of some Arab governments to afford people adequate levels of socio-economic development. Within a couple of years, however, the failure of the Arab Spring to deliver on its promises had left many disillusioned. One of the great beneficiaries of the Arab Spring was the Muslim Brotherhood movement, which won the election in Egypt in mid-2012; barely a year later, President Mohamed Morsi was deposed, following mass popular protests at the Muslim Brotherhood's failure to build a national consensus to address the country's problems. Since 2015, there have been repeated clashes between the government of President Abdel Fattah al-Sissi and the Muslim Brotherhood, which is now considered a terrorist organization by the governments of several Arab and non-Arab countries, including Bahrain, Egypt, the Russian Federation, Saudi Arabia, Syria and the United Arab Emirates. The Egyptian government has, meanwhile, forged ahead with its ambitious expansion of the Suez Canal (Box 17.1) and, in March 2015, organized a major conference in Sharm El-Sheikh on the theme of economic development (see p. 435).

Military spending is eating up resources for development

Military spending in the Middle East increased by 4% in 2013 to an estimated US$ 150 billion. Saudi Arabia's own budget shot up by 14% to US$ 67 billion, allowing it to leapfrog over the UK, Japan and France to become the world's fourth-largest military spender behind the USA, China and the Russian Federation, according to the Stockholm International

Box 17.1: **Upgrading the Suez Canal**

The Suez Canal provides a vital shipping link between Europe and Asia. On 5 August 2014, Egyptian President Abdel Fattah Al-Sissi announced plans for a 'new' Suez Canal that would run in parallel to the current waterway. This was to be the first major expansion of this vital trading route in its 145-year history.

The Egyptian plan to upgrade the Suez Canal could raise its capacity from 49 to 97 passing ships a day by 2023. The current Suez Canal, which connects the Mediterranean with the Red Sea, can mostly only facilitate one-way traffic and is too narrow at some points for vessels to pass one another. The new canal is expected to solve this problem and thereby cut the waiting time for ships from 11 to 3 hours. The area around the canal (76 000 km^2) is being turned into an international industrial and logistics hub. Officials expect the new development to boost annual revenue from the canal, which is operated by the state-owned Suez Canal Authority, from US$ 5 billion at present to US$ 13.5 billion. In October 2014, work began on deepening the Suez Canal.

Some shipping industry executives had expressed doubts as to whether Egypt could obtain sufficient funding to finish the project on schedule. The Egyptian government was adamant that the project would not be dependent on foreign funding. By September 2014, the total amount needed (US$ 8.4 billion) had been raised, according to the Egyptian central bank, through the issuance of 500 million shares reserved for Egyptians. The government inaugurated the new canal on 6 August 2015.

Despite widespread acknowledgment that the project is an economic necessity, some scientists fear that that it could damage the marine ecosystem. A group of 18 scientists from 12 countries published a letter in 2014 in the journal of *Biological Invasions* calling on the Egyptian government to take steps to minimize any ecological damage.

Source: compiled by authors

Peace Research Institute[3] (see also Figure 17.1) However, the largest increase in the region (27%) came from Iraq, which is reconstituting its armed forces.

The escalating pressures on Arab states, particularly those related to security and counterterrorism – including military confrontations with radical groups such as Al Qaida and Da'esh –, have spurred the governments of these countries to increase their own military spending.

Still a long way to go to improve governance

There is little doubt that corruption has played a pivotal role in the outbreak of turmoil since 2010. Available estimates suggest that the smuggling of funds amounted annually to US$ 2 billion in Egypt and US$ 1 billion in Tunisia, according to the institution charged with monitoring the soundness of the global financial sector (Global Financial Integrity, 2013). This amount represented 3.5% of Tunisia's GDP and 2% of Egypt's in 2005.

Government effectiveness has deteriorated in several Arab countries. Kaufmann *et al*. (2013) found that, in the Arab world, only the United Arab Emirates (UAE) and Qatar ranked above the 80th percentile in 2013. Bahrain and Oman ranked between the 60th and 70th percentiles and five countries between the 50th and 60th percentiles, namely, Jordan, Kuwait, Morocco, Saudi Arabia and Tunisia.

The voice and accountability indicator over the past ten years has been disappointing, according to Kaufmann *et al*. (2011; 2013). In 2013, the scores for the top five Arab states (Tunisia, Lebanon, Morocco, Kuwait and Jordan) were low by international standards (between the 45th and 25th percentiles). Algeria, Iraq, Libya and Palestine show some improvement but, overall, 12 Arab states registered a decline in voice and accountability between 2003 and 2013, namely: Algeria, Bahrain, Djibouti, Egypt, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Sudan, Syria and the United Arab Emirates.

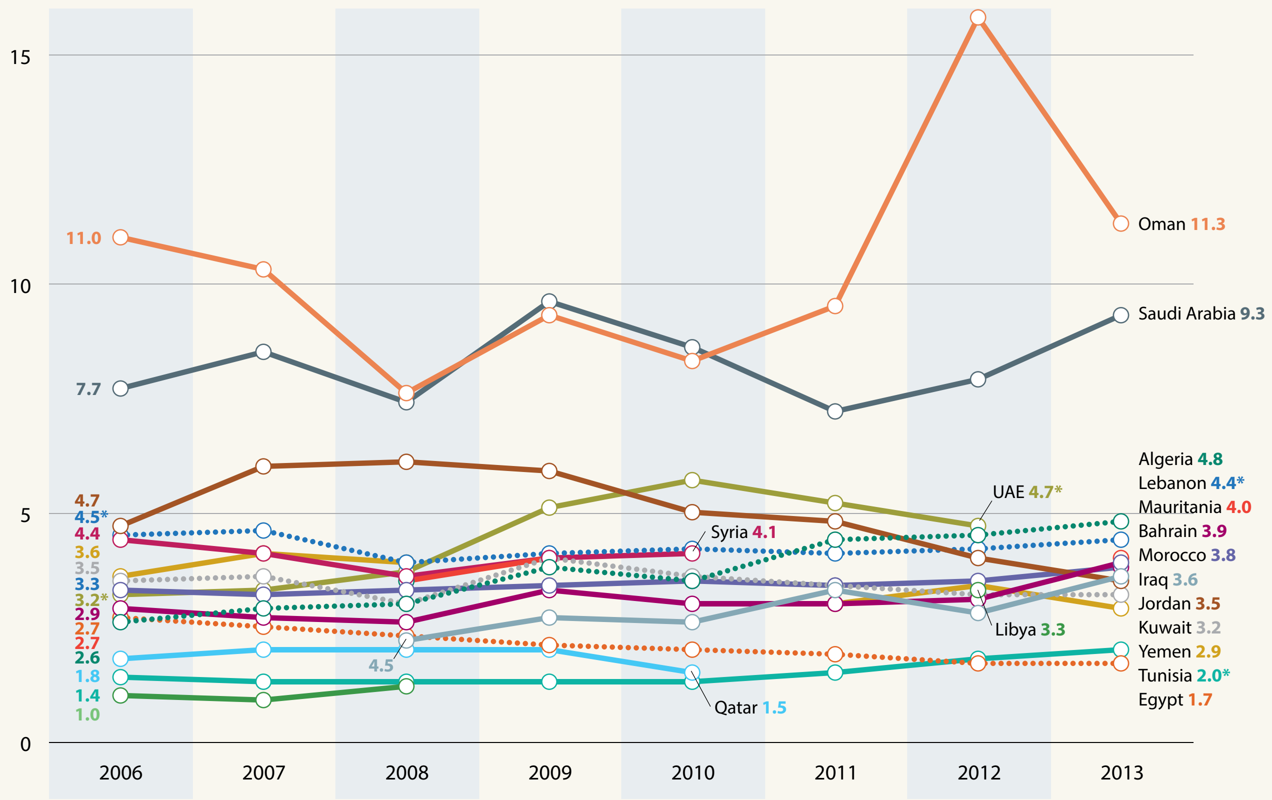
An economic downturn in most Mashreq countries

The countries of the Mashreq have a population of about 196 million, or 53.4% of the Arab population. With the exception of Iraq, they have few oil reserves. Thanks to high commodity prices for oil, Iraq was able to weather the global financial crisis better than its neighbours. The slump in Sudan's economy in 2012, however, was more a consequence of the birth of South Sudan in 2011 and subsequent skirmishes between the two Sudans than the impact of global shocks.

In 2013, GDP per capita in the Mashreq countries, Egypt and Sudan was highest in Lebanon and lowest in Sudan. From 2008 to 2013, annual growth slowed in all the countries of this group, even though it was less noticeable in Palestine in 2013. Over the same period, unemployment rates changed little in all but Egypt, where the slump in tourism and FDI following the revolution in 2011 pushed up unemployment (Table 17.1). With the return to stability, GDP growth recovered to 2.9% in 2014 and is expected to hit 3.6% in 2015. Economic growth

3. See: www.sipri.org/media/pressreleases/2014/Milex_April_2014 (accessed 16 January 2015)

Figure 17.1: **Military expenditure in selected Arab states as a % of GDP, 2006–2013**



*SIPRI estimate

Note: The low figure for Egypt (1.7%) in 2013 only tells half the story, as it excludes the economic activities of the Egyptian armed forces and American aid, which cover 80% of military procurement (Gaub, 2014).

Source: Stockholm International Peace Research Institute database, accessed January 2015

in Jordan and Lebanon, in particular, has been affected by the massive influx of Syrian refugees since 2011.

Together with Egypt and Sudan, the Mashreq countries are considered reservoirs of human talent which supply neighbouring states with teaching faculty, researchers and both skilled and unskilled workers. Egypt, Iraq Jordan, Lebanon, Palestine,[4] Sudan and Syria all boast relatively mature higher education infrastructure that includes some of the oldest universities in the Arab world, including the American University of Beirut (1866) and Cairo University (1908).

The Arab Spring has left a big imprint on the Libyan economy

Since 2008, the Maghreb countries have experienced mixed fortunes. Whereas the economies of Algeria and Mauritania have maintained healthy growth rates, countries directly affected by the Arab Spring have witnessed a more negative trend. Growth slowed to 2.2% in Tunisia and even contracted by 11.6% in Libya (Table 17.1). However, unemployment rates have remained unchanged, with variations from one country to another. Despite average growth of 5.9% between 2011 and 2013, Mauritania's unemployment rate was as high as 31% in 2013, indicating that growth had not been sufficient to provide much-needed jobs.

The Gulf States contribute nearly half of the Arab world's GDP

The six Gulf States, which contribute about 47% of total Arab GDP, are all economically dependent on oil. Some 75 million people (including a sizeable foreign labour force) belong to this group, representing around 20.4% of the Arab world population in 2014 (Table 17.1).

In 2014, the economy slowed in Oman and Qatar, primarily as a consequence of weaker exports and the drop in both private consumption and investment. At the same time, Kuwait and Saudi Arabia emerged from a period of economic contraction, with several sectors showing signs of recovery, including housing in Kuwait and banking in Saudi Arabia.

4. On 29 November 2012, the United Nations General Assembly voted to grant Palestine non-member observer status at the United Nations. Palestine has been a member of UNESCO since 31 October 2011.

Table 17.1: **Socio-economic indicators for the Arab States, 2008 and 2013**

	Population ('000s)		GDP per capita (current PPP$)		GDP average annual growth (%)		Employment rate (% of adult population)		Unemployment rate (% of labour force)	
	2008	2013	2008	2013	2008 – 2010	2011 – 2013*	2008	2013	2008	2013
Gulf States plus Yemen										
Bahrain	1 116	1 332	40 872	43 824	4.4	3.7	63.9	65.0	7.8	7.4
Kuwait	2 702	3 369	95 094	85 660^{-1}	-2.4	6.1	66.0	66.3	1.8	3.1
Oman	2 594	3 632	46 677	44 052	6.4	2.2	52.1	59.9	8.4	7.9
Qatar	1 359	2 169	120 527	131 758	15.4	7.5	85.1	86.2	0.3	0.5
Saudi Arabia	26 366	28 829	41 966	53 780	5.9	6.0	48.6	51.8	5.1	5.7
United Arab Emirates	6 799	9 346	70 785	58 042^{-1}	0.0	2.7	74.0	76.9	4.0	3.8
Yemen	21 704	24 407	4 250	3 958	3.8	-3.2	40.6	40.3	15.0	17.4
Mashreq plus Egypt and Sudan										
Egypt	75 492	82 056	9 596	11 085	5.7	2.0	43.9	42.9	8.7	12.7
Iraq	29 430	33 417	11 405	15 188	6.0	8.2	35.3	35.5	15.3	16.0
Jordan	5 786	6 460	10 478	11 782	5.0	2.7	36.6	36.3	12.7	12.6
Lebanon	4 186	4 467	13 614	17 170	9.1	1.7	43.2	44.4	7.2	6.5
Sudan	34 040	37 964	3 164	3 372	3.2	-6.5	45.3	45.4	14.8	15.2
Syria	20 346	–	–	–	–	–	40.1	–	10.9	–
West Bank & Gaza	3 597	4 170	3 422	4 921^{-1}	4.2	5.6	31.7	31.6	26.0	23.4
Maghreb										
Algeria	35 725	39 208	11 842	13 304	2.4	3.0	37.9	39.6	11.3	9.8
Libya	5 877	6 202	27 900	21 397	3.6	-11.6	43.2	42.6	19.1	19.6
Mauritania	3 423	3 890	2 631	3 042	2.2	5.9	36.3	37.2	31.2	31.0
Morocco	30 955	33 008	5 857	7 200	4.7	4.0	46.2	45.9	9.6	9.2
Tunisia	10 329	10 887	9 497	11 092	3.9	2.2	40.9	41.3	12.4	13.3

+*n*/-*n* = data refer to *n* years before or after reference year.

* For Kuwait, Oman and United Arab Emirates, the years are 2011–2012.

Note: Palestine is designated as the West Bank and Gaza here, owing to data coverage issues.

Source: World Bank's World Development Indicators, May 2015

The slump is hitting oil-rent economies hard

The slump in global oil prices from US$ 115 in June 2014 to US$ 47 in January 2015 has been mending holes in the budgets of Arab oil-importing countries such as Egypt, Jordan, Morocco and Tunisia. By contrast, it has punched holes in the budgets of oil-producing countries, including members of the Organization of Petroleum Exporting Countries (OPEC) [Figure 17.2]. The slump has not affected the export growth of Bahrain and the United Arab Emirates as much as that of other Gulf states, thanks to their diversification of exports. In order to diversify their own sources of income, other Arab governments will need to create a socio-economic environment in which all active stakeholders can thrive, including the private sector.

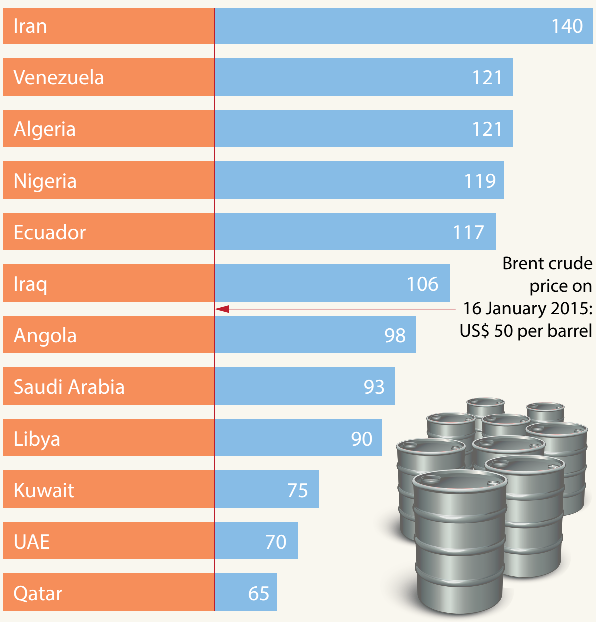
As early as 1986, the Gulf Cooperation Council identified economic diversification as a key strategic goal for its members. Whereas Saudi Arabia, the United Arab Emirates and Qatar have since developed their non-oil sectors, Bahrain and Kuwait are finding it harder to make the transition (Al-Soomi, 2012). Some voices from within the subregion have suggested transforming the Gulf Cooperation Council into a regional socio-economic and political bloc modelled on the European Union (O'Reilly, 2012).

The slump in oil prices comes at a particularly bad time for Iraq, which needs high oil revenue to revive its economy and combat terrorism, and for Libya which is facing internal instability and battling an insurgency by militia groups. Algeria raised its welfare spending in 2011 and now needs oil prices at US$ 121 a barrel to avoid a budget deficit, the International Monetary Fund estimates; it could slip into the red in 2015 for the first time in 15 years (*Wall Street Journal*, 2014). Oil and gas exports still represent two-thirds of national income for Algeria (see Figure 18.1), which has a tiny manufacturing sector (Figure 17.3). This said, Algeria may be less vulnerable the next time Brent crude prices tumble. It is developing solar and wind energy for domestic consumption and export (see p.447). Global investment in renewable energy technologies increased by 16% in 2014, triggered by an 80% decrease in the manufacturing costs of solar energy systems.

FDI flows to the Arab world have slowed

The economic fallout of the current upheaval has negatively affected the flow of FDI into Arab states, not to mention their tourism sector and real estate markets. Interestingly, the drop in FDI appears to have begun before 2011 (Figure 17.4). This can be traced back essentially to the global financial crisis of 2007–2008, thought to have been the worst since the Great Depression of the 1930s. Countries less affected by this turbulence, such as Algeria and Morocco, have seen greater stability in FDI inflows but they also enjoyed modest levels of foreign investment to begin with. There has been a surge in the flow of FDI to Morocco for new projects to expand the railways and deploy renewable energy on a massive scale. In Mauritania, FDI tends to be destined primarily for projects related to crude oil and natural gas exploration and drilling.

Figure 17.2: **Estimated oil price needed to balance the government budget in OPEC member states, 2014**



Source: adapted from Wall Street Journal (2014), based on data from the Government of Libya, Angolan Ministry of Finance, International Monetary Fund, Arab Petroleum Investments Corp., Deutsche Bank

In Egypt, FDI increased by 7% to US$ 4.1 billion between 2013 and 2014. The Sharm El-Sheikh Economic Development Conference organized by the government in 2015 attracted more than 1 700 investors, as well as former British prime minister Tony Blair, US Secretary of State John Kerry and the International Monetary Fund's managing director Christine Lagarde. By the conference's end, Egypt had attracted US$ 36.2 billion in investment, plus US$ 18.6 billion in infrastructure contracts and US$ 5.2 billion in loans from international financial institutions.

STI GOVERNANCE ISSUES

Bringing the business community in from the cold

In March 2014, the Council of Ministers of Higher Education and Scientific Research in the Arab World adopted the *Arab Strategy for Science, Technology and Innovation* at its 14th congress in Riyadh (Saudi Arabia). The strategy has three main thrusts: academic training in science and engineering, scientific research and regional and international scientific co-operation. One of the strategy's key objectives is to involve the private sector more in regional and interdisciplinary collaboration, in order to add economic and development value to research and make better use of available expertise. Up to now, STI policies in Arab states have failed to catalyse knowledge production effectively or add value to products and services because they focus on developing R&D without taking the business community on board. There has also been a lot of talk about re-orienting the education system towards innovation and entrepreneurship but little action thus far (Box 17.2). Of note are the recent higher education reforms launched by Egypt and Tunisia.

