Basic education is not sufficient to create wealth, to address concerns of food, water and energy security, to provide better health services and better infrastructure. For that, science is required.

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13 · Arab States

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INTRODUCTION

The Arab world stretches from the Indian Ocean in the East to the Atlantic Ocean in the West. Twenty Arab countries occupy the southern and eastern shores of the Mediterranean and border the Red Sea.

It is an area of historical importance, as it is the birthplace of the world's three Abrahamic religions. For centuries, the region was a hub of groundbreaking science. It is of contemporary strategic importance owing to its location and a wealth of subterranean natural resources, essentially in the form of oil and natural gas – 32% of the world's known natural gas reserves are to be found in the region – as well as phosphate: Morocco alone possesses more than half of the world's reserves.

The region encompasses remarkable cultural similarities as well as highly distinct political and economic systems with a heterogeneous social fabric. Its peoples share a commonality of language, history and religion but their societies are at variance in terms of natural wealth, governance, currency, traditions and socio-economic systems.

The period since the *UNESCO Science Report 2005* appeared has been one of mixed fortunes for Arab countries. The region has witnessed continuing political upheaval and military conflict in the Gaza Strip and the West Bank, Iraq, Lebanon and Sudan. The oil-exporting Arab states of Kuwait, the Libyan Arab Jamahiriya, Qatar, Saudi Arabia and the United Arab Emirates have enjoyed a short-lived downpour of revenue resulting from the hike in international oil prices to a peak of more than US$ 140 a barrel in July 2008. Conversely, oil-importing countries such as Jordan, Tunisia and Morocco have faced fiscal difficulties due to their mounting national energy bills, a situation compounded by the associated rise in the cost of imported food commodities.

The subsequent plummet in oil prices, which fell to about US$ 40 by the end of 2008 before recovering slightly in 2009, has brought this exceptional situation to an end. It has also highlighted the volatility of oil prices and the need for Arab oil-exporting countries to diversify their economies in future.

Notwithstanding these difficulties, the same period also witnessed renewed interest on the part of many Arab countries in reinvigorating science and technology (S&T) and higher education, with the launch of a number of top-down initiatives to support education and research. Some of these will be highlighted in the present chapter. A handful of countries have also approved plans to allocate more resources to research and development (R&D), among them Egypt, Tunisia and Qatar.

The current global economic recession may not affect Arab states in the immediate term, as the banking sector in the majority of Arab states is highly regulated and only loosely linked to international money markets. However, the economic fallout will ultimately be felt by all, negatively affecting foreign direct investment flowing into Arab countries and real estate markets. This will cause a slowdown in economic growth and a rise in unemployment in the region. Arab countries reliant on exporting goods and services to the USA and European Union (EU) and those that normally receive aid from these quarters may suffer. Even before the economic recession emerged in the last quarter of 2008, unemployment in the Arab world was higher than in any other part of the world, at around 12%. Young job-seekers constitute over 40% of the region's unemployed (UNESCWA, 2007).

Despite the international economic uncertainty, Arab states will have no choice but to stimulate science, technology and innovation (STI), together with the education sector, if only to overcome some lingering problems like food, water and energy insecurity. Arab countries can also learn from the remarkable socio-economic progress of countries such as Brazil, China, India, Malaysia and Mexico, due in part to S&T.

THE SOCIO-ECONOMIC SITUATION

Demography and economics

Arabs are young. Over 30% of the population of Arab countries is less than 15 years of age (UNESCWA, 2007). This is a double-edged sword for Arab decision-makers. Young populations can stimulate growth and create dynamic societies, particularly if they are well-trained and well-educated. However, the inability of Arab governments to provide the young with schooling or a university education or to expand the productive capacity to create a repository of jobs may well result in social upheaval (UN/LAS, 2007). The World Bank estimates that the region will have to create over 100 million jobs by 2020 to employ the young men and women joining the

Professor Lihadh Al-Gazali examining a young patient in the United Arab Emirates

Photo: Michelle Pelletier/l'Oréal

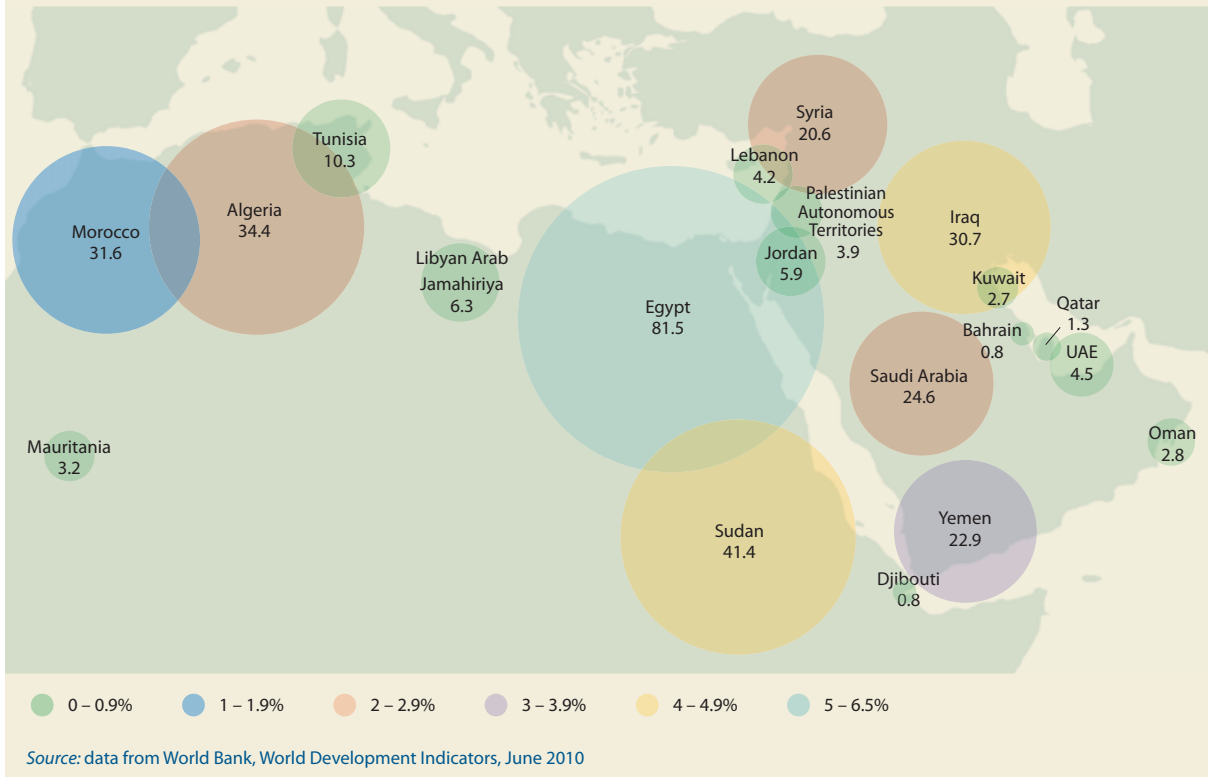
employment market. Whereas the problem of unemployment may prove to be insurmountable in some of the poorer Arab countries like Yemen, it will be manageable for those which count among the richest in the world: Qatar, Kuwait and the United Arab Emirates.

Countries of the Arab region may be grouped into three categories in terms of per capita income. The first category is characterized by almost total economic dependence on oil: the Gulf States of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates, with GDP per capita income being highest in Qatar (PPP US$ 65 182 in 2007) and lowest in Oman (PPP US$ 22 695). Some 37 million people belong to this group of countries, representing around 11% of the Arab population (Figure 1). The STI and higher education systems in these countries are new but developing rapidly thanks to sizeable investments by their heads of state and governments.

The second group encompasses Algeria, Egypt, Iraq, Jordan, Lebanon, the Libyan Arab Jamahiriya, Morocco, the Palestinian Autonomous Territories, Syria and Tunisia. Here, GDP per capita is highest in the Libyan Arab Jamahiriya at US$ 7 773 and lowest in Egypt at US$ 1 505. Although the countries in this category have modest oil reserves – with the notable exception of Iraq and the Libyan Arab Jamahiriya – they boast relatively mature higher education infrastructure. This includes some of the oldest universities in the Arab world, including Cairo University, the American University of Beirut, Ezzitouna University in Tunisia and the University of Al-Karaouine in Morocco. The population of this group amounts to around 219 million, constituting 70% of the population in the Arab world.

There is a distinct dichotomy between these two groups, as countries belonging to the former have the material and financial resources to carry out R&D but lack the solid S&T and higher education systems to generate knowledge. In the second group of countries, the situation is reversed. Egypt, for example, is not wealthy but is nevertheless considered a regional leader in terms of S&T human resources and scientific publications.

Figure 1: Population growth in the Arab region, 2002–2008
Population in millions in 2008 and growth since 2002 (%)



Source: data from World Bank, World Development Indicators, June 2010

The third group of countries is characterized by limited or underdeveloped natural resources and an equally meagre supply of trained human resources. Countries in this category also possess some of the lowest GDP per capita in the world, which classifies them as least developed countries (LDCs). They are Comoros, Djibouti, Mauritania, Sudan and Yemen. This group of countries represents around 19% of the total population of the Arab world. The proportion of those living below the national poverty line rose by almost 10% in the Arab LDCs between 1990–1995 and 2000–2004, from 37% to 47% (UN/LAS, 2007). The problems faced by Arab LDCs have been compounded by internal political strife over the past 20 years.

As Figure 2 demonstrates, the level of human development varies widely across the Arab world. Seven countries – Bahrain, Kuwait, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia and the United Arab Emirates – have achieved high human development. GDP per capita has risen steeply in all seven in recent years.

Between 2002 and 2007, the Arab region enjoyed average economic growth of around 4% per annum. The bulk of this growth was due to the hike in oil prices, although other factors also contributed, such as economic diversification, international free trade agreements and the rapid development of the financial sector and other services sectors, especially in the Gulf.

A key impediment to the region's economic development has been the lingering political conflicts in Iraq, Lebanon, the Palestinian Autonomous Territories and Sudan. These conflicts have erupted into violence since the turn of the century. Acts of terrorism in Algeria, Egypt, Jordan and Saudi Arabia have exacerbated the situation, causing many Arab countries to divert resources towards security, military and defence budgets at the expense of resources earmarked for development. Figure 3 shows military expenditure in Arab countries as a percentage of GDP, the highest ratio in the world, even if it has declined in relative terms. Much of this spending goes on the purchase of expensive armaments from industrialized countries. The world's top seven military spenders per capita all come from the Middle East: Iraq, Israel, Jordan, Oman, Qatar, Saudi Arabia and Yemen (CIA, 2009).

This phenomenon calls for serious review. Surely, the introduction of security arrangements by the countries of the region and the resolution of political problems would pave the way for a drop in defence spending, thereby freeing up resources for development.

Governance

Governance in the majority of Arab countries is in a state of turmoil. Arab regimes are torn between upholding national security – as they perceive it – and maintaining social order on the one hand, and generally adopting good governance practices, on the other; these practices include promoting democracy and the 'rule of law', promulgating accountability and combating corruption.

Notwithstanding the security issue, Arab governments can help knowledge and knowledge-based industries to flourish by creating an environment conducive to enlightening young minds, nurturing creativity and scientific enquiry and generally encouraging people to work harder. By allowing citizens to enjoy the basic freedoms of expression and association, in other words, by allowing citizens to participate in their own governance, governments can contribute to mitigating the brain drain of scientists and intellectuals.

By applying laws fairly and equally, governments support businesses and attract investment to their societies. Without good governance, achieving a knowledge society that simultaneously advances human development, innovation and economic growth will be difficult, if not impossible.

