Science and innovation in Egypt

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Foreword

Foreword from His Excellency Professor Dr Ekmeleddin İhsanoğlu, Secretary-General of the Organisation of Islamic Cooperation.

The research for *The atlas of Islamic-world science and innovation* report on Egypt was undertaken in collaboration with the various partners including the Organisation of Islamic Cooperation (OIC), COMSTECH, ISESCO, the Royal Society, Nature, British Council, the International Development Research Centre of Canada and Qatar Foundation.

Apart from various other factors which underpin Egypt's strategic significance within the OIC as well as on the broader international stage, Egypt stands out as a flag bearer of a civilization known for its scientific and cultural heritage. Contributions by the Egyptian scientists, researchers and thinkers in the fields of astronomy, mathematics, medicine, philosophy and architecture span over centuries, with the pursuit of knowledge receiving further impetus following the advent of Islam in the 8th century.

This report includes a survey of Egypt's current Science, Technology and Innovation landscape, its history, areas of strength, policy framework and institutions relevant to STI, as well as an assessment of the contemporary challenges and opportunities to research and scientific advancement. Despite its various challenges, Egypt continues to show promise in the fields of mathematics, engineering, physics, chemistry, IT, biotechnology and agriculture. Whether it be a Nobel Prize winner in Chemistry or the people behind Alexandria University's elevation in international rankings, Egypt has succeeded in regularly producing leading scientists in varied disciplines. Egypt ranks prominently amongst the top few OIC Member States in terms of the number of publications whose impact factor has been steadily growing.

The reaffirmation of commitment by the Egyptian leadership to the promotion of STI is reassuring for the people of Egypt as well as for many of the regional countries benefiting from Egyptian expertise through scientific cooperation and joint projects. I am hopeful, that the recommendations of this report will receive due consideration and may be taken as a modest contribution of the OIC in the transformation process in the country.

I thank all the partners who have contributed in the preparation of this report including the Academy of Scientific Research and Technology of Egypt, the National Focal Point for Egypt and the Library of Alexandria, the Research Partner, for their valuable assistance and support.

Introduction and summary

It is not often that a country is faced with the prospect of rebuilding from the ground up. Egypt's remarkable revolution – notwithstanding the many and inevitable challenges it presents – has ushered in an era of unprecedented hope and expectation, and the overriding sense that Egyptians have a golden opportunity to overturn three decades of social, economic and political neglect.

This is particularly true in the domains of scientific research and education, where there is near-unanimous agreement that decades of under-investment, poor planning of the way research funds are spent, excessive bureaucracy, uninspiring curricula and political meddling have severely weakened a system that once regularly produced scientists who were among the best in the world. Reforms are ongoing and excellence can still be found in many fields, but freedom of enquiry, entrepreneurship and innovation are thin on the ground in both universities and industry. Restoring these crucial pillars will be crucial to development, and will do much to help meet the demand so often heard in Tahrir Square during the revolution for "bread, freedom and social justice".

Egypt has a huge scientific legacy to draw on. Think of the astronomy and optics of Ibn Al-Haitham in the 10th-century, Ibn Al-Nafis's groundbreaking work on the circulation of the blood in the 13th century and the generations of medical scientists who preceded him, and the thousand-year-old rationalist tradition of Cairo's Al-Azhar University, the world's oldest (Mapping, Box 1.1). Reviving the country's scientific golden days will be a huge challenge, but in the spirit of Tahrir Square anything seems possible. "We believe we are alive now, whereas before we were really dead," one academic told us. "We saw corruption at every step, then suddenly we had people who were prepared to die for the country. Now everyone wants to contribute to making things better." He recalled a taxi driver in Cairo in the days after Mubarak's resignation remarking that "even the air I'm breathing seems cleaner". Anyone who knows Cairo will know that this is optimism indeed.

This report assesses the current state of Egypt's science, technology and innovation (STI) systems, their strengths and weaknesses, as well as the many ideas under consideration and programmes already in place for improving them. It is designed as an accessible guide for anyone interested in Egypt's future development at this vital time. It should be noted that much of the information is derived from interviews that were conducted in late 2010 before the Egyptian revolution. After the revolution, which triggered a change in the entire political system, we conducted further interviews and research, and subsequently revised the report to reflect the impact of the changes on the future of STI. This was done partly through a two-day open discussion event at the Bibliotheca Alexandrina in May 2011, at which young researchers and established scientists talked about their aspirations and expectations for science in Egypt and the reforms they thought were necessary.

One year on from the revolution, it was announced that Egypt is drawing up a strategy for promoting scientific research, which aims to draw on the knowledge of its scientific diaspora, encourage greater commercialisation of research results, and address key national problems such as food, energy, health and education.[1]

Here is a summary of the report:

1. Mapping With government funding of R&D at barely one-tenth the OECD average, and minimal contribution from the private sector, it is little wonder that researchers have struggled. This chapter investigates the effects of the funding shortfall, as well as looking at the structure, history and key strengths of the country's STI system. It also examines the recent attempts to revitalize the research landscape and the early signs of success.