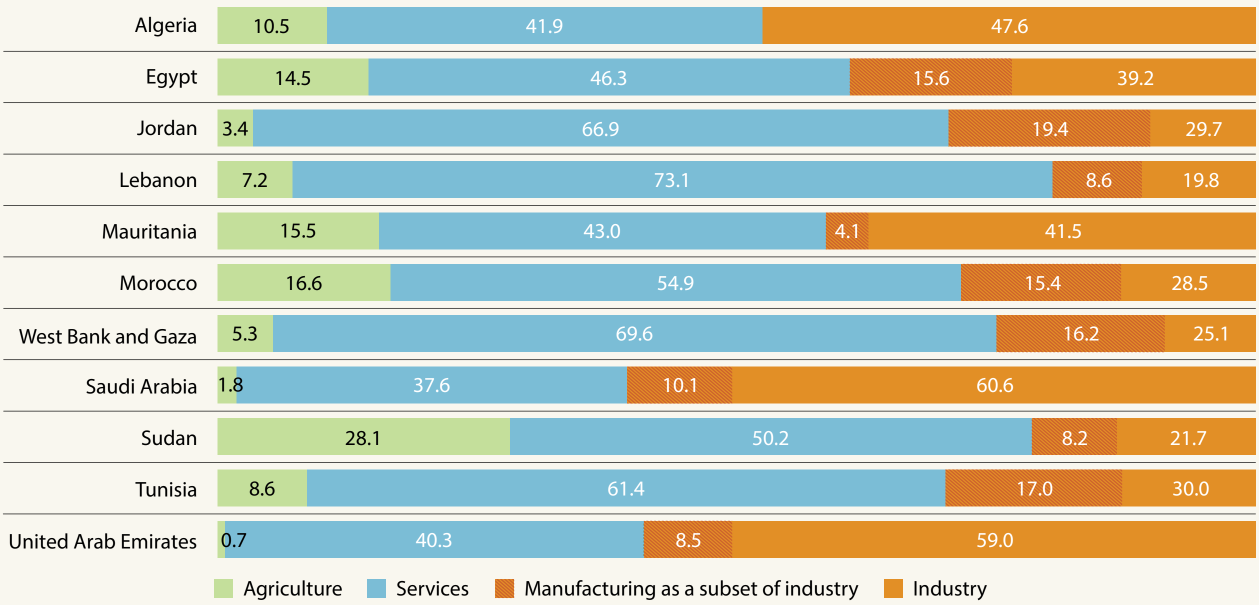
Tunisia and Saudi Arabia currently lead the Arab world in electronics and the United Arab Emirates is investing heavily in space technologies. In the field of renewable energy, Morocco is a leader in hydropower. Algeria, Jordan, Morocco and Tunisia are all developing solar energy. Egypt, Morocco and Tunisia have experience of wind energy that could benefit other countries keen to invest in this area, including Jordan, Libya, Saudi Arabia, Sudan and the United Arab Emirates. Morocco and Sudan are currently the main users of biomass.

The strategy proposes the following areas for co-operation:

- Development and management of water resources;
- Nuclear energy, with applications in the health sector, industry, agriculture, materials science, environment and nuclear energy production;
- Renewable energy: hydropower, solar, wind and biomass;

Figure 17.3: **GDP per economic sector in the Arab world, 2013 or closest year**

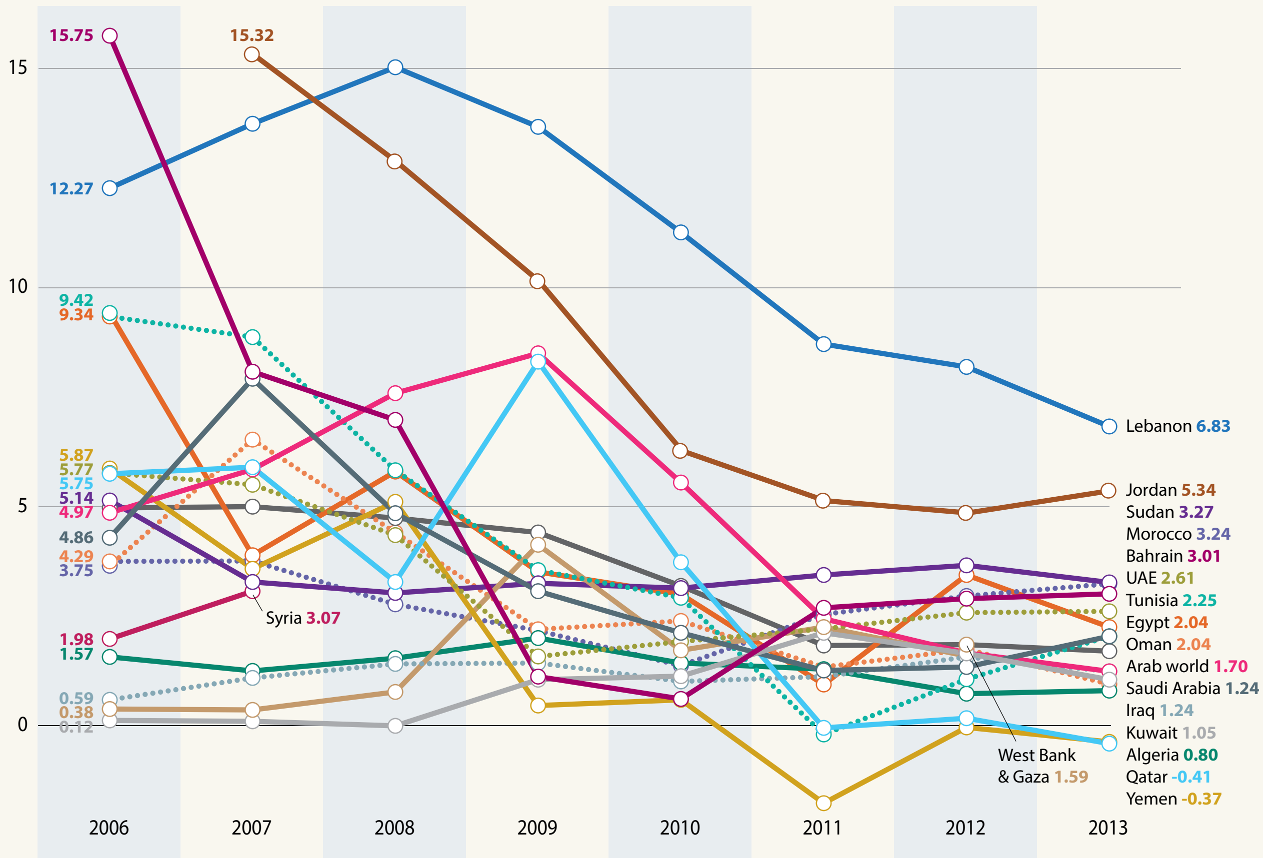
Selected economies



Note: For the West Bank and Gaza, data are for 2012. Palestine is designated as the West Bank and Gaza here, due to data coverage issues.

Source: World Bank's World Development Indicators, January 2015

Figure 17.4: **FDI inflow to selected Arab economies as a share of GDP, 2006–2013 (%)**



Source: World Bank's World Development Indicators, January 2015

- Oil, gas and petrochemicals industries;
- New materials;
- Electronics;
- Information technologies;
- Space sciences: applications in navigation systems, meteorology, irrigation, environmental monitoring, forest management, disaster risk management, urban planning, etc.;
- Nanotechnology: applications in health and pharmaceuticsal fields, food industry, environment, desalination, energy production, etc.;
- Agriculture, livestock and fisheries;
- Industry and production;
- Desertification, climate change and its impact on agriculture;
- Health sciences and biotechnology;
- Future convergent technologies: bioinformatics, nanobiotechnology, etc.

The strategy also emphasizes public outreach by scientists[5] and greater investment in higher education and training to build a critical mass of experts and staunch brain drain. It also advocates involving scientists from the diaspora. It was originally due to be adopted by ministers in 2011 but the timetable was perturbed by the events of 2011.

Priorities: problem-solving research, scientific mobility and education

In September 2013, ministers of research met in Morocco to lay the foundations for a common research policy between the five countries of the Maghreb and five countries of the Western Mediterranean: France, Italy, Malta, Portugal and Spain. These ten countries have met regularly since 1990 to discuss a wide range of issues, from security and economic co-operation to defence, migration, education and renewable energy but this was the first time that the 5+5 Dialogue, as

5. Tunisia's first dinosaur exhibition opened at Tunis Science City in mid-2011, with a focus on Saharan dinosaurs. The exhibition, which had taken two years to prepare, was originally scheduled to run until August 2012. It proved so popular that it was extended to mid-2013.

Box 17.2: **Matching university curricula to market needs**

The Network for the Expansion of Convergent Technologies in the Arab Region (NECTAR) was launched by the UNESCO Cairo Office in June 2011 to help correct the mismatch between the skills companies seek and the programmes provided by most universities.

Biotechnology, nanotechnology, ICTs and cognitive sciences are all convergent technologies which overlap considerably. By developing linkages between academia and industry in these fields, NECTAR plans to reorient academia towards problem-solving and remove the barriers between disciplines that currently hinder innovation in the Arab world.

A top priority for NECTAR has been to modernize the curricula of the Arab region's universities, in collaboration with renowned Arab scientists based at universities in the USA and in Egypt, where the majority of specialists in convergent technologies can be found in the Arab region. NECTAR targets both universities and technical colleges, as technicians are the group which gives convergent technologies their manufacturing edge.

The original plan was for professors from the USA to travel to Cairo to teach intensive courses (3-4 weeks maximum) every year. After the Arab Spring, Cairo and other key cities came to be considered a security risk, so the programme morphed into a virtual education programme. The e-content has been developed by Pennsylvania State University (PSU) and should be ready by August 2015. The courses will be permanently accessible via PSU's portal, with tutoring support on hand from the professors who own the courses. This approach will guarantee continuity and greater equity for Arab universities in terms of access to the coursework.

NECTAR has developed a virtual Higher Industrial Diploma Certificate and a master's degree in Applications of Nano-sciences. Initially, both programmes will be used to train university teaching staff (mainly PhD-holders). These staff members will then serve as the core team for the development of an undergraduate minor programme in nanosciences at each university. The tuition fees have been greatly reduced to encompass only PSU's costs in administering the programme. The diploma certificate will be accredited by PSU, whereas the master's programme will be accredited through participating universities in the Arab world.

There should be strong demand for NECTAR graduates from industries such as pharmaceuticals, chemicals, petrochemicals, oil production, opto-electronics, electronics, information technology, fertilizers, surface coating, building technology, foodstuffs and automotive.

NECTAR organized a regional forum in Cairo in November 2014 on the theme of Galvanizing Science Education and Higher Education towards a Knowledge-based Economy. Since the forum, UNESCO has submitted a proposal to the Egyptian government for a pilot education programme which would stretch from the first year of primary school to postgraduate levels.

Source: Nazar Hassan, UNESCO

the regional forum is known, had focused on research and innovation. In the *Rabat Declaration*, ministers undertake to facilitate training, technology transfer and scientific mobility by creating a specific visa for researchers; in parallel, the Maghreb countries are encouraged to join European research programmes as a first step towards harmonizing national policies and launching joint research projects.

The declaration adopted by ministers meeting in Rabat a year later at the Second[6] Forum on Science, Technology and Innovation in Africa reflects many of the concerns of the *Rabat Declaration:* the need for a greater focus on applied research to solve practical problems related to sanitation, health, agriculture, energy and climate change; the catalytic role of public investment in fostering a strong private sector; the need to improve the teaching of science, technology, engineering and mathematics and to facilitate the mobility of researchers.

Research takes a back seat in most universities

A growing number of Arab governments are setting up observatories to monitor their science systems, including in Egypt, Jordan, Lebanon, Palestine and Tunisia. When studying the data collected, however, analysts often see a direct correlation between the number of graduates or faculty and the number of researchers. This is misleading, as many students and faculty members do not conduct research and only a few actually publish in refereed journals listed by the Web of Science or Scopus and have international contacts. Many Arab universities are simply not research universities. Moreover, until recently, the terms of reference for a university professor in the Arab region did not include research.

The real test comes from counting the time spent effectively by an individual on research, as opposed to teaching or other tasks. It is rare for the actual research activity of teaching staff in government and most private universities to exceed 5–10% of their total academic duties, compared to 35–50% in European and American universities. A recent survey by the American University of Beirut shows that around 40% of academics' time is spent on research; this translates into an average of two publications per year for each full-time equivalent (FTE) researcher (ESCWA, 2014a).

In Jordan and many other Arab states, the bulk of scientific research is carried out within a higher education system that is faced with its own problems, including scarce resources and burgeoning student numbers. With the ranking craze sweeping Jordanian universities, rectors are no longer certain whether their institutions should aim to generate knowledge (i.e. scientific publications) or transmit knowledge (i.e. teach).

Scientists under pressure to target international journals

The pressure to publish in internationally recognized journals discourages publication in local journals. Moreover, Arab scientific journals suffer from fundamental problems, such as irregular periodicity and a lack of objective peer review. Many local periodicals are not regarded as credible vehicles for obtaining an academic promotion – even within the countries where they are published – thus reinforcing the desire of many academics to publish in international peer-reviewed journals whenever possible (ESCWA, 2014b).

In 2010, the Egyptian Academy of Scientific Research and Technology contacted a number of internationally renowned journals to establish a checklist of the criteria an article needed to meet to be accepted for publication. Five years on, there has been a 200% increase in peer-reviewed publications, according to the academy.

In 2014, UNESCO and the Arab League Educational, Cultural and Scientific Organization (ALECSO) decided to establish an online Arab observatory of science and technology. The observatory will host a portal for research projects and an inventory of Arab universities and scientific research centres, as well as patents, publications and master's and PhD theses in digital format; scientists will be able to use the forum to organize virtual conferences. The observatory will also host national observatories for Arab states to facilitate an interactive, semi-automated database of STI indicators.

Lessons can be learned from the Tunisian experience

Arab countries face a host of hurdles, including a lack of focus in research priorities and strategies, insufficient funding to meet research goals, little awareness of the importance of good scientific research, inadequate networking, limited collaborative efforts and brain drain. It is clear from available statistics that countries will need more sustained government support in future, if they are to strengthen university research, overcome weak university–industry linkages and give university graduates the professional and entrepreneurial skills to create viable national innovation systems.

There are lessons to be learned from the experience of Tunisia prior to December 2010 where, despite clear government support for research and higher education, socio-economic progress across the various strata of society had stalled and was failing to create jobs. This situation was at least in part a consequence of the lack of academic freedom and the fact that allegiance to the regime was considered more important than competence.

6. The first took place in Nairobi in March 2012. It focused on STI for youth employment, human capital development and inclusive growth. Both were organized by UNESCO, the Afrian Development Bank, United Nations Economic Commission for Africa and African Union in association with the Association for the Development of Education in Africa.

TRENDS IN R&D

Investment remains low but change is in the air

Gross domestic expenditure on research and development (GERD) as a percentage of GDP remains low in the Arab world. It is, of course, hard for wealthy oil-rent economies like the Gulf States to have a substantial GERD/GDP ratio, as GDP is so high. The countries with the greatest R&D intensity are Libya and Morocco (Figure 17.5). Tunisia used to have the Arab world's highest ratio but, after revising its national data, it published a GERD/GDP ratio of 0.71% in 2009 and 0.68% in 2012. The R&D intensity of Egypt, Jordan and Sudan has been low for decades, despite a growing number of public and private universities. That appears to be changing in Egypt, the only country for which there are recent data for this indicator: GERD reached an all-time high of 0.68% of GDP in 2013. Iraq, meanwhile, has failed to use the windfall of high oil prices in recent years to raise its own GERD/GDP ratio, which stood at about 0.03% in 2011. Most Arab States are still trailing fellow members of the Organization of Islamic Cooperation for this indicator, including Malaysia (1.07% in 2011) and Turkey (0.86% in 2011).

Although data on the type of R&D performed are only available for a handful of countries, they suggest a heavy focus on applied research in the Arab world. In 2011, Kuwait invested the entirety of GERD in applied research, compared to about two-thirds for Iraq and half for Qatar, according to the UNESCO Institute for Statistics. The remainder in Qatar was equally divided between basic research and experimental development. One-quarter of investment (26.6% in 2011) in Qatar went to medical and health sciences.

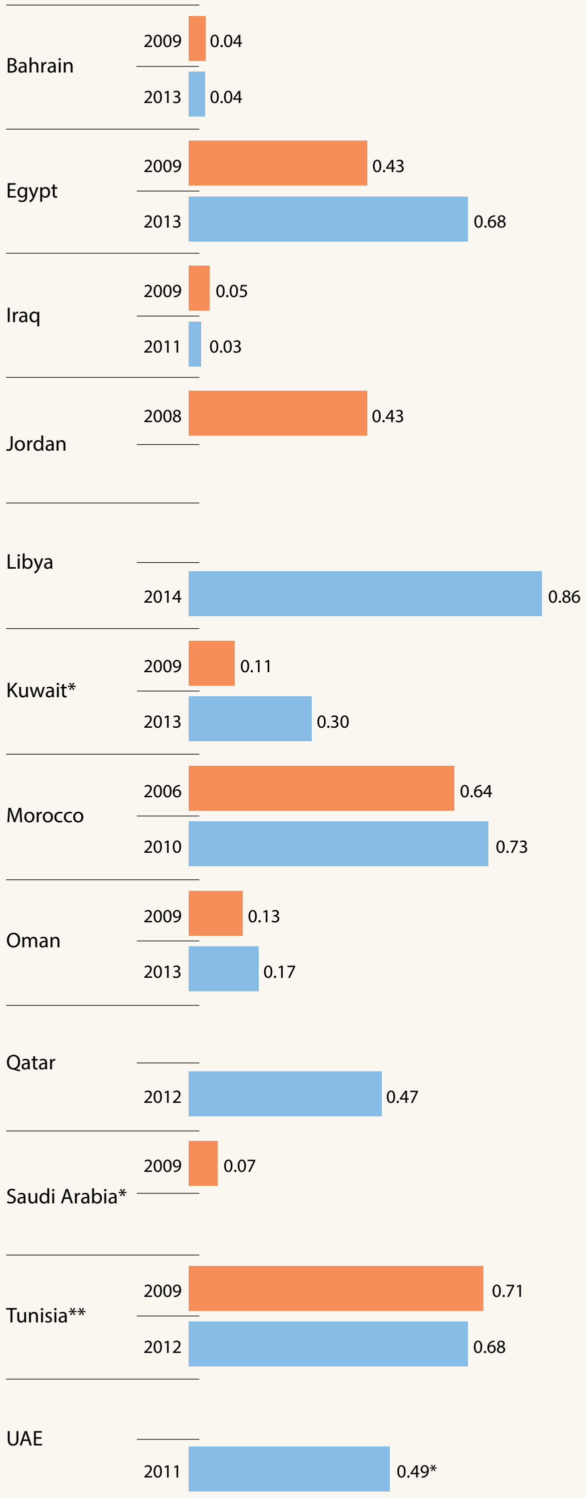
The greatest researcher density: Jordan, Morocco and Tunisia

In a context of rapid population growth, the number of researchers per million population is a more telling indicator of progress than sheer numbers. With 1 394 full-time equivalent (FTE) researchers per million inhabitants in 2012, Tunisia leads the Arab world for this category, followed by Morocco (Figure 17.6). Jordan has a density of researchers similar to that of Tunisia (1 913 in head counts) but this figure dates from 2008.

Egypt and Bahrain close to gender parity

Egypt (43% women) and Bahrain (41%) are relatively close to gender parity (Figure 17.7). In the majority of other countries for which data are available, women make up between one in three and one in five researchers. The notable exception is Saudi Arabia, where just 1.4% of researchers were women in 2009, although only the King Abdulaziz City for Science and Technology was surveyed. A number of countries have been building up their researcher intensity in recent years, albeit from low levels. Palestine is remarkable, in this respect. Thanks to the efforts of Palestinian universities, the government and the Palestine Academy of Science and Technology, 23% of researchers were women by 2013.

Figure 17.5: **GERD/GDP ratio in the Arab world, 2009 and 2013 or closest years (%)**



*estimation **based on national estimation

Note: Data are partial for Bahrain (higher education only), Kuwait (government sector only in 2009) and Saudi Arabia.