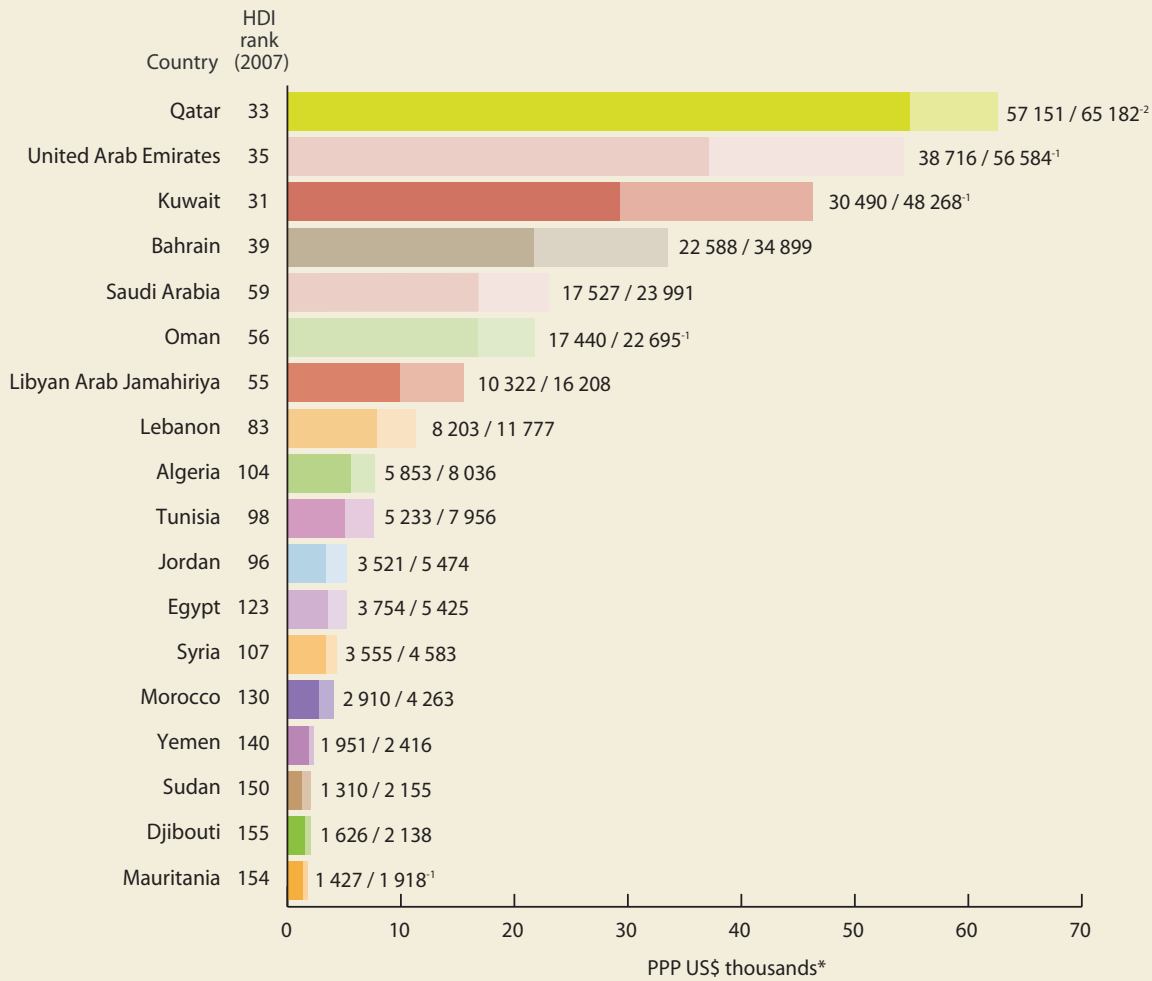
Universities, in particular, can only produce quality higher education and R&D that responds better to national socio-economic needs if freedom, democracy and tolerance are allowed to prosper within their walls.

For the purposes of the present report, two governance indicators will be examined to gauge where Arab countries stand: the rule of law and voice and accountability.

Rule of law

The 'rule of law' has been described as a yardstick as important as the Millennium Development Goals (*see Annex II*) and as being the key to achieving all of these goals. Strengthening the rule of law lays the foundations for safer societies that are able to offer their citizens security, justice and development. The *Arab Human Development Report* (UNDP, 2003) called for a 'fair and predictable rule of law'.

Figure 2: GDP per capita in the Arab region, 2002 and 2008



-*n* = data refer to *n* years before reference year
*in current international purchasing power parity dollars

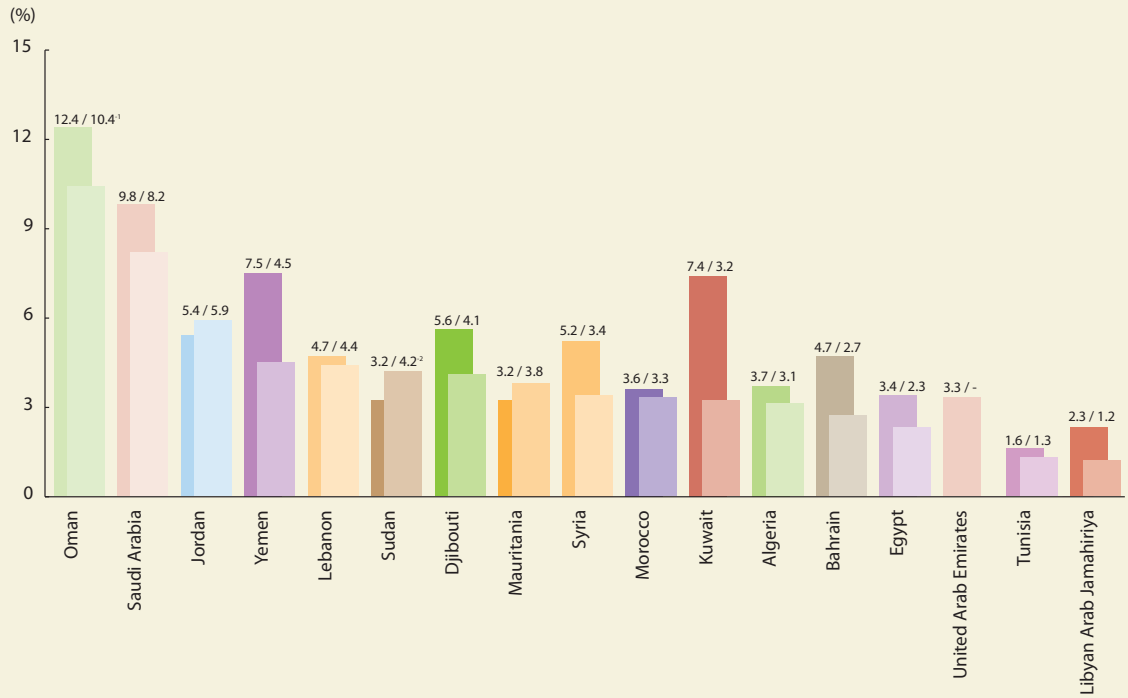
Source: UNDP (2009) *Human Development Report*; World Bank, World Development Indicators, June 2010

Recent research has shown that the performance of Arab countries is a mixed bag. Kaufmann *et al.* (2008) measured the 'rule of law' in 1998 and 2007 as the outcome of governance in Arab countries. Even if the standard error estimate is taken into account, Qatar emerges from their survey as the only Arab country to rank above the 75th percentile on a global scale in 2007. Four Arab countries rank around the 65th percentile: Oman, Kuwait, United Arab Emirates and Bahrain. These are followed by Jordan, Tunisia and Saudi Arabia around the 60th percentile. A further two Arab countries rank around the 50th percentile mark: Egypt and Morocco. The remaining countries rank below the 40th percentile, with Iraq recording the lowest score. Noteworthy is that the rule of law has actually receded since 1998 in Iraq, Lebanon, Morocco, Saudi Arabia, Syria and in the West Bank and Gaza.

Voice and accountability

An 'independent knowledge sphere', in which knowledge can be produced and shared without political interference, must be an objective of all Arab governments in their quest to achieve sustainable development. The foundation of this knowledge sphere lies in providing and sustaining an environment conducive to creativity and R&D

Figure 3: Military expenditure in selected Arab countries, 2002 and 2008
As a percentage of GDP



-n = data refer to *n* years before reference year

Source: World Bank, World Develpment Indicators, June 2010

entrepreneurship, where freedom of opinion, speech and assembly prevail to stimulate STI.

Although the Cold War of the 20th century and other recent history have shown that progress in S&T is possible under totalitarian regimes, any progress has rarely benefited the population under such regimes. Cutting-edge innovation is more likely to thrive – and endure – in open societies. Most importantly, gains in knowledge production in such societies are more likely to permeate society as a whole.

Here again, the region's showing for the 'voice and accountability' indicator over the past decade has been disappointing. According to the study by Kaufmann *et al.* (2008), the top five Arab countries for this indicator are Lebanon, Kuwait, Morocco, Qatar and Jordan. However, even for these countries, the scores are low by international standards, as all five rank between the 35th and 30th percentiles. A further four countries have shown a marked improvement: Bahrain, Algeria, Djibouti and Iraq. Overall, 12 out of 18 Arab countries and territories registered a decline in 'voice and accountability' between 1998 and 2007, including four of the top five countries for this indicator: Egypt, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Morocco, Oman, Syria, Tunisia, United Arab Emirates, the West Bank and Gaza and Yemen.

THE S&T LANDSCAPE

Innovation not yet part of S&T parlance

Interest in S&T was kindled in the majority of Arab countries after the Second World War, when most gained independence. Universities and research centres were founded principally by central governments from the 1960s onwards. National S&T policies would come much later. Jordan, for example, founded its main national university, the University of Jordan, in 1962 and its main industrial research centre, the Royal Scientific Society, in 1970, yet adopted a National Science and Technology

Policy only in 1995. Saudi Arabia adopted its own national policy for S&T as recently as 2003 (Al-Athel, 2003).

Today, many Arab countries still possess no national policies or strategies for S&T. However, they are in the process of taking this important first step. Where S&T policies do exist, they are either too ambitious or ambiguous. All Arab countries nevertheless have sectoral policies, such as those for agriculture, water resources and the environment.

Innovation is not yet part of S&T parlance in the region. This may be attributed to the weak linkages overall between private and public R&D, as evidenced by the low output of patents. In 2003, Tunisia carried out an innovation survey as a first step towards remedying this situation. The United Arab Emirates is the highest-ranking Arab country in terms of its capacity for innovation. It comes 27nd out of the 133 economies covered by the Global Competitiveness Index 2009/2010, followed by Saudi Arabia (32nd), Qatar (36th), Tunisia (38th), Oman (55th) and Jordan (59th) [WEF, 2009].

Among recent developments, a European Union–Egypt Innovation Fund has been established at the Egyptian Ministry of Scientific Research as part of a joint research, development and innovation programme. Set up in 2008, the fund will support projects for applied research on a competitive basis, with special emphasis on innovation (Mohamed, 2008).

The establishment of science parks in Bahrain, Morocco, Qatar, Saudi Arabia, Tunisia and the United Arab Emirates represents a move towards partnerships in innovation between private and public R&D. In 2009, Jordan was in the process of launching El-Hassan Science Park as part of a major science project in Amman and Egypt was setting up its own Mubarak Science Park.

Politics and policies

But why should any Arab country have an S&T policy in the first place? What would the objective be of such a policy? In answer to these questions, we can cite two examples from beyond the Arab world: Malaysia and the USA. Malaysia is often cited by Arab decision-makers as a developing country that has achieved economic success thanks, in part, to the contribution of S&T. As for the USA, this world leader in science is developing bilateral scientific relations with a number of Arab countries, including Algeria and the Libyan Arab Jamahiriya.

The former prime minister of Malaysia, Dr Mahathir Muhammad, declared back in 1992 that the basic objective of Malaysian S&T policy was to help Malaysia become fully developed by the year 2020. Three decades earlier, in 1961, John Fitzgerald Kennedy had said in a presidential address that the objective of the US space programme within US S&T policy was to put a man on the Moon before the end of the decade. This became a reality on 20 July 1969, nearly six years after the president's death.