2. People Here we look at the education system and how it is serving the needs of the research sector. Egypt has always produced brilliant science graduates, but today they are in a small minority. With universities complaining that they have to retrain new students to "think like scientists" and businesses critical of graduates' ability to apply knowledge appropriately, calls for a complete overhaul of school curricula and of teaching methods seem justified. School reforms have been under way for five years, but with 55% of the population under 25, turning the system around remains one of the most important challenges.

3. Business For many of Egypt's industries outside of the IT sector, spending money on R&D is akin to pouring it into the Nile. Serious attempts are underway to change attitudes by promoting a culture of entrepreneurship and bringing business and academia closer together. But with estimates of just 5% of the country's investment in R&D coming from non-governmental sources, and knowledge transfer between universities and industry worryingly low, further bridge-building initiatives will be needed to rekindle the private sector's appetite for innovation.

4. Places Here we look at the disparities in funding and resources across Egypt and pick out places that have achieved particular success. The capacity of universities and research centres to win a share of the modest R&D funds on offer – one of the most important factors determining scientific achievement – varies hugely across the country, with the odds tending to favour those closest to Cairo. Despite the patchy funding landscape, many labs and centres of excellence are engaged in first-rate research in chemistry, nanotechnology, IT and other areas that should have a strong impact on Egypt's development.

1 Badr H (2012). Egypt sets a new course for its scientific efforts. SciDev.Net, 17 February 2012. Available online at http://www.scidev.net/en/science-and-innovation-policy/science-in-the-islamic-world/news/egypt-sets-a-new-course-for-its-scientific-efforts-1.html

5. Culture Attitudes to innovation in Egypt's popular culture are examined, as well as cultural attitudes within the academic system itself. The public appetite for science appears diminished, a disappointing state of affairs for a country with so impressive an historical record in this field. Is the media to blame, or is there something in modern Egyptian culture that discourages innovation? Part of the problem seems to lie with conservative attitudes within the scientific community – attitudes that are deeply entrenched and that will require a huge effort on behalf of academic reformers to shift.

6. Sustainability With restricted water supplies, a growing population, a land mass dominated by desert and myriad threats from climate change already beginning to bite, Egypt faces a huge challenge in agricultural development in the coming decades. Ambitious programmes are under way to improve crop yields, reclaim desert and salt-affected land, build more efficient irrigation systems, improve water supply and exploit the country's abundant resources of renewable energy. To ensure that development is sustainable, a science-based approach seems crucial.

7. Collaboration In recent years Egypt has started to build up its collaborative efforts with Europe, Japan, Australia and the US, with promising results. It also plays a key linking role in the Middle East and North Africa and Central and West Asia regions and among Nile Basin countries, and is well placed to lead the way in future regional collaborations in renewable energy, nanotechnology, biotechnology, agriculture, water resources and pharmaceuticals. This chapter assesses this landscape of collaboration and reflects on the danger that Egypt's somewhat inflexible higher education system could hold things back.

8. Summary and recommendations Here we summarize the report's key findings, including highlighting the strengths and weaknesses of Egypt's STI and educational systems, and offer some recommendations for the new administration.

1 Mapping

Of the many extraordinary events and behaviours on display during the 18 days in January and February 2011 that led to the overthrow of Hosni Mubarak, one thing that consistently stood out was the ability of the protestors to innovate. When the regime shut down cell phone networks and the internet, they passed on satellite news broadcast via radio and distributed leaflets to keep the information flow going. They poured soft drinks on their faces to protect themselves from the effects of teargas. They even managed to neutralize the army by befriending them and making them part of the protests.

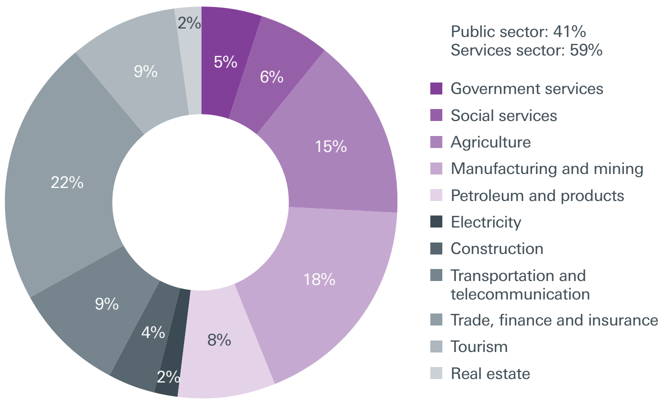
"This was an entrepreneurial revolution," says Hassan Azzazy, Professor of Chemistry and Associate Dean for graduate studies and research at the American University in Cairo. "It was about doing things out of the box. Innovation was the power behind the revolution." Azzazy has been campaigning for some time to have entrepreneurship taught as part of undergraduate science courses, and he is not alone in pondering how to rekindle in universities that innovative spirit that burned so brightly during the protests. All seem to agree it has been missing for too long, snuffed out by lack of funding and an ineffectual education system.