Source: UNESCO Institute for Statistics, January 2015; for Sudan: Noor (2012); for Oman: Al-Hiddabi (2014); for Libya: National Planning Council (2014) *National Strategy for Science, Technology and Innovation*

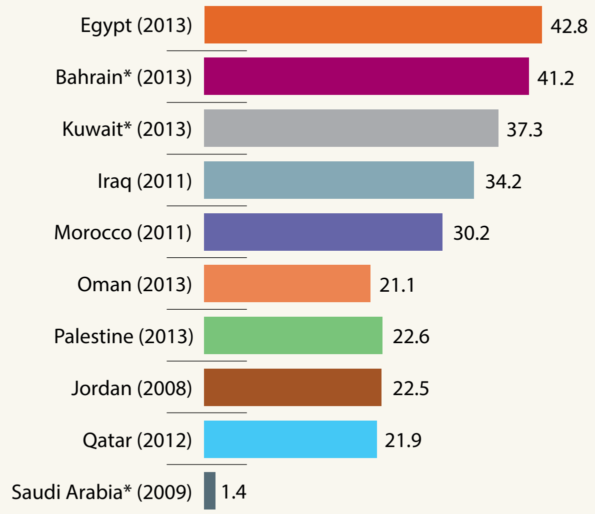
In several countries, women represent more than four out of ten researchers employed in natural sciences (Kuwait, Egypt and Iraq) and medical and health sciences (Kuwait, Egypt, Iraq, Jordan and Morocco). In Egypt, they have attained parity in social sciences and humanities. Most of the small group of Saudi women researchers works in medical and health sciences (Table 17.2).

The share of students graduating in S&T fields is relatively high, ranging from a low of 11% in Jordan to a high of 44% in Tunisia (Table 17.3). Recent data available for ten countries reveal that women represent between 34% and 56.8% of tertiary graduates in science, engineering and agriculture, a relatively high ratio (Table 17.4). In science and agriculture, women have achieved parity and even dominate these fields in most countries. They remain a minority in engineering, with the notable exception of Oman (Table 17.4).

Government expenditure on education represents a sizeable share of GDP in much of the Arab world. Moreover, most of the countries for which data are available devote more than 1% of GDP to higher education (Figure 17.8).

Figure 17.7: **Share of women Arab researchers, 2013 (%)**

Selected countries, in head counts



*partial data

Note: For Bahrain, data only cover the higher education sector; for Kuwait and Saudi Arabia, data only cover the government sector.

Source: UNESCO Institute for Statistics, January 2015

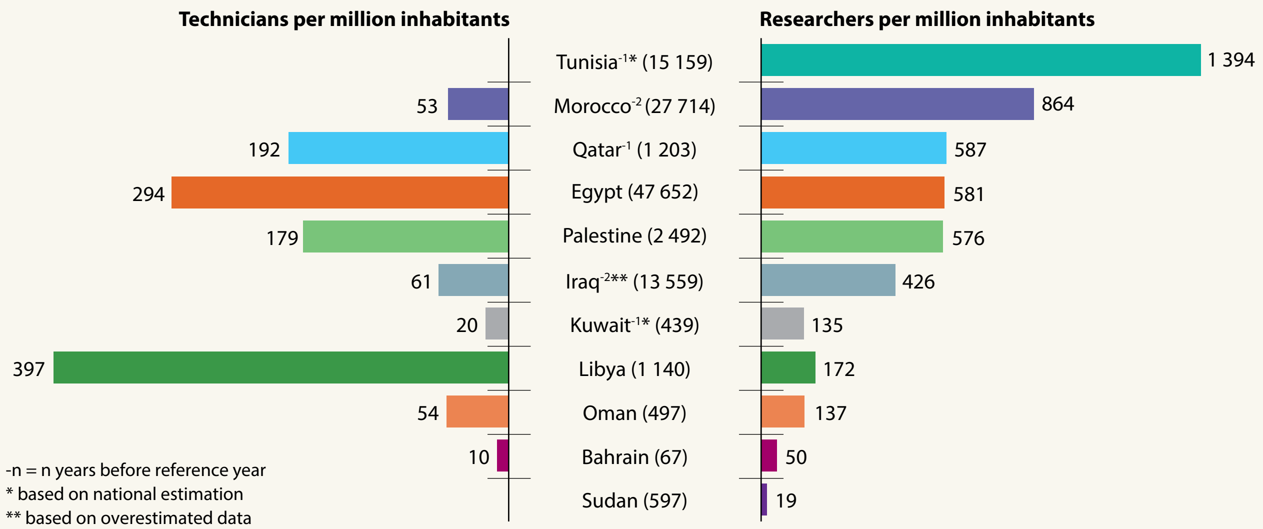
Little business R&D

In many Arab states, the bulk of GERD is performed by the government sector, followed by the higher education sector; the private sector assumes little or even no role in the research enterprise. In Egypt, for instance, the Academy of Scientific Research and Technology estimates that the private sector contributes only around 5% of the country's research expenditure (Bond *et al.*, 2012). Jordan, Morocco, Oman, Qatar, Tunisia and the United Arab Emirates are exceptions to the rule. Erawatch estimates that the private sector performs one-third of GERD in Jordan, 30% in Morocco (2010), 29% in the United Arab Emirates (2011), 26% in Qatar (2012) and 24% in Oman (2011). The figure is closer to 20% in Tunisia, according to the UNESCO Institute for Statistics. Business enterprises also finance about 24% of GERD in Qatar and 20% in Tunisia.

The data for FTE researchers by sector of employment and gender are scant for most Arab states. Available data for Egypt indicate that the majority of researchers were employed by

Figure 17.6: **Arab researchers and technicians (FTE) per million inhabitants, 2013 or closest year**

The total number of researchers is given in brackets



Note: For Bahrain, data only cover the higher education sector; for Kuwait, data only cover the government sector. Data are also partial for Moroccan technicians.

Source: UNESCO Institute for Statistics, January 2015; for Libya: Libyan Authority for Research, Science and Technology; for Sudan: National Research Centre

Table 17.2: **Arab researchers (HC) by field of employment, 2013 or closest year (%)**

Selected economies

	Year	Natural sciences		Engineering and technology		Medical and health sciences		Agricultural sciences		Social sciences		Humanities		Unclassified	
		Total	Women	Total	Women	Total	Women	Total	Female	Total	Women	Total	Women	Total	Women
Gulf States plus Yemen															
Kuwait	2013	14.3	41.8	13.4	29.9	11.9	44.9	5.2	43.8	8.8	33.4	13.3	35.6	33.2	36.5
Oman	2013	15.5	13.0	13.0	6.2	6.5	30.0	25.3	27.6	24.3	23.7	13.2	22.1	2.2	33.3
Qatar	2012	9.3	21.7	42.7	12.5	26.0	27.8	1.6	17.9	14.3	34.6	4.8	33.7	1.3	31.8
Saudi Arabia*	2009	16.8	2.3	43.0	2.0	0.7	22.2	2.6	–	0.0	–	0.5	–	36.4	–
Mashreq and Egypt															
Egypt	2013	8.1	40.7	7.2	17.7	31.8	45.9	4.1	27.9	16.8	51.2	11.4	47.5	20.6	41.0
Iraq	2011	17.7	43.6	18.9	25.7	12.4	41.4	9.4	26.1	32.3	35.7	9.3	26.7	0.0	28.6
Jordan	2008	8.2	25.7	18.8	18.4	12.6	44.1	2.9	18.7	4.0	29.0	18.1	32.3	35.3	10.9
Palestine	2013	16.5	–	10.9	–	5.8	–	4.8	–	27.7	–	34.2	–	0	
Maghreb															
Libya	2013	14.3	15.0	17.0	18	24.4	0.1	11.5	0.1	2.0	20.0	12.4	20.0	32.4	20.0
Morocco	2011	33.7	31.5	7.6	26.3	10.4	44.1	1.8	20.5	26.1	26.6	20.4	27.8	0	0

* government researchers only

Note: For Bahrain, data only cover the higher education sector. For Egypt, the distribution of researchers is only available for the higher education sector; data related to the government sector are 'unclassified.'

Source: UNESCO Institute for Statistics (UIS), June, 2015; for Libya: Libyan Authority for Research, Science and Technology

Table 17.3: **Arab tertiary graduates in science, engineering and agriculture, 2012 or closest year**

	Year	Total (all fields)	Science, engineering and agriculture		Science			Engineering, manufacturing and construction			Agriculture		
			Number	Share of total (%)	Number	Share of science, engineering and agriculture (%)	Share of total (%)	Number	Share of science, engineering and agriculture (%)	Share of total (%)	Number	Share of science, engineering and agriculture (%)	Share of total (%)
Algeria	2013	255 435	62 356	24.4	25 581	41.0	10.0	32 861	52.7	12.9	3 914	6.3	1.5
Egypt	2013	510 363	71 753	14.1	21 446	29.9	4.2	38 730	54.0	7.6	11 577	16.1	2.3
Jordan	2011	60 686	7 225	11.9	3 258	45.1	5.4	2 145	29.7	3.5	1 822	25.2	3.0
Lebanon	2011	34 007	8 108	23.8	3 739	46.1	11.0	4 201	51.8	12.4	168	2.1	0.5
Morocco	2010	75 744	27 524	36.3	17 046	61.9	22.5	9 393	34.1	12.4	1 085	3.9	1.4
Palestine	2013	35 279	5 568	15.8	2 832	50.9	8.0	2 566	46.1	7.3	170	3.1	0.5
Qatar	2013	2 284	671	29.4	119	17.7	5.2	552	82.3	24.2	0	0.0	0.0
Saudi Arabia	2013	141 196	39 312	27.8	25 672	65.3	18.2	13 187	33.5	9.3	453	1.2	0.3
Sudan	2013	124 494	23 287	18.7	12 353	53.0	9.9	7 891	33.9	6.3	3 043	13.1	2.4
Syria	2013	58 694	12 239	20.9	4 430	36.2	7.5	6 064	49.5	10.3	1 745	14.3	3.0
Tunisia	2013	65 421	29 272	44.7	17 225	58.8	26.3	11 141	38.1	17.0	906	3.1	1.4
UAE	2013	25 682	5 866	22.8	2 087	35.6	8.1	3 742	63.8	14.6	37	0.6	0.1

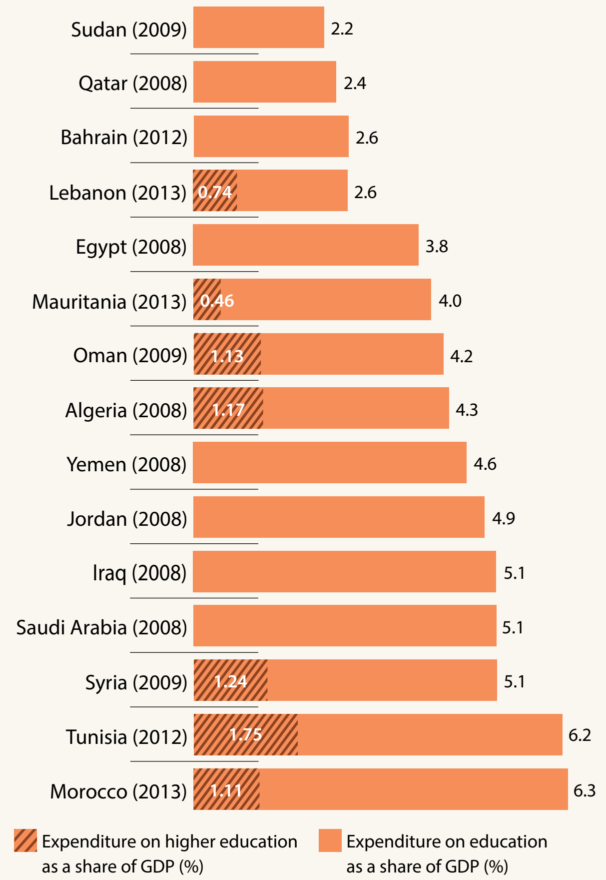
Source: UNESCO Institute for Statistics, July 2015

Table 17.4: **Share of Arab female graduates in science, engineering and agriculture, 2014 or closest year (%)**

Country	Year	Science	Engineering	Agriculture	Science, engineering and agriculture
Bahrain	2014	66.3	27.6	0.0	42.6
Jordan	2011	65.2	13.4	73.4	51.9
Lebanon	2011	61.5	26.9	58.9	43.5
Oman	2013	75.1	52.7	6.0	56.8
Palestine	2013	58.5	31.3	37.1	45.3
Qatar	2013	64.7	27.4	0.0	34.0
Saudi Arabia	2013	57.2	3.4	29.6	38.8
Sudan	2013	41.8	31.8	64.3	41.4
Tunisia	2013	63.8	41.1	69.9	55.4
UAE	2013	60.2	31.1	54.1	41.6

Source: UNESCO Institute for Statistics, July 2015

Figure 17.8: **Arab government expenditure on education as a share of GDP (%)**



Source: UNESCO Institute for Statistics, July 2015; for Iraq and Jordan: UNDP (2009) *Arab Knowledge Report,* Table 5-4, p. 193.

the higher education sector (54%) in 2013 and the remainder by government (46%), although the business sector was not surveyed (ASRT, 2014). In Iraq, as many as eight out of ten (83%) researchers are working in academia.

In Egypt, medical and health sciences occupy the greatest number of researchers, a reflection of the country's priorities. In Kuwait and Morocco, the majority of researchers are working in the natural sciences (Table 17.2). In Oman in 2011, the majority of researchers were social scientists, whereas Qatari researchers tend to be most numerous in engineering and technology. Interestingly, one-third of Palestinian researchers worked in the humanities in 2011, the highest ratio among Arab states.

Morocco leads for high-tech exports, Qatar and Saudi Arabia for publications

Given the modest role played by the private sector in the Arab world, it is hardly surprising that the share of high-tech products in manufactured exports is low, particularly for Gulf states (Figure 17.9). Morocco tops the region for high-tech exports and comes second only to Egypt for patents (Table 17.5).

Interestingly, two oil-rent economies published the most scientific articles per million inhabitants in 2014. Along with Egypt, their output has also grown faster than that of any other country in recent years. Qatar and Saudi Arabia also have the region's highest citation rate (Figure 17.10).

Two-thirds of articles produced by scientists in the Arab world between 2008 and 2014 were co-authored with international partners. Egypt, Saudi Arabia and the USA tend to be the closest collaborators but Chinese scientists have also become a key partner for Iraq, Qatar and Saudi Arabia (Figure 17.10). It is worth noting that the Thomson Reuters selection of Highly Cited Researchers of 2014[7] lists only three Arab scientists whose 'first' affiliation is with a university in the Arab world. They are Prof. Ali H. Nayfeh (University of Jordan and Virginia Tech), Prof. Shaher El-Momani (University of Jordan and King Abdulaziz University in Saudi Arabia) and Prof. Salim Messaoudi (Algeria), a faculty member of King Fahd University of Petroleum and Minerals in Saudi Arabia.

7. http://highlycited.com/archive_june.htm

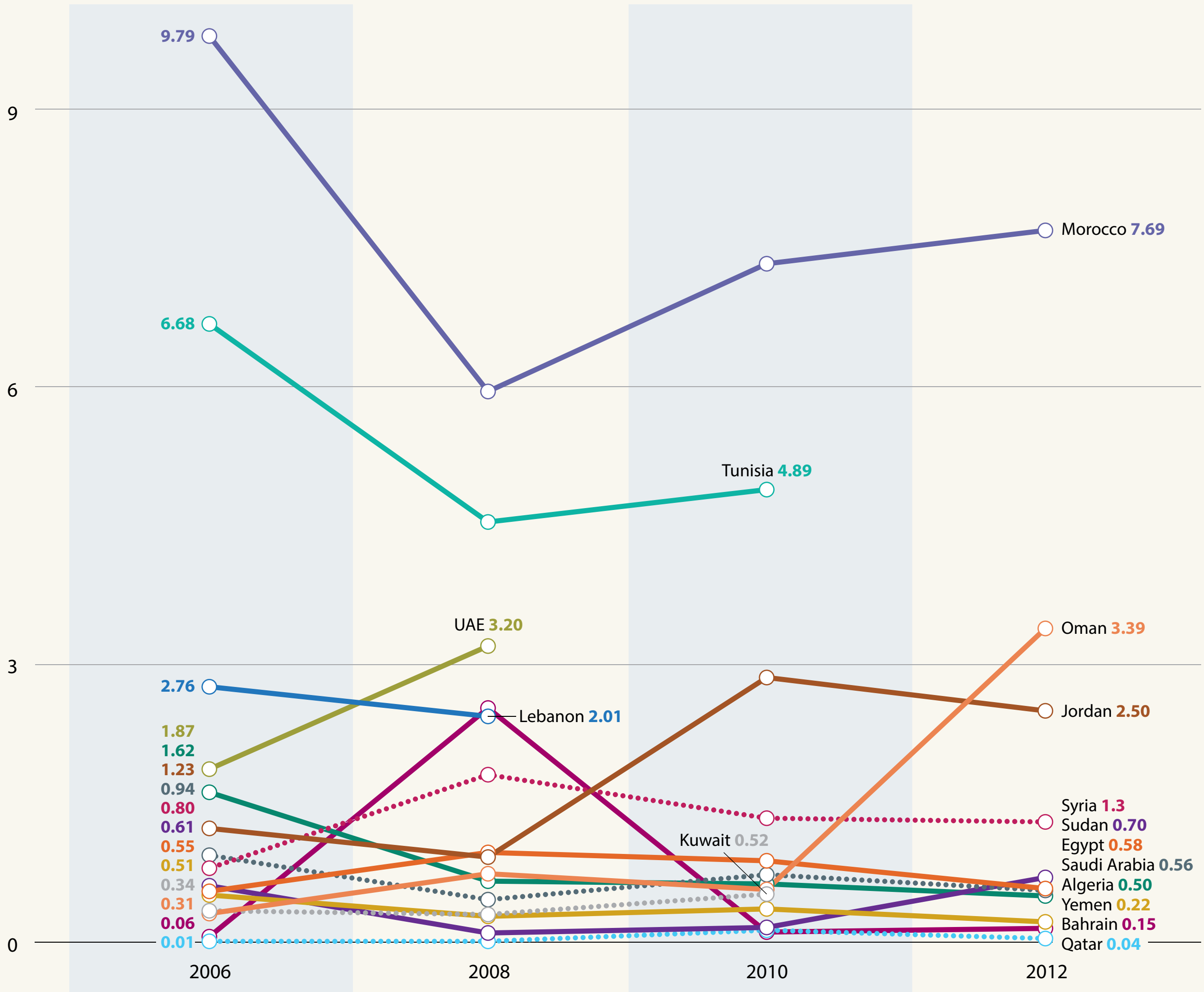
Table 17.5: **Patent applications in Arab states, 2010–2012**

	Patent applications residents			Patent applications non-residents			Total patent applications		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
Egypt	605	618	683	1 625	1 591	1 528	2 230	2 209	2 211
Morocco	152	169	197	882	880	843	1034	1 049	1 040
Saudi Arabia	288	347		643	643		931	990	
Algeria	76	94	119	730	803	781	806	897	900
Tunisia	113	137	150	508	543	476	621	680	626
Jordan	45	40	48	429	360	346	474	400	394
Yemen	20	7	36	55	37	49	75	44	85
Lebanon	0	0	0	13	2	2	13	2	2
Sudan	0	0	0	0	1	0	0	0	0
Syria	0	0	0	1	0	0	1	0	0

Source: WIPO statistics database, December 2014; Thomson Reuters' Web of Science, data treatment by Science-Metrix

Figure 17.9: **High-tech exports from the Arab world, 2006, 2008, 2010 and 2012**