At the United Nations' World Summit on Sustainable Development in 2002, former Secretary-General Kofi Annan outlined five key priority areas for sustainable development. Known collectively by the acronym of WEHAB, these areas are water, energy, health, agriculture and biodiversity. For Arab countries, key targets will need to be met in all five priority areas. Other priorities they need to address include wealth creation and the Arab region's contribution to world civilization.

National S&T capacity is required to address the priorities symbolized by WEHAB. The authorities can also draw upon this capacity in an emergency, such as in the event of a natural disaster or pandemic along the lines of the Severe Acute Respiratory Syndrome pandemic scare in late 2002 and the advent of avian influenza (bird flu) in 2003 and the H1N1 influenza virus in early 2009. In Egypt, the emergence on the global scene of H1N1, misnamed 'swine flu', caused mass confusion and the culling of all 250 000 of Egypt's pigs, even though the virus did not originate from pigs but rather was transmitted from one human being to another. These drastic measures will have no impact on the spread of the H1N1 virus in Egypt. Rather, they are a knee-jerk reaction to the wide criticism levelled at the authorities after they were slow to respond to the bird flu epidemic – thought to have resulted in the disease becoming endemic in the country – coupled with fears of the bird flu virus mutating in Egypt's pigs to form a new and more dangerous influenza virus (El-Awady, 2009). It is regrettable that the media missed a golden opportunity here to inform the public dispassionately of the facts and thereby avoid widespread panic.

Towards an Arab plan for S&T

During the Arab Summit of March 2010, the Heads of State adopted a resolution mandating the General Secretariat of the League of Arab States to develop an S&T strategy for the entire Arab region, in co-ordination with specialized Arab and international bodies. This strategy is

due to be submitted to the upcoming Arab summit in 2011 for adoption. It is expected to address the important issue of facilitating the mobility of scientists within the region and to enhance collaborative research with the sizeable community of expatriate Arab scientists.

Both the strategy and the subsequent *Arab Science and Technology Plan of Action* (ASTPA) will be drawn up by a panel of experts from the region with the institutional support of the Arab League Educational, Cultural and Scientific Organization (ALECSO), the Union of Arab Scientific Research Councils and UNESCO, among others.

ASTPA will envisage both national and pan-Arab initiatives in about 14 priority areas, including water, food, agriculture and energy. It is also expected to recommend the launch of an online Arab S&T observatory to monitor the S&T scene in Arab states and highlight any shortcomings in implementation. One of the keys to implementing measures at the country level will lie in first identifying some of the national challenges that Arab countries face.

One example from the Arab world is Kuwait, which for some time was a leading regional hub for S&T until the Second Gulf War of 1990–1991. In 2008, Kuwait adopted a plan to reform its S&T sector by facing up to a number of challenges that hindered development. According to the journal *Alrai* (2008), these include:

- the absence of an S&T governance mechanism at state level;
- low gross domestic expenditure on R&D (GERD);
- a lack of co-operation between scientific organizations and productive sectors;
- a low technology component, leading to few manufactured exports and a limited number of high-tech exports;
- a poor capacity to innovate according to society's needs;
- a lack of databases providing information on S&T;
- challenges facing organizations involved in science.

The above challenges are as true for Kuwait as for other Arab states. To address them, political support for S&T at the highest level is required, coupled with affirmative government action, an upgrade of existing STI infrastructure and an increase in GERD.

Needless to say, for any country's S&T policy to be implemented successfully with public backing, it is critical for its objectives to be clearly stated. These must also be understood by the executive branch of government. For instance, is the objective for a given Arab country to mould society into a fully industrialized, export-oriented economy? In the agriculture sector, is the objective to achieve food security? It would clearly be beneficial if reasonable targets were set at the outset, as this would provide the implementing agencies with a benchmark for measuring progress. Through regular appraisals, they could then make any necessary adjustments to improve the rate of implementation.

R&D governance

Research has shown that the bulk of S&T research in the Arab world is carried out within the higher education system, even in Egypt where this represents 65% of R&D (IDSC, 2007). Table 1 shows that, in eight Arab countries, it is the ministries of higher education and scientific research that are responsible for R&D. In another five countries, councils and government academies assume this role. This function falls to universities and research centres in four Arab countries, to ministries of education in three and to the ministry of planning in one (Saleh, 2008).

Only seven Arab countries or territories out of 22 have a national academy of sciences or play host to a supranational academy (Table 2). This is an astounding fact, as academies of sciences, being strong advocates of science and impartial advisory bodies, have been at the vanguard of scientific endeavour in advanced countries such as the USA, UK and France for centuries. They are also part of the landscape in economically emerging economies such as Brazil, China, India, Malaysia and Mexico (see also Box 1).

The organization of science at the institutional level is crucial for the effectiveness of R&D. In Arab countries, the indifference shown by decision-makers to S&T is a major contributor to the current vegetative state of S&T. Furthermore, the kaleidoscope of institutional models renders it quite difficult for Arab states to move forward collectively. If meaningful regional collaboration in S&T is to develop beyond individual scientists working together on small research projects and publishing joint research work, some uniformity needs to be established among the institutions responsible for science in the Arab region.

Table 1: Government bodies responsible for R&D policies and co-ordination in the Arab world, 2006

Algeria	Ministry of Higher Education and Scientific Research
Bahrain	Bahrain Centre for Studies and Research
Egypt	Ministry of State for Scientific Research
Iraq	Ministry of Higher Education and Scientific Research
Jordan	Ministry of Higher Education and Scientific Research
	Higher Council for Science and Technology
Kuwait	Kuwait Foundation for the Advancement of Sciences
	Kuwait Institute for Scientific Research
	Kuwait University/ Research Center
Lebanon	National Council for Scientific Research
Libyan Arab Jamahiriya	Higher Education and Research Secretary
	General Planning Council
	National Authority for Scientific Research
Mauritania	Ministry of National Education
Morocco	Hassan II Academy of Sciences and Technologies
	Ministry of National Education, Higher Education, Staff-Training and Scientific Research
	Permanent Interministrial Commission of Scientific Research and Technological Development
	National Centre for Scientific and Technical Research
	Co-ordination Council of Higher Education Institutions outside Universities
Oman	Research Council
Palestinian Autonomous Territories	Ministry of Higher Education
	R&D Unit at Ministry of Planning
Qatar	Secretariat General, Council of Ministers
Saudi Arabia	King Abdul Aziz City for Science and Technology
Somalia	Ministry of Agriculture
	Ministry of Education
Sudan	Ministry of Education and Scientific Research
Syria	Higher Council for Sciences
	Ministry of Higher Education
Tunisia	Ministry of Higher Education, Research and Technology
United Arab Emirates	University of United Arab Emirates
	Ministry of Agriculture
Yemen	Ministry of Higher Education and Scientific Research

Source: Saleh (2008) *S&T Indicators in the Arab States*

Table 2: Arab countries hosting a national or supranational academy of science, 2009

		Founded
Egypt	Academy of Scientific Research and Technology	1948
	Egyptian Academy of Sciences	1944
Iraq	Iraq Academy of Sciences	1944
Jordan	Islamic World Academy of Sciences	1986
Lebanon	Arab Academy of Sciences	2002
Morocco	Hassan II Academy of Sciences and Technology	2006
Palestinian Autonomous Territories	Palestine Academy of Sciences and Technology	1997
Sudan	Sudan National Academy of Science	2006

Source: Compiled by A. Badran, and M.R. Zou'bi from personal contacts and interviews

R&D INPUT

Trends in R&D expenditure

GERD as a percentage of GDP has been consistently low in the majority of Arab countries for over four decades (Figure 4). It is much lower than the world average. It varies from 0.1 to 1.0% of GDP, whereas advanced countries spend over 2.5% of GDP on R&D.

Countries such as Egypt, Qatar and Tunisia have set themselves ambitious targets for GERD. In November 2006, Qatar announced that it was lifting GERD to 2.8% of GDP over five years (Shobakky, 2007). Since then, Qatar has launched a number of initiatives in S&T and education and is approaching this figure for GERD, according to Weingarten (2009). The figure for Egypt remained stable at 0.23% of GDP in 2007, although there are plans to raise it to 1% of GDP over the next five years. Meanwhile, Tunisia's spending on R&D has been climbing steadily since 2000. In 2005, it was the leading Arab country in terms of its R&D effort, which stood at slightly more than 1% of GDP. The government's objective is to reach a GERD/GDP ratio of 1.25% by 2009, of which 19% would be funded by the business sector (Arvanitis and Mhenni, 2007).

In 2005, Jordan introduced a law whereby 1% of the net profit of public shareholding companies was transferred to a special R&D fund to finance research. Another law has since been introduced that compels public and private universities to allocate 5% of their budgets annually to R&D. Together with the funding made available by the Middle

Box 1: The Islamic World Academy of Sciences

Launched in 1986, the IAS was the brainchild of a handful of scientists who persuaded the Organisation of the Islamic Conference (OIC) to establish the academy to serve the S&T community in OIC countries and others in the developing world. It was created in Amman (Jordan) as an independent non-political, non-governmental organization.

The IAS combines three different functions. *Firstly*, it is a learned society that promotes the values of modern science. The IAS identifies and honours high achievement and disseminates the latest scientific achievements internationally through meetings and publications.

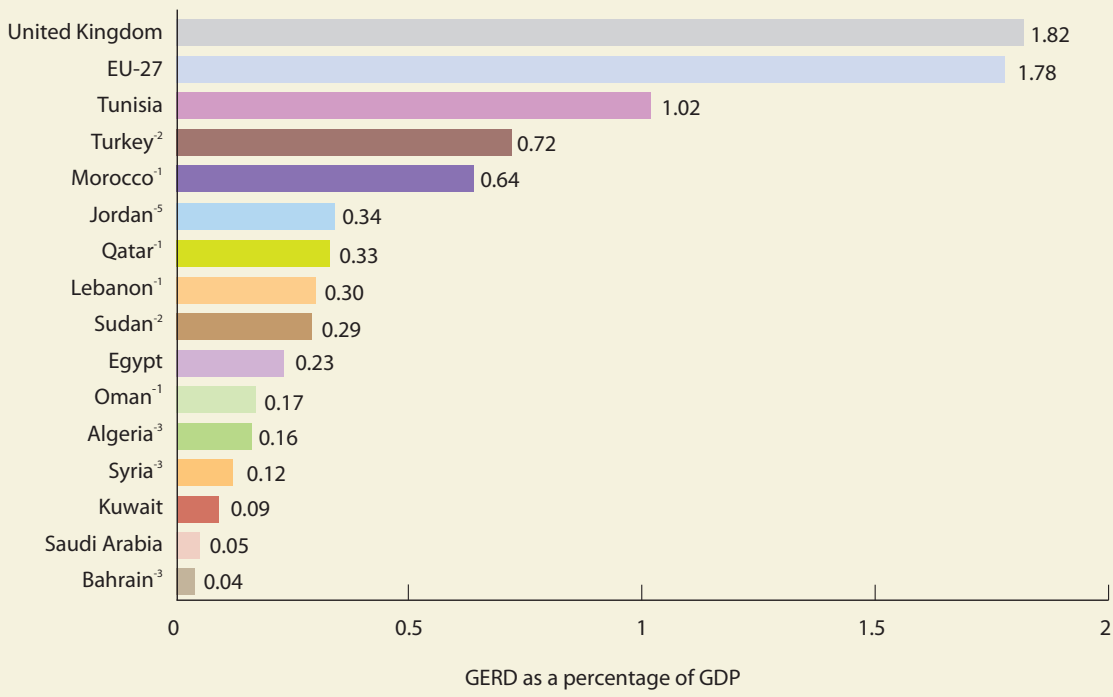
A *second* function of the IAS that is yet to be fully realized is that of acting as a funding agency to support outstanding scientists in undertaking imaginative and far-reaching research.