In this chapter we will assess the strengths and weaknesses of Egypt's STI system and outline some of the ambitious plans to reform it. Post-revolution, there appears to be widespread enthusiasm for ramping science and technology up the political agenda. "Science and technology have been totally forgotten in many ways, and that is one thing people expect to change drastically," says Farouk El-Baz, Director of the Center for Remote Sensing at Boston University and widely revered in Egypt for his work on NASA's Apollo missions. "We should be able to do better. We have the minds, the energy, a workforce that we can train. Science and technology must take the lead now in all kinds of ways."

Table 1.1: Egypt's vital statistics

GDP growth: 1.8% (2011; CIA World Factbook)	
GDP per capita (PPP): $6,500 (2011; CIA World Factbook)	
Foreign direct investments: $6.385 billion (2010; World Bank)	
Population: 82.866 million (Nov 2012; CAPMAS Egypt)	
Life expectancy at birth: 73.2 (2011; UNDP)	
Adult literacy rate: 66.4 (2010; UNDP)	

Figure 1.1. GDP per sector



Source: European Central Bank via presentation from Taher El Sherif, Secretary General of Egyptian-British Chamber of Commerce, June 2011

1.1 The current state of Egyptian innovation

There is no question that Egypt's research community – which today numbers some 98,000 theoretical and applied scientists in 19 government universities and 198 research centres (see Tables 1.3 to 1.4)[2] – has always harboured great talent. "We have a large pool of dedicated people who are extremely good," says Ismail Serageldin, Director of the Bibliotheca Alexandrina. "We have a powerful diaspora with whom to connect. We have some very well meaning and committed people in places of decision-making, and we have a legacy of education in society with deep roots that we can build on."

Yet despite these promising foundations, for three decades the Mubarak regime allowed scientific research and education to founder. As a result, the culture of innovation has all but evaporated. The World Economic Forum's Global Competitiveness Report 2011-2012 ranks Egypt 113th out of 142 countries on the quality of its scientific research institutions[3], and 83rd on its capacity for innovation."Scientific research in Egypt, which was ahead of South Korea, has now fallen to the tail of global rankings over the 30 years of the regime's governance," wrote the Nobel-prize winning chemist Ahmed Zewail in an editorial in the International Herald Tribune in February 2011[4]. The industrialist Ahmed Bahgat suggests Egypt could end up like North Korea if things carry on as they are. "We need a vision," he says. "It's about where we want to be in ten or twenty years."

1.2 Scraping the barrel for R&D

Which Korea Egypt ends up emulating will depend to a great extent on how much it spends on R&D – generally a good measure of how much faith a government has in scientific research as an engine of development. Between 2004 and 2010 governmental R&D expenditure averaged around 0.25% of GDP (see Table 1.2)[5], on a par with the Arab world but below the sub-Saharan African average (excluding South Africa) and barely one-tenth the OECD average[6]. It is also some way off the Organisation of the Islamic Cooperation 1% target for Islamic countries. By comparison the regime spent around 2-3% of GDP on military expenditure each year from 2000 to 2009[7].

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2 Supplied by the Egyptian Academy of Scientific Research and Technology (ASRT) 2011

3 This measure is based on the ability of researchers to publish peer-reviewed articles in international journals, to transfer the results of their research to production sectors, to preserve the environment and protect public health, to establish effective partnerships with various social sectors, and to attract funding from international programmes. From The Global Competitiveness Report 2011-2012 (World Economic Forum)

4 International Herald Tribune, 2 February 2011

5 ASRT 2011

6 UNESCO Institute for Statistics

7 World Development Indicators 2011 (World Bank)

Table 1.2: R&D spent by government as % of GDP

Year	Percentage	Annual change
2004/2005	0.24	-0.03
2005/2006	0.26	0.02
2006/2007	0.26	0.0
2007/2008	0.27	0.01
2008/2009	0.21	-0.06
2009/2010	0.24	0.03
2010/2011	0.40	0.16

Source: ASRT 2011

This is a critical issue for the development of Egypt. The correlation between R&D investment and economic growth has been demonstrated many times. As Serageldin puts it: "In their fight to raise living standards and realize their economic and social potential in the coming decades, there is one thing developing countries cannot do without: home-grown capacity for scientific research and technological know-how."[8] Furthermore, says Azzazy, Egypt should not rely on overseas funds as a source of R&D spending. "We have to put our own money on the table. I want to see billions of Egyptian pounds for research from the government. This is patriotism. Once you put money from your own pocket, then it shows you really believe in it." In June 2011 the interim government took a step in the right direction, increasing R&D spending for 2010/11 from LE2.4 billion to some LE3 billion, which represents 0.4% of GDP (up from 0.24% for the previous year). The Ministry of Higher Education and Scientific Research was to receive LE550 million to fund its research centres, up from LE390 million for 2010. The president, Mohamed Morsi, has pledged to continue this upward trend in funding.