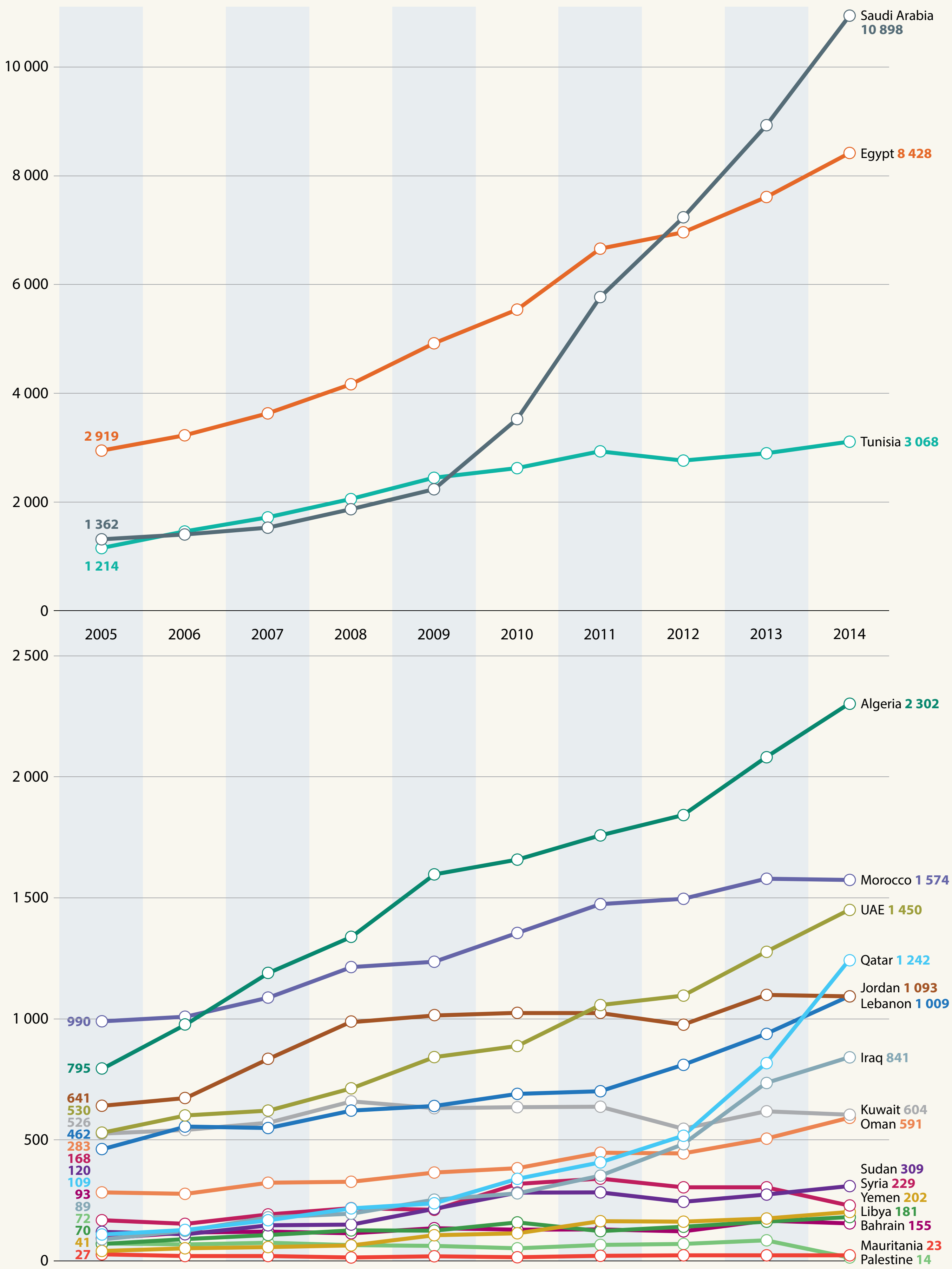
As a share of manufactured exports (%)



Source: United Nations Statistics Division, July 2014

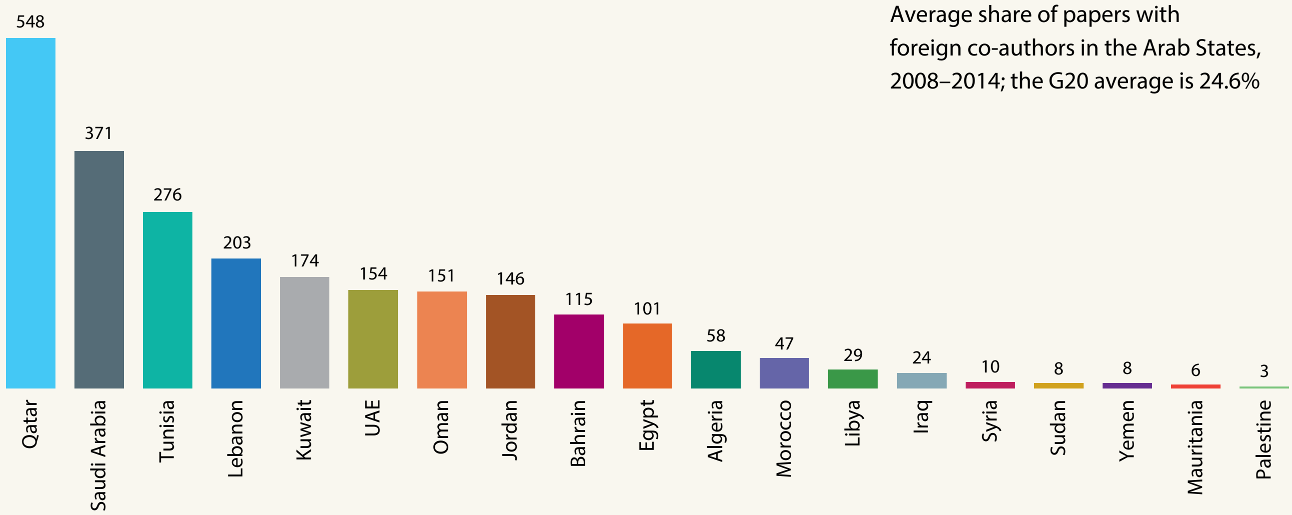
Figure 17.10: **Scientific publication trends in the Arab States, 2005–2014**

Strong growth in Saudi Arabia, Egypt and Qatar



Qatar, Saudi Arabia and Tunisia have the highest publication intensity

Publications per million inhabitants in 2014

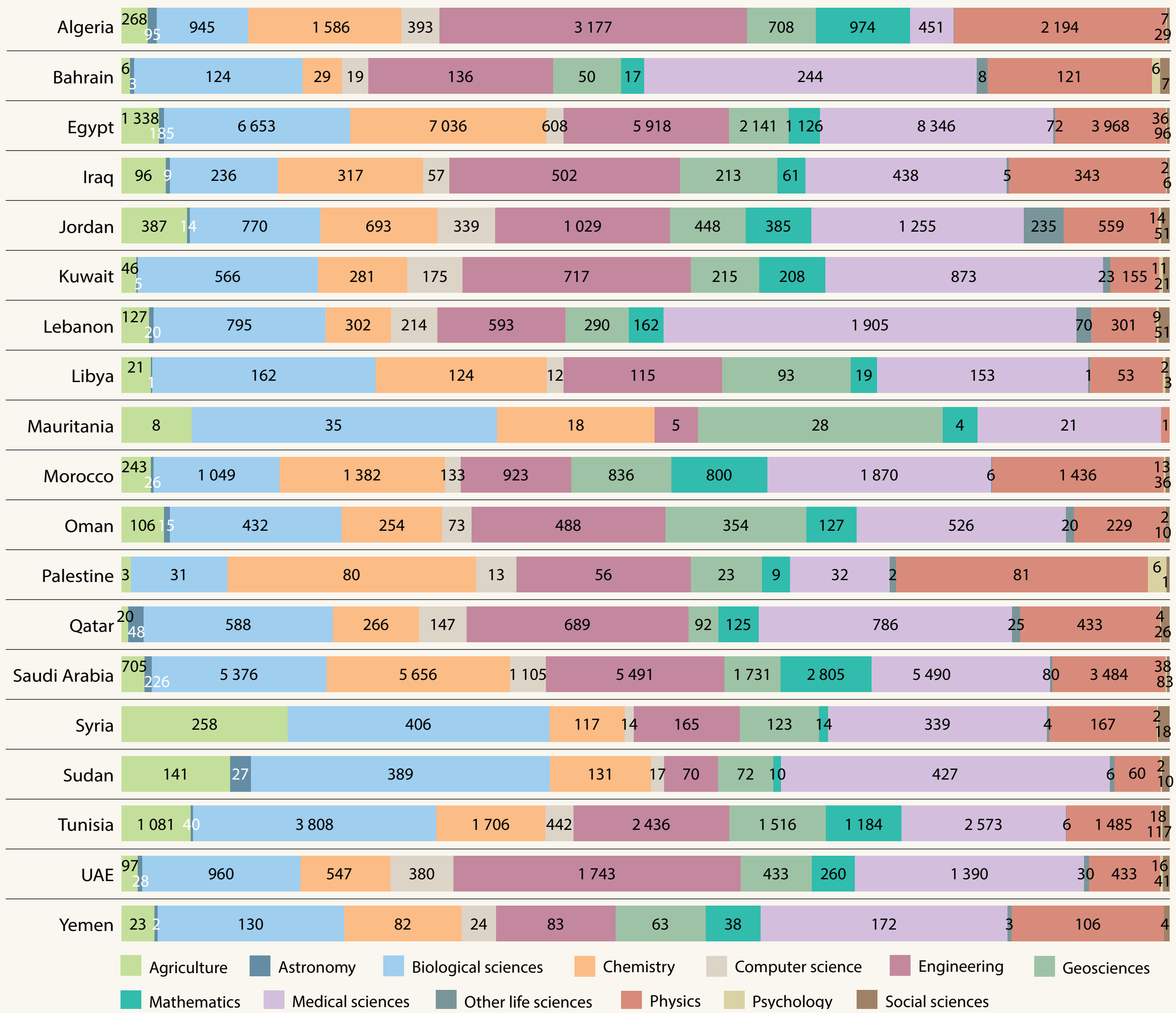


67.2%

Average share of papers with foreign co-authors in the Arab States, 2008–2014; the G20 average is 24.6%

The Arab States publish most in life sciences, followed by engineering and chemistry

Cumulative totals by field, 2008–2014

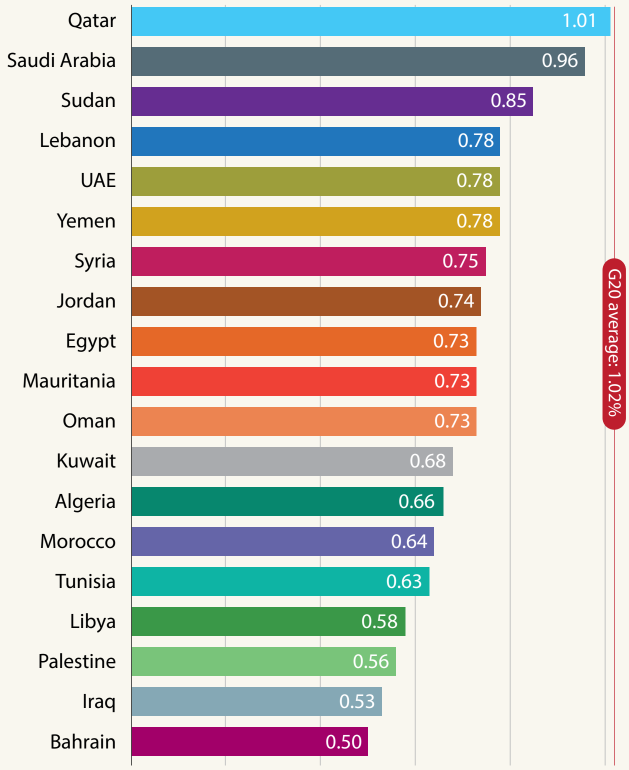


Note: The totals do not include unclassified publications, which make up a sizeable share in some cases: Saudi Arabia (8 264), Egypt (6 716), Tunisia (2 275), Algeria (1 747), Jordan (1 047), Kuwait (1 034) and Palestine (77).

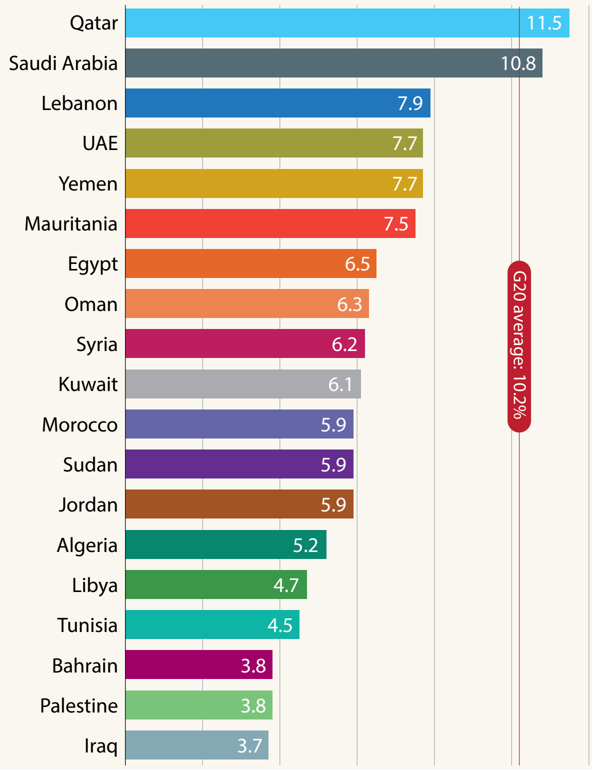
Figure 17.10 *(continued)*

Qatar and Saudi Arabia have the highest citation rate

Average citation rate for publications, 2008–2012



Share of papers among 10% most-cited, 2008–2012 (%)



China has become a key collaborator for Iraq, Qatar and Saudi Arabia

Main foreign partners, 2008–2014

	1st collaborator	2nd collaborator	3rd collaborator	4th collaborator	5th collaborator
Algeria	France (4 883)	Saudi Arabia (524)	Spain (440)	USA (383)	Italy (347)
Bahrain	Saudi Arabia (137)	Egypt (101)	UK (93)	USA (89)	Tunisia (75)
Egypt	Saudi Arabia (7 803)	USA (4 725)	Germany (2 762)	UK (2 162)	Japan (1 755)
Iraq	Malaysia (595)	UK (281)	USA (279)	China (133)	Germany (128)
Jordan	USA (1 153)	Germany (586)	Saudi Arabia (490)	UK (450)	Canada (259)
Kuwait	USA (566)	Egypt (332)	UK (271)	Canada (198)	Saudi Arabia (185)
Lebanon	USA (1 307)	France (1277)	Italy (412)	UK (337)	Canada (336)
Libya	UK (184)	Egypt (166)	India (99)	Malaysia (79)	France (78)
Mauritania	France (62)	Senegal (40)	USA (18)	Spain (16)	Tunisia (15)
Morocco	France (3 465)	Spain (1 338)	USA (833)	Italy (777)	Germany (752)
Oman	USA (333)	UK (326)	India (309)	Germany (212)	Malaysia (200)
Palestine	Egypt (50)	Germany (48)	USA (35)	Malaysia (26)	UK (23)
Qatar	USA (1 168)	UK (586)	China (457)	France (397)	Germany (373)
Saudi Arabia	Egypt (7 803)	USA (5 794)	UK (2 568)	China (2 469)	India (2 455)
Sudan	Saudi Arabia (213)	Germany (193)	UK (191)	USA (185)	Malaysia (146)
Syria	France (193)	UK (179)	Germany (175)	USA (170)	Italy (92)
Tunisia	France (5 951)	Spain (833)	Italy (727)	Saudi Arabia (600)	USA (544)
United Arab Emirates	USA (1 505)	UK (697)	Canada (641)	Germany (389)	Egypt (370)
Yemen	Malaysia (255)	Egypt (183)	Saudi Arabia (158)	USA (106)	Germany (72)

Source: Thomson Reuters' Web of Science, Science Citation Index Expanded; data treatment by Science–Metrix

COUNTRY PROFILES

ALGERIA

Diversifying the national energy mix

In 2008, Algeria adopted a plan to optimize its national innovation system. Piloted by the Ministry of Higher Education and Scientific Research (MoHESR), the plan proposed a reorganization of science, coupled with the development of infrastructure, human resources and research, as well as greater scientific co-operation and funding. Algeria devoted just 0.07% of GDP to GERD in 2005; although these data are partial, they suggest an extremely low R&D intensity in the years prior to the plan's adoption.

The National Commission for the Evaluation of Permanent Researchers was launched in 2000 to give scientists a boost by allocating more financial resources to research and introducing incentives for them to make better use of the results of their research. The aim was also to enhance collaboration with the Algerian diaspora. The commission met for the 12th time in February 2012. More recently, MoHESR has announced plans to establish a national academy of sciences in 2015.

Algerian scientists published most in engineering and physics between 2008 and 2014. Their output has progressed steadily, doubling between 2005 and 2009 then again between 2010 and 2014 (Figure 17.10). Over the seven years to 2014, 59% of Algerian scientific papers had foreign co-authors.

Although Algeria is Africa's third-biggest oil producer (see Figure 19.1) and the world's tenth-biggest producer of natural gas, the country's known gas reserves could be exhausted within half a century, according to British Petroleum's *Statistical Review of World Energy* in 2009 (Salacanin, 2015). Like its neighbours Morocco and Tunisia, Algeria is diversifying its energy mix. Sixty solar and wind projects have been approved within the country's Renewable Energy and Energy Efficiency Programme, which was adopted in March 2011 and revised in 2015. The aim is for 40% of electricity for national consumption to be produced using renewable energy sources by 2030. Up to 22 000 MW of power-generating capacity from renewable sources will be installed between 2011 and 2030, 12 000 MW to meet domestic demand and 10 000 MW destined for export. In July 2013, Algeria signed a memorandum of understanding with the EU in the field of energy which includes provisions for the transfer of technology to Algeria for both fossil fuels and renewable energy.

BAHRAIN

A need to reduce dependency on oil

Bahrain has the smallest hydrocarbon reserves of any Gulf state, producing just 48 000 barrels per day from its one onshore field (Salacanin, 2015). The bulk of the country's revenue comes from its share of the offshore field administered by Saudi Arabia. The gas reserve in Bahrain is expected to last for less than 27 years, leaving the country with few sources of capital to pursue the development of new industries.

The *Bahraini Economic Vision 2030* does not indicate how the stated goal of shifting from an economy built on oil wealth to a productive, globally competitive economy will be attained.

Apart from the Ministry of Education and the Higher Education Council, the two main hives of activity in STI are the University of Bahrain and the Bahrain Centre for Strategic, International and Energy Studies. The latter was founded in 2009 to undertake research with a focus on strategic security and energy issues to encourage new thinking and influence policy-making.

The University of Bahrain was established in 1986. It has over 20 000 students, 65% of whom are women, and around 900 faculty members, 40% of whom are women. From 1986 to 2014, university staff published 5 500 papers and books. The university spends about US$ 11 million per year on research, which is conducted by a contingent of 172 men and 128 women.