Thirdly, the IAS leads the scientific community of the OIC in its relations with governments, scientific societies and academies of sciences worldwide.

The IAS receives seed funding from Jordan and raises its budget for activities from the OIC and other international bodies, including UN agencies.

For details: www.ias-worldwide.org

Figure 4: GERD/GDP ratio for Arab countries, 2007 or latest year available (%)
Other countries and regions are given for comparison



-*n* = data refer to *n* years before reference year

Note: For Tunisia, Turkey and Sudan, the data are an estimation; for Egypt, Kuwait, Algeria and Saudi Arabia, the data are either underestimated or partial; for Mauritania, Qatar, Lebanon and Oman, the data are for gross national expenditure on R&D as a percentage of GDP.

Source: for Egypt: UNESCO Institute for Statistics database, July 2010; for Mauritania, Lebanon, Oman and Mauritania: Saleh (2008) *S&T indicators in the Arab States;* for Bahrain and Syria: Waast *et al.* (2008) *Draft Regional Report on Arab Countries: Study of National Research Systems*

Box 2: The Mohammed bin Rashid Al Maktoum Foundation

In 2007, Mohammed bin Rashid, the ruler of Dubai and Prime Minister of the United Arab Emirates, launched a foundation to help build 'a knowledge-based society' in the region. With an initial endowment of $10 billion, the foundation will invest in knowledge creation and in translating knowledge into goods and services, as well as in human development. It will focus on developing and nurturing a generation of future leaders and on elevating research, knowledge creation and higher education infrastructure to international standards. It will also stimulate entrepreneurship and innovation and pay special attention to culture, heritage and cross-cultural understanding in the region.

The foundation's programmes include publishing an annual *Arab Knowledge Report* issued in co-operation with the United Nations Development Programme, a scholarship programme and a grants programme to support Arab authors wishing to publish books in Arabic.

Future projects will include teacher training programmes, online education for women and initiatives for translating acclaimed scholarly and scientific works into, and from, Arabic.

Source: authors
For details: www.mbrfoundation.ae

East Science Fund, these measures will considerably raise Jordan's GERD, starting from 2008.

In 2008, Kuwait endorsed a five-year plan to reform the country's S&T sector, partly by increasing the budget from 0.2% of GDP in 2008 to 1% of GDP in 2014 (Alrai, 2008).

Turning now to the Arab private sector, by all accounts, spending here is minimal. Out of 131 countries studied, Tunisia ranked 36th in terms of private companies' expenditure on R&D. Qatar and the United Arab Emirates both ranked 42nd, Jordan 96th, Egypt 99th, Syria 108th and Bahrain 119th (Waast, 2008).

Two promising new initiatives have been launched recently in the United Arab Emirates and Jordan which will make more funds available in future for scientific activities. The first is the Mohammed bin Rashid Al Maktoum Foundation (Box 2) and the second, the Middle East Science Fund (Box 3). Both initiatives offer grant programmes for regional research projects in priority areas for Arab countries.

Researchers in the Arab world

Arab countries have not produced a critical mass of full-time equivalent (FTE) researchers in the majority of disciplines. Moreover, links between universities and research centres remain weak. This leads to little or no co-ordination at the national level between research communities. Also, even when fresh graduates are ready to become engaged in research, there is often no capacity within the R&D system to absorb them, or even any willingness on the part of senior researchers to mentor young minds.

To make matters worse, unemployment within the R&D community is high, especially among women researchers, who constitute around 35% of the total researcher community in Arab countries, according to estimates by the UNESCO Institute for Statistics (UIS).

Estimating R&D personnel is a difficult task, as counting only individuals whose primary function is to perform R&D would result in underestimating the national effort. On the other hand, to do a headcount of everyone spending some time on R&D would lead to an overestimate. The number of individuals engaged in R&D must, therefore, be expressed in full-time equivalents of the time spent on R&D, both in the government and private sectors.

The survey carried out in 2006 by UNESCO, ALECSO and the Arab Academy of Sciences covered both the numbers of FTE researchers and support staff in Arab states (Saleh, 2008). The figures for FTE researchers only are presented in Figure 5. It can be concluded from this study that the numbers of FTE researchers in the majority of Arab countries are small in comparison to a country like Argentina, for example, with its 980 FTE researchers per million population in 2007, or Spain (2 784), or Finland (7 382), according to the UIS.

Only a handful of Arab researchers have been internationally recognized. The annual L'Oréal–UNESCO Awards for Women in Science bestow US$ 100 000 each on five women, one from each continent. Of the 13 recipients of this award for the Africa and Arab States region between 1998 and 2010, five came from Arab countries: Egyptian

immunologist Rashika El Ridi (2010) and Egyptian physicist Karimat El-Sayed (2004), Tunisian physicists Zohra Ben Lakhdar (2005) and Habiba Bouhamed Chaabouni (2007), and Lihadh Al-Gazali from the United Arab Emirates, who won the prize in 2008 for her work on genetic disorders (*see photo, page* 250).

More surprising is the fact that only one of the world's top 100 highly cited scientists comes from the Arab world: Professor Boudjema Samraoui, a biologist at the University of Annaba in Algeria (ISI, 2009).

The only Nobel laureate in a scientific discipline to come from the Arab world is Egyptian-born Ahmed Zewail, who received the distinction for chemistry in 1999 while working at the California Institute of Technology in the USA.

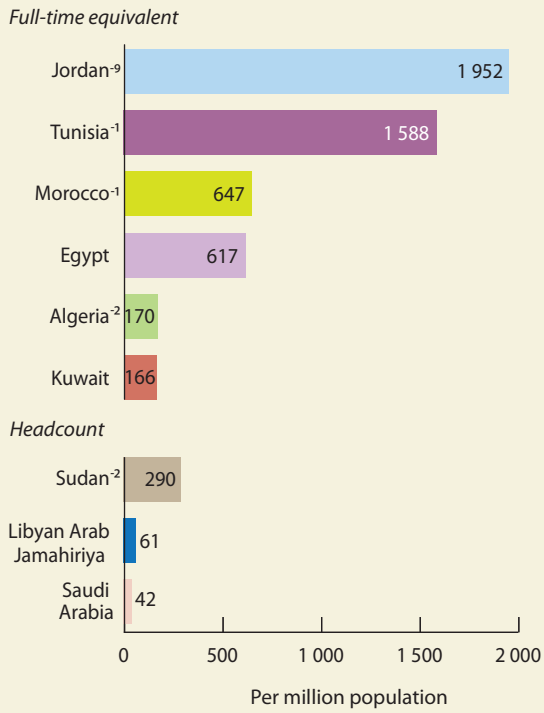
R&D PRIORITIES

Arab countries speak almost in unison when it comes to their designated S&T priorities: water and energy. The traditional sector of agriculture also features in the S&T policies of some Arab countries. The relatively new fields of information and communication technologies (ICTs), nanotechnology and biotechnology are also viewed as priority research areas (Arab League, 2008).

Water security

With the exception of Sudan and Iraq, all Arab countries are water-poor, meaning that water is unavailable in sufficient quantities for household use, industry or agriculture. In agriculture, modern water-saving technologies have been adopted in many Arab countries and some regional initiatives have been launched.

Figure 5: Researchers per million population in the Arab world, 2007
Selected countries



-n = data refer to *n* years before reference year

Note: For Tunisia, the data are overestimated; for Egypt, Morocco, Algeria, Kuwait, Libyan Arab Jamahiriya and Saudi Arabia, the data are underestimated or partial.

Source: UNESCO Institute for Statistics database, July 2010; for Mauritania, Oman, Qatar and Yemen: Saleh (2008) *S&T indicators in the Arab States*

Box 3: The Middle East Science Fund

The Middle East Science Fund was launched in Jordan in 2009 to support regional research projects and promote scientific co-operation and development. It supports regional scientific activities in the areas of medicine, physics, chemistry and economics. The fund also promotes scientific endeavour in vital areas that include energy and renewable energy sources, water management, the environment and technology.

The initial capitalization of the Middle East Science Fund is US$10 million with a seed contribution donated by King Abdullah II Ibn Al Hussein.

An International Advisory Council of Nobel Laureates advises the Middle East Science Fund on policy and reviews eligible proposals. They also advise on scientific projects deserving of funding and on policy matters related to scientific research in the Middle East.

Source: authors
For details: www.mesfund.org

One such initiative is the International Centre for Biosaline Agriculture, based in Dubai (Box 4).

The shortage of water for agriculture has led some Arab states to lease large plots of arable land in countries like Sudan to grow food. These countries include Saudi Arabia and Kuwait. Foreign direct investment in Sudan's agriculture sector in the form of land leasing amounted to US$279 million in 2007. The Sudanese government aims to secure US$1 billion in from Arab and Asian investment groups in 2009–2010. This amount has already been designated for 17 lead projects, covering a land area of 880 000 ha in northern Sudan (*Sudan Tribune*, 2008).

The United Nations Environment Programme (UNEP) is increasingly sceptical about the wisdom of such investments, however, and has pointed to failures of previous mechanized farming schemes to observe fallow periods, improve land use and respect prior tenure relations (UNEP, 2007). Although such projects seem to be commercially viable from the investor viewpoint, depending on the scale and types of crop grown, they cannot be a real alternative to attempting to achieve national, or at least regional, food security.

Energy security

Energy insecurity is another strategic quandary that many Arab countries face. In their quest to diversify energy sources, many Arab states have embarked on R&D programmes to develop alternative energy sources, such as solar and wind energies.

Jordan embarked on a solar energy research programme in 1972. Jordan's National Agenda, a government policy adopted in 2005, stipulated that the projected share of solar energy in the country's total energy mix should rise to 3% by 2015, by which time 80% of households ought to be using solar energy water collectors (Badran, 2006). This is an achievable target for Jordan which would reduce the national energy bill of imported oil by about the same percentage. Furthermore, it is an environment-friendly technology that is relatively cheap to install and maintain.

Morocco is also increasing investment in renewable energies. The country aims to raise the share of renewable energy sources from 4% of the total to 12% by 2012. A unit within the National Centre for Scientific and Technological Research is devoted to the Renewable Energy Economy and Technologies and the Moroccan National Electricity Office has put together a US$3.2 billion renewable energy investment plan for 2009–2014. The plan provides for the development of local wind energy technologies and farms, solar energy demonstration projects and greater investment in R&D. Within the plan, a 'knowledge campus' is to be designed to strengthen research and training in clean technology. An industrial park for clean energy is also under construction in Oujda near Morocco's border with Algeria. At a cost of US$219 million, the park is expected to open its doors in 2010. It will be supporting private investment and companies specializing in renewable energy (Sawahel, 2008*a*).

Box 4: The International Centre for Biosaline Agriculture

The International Centre for Biosaline Agriculture (ICBA) is a centre for applied R&D based in Dubai in the United Arab Emirates. The centre was established in 1999 with strong support from the Islamic Development Bank and the Government of the United Arab Emirates. It is developing and promoting the use of sustainable agricultural systems that use saline water to grow crops.

The centre initially focused on forage production systems and ornamental plants in countries of the Gulf Co-operation Council and other parts of the Islamic world. The technologies developed by ICBA are, however, of global value and importance. Wherever farmers face the problem of saline soils or irrigating with salty water, ICBA can help.

ICBA also endeavours to demonstrate the value of saline water resources for the production of environmentally and economically useful plants. It plans to transfer its research results to national research services and communities in the Islamic world and elsewhere.

ICBA will help water-scarce countries improve the productivity, social equity and environmental sustainability of water use through an integrated water resource systems approach, with special emphasis on saline water and water of marginal quality.

Source: authors
For details: www.biosaline.org

Box 5: The Regional Centre for Renewable Energy and Energy Efficiency

The Regional Centre for Renewable Energy and Energy Efficiency (RCREEE) came into existence in Cairo in June 2008. It acts as a platform for regional exchanges on policy issues and technological questions. In addition, RCREEE encourages the participation of the private sector in order to promote the growth of regional industry.