Lack of money for research, and the scant pay of researchers, has been a constant struggle for scientists and department heads across Egypt. This is especially true for those in public universities who until recently had to rely almost exclusively on the government's meagre annual funding allocation, which for some smaller universities amounts to a few million Egyptian pounds a year for R&D. "There's no chance of equipping a new laboratory with that," says Fayez El-Hossary, Dean of the faculty of science at Sohag University.

8 *Nature*, vol 456, p 18 (30 October 2008), doi:10.1038/twas08.18a

The situation is made worse by the fact that the private sector contributes an estimated 5% to the country's research budget, one of the lowest contributions anywhere[9]. Most industries in Egypt seem to doubt that R&D translates into profits. Non-governmental funders of science are thin on the ground, limited to a few enlightened entrepreneurs such as Ahmed Bahgat of the Bahgat Group and Ibrahim Abouleish of SEKEM; grant-giving bodies such as the Bibliotheca Alexandrina's Center for Special Studies and Programs, which offers research grants up to LE75,000 to Egyptian postdoctoral researchers younger than 35 working on projects with foreign counterparts; and the Misr El-Kheir Foundation, a development charity funded by Islamic donations that puts LE5-25 million a year into research areas that have the potential to alleviate poverty and disease, such as cancer diagnosis and treatment and the use of stem cells to tackle diabetes. Misr El-Kheir also sponsors undergraduate science projects and scholarships for PhD students.

While the need for greater funding is clear, increasing R&D expenditure by itself is unlikely to put Egypt back on the path to quality research and innovation. It is equally important to re-invigorate the academic system, says Nazar Hassan of science and technology at UNESCO's office in Cairo. "All higher education institutions should deliver graduates and researchers who can contribute to the economy instead of overloading it." He believes that Egypt currently spends millions of dollars on "redundant" research that will never translate into innovation.

9 Estimate by ASRT

10 For details about the 2011 grant programme see http://www.bibalex.org/cssp/researchs/2011.htm

1.3 Egypt's STI system

Over the past four decades, Egypt's ***Academy of Scientific Research and Technology (ASRT)*** has been largely responsible for shaping the country's science and innovation system. The academy was founded in 1972 as a non-profit organisation affiliated to the Ministry of Scientific Research, responsible for drawing up STI strategies to tackle Egypt's problems and assessing their impact. Until 2007 it controlled the budget for R&D in universities and research centres. Today, under its president Maged Al-Sherbiny – who has held the post since April 2010 – it is no longer a financing body but plays a central role as a think tank and policy adviser to the science ministry. It coordinates the country's research programmes, and brings together scientists and other experts from universities, research institutes, NGOs and the private sector in Egypt and the diaspora on its 15 specialised scientific councils, where participants debate critical issues and plan research studies that serve the country's development priorities and feed into government policy.

Egypt's STI system is highly centralised and dominated by the public sector, with R&D happening mostly in state-run universities and research centres supervised by the ***Ministry of Higher Education and Scientific Research***, which comprises both the Ministry of Higher Education (MOHE) and the Ministry of Scientific Research (MOSR) (recently promoted from a state ministry to a ministry with full portfolio). Working with the ASRT, the MOSR is responsible for the national research policy and the research strategy at the country's public universities and research institutes (see Tables 1.3 and 1.4). Egypt's research centres, which used to be scattered across different ministries, are currently being reorganised under the umbrella of the MOSR's ***Supreme Council of Scientific Research Centers and Institutes***, which should ensure their activities are more harmonised.

Table 1.3: Researchers in Egyptian government universities (2009/10)

University	Teacher Assistant	Assistant Lecturer	Lecturer	Assistant Professor	Professor	Total
Ain Shams	1,547	1,823	2,585	1,372	1,820	9,147
Alexandria	1,459	1,520	1,441	803	1,591	6,814
Assiut	546	884	830	455	647	3,362
Banha	665	670	650	415	615	3,015
Beni Suef	353	381	443	151	138	1,466
Cairo	2,077	2,469	2,522	1,758	2,503	11,329
Fayoum	368	366	405	205	143	1,487
Helwan	734	731	1,322	767	529	4,083
Kafr El-Sheikh	123	234	212	96	150	815
Mansoura	961	1,344	1,332	697	849	5,183
Menoufia	626	893	1,014	475	484	3,492
Minya	433	564	688	384	502	2,571
Sohag	227	353	356	146	142	1,224
South Valley	486	292	393	151	85	1,407
Suez Canal	770	950	1,145	507	447	3,819
Tanta	577	799	915	519	620	3,430
Zagazig	975	1,184	1,280	738	1,180	5,357
Total	12,927	15,457	17,533	9,639	12,445	68,001