New infrastructure for science and education

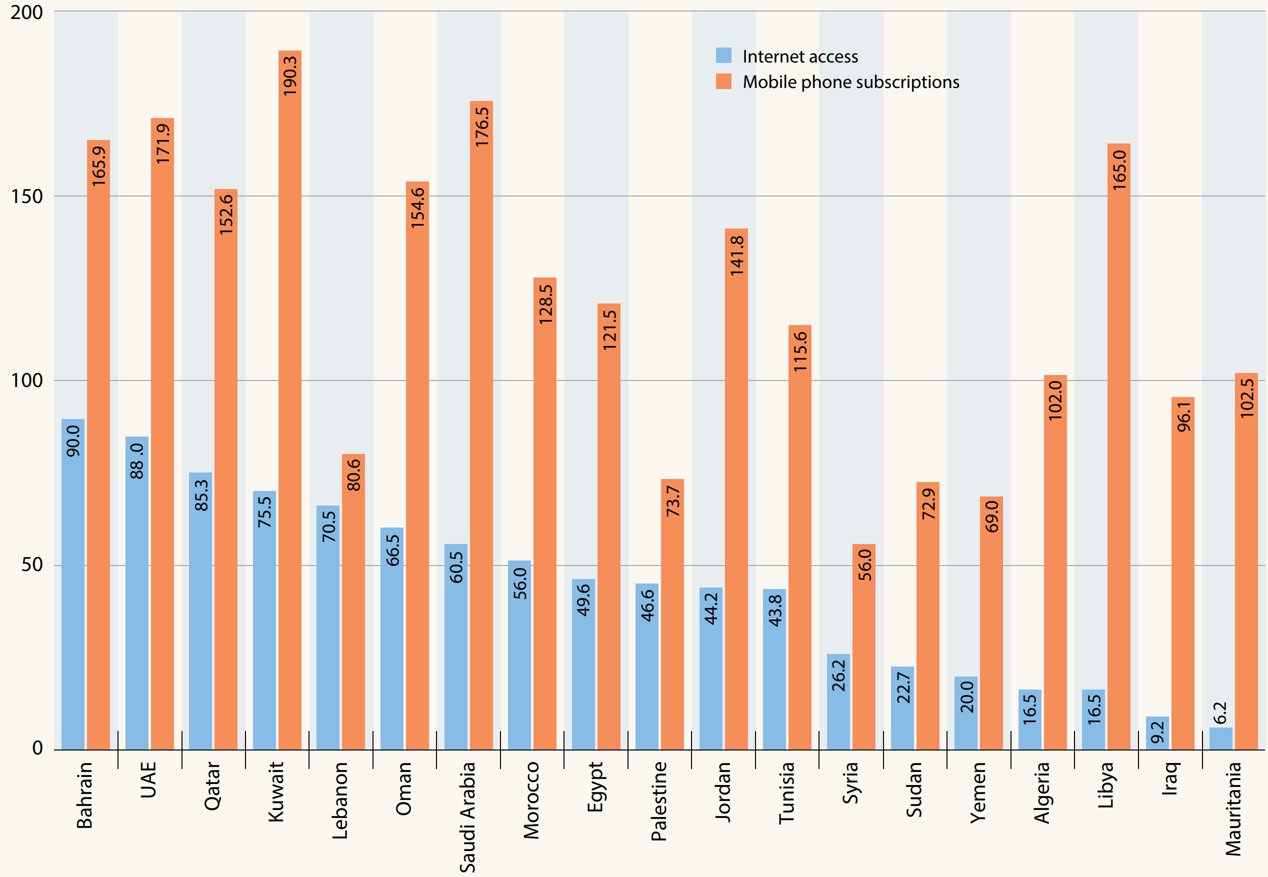
In November 2008, an agreement was signed by the Bahraini government and UNESCO to establish a Regional Centre for Information and Communication Technology in Manama under the auspices of UNESCO. The aim is to establish a knowledge hub for the six member states of the Gulf Cooperation Council. In March 2012, the centre hosted two high-level workshops on ICTs and education.

In 2013, the Bahrain Science Centre was launched as an interactive educational facility targeting 6–18-year olds. The topics covered by current exhibitions include junior engineering, human health, the five senses, Earth sciences and biodiversity.

In April 2014, Bahrain launched its National Space Science Agency. The agency is working to ratify international space-related agreements such as the Outer Space Treaty, the Rescue Agreement, the Space Liability Convention, the Registration Convention and the Moon Agreement. The agency will be establishing sound infrastructure for the observation of outer space and the Earth. It also hopes to

Figure 17.11: **Internet access and mobile phone subscriptions in Arab states, 2013**

Per 100 inhabitants



Source: International Telecommunications Union, February 2015

build a science culture within the kingdom and encourage technological innovation, among other goals.

Bahrain tops the Arab world for internet penetration, trailed by the United Arab Emirates and Qatar (Figure 17.11). Internet access has gone up tremendously in all Gulf States. Just half of Bahrainis and Qataris (53%) and two-thirds of those in the United Arab Emirates (64%) had access in 2009, compared to more than 85% in 2013. At the other end of the scale, fewer than one person in ten had internet access in Iraq and Mauritania in 2013.

EGYPT

Revolutionary fervour has spilled over into science

Current national policy documents in Egypt all consider science and technology to be vital for the country's future. The Constitution adopted in 2014 mandates the state to allocate 1% of GDP to 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 (Article 23).[8]

For decades, science and technology in Egypt were highly centralized and dominated by the public sector. R&D was carried out mostly by state-run universities and research centres supervised by the Ministry of Higher Education and Scientific Research, which split into the Ministry of Higher Education and the Ministry of Scientific Research (MoSR) in 2014. Egypt's research centres used to be scattered across different ministries but they are currently being reorganized under the umbrella of the Supreme Council of Scientific Research Centres and Institutes, in order to improve co-ordination.

The *UNESCO Science Report 2010* had recommended that Arab states establish national STI observatories. The Egyptian Science, Technology and Innovation Observatory was launched in February 2014 to provide advice on policy-making strategies and resource allocation through data collection and reporting on the development of national S&T capacities. The observatory is hosted by Egypt's Academy

8. See: http://stiiraqdev.wordpress.com/2014/03/15/sti-constitutions-arab-countries/

of Scientific Research and Technology. It published its first data collection in 2014 (ASRT, 2014). The observatory did not collect data for the business enterprise sector but nevertheless reported a rise in GERD from 0.43% to 0.68% of GDP between 2009 and 2013. The observatory also reports 22 000 FTE researchers in government research institutes and 26 000 at public universities. Just over half of Egypt's 42 universities (24) are public institutions but these also account for three-quarters of university enrolment.

A reform to produce market-ready graduates

Public expenditure on higher education stands at the acceptable level of 1% of GDP, compared to an average of 1.4% for OECD countries. This corresponds to 26% of the total public spending on education, close to the OECD average of 24%. Nonetheless, most of these resources cover administrative costs, in particular the salaries of academic and non-academic staff, rather than going on educational programmes. This practice has created a legacy of outdated equipment, infrastructure and learning materials. The amount spent on each student averages just US$ 902 (23% of GDP per capita), just one-tenth of the US$ 9 984 (37% of GDP per capita) spent on each student in OECD countries.

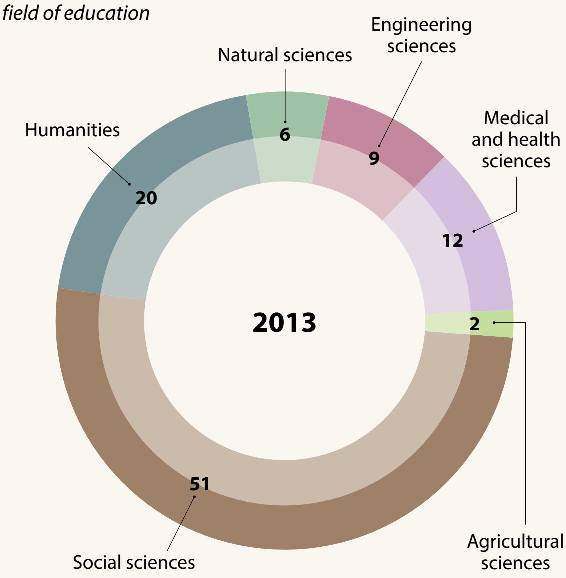
Universities offer a minimum degree course of four years and there tends to be a high ratio of students to staff, especially in humanities and social sciences which attract seven out of ten Egyptian students (Figure 17.12). The proportion of female university graduates in tertiary education has inched closer to gender parity in recent years but only in urban areas. The urban–rural gender divide is still alive and well.

Technical colleges offer a two-year programme of study in a number of specializations, including manufacturing, agriculture, commerce and tourism. A few technical colleges provide five-year courses leading to advanced diplomas but these technical diplomas lack the social status of university degrees. Whereas 60% of secondary school pupils are channelled towards technical and vocational secondary schools, almost 95% of enrolment in post-secondary technical colleges comes from general secondary schools; this leaves many pupils from technical and vocational secondary schools with no prospects for further education.

The government has announced a US$ 5.87 billion reform plan for higher education to produce market-ready graduates able to contribute to a knowledge economy. The plan runs from 2014 to 2022 and will be implemented in two phases. The plan is financed by the new constitutional entitlements that require the state to allocate at least 4% of the budget to education, 2% to higher education and 1% to scientific research (Articles 19–21 of the 2014 Constitution); it will also entail legislative reform to improve governance mechanisms.

Figure 17.12: **Egyptian student enrolment in public universities, 2013 (%)**

By field of education



Source: ASRT (2014)

A stronger focus on technical and vocational education

The plan aims to improve access to technical education within universities, ensure quality assurance, raise the level of educational services, link the output of the higher education system with labour market requirements and make universities more international. Recently, the government has begun preparing for the introduction of preferential admission criteria for promising students. This should improve the flexibility of their academic pathways.

Zewail City of Science and Technology revived

The Nile University is Egypt's first research university. Founded in 2006 by the non-profit Egyptian Foundation for Technology Education, this private institution was built on the outskirts of Cairo on land gifted by the government. In May 2011, the caretaker government reassigned the land and buildings to the Zewail City of Science and Technology and declared the complex a National Project of Scientific Renaissance (Sanderson, 2012).

The Zewail City of Science and Technology project had been lying dormant ever since its mentor, Nobel Prize laureate Ahmed Zewail, presented the concept to President Mubarak in 1999. The project was later revived, in recognition of the fact that Egypt would only be able to develop a knowledge economy if it could foster a technopreneurship culture led by projects such as Zewail's. In April 2014, President Al-Sissi decided to allot 200 acres to the Zewail City of Science and Technology for its permanent campus in the Sixth of October city, situated about 32 km from central Cairo. Once completed, Zewail City for Science and Technology[9] will have five constituents: a university, research institutes, a technology park, an academy and a centre for strategic studies.

The Academy of Scientific Research and Technology (ASRT) was founded in 1972. This non-profit organization is affiliated with the Ministry of Higher Education and Scientific Research (MoHSR), born of the merger with the Ministry of Higher Education in September 2015. It is not an academy of sciences in the conventional sense of the word as, until 2007, it controlled the budget for R&D in universities and research centres. Today, it acts as a think-tank and policy advisor to the ministry and co-ordinates the country's research programmes.

In early 2015, the Ministry of Scientific Research (MoSR) began putting the final touches to Egypt's *Strategy for Science, Technology and Innovation*. In February 2015, UNESCO provided the ministry with technical assistance in organizing a Policy Dialogue on STI in the presence of international experts. A report commissioned subsequently by UNESCO proposed a series of recommendations for nurturing scientific research in Egypt (Tindemans, 2015). These include:

- A platform should be established at cabinet level with stakeholders from the economy and society to devise a vision and strategy for enhancing the role played by STI in socio-economic development;
- In order to improve the monitoring and co-ordination of policy implementation and facilitate evaluation, MoSR should play a decisive role in the budgetary cycle for the institutes under its supervision and should publish each year a comprehensive overview of public and private sector expenditure on R&D; the ministry should also head a high-level permanent committee of civil servants from ministries entrusted with responsibility for collecting and validating basic information on the national innovation system;
- The Ministry of Scientific Research should develop close ties to the Ministry of Industry of Trade;
- Parliament should adopt a legal framework for scientific research comprised of both generic and more specialized laws;
- Patent law should be less rigid to favour innovation;
- Government departments need to be much more knowledgeable about the needs and aspirations of the private sector; they need to engage in much closer collaboration with the Industrial Modernization Centre, the Federation of Egyptian Industries;
- ASRT and MoSR should set up a framework to promote industrial innovation and co-operation by firms with universities and government research institutes;
- A national innovation funding agency should be set up to support private sector research and public–private co-operation, with the provision of competitive funding being its core task;
- The Egyptian Science, Technology and Innovation Observatory should consider it a priority to obtain information on both public and private sector investment in R&D; current data on GERD and researchers need to be subjected to critical analysis to ensure their reliability; the establishment of a panel of independent international experts could help with this critical analysis; and
- The Ministry of Scientific Research should develop close ties to the Ministry of Higher Education. The shortfall in scientific research is also reflected in the non-contextualization of learning materials in tertiary curricula.

9. see: www.zewailcity.edu.eg

IRAQ

Scientific research inscribed in the Constitution

Once a regional powerhouse of R&D, Iraq has lost its institutional and human capital to successive wars since 1980 and the subsequent exodus of its scientists. Since 2005, the Iraqi government has been seeking to restore the country's proud heritage. Iraq's Constitution of 2005 stipulates that 'the State shall encourage scientific research for peaceful purposes that serve humanity and shall support excellence, creativity, innovation and different aspects of ingenuity' (Article 34).

In 2005, UNESCO began helping Iraq to develop a Master *Plan for Science, Technology and Innovation* that would ultimately cover the period 2011–2015, in order to revive the economy in the aftermath of the US-led invasion in 2003 and to address pressing social needs such as poverty and environmental degradation. Following an analysis of the strengths and weaknesses of different sectors, UNESCO accompanied Iraq in preparing a *Framework and Agenda for Action* (2013) to complement the country's *National Development Plan* for the years 2013–2017 and to set the stage for a more comprehensive STI policy.

In 2010, the Universities of Baghdad, Basra and Salahaddin province joined the Avicenna Virtual Campus for Science and Technology. This gives them access to the teaching materials produced by other members of the UNESCO network,[10] which the Iraqi universities can then enrich with their own content. Further expansion of the Avicenna network within Iraq has been perturbed by the occupation of swaths of Iraqi territory by the Da'esh terrorist group.

10. Avicanna also involves universities from Algeria, Cyprus, Egypt, France, Italy, Jordan, Lebanon, Malta, Morocco, Palestine, Spain, Syria, Tunisia, Turkey and the UK.

On 20 June 2014, Iraq launched its first satellite for environmental monitoring. TigrisSat was launched from a base in the Russian Federation. The satellite is being used to monitor sand and dust storms in Iraq, as well as potential precipitation, vegetative land cover and surface evaporation.

JORDAN

Plans for an observatory of STI

Jordan's Higher Council for Science and Technology (est. 1987) is an independent public body that acts as a national umbrella organization for scientific research. It is the Higher Council for Science and Technology which drew up the first national policy for science and technology in 1995. In 2013, it completed the national *Science, Technology and Innovation Policy and Strategy* (2013–2017), which has seven broad objectives. These are to:

- incite the government and the scientific community to adopt the R&D priorities for developing a knowledge economy identified by the council and the Scientific Research Support Fund in 2010 in *Defining Scientific Research Priorities in Jordan for the Years 2011–2020*;
- generalize a science culture in the education system;
- harness R&D to development;
- build knowledge networks in science, technology and research;
- adopt innovation as a key stimulus for investment opportunities;
- translate the results of R&D into commercial ventures; and
- contribute to excellence in training and skills acquisition.

The Higher Council for Science and Technology has identified five domains in which projects are to be implemented to operationalize the policy: the institutional framework; policies and legislation; STI infrastructure; human resources; and the STI environment. An analysis of the national innovation system revealed that research was making an insufficient contribution to economic growth and to solving chronic problems, such as those related to water, energy and food. For the 2013–2017 period, some 24 projects have been proposed at a projected cost of around US$ 14 million that is still to be allocated by the government. These include a review of the national STI policy, institutionalizing innovation, developing incentive schemes for researchers and innovators, founding technology incubators and setting up a research database. A unit is to be created within the Higher Council for Science and Technology specifically for expatriate Jordanian scientists. The council is responsible for implementing, following up and evaluating all 24 projects, along with relevant ministries.

For over six years, the Higher Council for Science and Technology has been involved in a project that is setting up an Observatory of Science, Technology and Innovation, in collaboration with the United Nations' Economic and Social Commission for Western Asia (ESCWA). The observatory will maintain the country's first comprehensive database of domestic R&D and is to be hosted by the council.

In 2013, the Higher Council for Science and Technology published the *National Innovation Strategy*, 2013–2017, which had been prepared[11] in collaboration with the Ministry of Planning and International Co-operation with the support of the World Bank. Targeted fields include energy, environment, health, ICTs, nanotechnology, education, engineering services, banking and clean technologies.

Revival of two research funds

Jordan's Scientific Research Support Fund[12] was revived in 2010 after being instituted in 2006. Administered by the Ministry of Higher Education and Scientific Research, it finances investment in human resources and infrastructure through competitive research grants related to ecological water management and technological applications. The fund backs entrepreneurial ventures and helps Jordanian companies to solve technical problems; it also encourages private bodies to allocate resources for R&D and provides university students with scholarships based on merit. So far, the fund has provided 13 million Jordanian dinars (*circa* US$ 18.3 million) to finance R&D projects in Jordan, 70% of which has been used to fund projects in energy, water and health care.

The revamped Scientific Research Support Fund is also intended to streamline the activities supported by the Fund for Scientific Research and Vocational Training (est. 1997). This fund was launched partly to ensure that all public share-holding Jordanian companies either spent 1% of their net profits on research or vocational training within their own structure or paid an equivalent amount into the fund for redistribution for the same purpose. The problem was that the definition of what constituted research and vocational training was too broad. As a result, new regulations were adopted in 2010 to clarify the terms and provide for the collection of the 1% to be spent on R&D.

Jordan is home to the King Abdullah II Design and Development Bureau (KADDB), an independent government entity within the Jordanian Armed Forces that develops defence products and security solutions for the region. KADDB works with Jordanian universities to help students tailor their research projects to KADDB's needs.

11. Despite the similarity in name, this document differs from the *Science, Technology and Innovation Policy and Strategy* (2013–2017).

12. See: www.srf.gov.jo

Box 17.3: **SESAME project soon to light up the region**

Jordan is home to the region's first major interdisciplinary science centre, the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME), which houses the highest energy accelerator in the Middle East.

Synchrotrons work by accelerating electrons around a circular tube at high speed, during which time excess energy is given off in the form of light. By focusing this intense light, the tiniest structures can be mapped in great detail. The light source acts like a super X-ray machine and can be used by researchers to study everything from viruses and new drugs to novel materials and archaeological artefacts.

Synchrotrons have become an indispensable tool for modern science. There are some 50 such storage-ring-based synchrotron light sources in use around the world. The majority are found in high-income countries but Brazil (see Box 8.2) and China also have them.

By early 2017, construction of the storage ring will have been completed and the SESAME laboratory and its two beamlines will be fully operational, making it the first synchrotron light source in the region. Already, scientists are visiting SESAME for their work, thanks to the Fourier Transform Infrared microscope that has been in operation there since August 2014.

Construction of the centre began in 2003. SESAME has been established under the aegis of UNESCO as a co-operative intergovernmental venture by the scientists and governments of the region in which it is located. Its governance is assured by the SESAME Council.

The SESAME members are Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey. There are also observers: Brazil, China, the European Union, France, Germany, Greece, Italy, Japan, Kuwait, Portugal, the Russian Federation, Spain, Sweden, Switzerland, the UK and USA.

Alongside its scientific aims, SESAME promotes solidarity and peace in the region through scientific co-operation.

Source: Susan Schneegans, UNESCO
See: www.sesame.org.jo/sesame

Jordan has hosted the ESCWA Technology Centre since its inception in 2011. The centre's mission is 'to assist member countries and their public and private organizations to acquire the necessary tools and capabilities to accelerate socio-economic development.'

Jordan also hosts the the Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME), which should be fully operational by 2017 (Box 17.3).

KUWAIT

A difficult transition

The contribution of most non-oil economic sectors in Kuwait declined after the Iraqi invasion in 1990, especially after hundreds of companies and foreign institutions, including banking and investment brokers, moved their operations elsewhere in the region. The economic slowdown was mainly due to the flight of capital and the cancellation of important development projects like the petrochemical project with the Dow Chemical Company, which filed a lawsuit against Kuwait demanding compensation of US$ 2.1 billion. In May 2012, Dow Chemical won the case, thus increasing Kuwait's financial losses (Al-Soomi, 2012).