RCREEE has ten founding members: Algeria, Egypt, Jordan, Lebanon, Libyan Arab Jamahiriya, Morocco, Palestinian Autonomous Territories, Syria, Tunisia and Yemen. Egypt is serving as host country for the centre.

During the launch phase, RCREEE is being sponsored by Egypt through the Ministry of Electricity and Energy. The European Union, German Agency for Technical Co-operation and Danish International Development Agency are its development partners. These three development partners have pledged to provide financial and technical assistance to RCREEE worth an aggregate value of 15 million € over the initial five years from 2008 to 2012. In the future, RCREEE will be funded through contributions from the member states and income generated from research and consultancy work.

Source: authors
For details: www.rcreee.org

Jordan and Morocco are two of the ten founding members of a think tank set up in 2008, the Regional Centre for Renewable Energy and Energy Efficiency (Box 5).

Nanotechnology

Plans are underway to boost nanotechnology R&D in Egypt and Saudi Arabia. In Egypt, a North African Nanotechnology Research Centre was set up in 2009. Located at the 'Smart Village' near Cairo, this is a joint initiative of IBM and the Egyptian government for research in such nanotechnology-related fields as: Thin Film Silicon Photovoltaics; Spin-On Carbon-Based Electrodes for Thin Film; Photovoltaics; and Energy Recovery from Concentrated Photovoltaic for Desalination.

In Saudi Arabia, the national R&D organization is the King Abdulaziz City for Science and Technology (KACST) based in Riyadh. In February 2008, KACST and IBM agreed to establish the Nanotechnology Centre of Excellence at KACST. The centre will conduct research into nanomaterials for solar energy and nanomembranes for water desalination, combined with investigating new methods for recycling plastics (Sawahel, 2008*b*).

R&D OUTPUT

Patents and publications

From the foregoing, we can see that the R&D landscape in the Arab region is changing. However, it will take some time before the results of current initiatives start to emerge. Furthermore, the success of such initiatives will depend largely on sustained national interest and support, hard work and regional co-operation. Another key factor will be whether or not researchers and research institutions have the capacity to pool the know-how that each has acquired so that this can be reinvested to develop related new technologies and products that are economically viable.

Notwithstanding the fact that the number of published journal articles is but one measure of the research interest of a country, research carried out by Thomson Reuters and cited by Naim and Rahman (2009) reveals a certain heterogeneity in research strengths in the region. The research strength of Egypt, Morocco and Algeria lies in chemistry, whereas it is clinical medicine for Jordan, Kuwait, Lebanon, Oman, Saudi Arabia, Tunisia and the United Arab Emirates. Syria's strength lies in plant and animal science, whereas Qatar makes its mark in engineering.

Given the meagre resources allocated to R&D in Arab countries, it is imperative that an attempt be made to synchronize research strengths, R&D initiatives and national S&T priorities. Each country will have to optimize resources carefully between investment in basic sciences – the backbone of S&T capacity – and investment in demand-driven research that can address national S&T priorities and/or increase national wealth. One major interdisciplinary project that can stimulate regional co-operation in S&T and thereby drive output is the SESAME project being launched in Jordan (Box 6).

Arab countries produce fewer books and fewer S&T articles than many other regions of the world. According to the Mohammed bin Rashid Al Maktoum Foundation, 20 Arab countries produce 6 000 books per year, compared to 102 000 in North America (Lord, 2008).

According to Thomson Reuters Inc., the total number of scientific research articles originating from Arab countries stood at 13 574 in 2008, up from 7 446 in 2000. In terms of articles per million population, it is Kuwait which ranks first, followed by Tunisia (Figure 6). For this indicator, the average for Arab countries is only 41, compared to a world average of 147. Over the 2002–2008 period, all but Mauritania showed an increase in the number of authored scientific articles (Figure 7). With 2 026 published articles, Tunisia came close to quadrupling its output. Egypt, however, continues to lead the region for this indicator.

From 2000 to 2008, there was a steady increase in the number of Arab scientists collaborating with the diaspora. This is evident from the number of scientific publications in international collaboration. The notable exception is Morocco. Of the 3 963 publications published by Egyptian scientists in 2008, one-third (1 057) were co-authored by scientists outside Egypt (Figure 8).

As for patents, Figure 9 shows that their number increased in most Arab countries from 2004 to 2008. However, Arab countries still lag a long way behind in comparison with relatively small countries such as Chile (19 patents in 2008) and Finland (894 in 2008). The Republic of Korea, which back in the 1960s was on a par with Egypt in terms of S&T output, acquired an astonishing 84 110 patents in 2008, compared to a total of just 71 patents for the entire Arab region.

Box 6: The SESAME story

It was Pakistani Nobel Laureate Abdus Salam who first recognized the need for an international synchrotron light source in the Middle East more than 25 years ago. An opportunity arose when it was announced that the Bessy I synchrotron source in Berlin, Germany, was about to be decommissioned. The Chair of the Middle East Scientific Co-operation Group, Sergio Fubini, and Herwig Schopper, former Director-General of the European Organization for Nuclear Research (CERN), invited the German government to donate the Bessy I components to a project for an international synchrotron light source in the Middle East (the future SESAME). The government agreed.

At a meeting convened by UNESCO in 1999, countries from the region set up an Interim Council for SESAME under the chairmanship of Herwig Schopper. In 2002, UNESCO's Executive Board approved the request to place the SESAME centre under UNESCO's auspices.

Construction of the centre was completed in Allan, Jordan, in 2008. Once fully operational in 2014 with three initial beamlines, SESAME will offer the Middle East a world-class laboratory for basic research and numerous applications in biology, medical sciences, material sciences, physics, chemistry and archaeology.

Synchrotron radiation is produced by an electron beam accelerated in a ring at almost the speed of light. The refurbished microtron (Bessy I) installed at SESAME successfully produced an electron beam on 14 July 2009. The booster synchrotron (also from Bessy I) was being upgraded and installed in 2010. To meet the users' demands, a completely new 2.5 GeV storage ring with a circumference of 133 m has been designed by the SESAME staff and will be built by 2014.

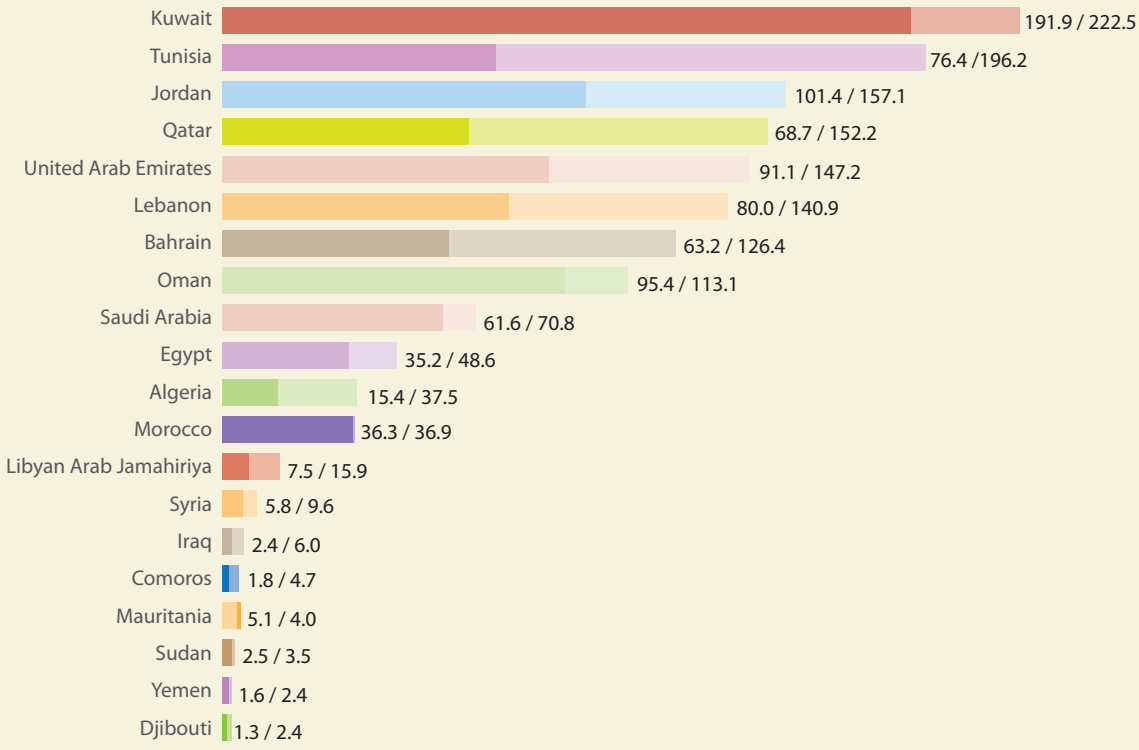
By 2010, more than 400 scientists and engineers had participated in 17 workshops and schools in the Middle East and elsewhere on applications in biology, materials science and other fields, as well as on accelerated technology. Approximately 65 of these men and women have spent periods of up to two years working at synchrotron radiation facilities in Europe, the USA, Asia and Latin America. The majority of these facilities are situated in observer countries, some of which have been donating beamline components. The 12 observer countries include France, Japan, Kuwait, the UK and USA.

SESAME will enable scientists to work together across countries and cultures within the same research facility. UNESCO calls it a model project for other regions, as it has brought together people from nine countries and territories who do not all see eye to eye politically. In 2009, the members of SESAME were Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority and Turkey.

Source: UNESCO

For details: www.sesame.org.jo

Figure 6: Scientific publications per million population in the Arab world, 2002 and 2008



Source: Thomson Reuters (Scientific) Inc. Web of Science. Science Citation Index Expanded, compiled for UNESCO by the Canadian Observatoire des sciences et des technologies; for population data: World Bank, World Development Indicators, June 2010

TOWARDS THE KNOWLEDGE ECONOMY

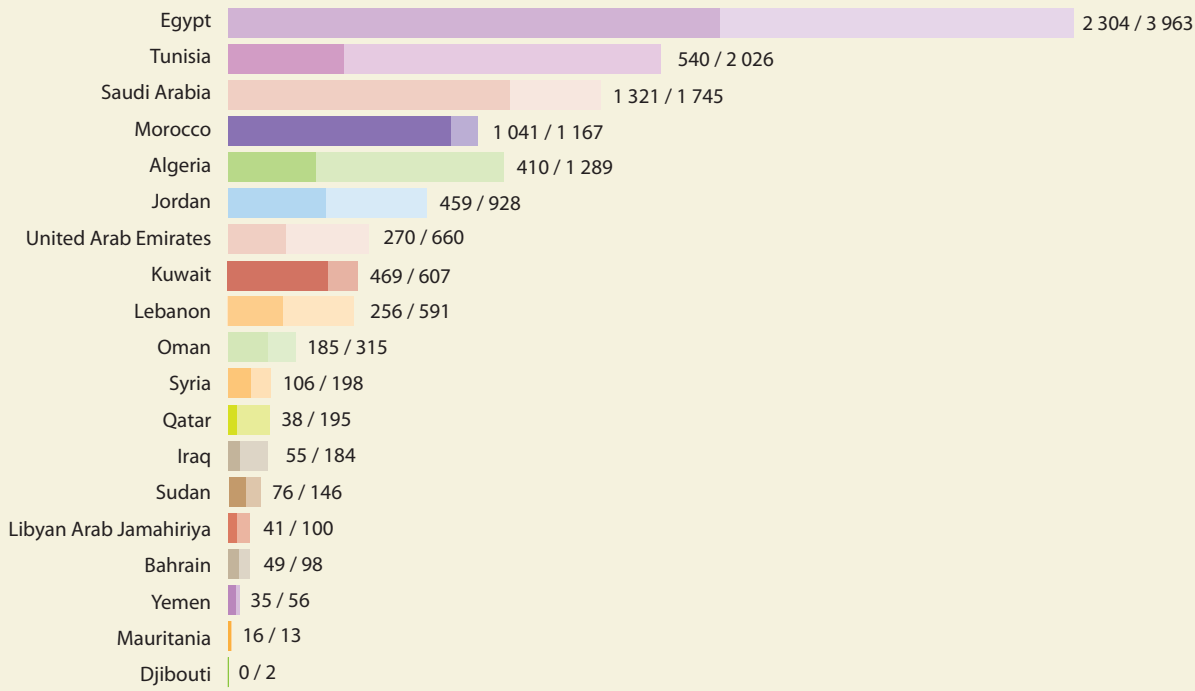
ICTs

The development of ICTs and their primary manifestation, the Internet, has offered societies – and the STI communities within – a new means of knowledge accumulation, assimilation and production, a new means of teaching, learning and communicating. ICTs have undoubtedly helped research communities to access a greater volume of information than before at a faster pace, to undertake more complex research, achieve better results and communicate with much more ease. Even if R&D in informatics and computer science can be a complex and expensive business, it necessitates relatively basic tools. Writing complex software, for instance, does not require elaborate laboratory equipment.