Source: ASRT 2010. Table excludes Port Said University (established in 2010) and Al-Azhar University

Table 1.4: Scientists in largest government research centres (2009/10)

Ministry	Research Centre	Total Researchers
Scientific research	Central Metallurgical Research and Development Institute	166
	Egyptian Petroleum Research Institute	343
	Electronic Research Institute	217
	City of Scientific Research and Technology Applications	129
	National Authority for Remote Sensing and Space Sciences	89
	National Institute of Oceanography and Fisheries	425
	National Institutes of Standard	196
	National Research Center	4,002
	National Research Institute of Astronomy and Geophysics	252
	Research Institute of Ophthalmology	249
	Theodor Bilharz Research Institute	403
Agriculture	Agricultural Research Center	6000
	Desert Research Center	630
Communications	National Institute of Telecommunications	60

Ministry	Research Centre	Researchers
Education	National Center for Educational Research and Development	140
Electricity and Energy	National Center for Radiation Technology and Research	400
	National Center for Nuclear Safety & Radiation Control	265
	Nuclear Materials Authority	278
Health	Center for Applied Research and Field	20
	Research Institute of Medical Insects	32
	National Organization for Drug Control and Research	346
	National Institute of Nutrition	96
	Center for Dental Research	45
Housing	Housing and building National Research Center	264
	New and renewable energy Authority	171
Industry	Tabbin Institute for Metallurgical Studies	21
Water Resources	National Water Research Center	1017

Source: ASRT 2010

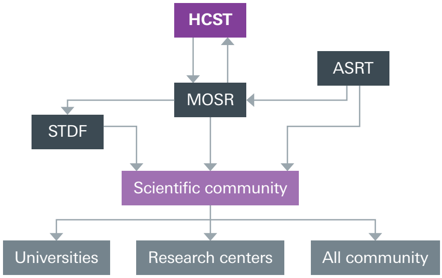
Egypt's higher education system is governed by the MOHE, which coordinates all post-secondary education; the ***Supreme Council of Universities***, which harmonises academic activities in government-run universities and the number of students admitted to each faculty; the ***Supreme Council of Private Universities***, which does the same for the private education sector; the ***Central Administration of Al-Azhar Institutes***, which supervises the schools and institutes of the Al-Azhar religious education system that runs in parallel with the public system; and the ***National Authority for Quality Assurance and Accreditation of Education***, an independent agency charged with developing quality assurance and accreditation standards for various educational levels.

1.4 The 2007 reforms and the new vision for R&D in Egypt

As we have already noted, the revolution in Egypt has raised the hopes of millions in academia that the new government will revitalise the education and research systems and turn the tide of decades of neglect. "We are looking for a scientific society, one that can apply scientific solutions to all our needs and problems," says Maged Al-Sherbiny. "Our mission [at the ASRT] is to advance innovation and creativity in an environment of competitiveness and excellence, and thus boost economic growth." He has high ambitions for the government's commitment to spending on scientific research, hoping for an increase in the annual R&D budget to 2% of GDP within three years, which would represent nearly a tenfold increase.

Al-Sherbiny is one of the chief architects of an STI reform programme that is ongoing and that dates back to 2007 when Hany Helal was Minister for Higher Education and Scientific Research. Helal, a former professor of engineering at Cairo University, commissioned a thorough review of Egypt's STI infrastructure, looking at the ways other countries managed their research sectors and devising a model of organisation and funding that puts education and scientific research at the heart of development.

Figure 1.2. Structure of Egypt's STI system



HCST Higher Council for Science and Technology
MOSR Ministry of Scientific Research
ASRT Academy of Scientific Research and Technology
STDF Science and Technology Development Fund

Source: Ministry of Higher Education and Scientific Research

The reforms led to a significant change in the way the country's STI system is structured (see Figure 1.2). The new system is built on several pillars:

- The **Higher Council for Science and Technology**. A panel of ministers and nongovernmental experts (including expatriate scientists), re-elected every three years, whose remit is to determine Egypt's developmental priorities and how they should be supported by science. Modelled on similar bodies in Japan and South Korea, the Higher Council is chaired by the prime minister and includes eight key ministers responsible for higher education, trade and industry, electricity and energy, health, agriculture, planning, communications and international relations, as well as leading scientists and representatives from civil society. Previous members have included Ahmed Zewail, Farouk El-Baz, Mostafa El-Sayed, Magdi Yacoub, Ismail Serageldin and Naguib Sawiris. Once the Higher Council has decided on research priorities – assisted by the MOSR – the ASRT prepares the strategies to carry them out.
- **The Science and Technology Development Fund (STDF)**, a competitive peer-review grant-awarding scheme that was modelled on Germany's DFG and is now the main funding mechanism in all research disciplines in Egypt, having taken over this role from the ASRT. It has been widely welcomed by researchers. Since its inception in 2008 up to the end of 2010 it had given out LE500 million in grants, which researchers must apply for online. It was due to distribute LE200 million in 2012[11].