In the past few years, there have been some missed opportunities to implement development projects of significant economic value; in parallel, Kuwait's dependence on oil revenue has grown. Kuwait was a regional leader in science and technology and higher education in the 1980s but has been losing ground ever since. The World Economic Forum's 2014 *Global Competitiveness Report* reveals a significant deterioration in many STI-related indicators.

Besides the Ministry of Education and the Ministry of Higher Education, the three major players in science in Kuwait are the Kuwait Foundation for the Advancement of Sciences, Kuwait Institute of Scientific Research and Kuwait University. The Kuwait Foundation for the Advancement of Sciences developed a new plan in 2010–2011 to mobilize financial and human resources, in order to reinvigorate both the government and private sectors, with a concomitant desire to improve public understanding of science.

The Kuwait Institute of Scientific Research (est. 1967) carries out applied research in three broad fields: oil, water, energy and construction; environment and life sciences; and techno-economics. It also advises the government on research policy. In recent years, the institute has emphasized scientific excellence, a client focus, achieving international technological leadership, the commercialization of research results and the establishment of new centres. The current eighth strategic plan covering 2015–2020 focuses on technology roadmapping to develop system solutions for selected technologies in oil, energy, water and life sciences.

The Kuwait University Research Sector supports faculty initiatives in basic and applied research and in humanities. It offers research grants within a number of funding schemes and finances a joint research programme in the area of natural resources development with the Massachusetts Institute of Technology in the USA. For its part, the Kuwait University Research Park has a more commercial focus. It aims to lay the foundations for innovation and spin-off technologies with scope for industry–research linkages and potential for patenting and marketing. Faculty researchers have made headway; they announced the acquisition of six US patents during the 2010/2011 academic year, two new patent awardees the following year and four in 2012/2013.

LEBANON

Three instituitions dominate research

Despite the existence of over 50 private universities and one public one, most research[13] in Lebanon is carried out by just three institutions: the Lebanese University, Saint-Joseph University and the American University of Beirut. On occasion, these three institutions collaborate with one of the four research centres managed by the National Council for Scientific Research (CNRS, est. 1962) and/or the Lebanese Agricultural Research Institute.

Lebanon counts several NGOs active in science, including the Arab Academy of Sciences (est. 2002) and the Lebanese Association for the Advancement of Science (est. 1968). The Lebanese Academy of Sciences was created by government decree in 2007.

As there is no ministry in charge of national policy-making in science and technology, the CNRS is considered as the main umbrella organization for science and the government advisor in this field, under the authority of the prime minister. The CNRS fulfils an advisory function, drawing up the general outline of Lebanon's national science policy. It also initiates, encourages and co-ordinates research projects. It is also responsible for managing the Centre for Geophysics, the Centre for Marine Sciences, the Centre for Remote Sensing and the Lebanese Atomic Energy Commission.

In 2006, the CNRS finished drafting the national *Science, Technology and Innovation Policy* with support from UNESCO and ESCWA.[14] The policy introduced new funding mechanisms for research and encouraged researchers from various institutions to work together under the umbrella of an associated research unit on major multidisciplinary themes. It also introduced new programmes to boost innovation and capacity-building, joint PhD programmes and established the basis for Lebanese participation in key Euro-Mediterranean projects.

The policy also identified a series of national priority research programmes inspired by the work of specialized task forces:

- Information technology (IT) deployment in the enterprise sector;
- Web and Arabized software technologies;
- Mathematical modelling, including financial/economic applications;
- Renewable energy sources: hydro-electric, solar, wind;
- Material/Basic sciences for innovative applications;
- Sustainable management of coastal areas;
- Integrated water management;
- Technologies for new agricultural opportunities, including the medicinal, agricultural and industrial use of local plant biodiversity;
- Nutritional food quality;
- Research in subfields of molecular and cellular biology;
- Research in clinical sciences;
- Forging links between practitioners of medical and health sciences, social sciences and paramedical professions.

An observatory of STI

The CNRS has incorporated these R&D priorities into its own research grant programme (Figure 7.13). Moreover, as follow-up to the *Science, Technology and Innovation Policy,* it embarked on establishing the Lebanese Observatory for Research, Development and Innovation (LORDI) in 2014 with support from ESCWA, in order to monitor key indicators of R&D input and output. Lebanon participates in a platform linking Mediterranean observatories of STI. This co-operative platform was set up by the Mediterranean Science, Policy, Research and Innovation Gateway (Med-Spring project) within the EU's Seventh Framework Programme for Research and Innovation (2007–2013).

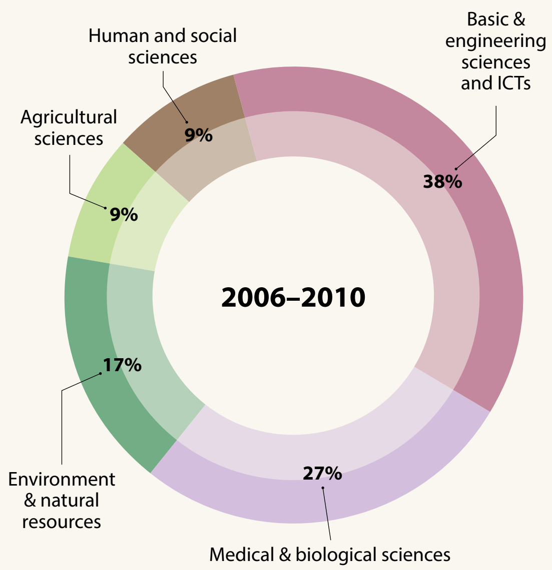
Lebanon's first comprehensive energy strategy

In November 2011, the Lebanese Council of Ministers officially adopted the *National Energy Efficiency Action Plan* for the years 2011–2015. This plan had been developed by the Lebanese Centre for Energy Conservation, the technical arm of the Ministry of Energy and Water in the areas of energy efficiency, renewable energy and 'green' buildings. This is the first comprehensive strategy in energy efficiency and renewable energy for a country

13. http://portal.unesco.org/education/en/files/55535/11998897175Lebanon.pdf/Lebanon.pdf

14. UNESCO has an office in Beirut and ESCWA is hosted by Lebanon.

Figure 17.13: **Distribution of research grants by the Lebanese National Council for Scientific Research, 2006–2010 (%)**



Source: presentation by the Lebanese National Council for Scientific Research (CNRS) to a meeting of the Mediterranean network of observatories of STI, December 2013

that depends on imports for 95% of its energy requirements. The plan is a Lebanese version of the *Arab Energy Efficiency Guidelines* developed by the League of Arab States and comprises 14 national initiatives designed to help Lebanon reach its target of 12% renewable energy by 2020.

LIBYA

The legacy of extreme state control still visible

During the four decades preceding the 2011 uprising, the Libyan economy had drifted towards near-complete state control. Private property ownership and private sector activity in sectors such as retail and wholesale trading were severely curtailed by law, while uncertainty over tax and regulatory regimes prevented the development of economic activity beyond the oil sector; today, this sector is still officially controlled by the National Oil Corporation, which mimics a ministry, in addition to being a regulatory agency and state-owned company. Mining and quarrying represented 66% of GDP in 2012 and 94% of government revenue a year later (AfDB, 2014).

This economic and intellectual suffocation led to large-scale brain drain, making Libya dependent on a sizeable immigrant population to drive highly skilled sectors, among others. There are currently an estimated 2 million foreign workers in Libya, most of whom are illegal (ETF, 2014).

Despite immigrant labour, the Libyan economy was also characterized by a relatively low economic participation rate of around 43% of the adult population between 2008 and 2013 (Table 17.1). Moreover, in its *Rapid Assessment of the Libyan Labour Market* in 2012, the World Bank estimated that 83% of employees were working in government or government-owned enterprises.

The extreme degree of state control was also reflected in Libya's STI environment. Between 2009 and 2013, every single researcher in Libya was employed by the government sector, according to the Libyan Authority for Research, Science and Technology, although it does not survey the business enterprise sector. According to the same source, the number of FTE researchers rose over this period from 764 to 1 140, representing a leap from 128 to 172 FTE researchers per million inhabitants, even if this remains a low ratio for a high-income country like Libya. Despite the turmoil, Libyan researchers managed to increase their annual output from 125 to 181 papers between 2009 and 2014, according to the Web of Science. There are no available data but the Libyan oil industry is known to conduct research on its own behalf.

Political fragmentation delaying recovery

Libya's first post-revolution national elections in July 2012 formally transferred power from the National Transitional Council to the General National Congress in August 2012. Soon afterwards, the country descended into armed conflict. The Council of Deputies (parliament) was formed after the June 2014 elections and is recognized as the legitimate government of Libya by the international community. Currently, it meets in virtual exile in Tobruk, near the Egyptian border. Meanwhile, the country's constitutional capital, Tripoli, is held by supporters of a New General National Congress composed of Islamists who fared poorly in the low-turnout elections. In Benghazi and elsewhere, the climate of insecurity has delayed the start of the school and academic years.

Initially, disruptions to oil production caused a 60% contraction in GDP in 2011 but the economy recovered remarkably quickly, rebounding by 104% in 2012. The deteriorating security situation since, coupled with protests at oil terminal cities since the second half of 2013, have augmented macro-economic instability, causing GDP to contract by 12% in 2013 and the fiscal balance to plummet from a surplus of 13.8% in 2012 to a deficit of 9.3% in 2013 (AfDB, 2014). Private sector activity remains subdued, given the current political uncertainty, exacerbating weak regulatory and institutional conditions and restrictive regulations that limit job creation. Libya's development potential has been further weakened by new laws passed in 2013 limiting foreign ownership of companies to 49% (down from 65% under earlier legislation).

Returning Libyans could help to rebuild higher education

Once security returns, Libya can hope to tap into its large oil wealth to begin building its national innovation system. Priority areas should include strengthening the higher education system and wooing talented Libyans living abroad.

According to the Libyan Authority for Research, Science and Technology, there were an estimated 340 000 tertiary students in 2013/2014 (54% female), down from 375 000 in 2003. This compares with an 18–25-year cohort in excess of 600 000, according to the UNESCO Institute for Statistics. A development plan for 2008–2012 with a budget of US$ 2 billion had envisaged the creation of 13 new universities, on top of the existing 12. While much of the physical infrastructure has since been built, the upheavals since 2011 have prevented these new universities from opening their doors.

Returning Libyan brains could potentially play a major role in rebuilding the Libyan higher education system, with the right incentives. Currently, an estimated 17 500 Libyans are pursuing postgraduate studies abroad, compared to 22 000 within the country. According to the Libyan higher education authorities, there were approximately 3 000 Libyan students enrolled in postgraduate studies at British universities alone and almost 1 500 in North America in 2009. Anecdotal evidence suggests that the security situation has since triggered a fresh exodus of talent: the number of Libyan students enrolled in Malaysian universities, for instance, grew by 87% between 2007 and 2012 from 621 to 1 163 (see Figure 26.9).

A national strategy for STI

In October 2009, the Libyan Ministry of Higher Education and Scientific Research launched the first programme to provide Libyan researchers with direct funding. The aim of this ongoing programme is to disseminate a research culture in Libyan society, including both the government and business enterprise sectors. The programme disbursed more than US$ 46 million between 2009 and 2014.

In December 2012, the ministry established a national committee to lay the foundations of a national innovation system, under the stewardship of the Libyan Authority for Research, Science and Technology and in collaboration with all economic sectors. The committee prepared a draft National Strategy for Science, Technology and Innovation and instigated several prizes: students from the country's main universities competed in the first round of the entrepreneurship prize – supported by the British Council – in the 2012/2013 academic year and in the first round of the innovation prize in the 2013/2014 academic year.

The *National Strategy for Science, Technology and Innovation* was approved by the Libyan National Planning Council in June 2014. The strategy fixes some long-term targets, such as that of raising GERD to 2.5% of GDP by 2040 (Table 17.6). It also foresees the establishment of centres of excellence, smart cities, business incubators, special economic zones and technology parks, as well as the creation of an STI information database. Science and technology are to be harnessed to ensure sustainable development and security.

Table 17.6: **Libyan targets for STI to 2040**

	2014	2020	2025	2030	2040
FTE researchers per million inhabitants	172^{-1}	5 000	6 000	7 500	10 000
GERD/GDP ratio (%)	0.86	1.0	1.5	2.0	2.5
Number of patents	0	20	50	100	200
Number of published journals	25	100	200	500	1 000
Number of research proposals	188	350	650	1 250	2 250
Number of SMEs specializing in STI	0	10	50	100	200
Share of private sector expenditure on R&D in GERD (%)	0	10	15	20	30
Private sector income from R&D (% of GDP)	0	1	5	10	30
Share of technological products in exports (%)	0	5	10	15	40
Number of PhD students	6 000	8 000	10 000	8 000	8 000
Innovation score (Global Innovation Index)	135	90	70	50	30
Global Competitiveness Index (World Economic Forum)	3.5	3.7	3.9	4.0	4.5

-*n* = *n* years before reference year

Source: Libyan National Planning Council (2014) *National strategy for Science, Technology and Innovation*

R&D priorities have yet to be identified but, according to the strategy, should focus on problem-solving research, Libya's contribution to international knowledge production and on diversifying Libya's technological capabilities through investment in such areas as solar energy and organic agriculture.

MAURITANIA

Towards a national strategy for STI

The main finding of the *Science Technology and Innovation Policy Review of Mauritania*[15] undertaken by the United Nations Conference on Trade and Development and UNESCO in 2010 was that current capabilities were inadequate to address the challenges faced by the country. Most public and private enterprises lack the capacity to innovate that would make them internationally competitive. The skills base needs developing, particularly in scientific and technical disciplines, as well as in entrepreneurship and management. Also needed are more rapid technology diffusion and a greater absorptive capacity of technology. Some of the main shortcomings identified were:

- Limited and uncertain public financing for public R&D and lack of private sector investment in R&D or training;
- No active promotion of domestic quality standards as a means of improving the quality of domestic production and encouraging private investment in training and improved technologies;
- An excessively theoretical (as opposed to applied) focus of research at the University of Nouakchott and a lack of co-ordination between the university, public research institutes and ministries for training and R&D;
- A need to reduce bureaucratic obstacles to starting and operating a business;
- A weak entrepreneurial base sustained by the lack of business development services and by a culture of trading rather than investment in production;
- Lack of access by domestic enterprises to information on available technologies and the transfer and absorption of foreign technologies; and
- A lack of policies to leverage the significant reserve represented by the diaspora for domestic benefit.

With the technical assistance of UNESCO, Mauritania is currently drafting the national STI strategy recommended by the review. The focus is on developing skills and physical infrastructure, as well as on improving the co-ordination of private sector development policies, education reform and trade and foreign investment policies. Reforms will also need to build strong productive capacities in agriculture and fisheries, the mining industry and services sector, in order to take advantage of any improvement in macro-economic conditions.

New institutions and a plan for higher education

Mauritania's first tertiary institution, the National School of Administration, dates back to 1966; it was followed by the National School of Higher Studies (École nationale supérieure) in 1974 and the University of Nouakchott in 1981. Between 2008 and 2014, the government licensed three private tertiary colleges and founded the Institute of Higher Technological Studies (Institut supérieur des études technologiques, 2009) in Rosso and the University of Science, Technology and Medicine (2012). The new university has about 3 500 students and 227 teaching staff, including researchers. It is comprised of a Faculty of Science and Technology, a Faculty of Medicine and a professional training institute.

These developments reflect the government's will to improve access to higher education for the growing population. In accordance with the ten-year *Strategy for Science, Technology and Innovation* adopted by the African Union in 2014 (see Chapter 19), the government intends to use higher education as a lever for economic growth.

In April 2015, the Ministry of Higher Education and Scientific Research adopted an ambitious *Three-Year Plan for Higher Education* covering 2014–2017. This plan has four main objectives:

- Strengthen institutional management and governance of tertiary institutions;
- Improve the relevance of the curricula, the quality of training and the employability of graduates;
- Broaden access to tertiary study programmes; and
- Promote scientific research on major national development issues.

For the first time, the current administration has managed to collect relatively comprehensive data on higher education and scientific research data across the country. These data should enable the Ministry of Higher Education and Scientific Research and line ministries to identify the main obstacles to research.

15. See: http://unctad.org/en/Docs/dtlstict20096_en.pdf

MOROCCO

Added value a must to maintain competitiveness

Morocco has managed to navigate the fallout from the global financial crisis relatively well, with average growth of over 4% between 2008 and 2013. As Europe is the main destination for Moroccan exports, these have nevertheless been affected by the slowdown in the European economy since 2008. The economy is diversifying but remains focused on low value-added products; the latter still represent about 70% of manufactured goods and 80% of exports. Unemployment remains high, at over 9% (Table 17.1), and about 41% of the labour force lacks any qualification. There are also signs of waning competitiveness in some areas: in recent years, Morocco has conceded market shares for clothing and shoes in the face of tough international competition from Asia, in particular, but managed to expand its market share for fertilizers, passenger vehicles and equipment for the distribution of electricity (Agénor and El-Aynaoaui, 2015).

Morocco's S&T system is essentially centred around the Ministry of Higher Education and Scientific Research (MoHESR) and the Inter-Ministerial Permanent Committee on Scientific Research and Technological Development (est. 2002), together with the Hassan II Academy of Science and Technology (est. 2006). The National Centre for Scientific and Technical Research (CNRST) is another key player; it runs the National Support Programme for Sectorial Research, for instance, which issues calls for research proposals to public institutions.

Less than a year after its inception, the Higher Council for Education, Training and Scientific Research[16] presented a report to the king on 20 May 2015 offering a *Vision for Education in Morocco 2015–2030*. The report advocates making education egalitarian and, thus, accessible to the greatest[17] number. Since improving the quality of education goes hand in hand with promoting R&D, the report recommends developing an integrated national innovation system which would be financed by gradually increasing the share of GDP devoted to R&D 'to 1% in the short term, 1.5% by 2025 and 2% by 2030'.

The *Moroccan Innovation Strategy* was launched at the country's first National Innovation Summit in June 2009 by the Ministry of Industry, Commerce, Investment and the Digital Economy. It has three main thrusts: to develop domestic demand for innovation; foster public–private linkages; and introduce innovative funding mechanisms. Today, the latter include Intilak for innovative start-ups and Tatwir for industrial enterprises or consortia. The ministry is supporting research in advanced technologies and the development of innovative cities in Fez, Rabat and Marrakech.

The *Moroccan Innovation Strategy* fixed the target of producing 1 000 Moroccan patents and creating 200 innovative start-ups by 2014. In parallel, the Ministry of Industry, Commerce and New Technologies (as it had since become) created a Moroccan Club of Innovation in 2011, in partnership with the Moroccan Office of Industrial and Commercial Property. The idea is to create a network of players in innovation, including researchers, entrepreneurs, students and academics, to help them develop innovative projects.

Morocco's third technopark is scheduled to welcome its first start-ups and SMEs in September 2015. Like its two predecessors in Casablanca and Rabat, the new technopark in Tangers will be hosting companies specializing in ICTs, green technologies and cultural industries. Through a public–private partnership, offices in an existing building have been converted for an estimated cost of 20 million dirhams (MAD, *circa* US$ 2 million). They should be able to accommodate up to 100 enterprises, which will be sharing the premises with some of the project's key partners, such as the Moroccan Entrepreneurial Network and the Association of Women CEOs of Morocco (Faissal, 2015).

The National Fund for Scientific Research and Technological Development was adopted by law in 2001. At the time, domestic enterprises funded just 22% of GERD. The government encouraged companies to contribute to the fund to support research in their sector. Moroccan telecom operators were persuaded to cede 0.25% of their turnover; today, they finance about 80% of all public research projects in telecommunications supported through this fund. The financial contribution of the business enterprise sector to GERD has meanwhile risen to 30% (2010).