The majority of Arab states have successfully ridden the IT wave, as the figures for Internet penetration in Table 3 demonstrate. This is due to the fact that ICTs are pervasive and general-purpose technologies. Even before the current global economic recession, telecommunications the world over were undergoing a transformation towards advanced Next Generation Networks and converged services. This is revolutionizing the roles of telephone companies, Internet service providers and media and content delivery companies (GAID, 2009).

The leading Arab country in terms of Internet use is the United Arab Emirates, which has a penetration rate of almost 50%. Saudi Arabia and Morocco have both overcome their late start in introducing Internet access and have caught up with other countries in the region, with Internet penetration rates of 22% and 21% respectively. Syria, Algeria and to a lesser extent Iraq seem to be trying to catch up, although language in the case of the former two countries may represent a barrier, as the second spoken language in both is French rather than English.

Figure 7: Scientific articles published in the Arab world, 2000 and 2008



Source: Thomson Reuters (Scientific) Inc. Web of Science, Science Citation Index Expanded, compiled for UNESCO by the Canadian Observatoire des sciences et des technologies

The ICT sector in Jordan planned to reduce Internet access tariffs in 2009, in order to raise the Internet penetration rate to around 24% by the end of the same year.

One regional organization that was 'born digital', however, is the Bibliotheca Alexandrina (Box 7).

High-tech exports

High-tech exports are products with high R&D intensity, such as in aerospace, computers, pharmaceuticals, scientific instruments and electrical machinery. Some Arab countries have a relatively advanced pharmaceutical industry that can contribute to high-tech exports.

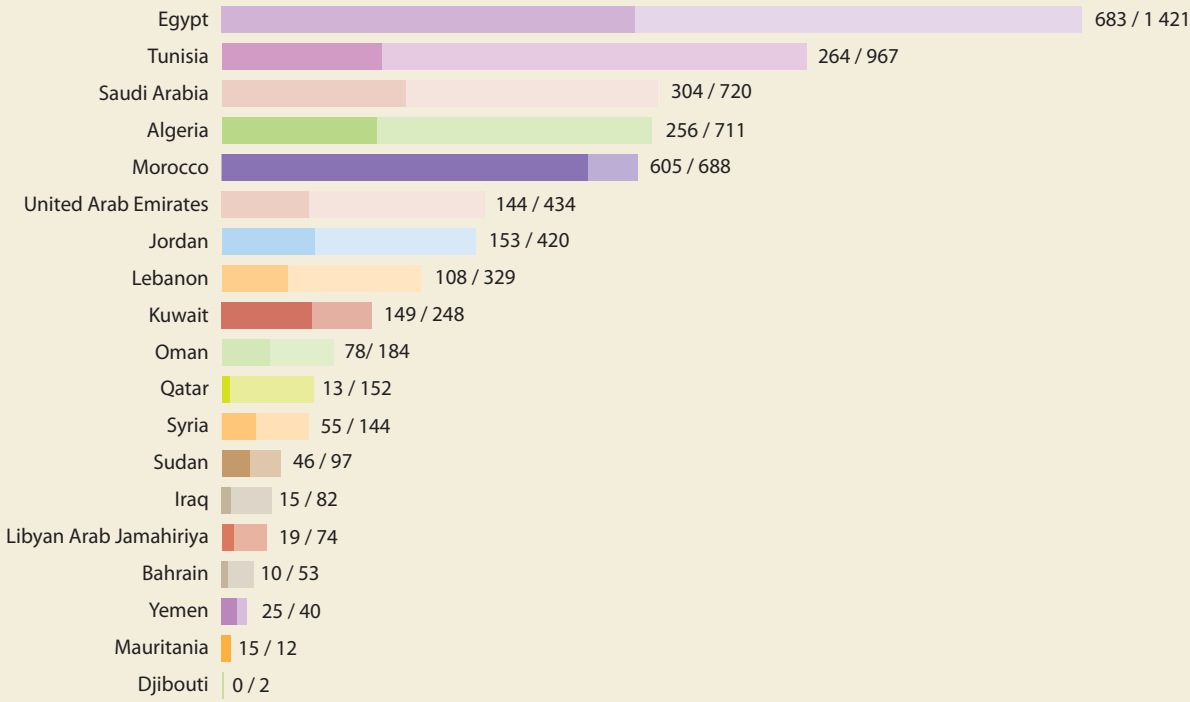
High technology contributes to rapid growth and is a major source of wealth generation. It contrasts with the resource-based industries that dominated the 20th century. High-tech exports are a function of a country's level of inward foreign direct investment, consumer demand at home and technological infrastructure.

Seyom (2005) has shown that the state of a nation's technological infrastructure is dependent on two variables: GERD per capita and the number of scientists and engineers engaged in R&D. He has concluded that good technological infrastructure has a positive, significant influence on high-tech exports.

Figure 10 shows the share of high-tech exports as a percentage of total exports for selected Arab countries. With high-tech exports constituting around 10% of all national exports, Morocco is the leading Arab country for this indicator. However, the high-tech exports of a country like Malaysia constitute as much as 55% of total exports. This is due in part to the country's developing technological infrastructure but also to the multitude of multinational companies that have set up manufacturing hubs in Malaysia, unlike in the majority of Arab countries.

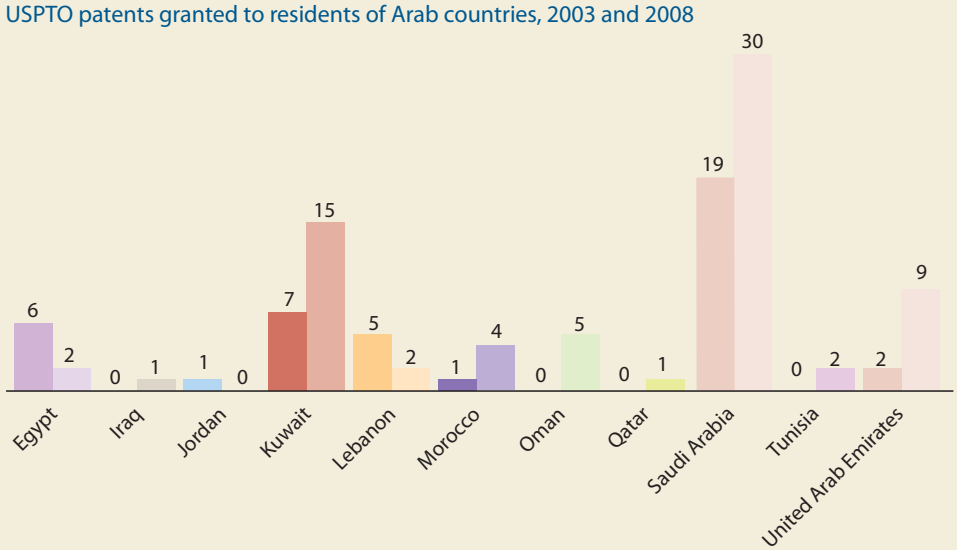
Figure 11 shows the Knowledge Economy Index (KEI) for the majority of Arab countries. Among non-oil economies, Jordan achieves the highest score for this

Figure 8: Scientific co-publications in the Arab world, 2000 and 2008



Source: Thomson Reuters (Scientific) Inc. Web of Science, Science Citation Index Expanded, compiled for UNESCO by the Canadian Observatoire des sciences et des technologies

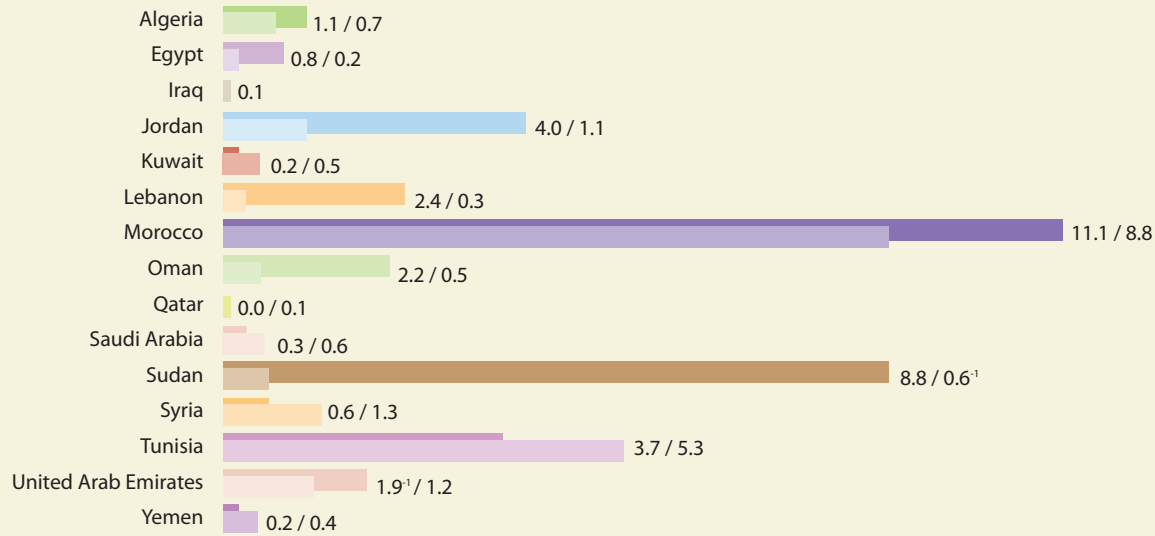
Figure 9: USPTO patents granted to residents of Arab countries, 2003 and 2008



Note: The country of origin is determined by the residence of the first-named inventor. No patents were granted to residents of Algeria, Bahrain, Libyan Arab Jamahiriya, Mauritania, Sudan and Yemen in 2003 and 2008.

Source: United States Patents and Trademark Office

Figure 10: Share of Arab high-tech exports in total manufactured exports, 2002 and 2007 (%)



-n = data refer to *n* years before reference year

Note: The relatively high share of high-tech exports for Sudan in 2002 can be explained by the fact that overall export figures for Sudan are very low, so a single large order in a given year may represent a large share of the total.

Source: World Bank, World Development Indicators, June 2010

index, closely followed by Oman and Lebanon. Morocco, on the other hand, has some way to go for the education and innovation parameters used to calculate the KEI, even though it boasts a high rate of Internet penetration.

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Higher education: forming the S&T labour force

In the Arab world, the number of students in higher education has increased considerably, from 5.4 million in 2000 to 7.3 million in 2008. In 2000, there were 1 907 students for 100 000 inhabitants. By 2008, this number had increased to 2185, according to the UIS.

These increases have not been uniform across Arab countries. This is due not only to the lack of financial resources in some countries but also to factors related to policies, social values and so on. The issue of equal access to higher education, on the other hand, can be attributed to wealth divides between communities within societies, geographical areas and social categories, as well as to disparities in gender and age.