11 For information on how to apply see http://www.stdf.org.eg

The STDF distributes funds through several mechanisms:

- – National Research Grants, which includes separate allocations for basic and applied science (up to LE1 million per grant), young researchers (up to LE600,000 per grant) and the reintegration scheme mentioned above (up to LE1.5 million per grant).
- – A targeted call for applied research projects in the priority areas identified by the Higher Council as crucial for Egyptian development (see below). "We are putting our limited resources into these but at the same time we are not closing the door on basic science," explains Al-Sherbiny. There is no pre-set limit to the size of these grants, which average between LE1.5 million and LE2 million.
- – Joint Research Grants with other countries for bi-national collaborations, with equal funding from both sides. Typical grant size is up to half a million Egyptian pounds. The STDF is currently running joint funds with the US, Germany, Japan and France.
- – A combined track with the Industrial Modernization Center – an independent body set up in 2000 with funds from the government, the EU and the private sector to increase the competitiveness of Egypt's industry – to strengthen ties between academia and industry.

- The **Research, Development and Innovation (RDI)** programme, a separate funding stream, designed to encourage applied research that is useful to industry. Backed by EUR 31 million from the EU between 2007 and 2015, it supports the development of ideas from drawing board to commercial product, as well as increasing cooperation between researchers and those in industry and promoting the culture of innovation in schools and society. An important component is a network of focal points throughout universities and institutions which provide guidance to researchers wishing to apply for grants from the RDI or other EU funds, such as the Seventh Framework Programme (FP7), the EU's main instrument for funding research between 2007 and 2013[12].
- A programme of international collaboration known as the **Decade of Science**, which involves building links with a different country each year between 2007 and 2016, including establishing joint research funds, boosting academic integration and developing centres of excellence. Partners so far include Germany, Japan, Italy, France and the US.

12 For more information on the RDI programme see http://www.rdi.eg.net

Despite the inevitable political uncertainty since the ousting of Mubarak, the ASRT under Al-Sherbiny and the Ministry of Higher Education and Scientific Research under first Amr Salama and then Motaz Khorshid put forward several additional proposals that should further improve the prospects for research and innovation in Egypt. These include plans to:

- increase the salaries of researchers at government universities and research centres by between $1,200 and $4,200, including adding quality of performance bonuses for all grades
- employ an extra 40,000 to 50,000 graduates as researchers. Most of these will work at government universities and research institutes, increasing the state research workforce from 98,000 to 130,000 over the next few years. The government will also subsidise graduate jobs at private universities, and for groups of graduates to work as researchers in industry, led by professors to maintain a link with academia. The extra jobs will go to the leading students who have graduated from each college or university over the past 8 years. LE2 billion has been set aside for this
- raise the number of large government research institutes from 18 to 28, and the number of small ones from 180 to 230
- harmonise the organisation of publicly funded research centres so they are all affiliated to the MOSR (see section 1.3 above)
- make governmental sources of research funding available to private universities for the first time
- increase the number of papers by Egyptian researchers published in international journals to 30,000 a year from the current level of 7,500 a year.

All these reform measures are geared towards supporting Egypt's national programme of research, which is focused on seven areas considered essential for development:

- renewable energy (solar and wind)
- water management (including desalination, more efficient irrigation and new sources of groundwater)
- food and agriculture (especially development of new cash crops and improved production of wheat, rice and aquaculture)
- health (in particular Hepatitis C, cancer and obesity)
- information and communication technology
- space technology
- socio-economic sciences.

1.5 How successful have the reforms been so far?

According to the most commonly used measure of scientific performance – the number of papers published in scientific journals – early indications are positive. Egypt's output rose from 4,712 publications in 2006 to 7,411 in 2009 (according to the SciVerse SCOPUS database of peer-reviewed literature), with notable improvements in agricultural sciences, engineering, computer science, medicine and biochemistry, genetics and molecular biology[13]. Over the same period its global share of publications rose from 0.26% to 0.36%, and its regional share from 12.8% to 13.7%.