The government is also encouraging citizen engagement in innovation on the part of public institutions. For instance, the Moroccan Phosphate Office (Office chérifien des phosphates) is investing in a project to develop a smart city, King Mohammed VI Green City, around Mohammed VI University located between Casablanca and Marrakesh, at a cost of MAD 4.7 billion (*circa* US$ 479 million).

University–business partnerships remain very limited in Morocco. Nevertheless, a number of competitive funds fostering this type of collaboration have been renewed in recent years. These include the following:

16. The council was founded in accordance with the provisions of Article 168 of the Moroccan Constitution of 2011.

17. The *National Strategy for the Development of Scientific Research to 2025* (2009) recommended raising the secondary enrolment rate from 44% to at least 80% and the tertiary enrolment rate for 19–23 year-olds from 12% to over 50% by 2025.

- The third InnovAct programme was launched by the Moroccan Research Association in 2011, according to Erawatch. Whereas the programme's two predecessors (launched in 1998 and 2005) had targeted SMEs, the new programme has extended the beneficiary groups to include consortia of enterprises. SMEs are expected to pay 50–60% and consortia 80% of the project costs. The scheme encourages university–industry collaboration; companies receive logistical support and the financial means to recruit university graduates to work on their research project. The programme aims to support up to 30 enterprises each year operating mainly in the following industries: metallurgical, mechanical, electronic and electrical; chemical and parachemical; agro-food; textiles; technologies for water and environment; aeronautics; biotechnology; nanotechnology; off-shoring; and automotive;
- The Hassan II Academy of Sciences and Technology funded 15 research projects in 2008 and 2009. Calls for research proposals encourage private–public collaboration and take into consideration the project's potential socio-economic impact or spillovers;
- MoHESR places a number of poles of competence under contract for four years to bring together public and private research establishments together on a joint project through its accredited laboratories. There were 18 poles of competence up until 2010 but these have since been whittled down to 11 after several did not meet the ministry's new criteria for funding. The networks include one on medicinal and aromatic plants, another on higher energy physics, a third on condensed matter and systems modelling and a fourth on neurogenetics;
- The Moroccan Spin-off and Incubation Network *(Réseau Maroc incubation et essaimage)*[18] supports business incubation, in general, and technology transfer through university spin-offs, in particular. It provides start-ups with pre-seed capital to help them develop a solid business plan. The network is co-ordinated by the CNRST and currently groups 14 incubators at some of the top Moroccan universities.

18. See: www.rmie.ma

One in five graduates moves abroad

Each year, 18% of Moroccan graduates head mainly for Europe and North America; this trend has led to calls for foreign universities to be established in Morocco and for the development of prestigious campuses.

The Hassan II Academy of Science and Technology has international scientific outreach. In addition to recommending research priorities and evaluating research programmes, it helps Moroccan scientists to network with their national and international peers. The academy has identified a number of sectors where Morocco has a comparative advantage and skilled human capital, including mining, fisheries, food chemistry and new technologies. It has also identified a number of strategic sectors, such as energy, with an emphasis on renewable energies such as photovoltaic, thermal solar energy, wind and biomass; as well as the water, nutrition and health sectors, the environment and geosciences (HAST, 2012).

A growing investment in renewable energy

Morocco is expanding its investment in renewable energies (Box 17.4). A total of MAD 19 million (*circa* US$ 2 million) has been earmarked for six R&D projects in the field of solar thermal energy, under agreements signed by the Institute for Research in Solar and New Energy (IRESEN) with scientific and industrial partners. Moreover, IRESEN is currently financing research in the field of renewable energy that is being conducted by more than 200 engineers and PhD students and some 47 university teachers-cum-researchers.

Box 17.4: Morocco plans to lead Africa in renewables by 2020

Morocco has decided to compensate for its lack of hydrocarbons by becoming the leader in Africa for renewable energy by 2020. In 2014, it inaugurated the continent's biggest wind farm at Tarfaya in the southwest of the country.

The government's latest project is to create the world's biggest solar farm at Ouarzazate. The first phase, known as Noor I, should be completed by October 2015.

A consortium led by the Saudi Arabian company Acwa Power and its Spanish partner Sener won the call for tenders for the first phase and Acwa Power has just won the same for the second phase. It is estimated that it will cost the consortium nearly € 2 billion to build and run Noor II (200 MW) and Noor III (150 MW).

The project is also being funded by donors such as the German public bank Kreditanstalt für Wiederaufbau (€ 650 million) and the World Bank (€ 400 million).

Ultimately, the Ouarzazate solar farm will have a capacity of 560 MW but the government doesn't intend to stop there. It plans to produce 2 000 MW of solar power by 2020.

Source: Le Monde (2015)

OMAN

An incentive scheme to bolster research

According to the 2012 country report by the US Energy Information Administration, hydrocarbons accounted for about 86% of government revenue and half of GDP in 2013. Oman has an ambitious plan to reduce the oil sector's contribution to GDP to 9% by 2020. The aim is to diversify the economy, such as by developing the tourism sector, as part of the government's *Economic Vision 2020*. There is little latitude for expanding agricultural production but Oman hopes to exploit its long coastline's potential for the development of fisheries and gas-based industries to achieve the goals of *Economic Vision 2020* (Salacanin, 2015).

Oman's S&T system is centred around the Ministries of Education and Higher Education and Sultan Qaboos University. The Research Council is Oman's sole research funding body and thus spearheads R&D in the country. Established in 2005, it has an extensive mandate. The Research Council has identified the hurdles facing Oman, such as complex administrative processes, little funding, research of poor quality and the lack of relevance of R&D to socio-economic needs (Al-Hiddabi, 2014).

To address these difficulties, the Research Council developed a *National Research Plan for Oman* in 2010 which is linked to Oman's overall development plans. The plan outlines three stages: the first priority is to improve the status of research and boost productivity; at the second stage, the priority will be to build national research capacity in priority areas determined by the availability of appropriately qualified personnel and the establishment of the requisite infrastructure; at the last stage, the focus will be on strengthening the country's niche areas.

The Research Council has also developed an incentive scheme to foster research excellence. The programme rewards researchers through an open research grant scheme tied to their output. Besides stimulating productivity, the idea is to increase the number of active researchers, motivate them to mentor postgraduate students and encourage them to publish in international, refereed journals and to apply for patents.

In October 2014, Oman hosted the General Meeting of the World Academy of Sciences (TWAS). Two months later, the Research Council co-organized the second Arab–American Frontiers Symposium with the US National Academy of Sciences to facilitate research collaboration between outstanding young scientists, engineers and medical professionals from the USA and a number of Arab states.

PALESTINE

More research links needed with the market

Although Palestine does not have a national STI policy, a recent innovation survey by Khatib *et al.* (2012) of the two industrial sectors of stone quarrying and food and beverages yielded encouraging findings. The survey found that both sectors were innovative and having a positive impact on employment and exports. The survey recommended directing academic programmes towards local economic development to help establish the necessary co-operative links between the public and private sectors.

The Palestine Academy of Sciences and Technology (PALAST) acts as an advisory body for the government, parliament, universities and research institutes, as well as for private donors and international organizations. One of PALAST's special features is the presence of a powerful standing committee made up of a number of government ministers; the standing committee operates alongside a scientific council of elected members from PALAST (PALAST 2014).

An observatory of STI

In 2014, PALAST launched its Science, Technology and Innovation Observatory, which had been developed with the support of ESCWA. The observatory's main purpose is to collect data on STI on a regular basis and promote networking.

Hundreds of entrepreneurial web sites have been created by young Palestinians in the past few years to showcase new digital products that include games and software for specific professions. Although internet connection costs have fallen by almost 30% in recent years, the lack of connectivity to a 3G network in the West Bank and Gaza Strip hinders the use of mobile applications for education, health and entertainment.

QATAR

Incentives for entrepreneurship

Besides its oil and gas industry, Qatar relies on the petrochemical, steel and fertilizer industries to drive the economy. In 2010, Qatar showed the world's fastest growth rate for industrial production: 27.1% over the previous year. Qataris enjoy the world's highest GDP per capita (PPP$ 131 758) and one of the world's lowest unemployment rates: 0.5% (Table 17.1).

The *Qatar National Vision 2030* (2008) advocates finding an optimum balance between the current oil-based economy and a knowledge economy characterized by innovation and entrepreneurship, excellence in education and the efficient delivery of public services. To support this shift towards a knowledge economy, the government budget for education to 2019 has been raised by about 15%.

The government has also begun offering investors tax breaks and other incentives to support entrepreneurship and promote SMEs. Its efforts to diversify the economy appear to be paying off. Industries and services derived from hydrocarbons have been expanding, fuelling private-sector growth. Although the manufacturing sector is still in its infancy, there has been a boom in the construction sector, thanks largely to heavy investment in infrastructure; this in turn has boosted the finance and real estate sectors (Bq, 2014). Much of construction is occurring in the non-hydrocarbon sector: in transportation, health, education, tourism and sport – Qatar is hosting the World Football Cup in 2022. The government is also promoting Qatar as a tourist destination among its neighbours, in particular. Consequently, non-hydrocarbon sectors grew by 14.5% in 2013.

Qatar's new park is country's primary technology incubator

The *Qatar National Research Strategy* (2012) identified four priority areas: energy, environment, health sciences and ICTs. When the Qatar Foundation subsequently established the Qatar Science and Technology Park, it focused on these four areas. The park has become Qatar's primary incubator for technological development, the commercialization of research and support for entrepreneurship. Located within the Qatar Foundation's Education City, the park has access to the resources of a cluster of leading research universities with antennae in the park, including five US institutions: Virginia Commonwealth University School of the Arts, Weill Cornell Medical College, Texas A&M University at Qatar, Carnegie Mellon University and Georgetown University.

SAUDI ARABIA

Policies to reduce dependence on foreign labour

As part of its agenda for embracing the knowledge economy, the government has launched a multibillion dollar development scheme to build six greenfield cities and industrial zones. By 2020, these industrial cities are expected to generate US$ 150 billion in GDP and create 1.3 million jobs. This strategy has been endorsed by the record number of non-oil exports in 2013. However, Saudi Arabia remains overdependent on foreign labour: there are only 1.4 million Saudis employed in the private sector, compared with 8.2 million foreigners, according to the Ministry of Labour (Rasooldeen, 2014). The government is trying to recruit citizens through a drive dubbed 'Saudization'.

In parallel, the government is investing in professional training and education as a way of reducing the number of foreign workers in technical and vocational jobs. In November 2014, it signed an agreement with Finland to utilize Finnish excellence to strengthen its own education sector (Rasooldeen, 2014). By 2017, the Technical and Vocational Training Corporation of Saudi Arabia is to have constructed 50 technical colleges, 50 girls' higher technical institutes and 180 industrial secondary institutes. The plan is the first step in creating training placements for about 500 000 students, half of them girls. Boys and girls will be trained in vocational professions such as IT, medical equipment handling, plumbing, electricity, mechanics, beauty care and hairdressing.

Two universities among the top 500

Saudi Arabia has now entered the third phase of implementation of its first national S&T policy (2003). The policy called for the establishment of centres of excellence and for upgrading the skills and qualifications of human resources. The country is keen to co-operate with the outside world, invest more in information technologies and harness S&T to preserving its natural resources and protecting the environment.

The *Five-Year Development Plan* adopted in 2010 proposed allocating US$ 240 million in research grants each year, together with the creation of a number of research centres and technology incubators at different universities.

According to the 2014 Academic Ranking of World Universities, both King Abdulaziz University and King Saud University rank among the world's top 500. The former has succeeded in attracting over 150 highly cited[19] researchers from around the world as adjunct professors and the latter 15. Internationally recruited faculty are expected to undertake research in Saudi Arabia and collaborate with Saudi faculty members. This policy has allowed both universities to move up the field in international rankings, while boosting overall research output and building endogenous capacity in R&D.

King Abdulaziz City for Science and Technology (KACST) serves as both the national science agency and as a hub for national laboratories. It is involved in policy-making, data collection and funding of external research. It also acts as the national patent office. KACST's planning directorate is responsible for developing national databases with STI indicators. KACST conducts applied research in a wide range of areas, including petrochemicals, nanotechnologies, space and aeronautics, advanced materials, mathematics, health, agriculture and construction technologies. It also acts as a technology incubator by fostering ties between research universities and between the public and private sectors to

19. http://highlycited.com/archive_june.htm

Box 17.5: Fellowships for budding inventors from the Gulf

The Institute for Imagination and Ingenuity (i2 Institute) is the brainchild of Hayat Sindi, co-founder of Diagnostics for All, a non-profit company designated one of the world's ten most innovative biotech companies in 2012 by *FastCompany* magazine in the USA. Originally from Saudi Arabia, Dr Sindi was the first woman from the Gulf to obtain a PhD in biotechnology, while she was studying at Cambridge University (UK).

For Dr Sindi, 'the Middle East has to overcome huge barriers to entrepreneurship'. Chief among these are a lack of formal business skills among scientists and engineers; a culturally intrinsic fear of failure; a lack of potential investors willing to provide the necessary venture capital; and the fact that investors in the region do not focus on science-based ventures.

Dr Sindi founded the Institute for Imagination and Ingenuity in 2011 to accompany budding young inventors from the region at the incubation stage of their project. Her NGO helps them package their idea and attract venture capital through a three-stage fellowship programme, the only one of its kind in the Arab world.

The first call for applications took place in November 2012. Master's and PhD students were invited to apply for a grant in one of four areas: water, energy, health or environment. Some 50 candidates who already held a local and international patent for their idea were selected. They were then invited to pitch their idea to an international jury made up of scientists and business leaders in February 2013. Ultimately, just 12 fellows were singled out to share a grant of US$ 3–4 million; each was then assigned a regional and global mentor to help him or her develop a business plan.

The fellows were able to develop their business plan during the first stage of their eight-month fellowship, through the entrepreneur programme run jointly with Harvard Business School and the Massachusetts Institute of Technology (MIT) in the USA for a period of six weeks.

The second stage of their induction was the social science programme. Here, they met other fellows who had specialized in social innovation, such in as the provision of clean energy or water. All 12 fellows were asked to come up with a solution to a specific social problem. The aim of this exercise was to give them confidence in their ability to take on new challenges.

The third programme developed the i2 fellows' communication skills at MIT's Media Lab, teaching them how to sell their project to different audiences and how to speak in public.

In 2014, potential investors were invited to a conference hosted by King Abdullah Economic City in Riyadh (Saudi Arabia) to hear the fellows present their projects. The deadline for the second round of applications was end April 2014.

Source: www.i2institute.org; UNESCO (2013)

encourage innovation and the transfer and adaptation of technology with commercial potential.

One interesting initiative is the Institute for Imagination and Ingenuity founded by Makkah-born Dr Hayat Sindi in 2011; it is striving to develop an entrepreneurial culture in the Arab world through mentorship (Box 17.5).

Research to curb energy consumption

Saudi Arabia needs to engage in a serious deliberation about its domestic energy consumption, which is expected to increase by 250% by 2028. One-third of oil production was being used domestically in 2012 and demand is growing by about 7% per year, driven by increasing wealth, rapid population growth and low domestic energy prices. The OECD's International Energy Agency recorded about US$ 40 billion in domestic energy subsidies in 2011.The government is cognizant of the problem. In 2010, it upgraded the National Energy Efficiency Programme (launched in 2003) to a permanent faciliity, the Saudi Energy Efficiency Centre. In May 2015, the government announced a programme to develop solar energy which should allow the country to export gigawatts of electric power instead of fossil fuels.

The late King Abdullah was a keen proponent of education and research. In 2007, he called for the establishment of an independent centre to conduct objective research in the field of energy. This gave rise to the King Abdullah Petroleum Studies and Research Centre, which opened in Riyadh in 2013; a Board of Trustees ensures the centre's independence and oversees its endowment. In 2009, Saudi Arabia launched the King Abdullah University of Science and Technology.

SUDAN

Conflict and brain drain undermining development

Sudan has been plagued by armed conflict in the past decade: the conflict in Darfur, which lasted from 2003 until the signing of a ceasefire agreement with rebel groups in 2010; and a long-standing conflict in the south of the country, which resulted in the establishment of South Sudan as an independent state in 2011.

Sudan has had its own academy of sciences since 2006 but otherwise has struggled to consolidate its science system over the past decade. One impediment is the loss of young talent to brain drain: between 2002 and 2014, Sudan lost more than 3 000 junior and senior researchers to migration, according to the National Research Centre and Jalal (2014). Researchers are drawn to neighbouring countries such as Eritrea and Ethiopia by the better pay, which is more than double that offered to university staff in Sudan. More recently, Sudan has become a refuge for students from the Arab world, particularly since the turmoil of the Arab Spring. Sudan is also attracting a growing number of students from Africa.

In 2010, the privately run Future University in Khartoum was upgraded from a college to a university. Established in 1991, it was the first college in the region to introduce an IT programme, offering degrees in a wide range of fields, including computer science, artificial intelligence, bio-informatics, electronics engineering, geo-informatics and remote sensing, telecommunication and satellite engineering, biomedical engineering, laser and mechatronics engineering and architecture. The Future University is participating in NECTAR (Box 17.2).

A fresh policy impetus

In 2013, the Ministry of Science and Communication embarked on a revision of its *Science and Technology Policy* (2003) with the technical assistance of UNESCO. A number of consultation meetings were organized with high-level experts from around the world; these produced a series of recommendations, including those advocating:

- the re-establishment of a higher council for science and technology, to be headed by the First Deputy President of the Republic, which would co-ordinate and oversee relevant institutions and research centres attached to various ministries, with the Ministry of Science and Communications acting as rapporteur of the council.;
- the establishment of a fund to finance government research, with a focus on employing the proceeds of Awqaf and Zakat;[20] this should be combined with the adoption of legislation increasing financial allocations to scientific research, such as exemptions from some or all of customs duties on imported goods and equipment that support research; these measures should enable GERD to rise to 1% of GDP by 2021; and
- the establishment of an observatory of STI indicators, with the technical support of UNESCO.

Sudan has a fairly diverse institutional framework. The following research centres, among others, fall under the umbrella of the Ministry of Science and Communication:

- Agricultural Research Corporation;
- Animal Resources Research Corporation;
- National Research Centre;
- Industrial Research and Consultancy Centre;
- Sudan Atomic Energy Corporation;
- Sudanese Metrology Authority;
- Central Laboratories; and the
- Social and Economic Research Bureau.

Unfortunately, Sudan does not yet possess the human or financial resources necessary to promote science and technology effectively. Were it to encourage more private sector involvement and regional co-operation, restructure its essentially agriculture-based economic system and pool its resources, it would be in a position to develop its S&T capacity (Nour, 2012). The bilateral co-operation agreement signed by the Ministry of Science and Communication with the South African Department of Science and Technology in November 2014 is a step in the right direction. During the minister's visit to South Africa in March 2015, the Sudanese government identified space science and agriculture as priority areas for collaboration (see Table 20.6).

SYRIA

An exodus of scientific talent

Despite hosting prestigious international research institutes such as the International Centre for Agricultural Research in Dry Areas and the Arab Centre for the Study of Arid Zones and Dry Lands, Syria's S&T system was in a dire state even before the outbreak of civil war in 2011. Syrian parliamentarian Imad Ghalioun estimated in 2012 that, even before the uprising, the government had allocated just 0.1% (US$ 57 million) of GDP to R&D and, afterwards, as little as 0.04% of GDP (Al-Droubi, 2012). The civil war has led to an exodus of scientific talent. In 2015, the United Nations estimated that four million Syrians had sought refuge in neighbouring countries since 2011, mainly Jordan, Lebanon and Turkey.

TUNISIA

Greater academic freedom

During the difficult transition to democracy over the past four years, science and technology have often taken a back seat to more pressing problems. This has led to frustration in the scientific community at the speed of reform. The situation has improved for scientists in terms of academic freedom but other concerns persist.

20. Within Islam, Awqaf is a voluntary donation of money or assets which are held in trust for charitable purposes. Zakat is an obligatory religious tax paid by every Muslim that is considered one of the five pillars of Islam. There are established categories of beneficiary of this tax, which is used to maintain a socio-economic equilibrium by helping the poor.