In 20 Arab countries, there are over 300 public and private universities (Saleh, 2008). This corresponds to one university per million population. This is less than the world average, as there are around 10 000 universities worldwide for a global population of about 6.7 billion.

How do Arab universities compare with others?

The majority of universities in Arab countries are new. The older ones have not been able to keep up and have seen their standing fall by international yardsticks.

Rankings of universities, although controversial, have become increasingly popular. Two publications have attracted wide attention from policy-makers, scientific communities and the media since they began publishing their own rankings: the journal of *Shanghai Jiao Tong University* in China (*SJTU*, since 2003) and the *Times Higher Education Supplement* in the UK (*THES*, since 2004). In 2007, Cairo University was the only Arab university to rank among *SJTU*'s top 500 universities in the world. No Arab university has ever appeared in the *THES* ranking.

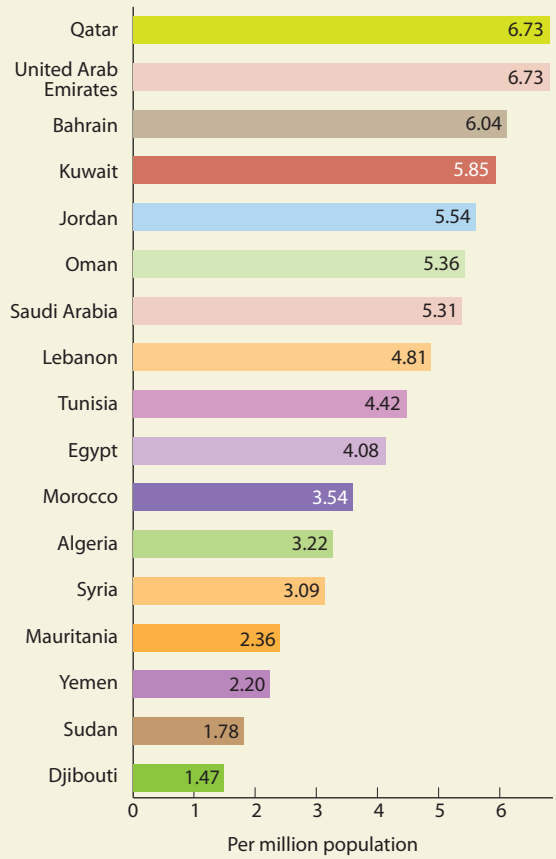
Research by the statistical agency of the OIC placed only nine Arab universities in the top 50 of the OIC member countries (Table 4). Arab universities do not seem to compare favourably with their OIC counterparts in Iran, Malaysia or Turkey, in particular (SESRTCIC, 2007).

Table 3: Internet penetration in the Arab region, 2002 and 2009

Country/ territory	Internet users per 100 population		Growth 2002–2009
	2002	2009	(%)
United Arab Emirates	28.3	82.2	272
Bahrain	18.1	82.0	429
Oman	6.9	43.5	624
Saudi Arabia	6.4	38.1	600
Kuwait	10.3	36.9	340
Tunisia	5.3	34.1	592
Morocco	2.4	32.2	1 371
Qatar	10.2	28.3	470
Jordan	6.0	27.6	466
Lebanon	10.3	23.7	150
Egypt	2.7	20.0	739
Syria	2.1	18.0	978
Algeria	1.6	13.5	840
Sudan	0.4	9.9	2 525
Palestinian Autonomous Territories	3.1	8.3	239
Libyan Arab Jamahiriya	2.2	5.5	183
Comoros	0.6	3.6	659
Djibouti	0.5	3.0	600
Mauritania	0.4	2.3	650
Yemen	0.5	1.8	320
Iraq	0.1	1.1	1 200
World	10.7	26.8	140

Source: International Telecommunications Union, World Telecommunications/ICT Indicators, July 2010

Figure 11: Knowledge Economy Index for selected Arab countries, 2008



Note: Data are weighted by population ranges from a low of 0 to a high of 10.

Source: World Bank http://info.worldbank.org/etools/kam2/KAM_page5.asp

Box 7: The Bibliotheca Alexandrina

Inaugurated in 2002, the Bibliotheca Alexandrina in Egypt seeks to recapture the legacy of the original Alexandria library which burnt down 2000 years ago, by disseminating knowledge and becoming a forum for dialogue, learning and understanding between cultures and peoples.

The Bibliotheca Alexandrina has capitalized on opportunities presented by ICTs. Library patrons can access 21 core databases and 19 584 scholarly electronic journals, e-book databases and other Internet resources. The library has emerged as a leader in the digitization of Arabic manuscripts, maps, books and pictures. It is also an active participant in global campaigns to make knowledge universally accessible.

The Bibliotheca Alexandrina reaches out to the general public, especially the young. The library includes special collections for youth, as well as cultural performances and programmes designed for young audiences.

Source: authors
For details: www.bibalex.org

We can deduce from the afore-mentioned studies that higher education across the Arab region is in need of serious reform. In the majority of countries, higher education is succeeding only in producing bureaucrats with little innovative capacity to meet the needs of the private sector. There is a dire mismatch between the skills companies are seeking and what most universities in the region are producing. The result is millions of young people with high expectations and no hope of fulfilling their dreams.

Investment trends in higher education

Various governance models for higher education exist in Arab countries. In the majority, a Ministry of Higher Education is in charge of management, planning, policies and strategies. In some countries, such a ministry is also responsible for scientific research. Despite such an elaborate set-up, it is almost impossible to estimate, for example, how much Arab countries invest in higher education.

Research published by the Economic Research Forum (Kanaan *et al.,* 2009) reveals that government expenditure on higher education amounted to 1.4% of GDP on average for the countries of the Organisation for Economic Co-operation and Development (OECD) in 2007. This compares with 1.7% in Tunisia, 1.5% in Saudi Arabia, 1.3% in Egypt, 1.2% in Yemen and Egypt, 0.8% in Jordan and 0.5% in Syria. Jordan spends no less than 4.3% of GDP on higher education but most of this comes from the private sector (Kanaan *et al.,* 2009).

Tunisia's public spending on higher education constituted around 25% of total public expenditure on education in 2007 (Abdessalem, 2009). Egypt made a similar commitment in 2004 (28%) but investment was lower in Jordan (18%) and Morocco (15%) for the same year.

Table 5 compares average annual expenditure on education in Arab states for 2001 and 2006. For many Arab countries, there has been little change, even though government expenditure on education has shown a marked increase in Oman, the United Arab Emirates and, to a lesser extent, in Morocco.

The stampede towards higher education

The percentage of young men and women enrolled in higher education in Arab countries is increasing overall. In Lebanon and the Palestinian Autonomous Territories, about 50% of the age cohort is on the student rolls. In Algeria, Jordan, Lebanon, Oman, the Palestinian Autonomous Territories, Qatar, Saudi Arabia, Tunisia and the United Arab Emirates, more women than men opt for higher education.

Table 4: Arab universities in top 50 for Islamic countries
Composite index for number of citations 2001–2006

University	Country	Ranking
American University in Beirut	Lebanon	8
United Arab Emirates	United Arab Emirates	9
Suez Canal University	Egypt	10
Kuwait University	Kuwait	11
Cairo University	Egypt	25
King Fahd University of Petrol and Minerals	Saudi Arabia	34
Tanta University	Egypt	43
Jordan University of Science and Technology	Jordan	44
Sultan Qaboos University	Oman	50

Source: SESRTCIC (2007) *Academic Rankings of Universities in the OIC Countries: a Preliminary Report*: www.sesrtcic.org/files/article/232.pdf

If we compare the figures in Table 6, we find that the total number of students enrolled in tertiary education has increased significantly in Algeria, Jordan, Lebanon, Oman, the Palestinian Autonomous Territories, Saudi Arabia and Tunisia. The situation in Qatar has deteriorated.

Arab countries fare well in terms of student gender balance in higher education. At the bachelor degree level however, the percentage of female students enrolled in social sciences and humanities is around 10% higher than for S&T disciplines (Table 7). It is interesting to note that, although there were no female PhD students in S&T streams in Bahrain, Oman or Jordan in 2006, women accounted for more than 41% of PhD students in S&T streams in Algeria, 38% in Egypt, 31% in Morocco and a sizeable 29% in Saudi Arabia.

More than 125 000 university faculty members in Arab countries are MSc and PhD holders, 30% of them women. Some researchers have put this figure at over 170 000 (Waast *et al.,* 2008) but this could be due to the inclusion of faculty teaching at more than one university, meaning they would be counted more than once.

Table 5: Public expenditure on education in the Arab world, 2002 and 2008
Selected countries

Country	Public expenditure on education			
	as % of GDP		as % of total government expenditure	
	2002	2008	2002	2008
Algeria	–	4.3	–	20.3
Bahrain	–	2.9	–	11.7
Djibouti	8.4	–	–	–
Egypt	–	3.8	–	11.9
Kuwait	6.6	–	14.8	–
Lebanon	2.6	2.0	12.3	8.1
Mauritania	3.5	4.4	–	15.6
Morocco	5.8	5.7	26.4	25.7
Oman	4.3	–	22.6	–
Saudi Arabia	7.7	5.7	26.9	19.3
Tunisia	6.4	–	16.5	–
United Arab Emirates	2.0	0.9	23.5	27.2
Yemen	–	5.2	–	16.0

Note: For Mauritania, the 2008 data are an estimate by the UNESCO Institute for Statistics; for the UAE, the 2002 data are a national estimate.

Source: UNESCO Institute for Statistics database, July 2010

Despite a sizeable teaching community, in the majority of Arab countries, the student/teacher ratio falls short of the OECD average of 14 students per faculty member or even the world average of 16 students. Statistics dating from 2004 reveal that, in Egypt for example, the ratio was 1:30 and 1:27 in Jordan. Only in Lebanon does the ratio surpass the OECD and world ratios by an impressive margin, at 1:8 (Waast *et al.,* 2008).

Three regional initiatives exemplify recent top-down initiatives in higher education: Qatar's Education City; the Masdar Institute in Abu Dhabi, and the King Abdullah University of Sciences and Technology in Saudi Arabia (Boxes 8, 9 and 10). These initiatives are likely to staunch brain drain in Arab countries like Algeria and Egypt which have been hit by an exodus of talent.

Figures released by the National Science Foundation in 2000 reveal that there are thousands of Arab scientists and engineers living in the USA: 12 500 Egyptians, 11 500 Lebanese, 5 000 Syrians, 4 000 Jordanians and 2 500 Palestinians. Scientists from Morocco and Tunisia tend to head for Europe (Waast *et al.,* 2008).

The causes of low academic standards in higher education

A number of features in the Arab region contribute to low academic standards. Some are outlined below.

- Although extensive and well-established, the higher education system in the Arab region has not maintained the distinction it once had. Despite being confronted with globalization and the ascendance of private education, new knowledge and knowledge delivery modes, it remains essentially supply-driven rather than demand-driven.

- Arab universities are under pressure to fulfil many complementary yet conflicting roles: knowledge transmission (teaching), knowledge generation (research) and knowledge preservation and diffusion. University governance in the majority of Arab countries remains unsteady, unable to assume one or more of these roles successfully. This is further complicated by governments exerting undue influence over universities, mainly out of political considerations.

- The archaic hierarchical system of promotion and incentives at universities remains a major hurdle. As knowledge transmitters, universities in Arab countries must aim to form highly productive work-ready professionals, not bureaucrats, with the appropriate skills to address economic needs and opportunities, as well as those of the economy's component industries and sectors. This requires student admission policies and faculty recruitment policies that are essentially merit-based and transparent.