Egypt ranks fourth behind Turkey, Iran and Israel among OIC and Middle Eastern countries on numbers of papers published, yet lies 41st globally, with Harvard University alone publishing twice as many. When you consider the number of papers published per million population (see Table 1.5), Egypt still looks uncompetitive next to some Middle Eastern countries, and markedly so next to economically advanced countries such as Finland and Korea. However there are clear signs that the quality of its research is improving. Since the early 1990s its impact factor – derived from the number of times a paper is cited in referenced articles – has risen from a quarter to half the world average[14].

Some of the improvement in output and impact factor undoubtedly derives from an agreement the previous minister of higher education and scientific research Hany Helal signed with the publisher Elsevier to give certain local Egyptian journals international status. The initiative costs $15,000 per journal, half of which is paid by the journal and half by the MOSR. The journals continue to be printed in Egypt but are published by Elsevier on its ScienceDirect platform.

Table 1.5: Scientific publications per million population in selected OIC and comparative countries 2010

Finland	2645	Iran	377	Egypt	102
Korea	1141	Kuwait	375	Algeria	82
Malaysia	524	Jordan	344	Libya	73
Qatar	495	Lebanon	300	Morocco	71
UAE	448	Oman	278	Iraq	23
Tunisia	425	Saudi	226	Syria	19
Turkey	409	Brazil	233		

Source: SCImago Journal and Country Rank portal and World Bank

13 All data from the SCImago Journal and Country Rank portal based on the SCOPUS database, www.scimagojr.com, unless otherwise stated

14 Thomson Reuters Global Research Report Middle East (February 2011)

There are small signs of progress too in ***patents***, a key innovation indicator and a measure of how successful scientists are at converting research results into new products or services. In 2010, the US Patent and Trademark Office granted researchers in Egypt 20 patents, a relatively small number given the size of the country's science community but more than the previous three years combined[15]. Since 1977 Egypt has won 117 US patents, which looks favourable compared with Jordan (25), Tunisia (20) and United Arab Emirates (86), less so with Saudi Arabia (382), Singapore (5592) and South Korea (84,840). Of the 2000 or so patent applications filed in Egypt every year, little over a quarter come from Egyptian researchers (see Table 1.6)[16].

Table 1.6: Patents applied for in selected OIC and comparative countries 2010

Country	Residents	Non-residents	Total
Algeria	76	730	806
Brazil	2705	19981	22686
Bangladesh	66	276	342
Egypt	605	1625	2230
Finland	1731	102	1833
Jordan	45	429	474
Korea	131805	38296	170101
Kyrgystan	134	6	140
Malaysia	1233	5230	6463
Morocco	152	882	1034
Saudi Arabia	288	643	931

Source: World Intellectual Property Indicators 2011, WIPO

15 Data gathered from www.uspto.gov

16 World Intellectual Property Indicators 2010 (World Intellectual Property Organization)

Box 1.1: A brief history of science in Egypt

Egypt has been fertile ground for science and scientists for several thousand years, and you don't have to look hard to find the evidence. A good place to start is the step pyramid of Zoser at Saqqara, 30 kilometres south of modern-day Cairo, which was built during the 27th century BC – before the more famous pyramids of Giza – by Imhotep, renowned as an architect, sage, astronomer and chief priest, but most importantly as a physician. After his death, Imhotep was recognized as a medical deity.

Several ancient artefacts demonstrate that medicine continued to thrive in Egypt thereafter. The Ebers papyrus, best known as the Egyptian Medical papyrus, which dates to 1600 BC, contains 700 formulas and remedies and identifies the heart as the centre of the blood supply. The Edwin Smith Papyrus, from 1550 BC, is known as the ancient Egyptian medical text on surgical trauma. The discovery in 1858 of another piece of papyrus from this time near the ancient capital of Thebes (now Luxor) shows that Egypt was also a centre of excellence in mathematics. The Rhind papyrus, 33 cm tall and over 5 metres long, contains a collection of arithmetic, algebraic and geometric problems, and even some dealing with the slopes of pyramids.

The establishment of Islam in Egypt in the 8th century AD inspired a quest for knowledge, with the very first word of the Koran compelling followers to *Iqraa* (read). Muslim scientists and scholars began by translating the works of their predecessors, and Egypt was part of the scientific explosion that followed. Ibn Al-Haytham (965-1040) made significant contributions to many fields, including optics, physics, astronomy, mathematics, ophthalmology and philosophy, but his major contribution was his description of the scientific method of observation, hypothesis and experiment that exists to this day. The medical scientist Ibn-Al Nafis (1213-1288) was the first to describe the pulmonary circulation of the blood. This era also marked the founding in Cairo (in 971) of Al-Azhar, the oldest degree-granting university in the world.