The first reform was introduced within weeks of the revolution. During her brief stint as Secretary of State for Higher Education from January to March 2011 in the caretaker government, Faouzia Charfi changed the procedure for filling top university posts. For the first time in Tunisia, elections were held in June 2011 for faculty directors and university presidents (Yahia, 2012). This is a step forward, even if corruption continues to plague the Tunisian university system, according to a study published in June 2014[21] by the Tunisian University Forum, an NGO formed after 14 January 2011.

That this NGO could even publish such a study without fear of retribution is a sign, in itself, of greater academic freedom in Tunisia since President Zine El-Abidine Ben Ali fled the country on 14 January 2011. According to Faouzia Charfi, under the former president, 'universities and researchers had little freedom to develop their own strategies or even to choose who they worked with'. Other scientists have said that regime bureaucrats thwarted their attempts to establish independent links with industry (Butler, 2011). Scientists were also discouraged from maintaining international ties. Organizers of scientific meetings, for instance, were obliged to submit the topics and research on the agenda to regime bureaucrats, in order to obtain prior authorization. Ten months after the revolution, a group of PhD holders and students formed the Tunisian Association of Doctors and PhD Students in Science to help Tunisian scientists network with one another other and with scientists abroad (Yahia, 2012).

Despite restrictions, 48% of scientific articles published by Tunisian researchers had foreign co-authors in 2009. This share had risen to 58% by 2014. In 2009, the government began negotiating an agreement for a joint research programme with the European Union (EU). The three-year programme was ultimately launched on 12 October 2011, with € 12 million in EU funding. The Tunisian Agency for the Promotion of Scientific Research was given responsibility for distributing the programme funds in accordance with the country's priority research areas: renewable energy, biotechnology, water, the environment, desertification, micro-electronics, nanotechnology, health and ICTs. The programme also sought to forge links between academic research and the Tunisian industrial sector. The German Society for International Cooperation, for instance, conducted a study of market needs to help simplify co-ordination between the academic and industrial sectors. At the launch of the programme, the Tunisian Minister for Industry and Technology, Abd El-Aziz Rasaa, announced plans to raise Tunisia's technological exports from 30% of the total in 2011 to 50% by 2016 (Boumedjout, 2011).

21. See: www.businessflood.com/forum-universitaire-tunisien-etude-sur-le-diagnostic-et-la-prevention-de-la-corruption-dans-le-milieu-universitaire-tunisien

The economy has proved relatively resilient over the past four years, thanks partly to its broad base, with well-developed agricultural, mining, petroleum and manufacturing sectors. This helped to cushion the drop in tourism, which accounted for 18% of GDP in 2009 but only 14% four years later. Tourism was beginning to recover when terrorist acts against a museum and hotel complex in March and June 2015 once more destabilized the industry. Tunisia's relative stability and reputed health clinics have also made it a beacon for medical tourism.

High-level support for science

Compared to most African and Arab states, the STI system in Tunisia is fairly advanced and enjoys strong government support. The Higher Council of Scientific Research and Technology is chaired by none other than the prime minister himself. The body responsible for formulating policy and implementation strategies, the Ministry of Higher Education, Scientific Research and Information and Communication Technologies, can count upon the expertise of both the National Consultative Council of Scientific Research and Technology and the National Evaluation Committee of Scientific Research Activities. The latter is an independent body in charge of evaluating both public scientific research and private sector research programmes benefiting from the public purse. The National Observatory of Science and Technology is another vital component of the Tunisian STI system. It was established in 2006, two years before being placed under the Ministry of Higher Education and Scientific Research.

A strategy to build bridges between universities and industry

The University Council is presided by the Minister of Higher Education, Scientific Research and Information and Communication Technologies. In January 2015, the University Council approved a broad reform of scientific research and higher education that is to be implemented over the period 2015–2025. The reform will focus on modernizing university curricula, in order to give graduates the skills employers need, and on giving universities greater administrative and financial autonomy. In 2012, the ministry had already taken a step in this direction by placing its relations with universities on a contractual basis[22] for the first time.

The reform will also strengthen university–industry ties and revise the university map to ensure greater equity between regions. Central to this strategy is the ongoing development of technoparks, as they foster research and job creation in the regions.

Tunisia is investing heavily in technoparks. Elgazala Technopark in the Tunis region was the first, both for Tunisia and the

22. The two parties concluded a framework contract which authorizes universities and institutions to devise their own teaching and research strategies for a period of four years within the framework of specific projects and programmes; these strategies are accompanied by implementation plans.

Maghreb. Established in 1997, it specializes in communication technologies and now hosts about 80 companies, including 13 multinationals (Microsoft, Ericsson, Alcatel Lucent, etc). Several other technoparks have been established since, including those in Sidi Thabet (2002, for biotechnology and pharmaceuticals), Borj Cedria (2005, for environment, renewable energy, biotechnology and materials science), Monastir (2006, for textiles) and Bizerte (2006, for the agro-industry). In 2012, the government announced the creation of a new technopark in Remada specializing in ICTs. Meanwhile, the Ecosolar Village of Zarzis–Jerba should soon be operational. It will create jobs in renewable energy production, seawater desalination and organic farming; this technopark also plans to position itself as a training platform for the entire African region. Tunisia intends to raise the share of renewables in the energy mix to 16% (1 000 MW) by 2016 and to 40% (4 700 MW) by 2030, within its *Solar Plan*[23] adopted in 2009.

The longer term goal is to develop an internationally competitive research system. In November 2013, the government signed an agreement with France Clusters, which groups French technoparks, for the provision of training and advice on the creation of new technoparks in Tunisia. Elgazala and Sidi Thabet Technoparks are both members of the International Association of Science Parks. Gafsa Technopark, which specializes in useful chemical substances, has been designed in partnership with the Korean International Cooperation Agency; it is being funded by the government, the park management companies and the tandem formed by the Chemical Group and the Compagnie des phosphates de Gafsa.

The adoption of a new Constitution by parliament in June 2014, followed by the smooth handover of power, first in the October parliamentary elections then by the incumbent president to his successor, Beji Caid Essebsi, in late 2014, suggest that the country is well on the way to political stability. Moreover, science has not been forgotten in the new Constitution. Article 33 expressly states that 'the state provides the means necessary to the development of technological and scientific research'.

23. See: www.senat.fr/rap/r13-108/r13-108.pdf

UNITED ARAB EMIRATES

A good business climate

The United Arab Emirates has been reducing its dependence on oil exports by developing other economic sectors, including the business, tourism, transportation and construction sectors and, more recently, space technologies. Abu Dhabi has become the world's seventh-biggest port. The global financial crisis of 2008–2009 affected Dubai's real estate market, in particular. Companies like Dubai World, which supervised a government investment portfolio in urban development, ran up substantial external debt.

With the slump in oil prices since mid-2014, current economic growth is being buoyed mainly by the sustained recovery of Dubai's construction and real estate sectors, together with significant investments in transportation, trade and tourism. Dubai has launched a megaproject for the construction of the world's biggest shopping centre and no fewer than 100 hotels. It is also erecting a 'greenprint' for sustainable cities (Box 17.6) and investing in a fully functional 3D building (Box 17.7). A project to develop a national railway is also 'back on track' after being brought to a halt by the global financial crisis.

The United Arab Emirates has a reputation for having one of the best business climates in the region. In mid-2013, the United Arab Emirates Federation adopted a new Companies Law that comes closer to respecting international standards.

Box 17.6: **Masdar City: a 'greenprint' for the city of the future**

Masdar City is located about half an hour from Abu Dhabi. This artificial city is being constructed between 2008 and 2020 as a 'greenprint' for the city of the future. The aim is to build the world's most sustainable city, one capable of combining rapid urbanization with low consumption of energy, water and waste.

The city blends traditional Arabic architectural techniques with modern technology to cope with high summer temperatures and capture prevailing winds. Masdar City has one of the largest installations of photovoltaic panels on rooftops in the Middle East.

The city is sprouting around the Masdar Institute of Science and Technology, an independent research-driven, graduate-level university set up in 2007 with a focus on advanced energy and sustainable technologies. Companies are being encouraged to foster close ties with the university to accelerate the commercialization of breakthrough technologies.

By 2020, it is estimated that Masdar City will be home to 40 000 people, plus businesses, schools, restaurants and other infrastructure.

There are some who argue that the money might have been better spent on greening the country's existing cities rather than on creating an artificial one.

Source: adapted from: www.masdar.ac.ae

Box 17.7: Dubai to 'print' its first 3D building

Dubai is planning to erect the world's first fully functional three-dimensional (3D) printed building. The building will temporarily house the staff of the Museum of the Future, pending completion of permanent facilities in 2017.

Experts estimate that 3D printing technology could reduce construction time of buildings by 50–70%, labour costs by 50–80% and construction waste by 30–60%.

The office building will be printed layer by layer using a 3D printer then assembled on site in Dubai. All the furniture and structural components will also be built using 3D printing technology, combining a mixture of special reinforced concrete, glass fibre reinforced gypsum and fibre-reinforced plastic.

The scheme is backed by the National Innovation Committee. Its chairman, Mohammad Al Gergawi, considers that 'this building will be a testimony to the efficiency and creativity of 3D printing technology, which we believe will play a major role in reshaping the construction and design sectors'.

Dubai is partnering with the Chinese firm WinSun Global on this project, along with leading global architecture and engineering firms Gensler, Thornton Thomasetti and Syska Hennessy.

Source: Gulf News (2015)

It does not soften the rule, however, that prevents a majority foreign participation in local companies. It also introduces an 'Emirization' jobs programme advocating recruitment based on nationality, a measure which could curtail foreign investment, according to the Coface credit insurance[24] group.

No knowledge economy without science

The *Government Strategy* (2011–2013) lays the foundations for realizing *Vision 2021*, adopted in 2010. One of the strategy's seven priorities is to develop a competitive knowledge economy. Under this priority figures the objective of promoting and enhancing innovation and R&D, among others.

In May 2015, the Ministry of the Economy announced the launch of the Mohammed Bin Rashid Al Maktoum Business Innovation Award, in partnership with the Dubai Chamber of Commerce and Industry. This initiative crowns the United Arab Emirates' Year of Innovation and is coherent with the country's strategy of developing the pillars of a knowledge economy.

The Dubai Private Sector Innovation Index

The Dubai Chamber of Commerce and Industry is also launching two novel initiatives to nurture innovation. The first is the Dubai Private Sector Innovation Index, the first of its kind, to measure Dubai's progress towards becoming the world's most innovative city. The second initiative is the Dubai Chamber Innovation Strategy Framework, the first outside the USA; it will provide a benchmarking tool against other countries and a road map for future implementation.

Two satellites in place for Earth monitoring

The Emirates Institution for Advanced Science and Technology (EIAST, est. 2006) placed its first Earth-observation satellite in orbit in 2009, Dubai Sat 1, followed by Dubai Sat 2 in 2013. These satellites were designed and developed by the Korean company Satrec Initiative, along with a team of EIAST engineers; they are intended for urban planning and environmental monitoring, among other applications. EIAST engineers are now working with their partner on a third satellite, Khalifa Sat, due to be launched in 2017. In 2014, the government announced plans to send the first Arab spaceship to Mars in 2021. The United Arab Emirates has been advocating the creation of a pan-Arab space agency for years.

A National Research Foundation

The National Research Foundation was launched in March 2008 by the Ministry of Higher Education and Scientific Research. Individuals or teams of researchers from public and private universities, research institutes and firms may apply for competitive grants. To be approved, research proposals must survive international peer review and prove that they offer socio-economic benefits.[25]

The United Arab Emirates University is the country's premier source of scientific research. Through its research centres,[26] it has contributed significantly to the country's development of water and petroleum resources, solar and other renewable energies and medical sciences. Since 2010, the university has filed at least 55 invention patents. As of June 2014, about 20 patents had been granted to the university.[27]

The United Arab Emirates University has established strong research partnerships in areas such as oil and gas, water, health care, agricultural productivity, environmental protection, traffic

24. See: www.coface.com/Economic-Studies-and-Country-Risks/United-Arab-Emirates

25. See www.nrf.ae/aboutus.aspx

26. These include the Zayed bin Sultan Al Nahyan Centre for Health Sciences; National Water Centre; Roadway Transportation and Traffic Safety Research Centre; Centre for Public Policy and Leadership; Khalifa Center for Genetic Engineering and Biotechnology and the Centre for Energy and Environmental Research

27. See: www.uaeu.ac.ae/en/dvcrgs/research safety and the rehabilitation of concrete structures. It has established an active research network of partners in countries that include Australia, France, Germany, Japan, Republic of Korea, Oman, Qatar, Singapore, Sudan, the UK and USA.

YEMEN

No scope for science in current political quagmire

Yemen boasts several universities of repute, including the University of Sana'a (est. 1970). Yemen has never adopted a national S&T policy, though, nor allocated adequate resources to R&D.

Over the past decade, the Ministry of Higher Education and Scientific Research has organized a number of conferences to assess the reality of scientific research in the country and identify barriers to public-sector research. The ministry also launched a task force in 2007 to establish a science museum and instituted a presidential science prize in 2008. In 2014, ESCWA received a request from the ministry for assistance in establishing an STI observatory in Yemen; this endeavour has since come to a standstill in the face of the escalating conflict.

Yemen has not held parliamentary elections since 2003. The tremors of the Arab Spring led to President Saleh ceding power to his deputy, Abd Rabbuh Mansur Hadi, in February 2012, and to the establishment of a National Dialogue Conference at the initiative of the Gulf Cooperation Council. In 2015, tensions deteriorated into war between forces of the former regime and those of President Abd Rabbuh Mansur Hadi, who is backed by several Arab countries.

CONCLUSION

A need for a coherent agenda and sustainable funding

The *Arab Strategy for Science, Technology and Innovation* adopted by the Council of Ministers of Higher Education and Scientific Research in the Arab World in 2014 proposes an ambitious agenda. Countries are urged to engage in greater international co-operation in 14 scientific disciplines and strategic economic sectors, including nuclear energy, space sciences and convergent technologies such as bio-informatics and nanobiotechnology. The *Strategy* advocates involving scientists from the diaspora and urges scientists to engage in public outreach; it also calls for greater investment in higher education and training to build a critical mass of experts and staunch brain drain.

The *Strategy* nevertheless eludes some core issues, including the delicate question of who will foot the hefty bill of implementing the strategy. How can heavily indebted countries contribute to the platform? What mechanisms should be put in place to combat poverty and offer greater equity of access to knowledge and wealth at national levels? Without pondered answers to these questions, coupled with innovative out-of-the-box solutions, no strategy will be able to exploit the region's capabilities effectively.

For the *Strategy* to fly, the region's scientific community needs a coherent agenda containing a portfolio of solution-oriented scientific projects and programmes that expressly serve the region's needs, along with clearly identified sources of funding.

The events of the past few years may have stirred the cooking pot but real progress will only be measured against collective structural change at the economic, social and political levels. From the preceding country profiles, we can see that some countries are losing their winning ticket to development and progress; the motives may be economic or political but the result is the same: an exodus of experts and researchers from countries which have spent millions of dollars educating them. In many of these countries, there is a lack of a well-functioning innovation system with a clear governance and policy framework, compounded by poor ICT infrastructure that hampers access to information and opportunities to create knowledge and wealth. Governments can leverage social innovation to tackle some of these problems.

The poor state of Arab innovation systems can be attributed to many factors. The present report has highlighted, for instance, the region's low spending levels on R&D, the relatively small pool of qualified experts and research scientists and engineers, the small number of tertiary students enrolling in scientific disciplines, poor institutional support and the effects of the inimical political and social perspectives on the promotion of science.

Despite Heads of State having committed to raising GERD to 1% of GDP more than 25 years ago, not a single Arab country has yet reached that target. In most countries, the education system is still not turning out graduates who are motivated to contribute to a healthier economy. Why not? Governments should ask themselves whether the fault lies solely with the education system, or whether other impediments are stifling innovation and an entrepreneurial culture, such as a poor business climate.

How will countries of the Gulf embrace economic diversification without building a critical mass of experts, technicians and entrepreneurs? Higher education curricula are mostly fact-heavy and lecture-based, with a limited use of ICT tools and hands-on learning and little contextualization. This environment favours passive learning and examination-based assessments that measure students' ability to memorize knowledge and curriculum content rather than their ability to develop the necessary analytical skills and creativity to innovate. Teachers need to adopt novel approaches that transform them from a teleprompter into a facilitator.

There is a clear mismatch between the skills graduates are being given and labour market demand. The oversupply of university graduates and the channelling of students who perform poorly into vocational education – rather than acknowledging the key role qualified technicians play in the knowledge economy – is fuelling unemployment among tertiary graduates and leaving the market without skilled labour. The Saudi experiment since 2010 in technical and vocational education is worth noting, in this regard.

Morocco has announced its intention of making education more egalitarian. Other Arab countries could do likewise. Governments should institute scholarship schemes to give rural and poor tertiary students the same opportunities as their peers from wealthier and urban backgrounds. Recent statistics show that a fresh university graduate remains unemployed for 2–3 years on average before landing his or her first job. This situation could be turned to advantage. A national programme could be launched to recruit and train young university graduates from all academic disciplines to teach for one or two years after graduation in rural areas where there is a chronic lack of primary and secondary school teachers.

Several Arab governments are setting up observatories to improve the monitoring of their science systems through data collection and analysis. Others should follow suit, in order to monitor the effectiveness of national policies and form a network of observatories to ensure information-sharing and the development of common indicators. Some are already taking this course of action; Lebanon, for instance, is participating in a platform linking Mediterranean observatories of STI.

There is more to developing a national innovation system than putting in place material institutions. Intangible considerations and values are vital, too. These include transparency, rule of law, intolerance of corruption, reward for initiative and drive, a healthy climate for business, respect for the environment and the dissemination of the benefits of modern science and technology to the general population, including the underprivileged. Employability and placement in public insitutions should depend solely on the expertise and seniority of the individual, rather than on political considerations.

Lingering political conflicts in the Arab region have created a tendency to define national security in military terms. As a result, resources are allocated to defence and military budgets rather than to R&D that could help address the poverty, unemployment and erosion of human welfare that continue to plague the region. The countries with the highest share of military spending in GDP come from the Middle East. The resolution of political problems and the creation of collective security arrangements for the region would free up public resources that could be devoted to finding solutions to pressing problems through scientific research. Such a re-orientation would accelerate the process of economic diversification and socio-economic development.

The private sector could be encouraged to contribute to the R&D effort. We have seen how Moroccan telecom operators support public research projects in telecommunications by ceding 0.25% of their turnover to a dedicated fund. One could imagine a token amount being collected from large companies to finance R&D in their own sectors, especially in water, agriculture and energy. For the Arab States, it is imperative to accelerate the transfer of innovative technologies by developing educational large-scale pilot projects in priority areas, including renewable energy systems. This will also help to build up a critical mass of technicians in the region.

A 'value chain' is comprised of a series of interdependent components, each of which influences and is influenced by the other. Top-down approaches cannot bring about the required change. Rather, decision-makers need to create an environment that liberates the nation's dynamic forces, be they academic or economic – forces like Hayat Sindi, who is using mentors to develop an entrepreneurial culture in the region. The Arab world needs more champions of science and technology, including in the political arena, to bring about the positive change to which it aspires.

KEY TARGETS FOR ARAB COUNTRIES

- Raise GERD to at least 1% of GDP in all Arab countries;
- Raise GERD in Libya to 1% of GDP by 2020;
- Raise GERD in Morocco to 1.5% of GDP by 2025;
- RaiseTunisia's technological exports from 30% (2011) to 50% of the total by 2016;
- Produce 1 000 patents and create 200 innovative start-ups in Morocco by 2014;
- Ensure that renewable energy accounts for 12% of Lebanon's energy mix by 2020

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