- Arab universities and research centres have been unable to develop a smart R&D environment over the past four decades. There is a certain improvisation in the way R&D is rewarded. As clear long-term research policies are generally lacking, researchers are never certain that they will obtain requisite funding. Often educated and trained in the West, faculty could implement the best research practices they picked up during their studies. Instead, they are frequently forced to take on heavy teaching loads to supplement their income, leaving little time for scientific research. Even sabbatical leave is rarely used for research. As knowledge generators, universities are the

Table 6: Tertiary student enrollment in the Arab region, 2002 and 2008
As a percentage of the age cohort

Country	2002 Male (%)	2002 Female (%)	2002 Total student enrollment (%)	2008 Male (%)	2008 Female (%)	2008 Total student enrollment (%)
Algeria	–	–	17.8	25.3	36.4	30.7
Djibouti	1.1	0.9	1.0	–	–	–
Egypt	–	–	–	–	–	28.5
Iraq	16.0	8.7	12.4	–	–	–
Jordan	29.5	30.6	30.0	38.5	42.9	40.7
Kuwait	15.1	29.2	21.8	–	–	–
Lebanon	38.9	42.8	40.9	48.0	57.1	52.5
Libyan Arab Jamahiriya	51.8	56.7	54.2	–	–	–
Mauritania	4.6	1.3	3.0	–	–	–
Morocco	11.7	8.9	10.3	13.0	11.6	12.3
Oman	15.9	12.4	14.3	27.2	32.0	29.5
Palestinian Autonomous Territories	30.4	29.7	30.0	42.5	52.2	47.2
Qatar	7.6	31.1	16.8	5.1	31.1	11.0
Saudi Arabia	17.3	28.0	22.3	22.6	37.4	29.9
Tunisia	21.0	25.7	23.3	27.2	40.5	33.7
United Arab Emirates	12.9	36.9	22.8	17.4	35.7	25.2

Note: For Algeria, Iraq, Morocco, Oman, Saudi Arabia and the United Arab Emirates, the data for 2002 are an estimate by the UNESCO Institute for Statistics.

Source: UNESCO Institute for Statistics database, July 2010

Arab world's engine room for discovery and invention; the principal creators and disseminators of new knowledge. Research is considered the most salient example of a country's intellectual resources, economic strength and global competitiveness. Universities should be producers of research, not investors. They currently spend too much time looking for funding for research projects.

- The present system is eating away at precious resources from teaching programmes, in order to maintain research performance. Heavy teaching loads may be relieved by a long-term faculty development programme, the introduction of innovative university management practices and by facilitating further the movement of faculty between countries.

- Bilateral and trilateral exchanges of faculty and joint research projects are rare among Arab universities compared to the co-operation programmes concluded with parties beyond the Arab world. Arab countries should each attempt to have at least one model university that excels in one role: teaching, research or knowledge diffusion. This will make networking between Arab universities of similar outlook easier.

- An Arab Bologna Process is required to create an Arab Higher Education Area along the lines of the European model (*see page* 150). There is a need for Arab ministries and other bodies responsible for higher education to co-operate in areas such as the recognition of diplomas and the exchange of information and expertise in higher education. An Arab Bologna Process could make Arab higher education more comparable, more competitive and more attractive.

CONCLUSION

Arab countries have been aware of the importance of STI for socio-economic development for at least four decades. Many Arab countries have had a core STI system for as long. However, little has changed in terms of the impact of science and the scientific enterprise on achieving socio-economic development, or generating new knowledge.

The challenges facing Arab countries in S&T is enormous. However, they can be overcome with vision, commitment and hard work. The huge strides made by countries that two or three decades ago were at the same level of development as Arab states, including Brazil, China, India, Ireland, Mexico and the Republic of Korea, show that it is possible.

Table 7: Postgraduate students at Arab universities, 2006

Country	Science and technology						Total social sciences and humanities plus science and technology						Total headcount
	MSc			PhD			MSc			PhD			
	M	F	Total	M	F	Total	M	F	Total	M	F	Total	
Algeria	8 104	7 204	15 308	4 503	3 186	7 689	13 176	12 006	25 181	7 689	4 917	12 606	37 787
Bahrain	30	53	83	1	0	1	273	278	551	1	0	1	552
Egypt	28 811	21 476	50 287	9 080	5 529	14 609	41 204	37 528	78 732	14 590	9 221	23 811	102 543
Jordan	434	345	779	30	0	30	881	697	1 578	36	0	36	1 614
Morocco	4 005	2 112	6 117	3 591	2 111	6 702	8 201	4 416	12 617	8 565	4 078	10 849	23 466
Oman	172	91	263	1	0	1	353	212	565	1	0	1	566
Saudi Arabia[-1]	2 249	1 154	3 403	239	99	338	5 251	3 884	9 136	1 189	1 011	2 200	11 336
Tunisia	3 415	3 439	6 854	–	–	–	7 146	11 438	18 584	–	–	–	
Yemen	341	155	496	–	–	–	1 444	546	1 990	–	–	–	

-*n* = data refer to *n* years before reference year

Note: Data cover both national and foreign-born students. Science and technology include natural sciences, engineering and technology, medicine, health sciences and agricultural sciences.

Source:Saleh (2008) S&T indicators in the Arab States

Box 8: Education City, Qatar

The Qatar Foundation founded Education City in 2001 as a hub for capacity-building and character development. At the heart of Education City are six international universities. In 2007 and 2008, these established branches with the campuses of prestigious institutions in the USA: Carnegie Mellon University, Georgetown University's School of Foreign Service, Virginia Commonwealth University, Weill Medical College of Cornell University and the Texas Agricultural and Mechanical University (Texas A&M).

A significant percentage of the Qatari students enrolled in these branch campuses are girls seeking to pursue higher education close to home. For instance, 75 of the 120 Qatari students at the Carnegie Mellon satellite campus are female. On Georgetown's satellite campus, 68 of the 107 students are female. Education City includes an Academic Bridge Programme which prepares students for study in world-class universities.

For details: www.qf.org.qa

Box 9: The Masdar Institute of Science and Technology

Abu Dhabi in the United Arab Emirates launched the Masdar Initiative in 2006 as a global co-operative scientific platform to address pressing issues, such as energy security, climate change and the development of human expertise in sustainability science. Masdar aims to position Abu Dhabi as a world-class R&D hub for new energy technologies and to drive the commercialization and adoption of these and other technologies in sustainable energy, carbon management and water conservation.

Developed in co-operation with the Massachusetts Institute of Technology (MIT), the Masdar Institute of Science and Technology emulates MIT's high standards and offers Master's and PhD programmes focused on the science and engineering of advanced energy and sustainable technologies. MIT is working with Masdar to establish a sustainable, home-grown academic and scientific research institute. The Masdar Institute aspires to become a centre of high-calibre renewable energy and sustainability research capable of attracting leading scientists from around the world.

For details: www.masdaruae.com

Box 10: King Abdullah University of Science and Technology

King Abdullah University of Science and Technology (KAUST) has been built in Saudi Arabia as an international, graduate-level research university dedicated to inspiring a new age of scientific achievement in Saudi Arabia, the region and the world. It is supported by a multi-billion dollar endowment that is governed by an independent, self-perpetuating Board of Trustees. KAUST is merit-based and open to men and women from around the world.

KAUST's core campus is located on more than 36 000 km^2 on the Red Sea 80 km north of Saudi Arabia's second-largest city, Jeddah.

Since it opened in September 2009, AUST has pursued a research agenda in four strategic areas: energy and the environment; biosciences and bioengineering; materials science and engineering; and applied mathematics and computational science.

Source: authors
For details: www.kaust.edu.sa

Although Arab decision-makers have been increasing expenditure on education, there is still little political patronage of science and the scientific endeavour, despite a legacy of creativity and innovation. Lack of expenditure on R&D is a major cause of the poor output of the Arab STI system but it is not the only quandary. The lack of a science culture in turn leads to a lack of appreciation for science. So why do Arab decision-makers seem more concerned with education than STI? Can it be that education is viewed as a necessity, whereas STI is considered a luxury? Basic education empowers citizens to read, comprehend basic mathematics and make a living. However, basic education is not sufficient to create wealth, to address concerns of food, water and energy security, to provide better health services and better infrastructure. For that, science is required.

The major contemporary problems Arab countries face which require scientific or technological solutions are well known. Despite this, the purpose of scientific research remains unclear. Research undertaken by the higher education sector, although important, often serves purely academic purposes.

Appreciation for S&T is also an almost alien concept in the mindset of the Arab private sector, which has always been strong in trading goods and services rather than manufacturing. Even in instances where funding has been no object, the private sector has been unable to produce a critical mass of knowledge workers to utilize these resources to meet national objectives, add to the national and global pool of knowledge or produce patents leading to products and services.

Another factor stalling change in Arab countries has historically been the top-down approach to governance. This places political leaders in a position where they have to assume the role of championing science for the scientific enterprise to blossom.

Arab countries today are nation states, a particularly European invention that became obsolete with the signing of the Treaty of Rome in 1959. Since then, European countries have set about harmonizing their economic and scientific policies.

It is true that, in the Arab world, there are regional umbrella organizations that do the job of the European Union. There is the Arab League, which has been in existence for over six decades. Its primary concern has been to deal with political problems, however, causing issues in S&T and higher education to be neglected by this body. There is also the Organisation of the Islamic Conference. This umbrella organization embracing both Arab and non-Arab Islamic countries has made some bold attempts to address S&T issues. However, due to a chronic shortage of funds, it too has been unable to implement its programmes fully.

Oil wealth has been a double-edged sword. On the one hand, it has helped Arab countries to consolidate their infrastructure, invest in service industries and promote trade. On the down side, 'easy money' has meant that STI-based development and industries took a back seat until very recently. The slump in oil prices since 2008 has given oil states a glimpse into the future when they will no longer be able to count on oil for their major source of income.

High-tech exports form Arab countries are negligible. The acquisition and application of technology is a function of an enabling environment, yet this environment is almost non-existent in many parts of the Arab world. For instance, although expenditure on defence in Arab countries is among the highest in the world, there is no home-grown defence industry.

There is very little linkage between universities and industry when it comes to research output and thus little wealth generation via the commercialization of R&D. In the majority of Arab states, intellectual property regimes are very weak, providing little protection for the output of scientists. A patent culture being almost non-existent, researchers often come up against a blank wall when attempting to commercialize or otherwise develop their research output.

A number of Arab countries have a sizeable S&T potential. This potential is often dispersed and championed by individuals rather than institutions. S&T output has been growing unsteadily over the past three decades. Today, exploiting this output still relies on a handful of dedicated knowledge workers based at a few universities and research centres in the Arab world.

Some countries have begun to streamline R&D into basic research, applied research and technological development. They have also started assimilating market parlance, not only when it comes to producing papers and patents but also prototypes and products. There are also those which are attempting to leapfrog the development cycle by importing ready-made models of research centres and universities; this may yield success but only at the local level unless an inter-regional component is added.

Last but not least, the stability and security of Arab countries cannot simply be a function of military expenditure and expenditure devoted to upholding law and order. Long-term security and prosperity for all countries in the region can only be achieved by assuring the triple helix of food, water and energy security, combined with sustainable and equitable socio-economic development in tolerant societies where accountability and rule of law prevail. S&T can achieve some of these goals, if not all.

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Born in Jerash, Jordan, in 1935, Dr Badran received his PhD from Michigan State University in 1963. After conducting basic research in plant physiology in the USA, he became a Professor of Biology at the University of Jordan. He was later appointed Dean of the Faculty of Sciences at the same university then founding President of Yarmouk University and of Jordan University of Science and Technology, where he served from 1976 to 1986.

Currently, he is President of Petra University, Senator and Chair of the Senate Committee on Science, Education and Culture, and President of the National Centre of Human Rights of Jordan. He is a Fellow of the Academy of Sciences for the Developing World (TWAS) and of the Islamic World Academy of Sciences and President of the Arab Academy of Sciences.

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Over the course of his career, he has published over 45 papers on issues related to S&T policy and has edited or co-edited 10 books on higher education, the environment and water resources. He has also been involved in various studies implemented by the Islamic Development Bank and the General Secretariat of the Organisation of the Islamic Conference.