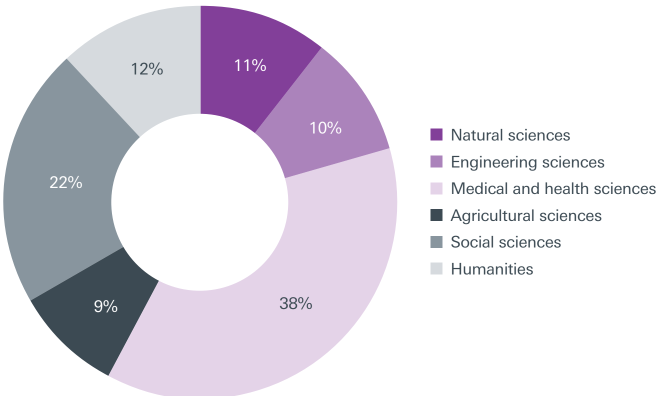
The foundations of modern Egypt were laid down under the 30-year reign of Mohamed Ali Pasha, who was installed in 1805. Ali brought in western physicians such as Clot Bey to teach, opened new schools and laid down modern systems of education. He established a centre of art and mathematics in the citadel of Cairo. He sent students from Al-Azhar on missions to France and England to be educated so that when they returned they could help broaden his new institutions. He even established the country's first large-scale water management scheme by building barrages on the Nile at El-Kanater El-Khairia 20 kilometres north of Cairo to protect the Nile Delta from flooding.

Egypt's largest academic establishment – Cairo University – was founded in 1908 after thinkers such as Mustafa Kamil raised the idea of a modern university that could act as a beacon of liberal thought and spearhead an academic revival in all fields of knowledge. The university opened its doors to women in 1928, with the aid of Taha Hussien (1889-1973), who was the first graduate of the university to receive a PhD in 1914 and the first Egyptian dean of the faculty of the arts; later he became minister of education. Since then Cairo University has been the cornerstone for the launch of many of Egypt's modern universities, including Alexandria, Ain Shams and Assiut.

1.6 Egypt's key strengths in research and innovation

In Egypt's research output as a proportion of the world's, field by field, its most significant contributions in the 2005-2009 period were in pharmacology (0.71%) and the physical sciences (materials science 0.66%, chemistry 0.64%, engineering 0.57%, and physics 0.4%)[17], which largely reflects the way its researchers are distributed across the disciplines (see Figure 1.3)[18]. It is also worth noting that in mathematics it exceeds the world average in citation impact[19].

Figure 1.3. Researchers in Egyptian governmental universities according to specialisation (2009/10)



Source: ASRT 2011

17 Thomson Reuters Global Research Report Middle East (February 2011)

18 ASRT 2011

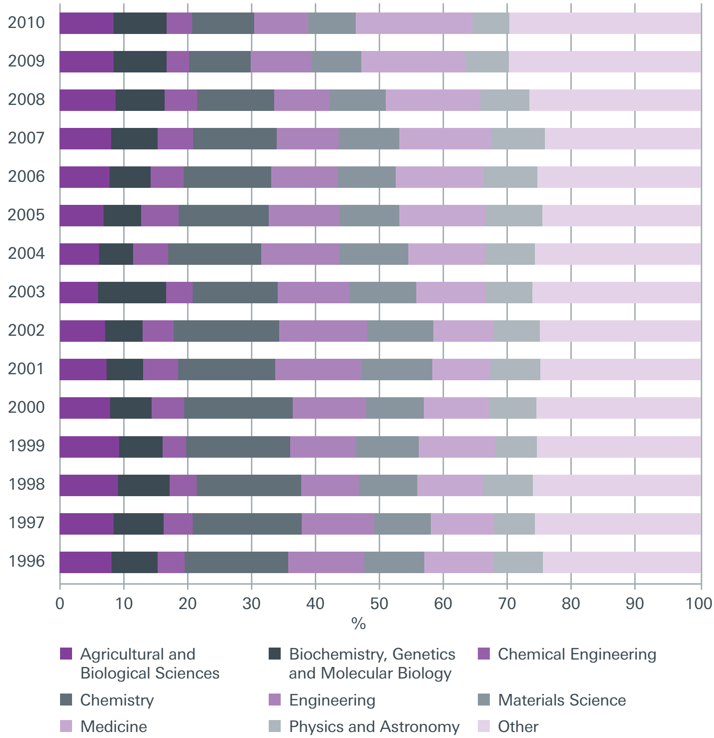
19 Thomson Reuters Global Research Report Middle East (February 2011)

Figure 1.4 shows how the country's publication landscape has changed since 1996, with medicine, chemistry and engineering the most dominant fields today, followed by agricultural sciences, biochemistry and materials sciences[20]. However, this picture is likely to shift in the next few years if the next government continues to concentrate R&D funding on priority development areas such as energy, water, food and health. The latest statistics also likely do not reflect the recent rapid growth in interest and funding in nanotechnology and IT.

There are no reliable indicators yet showing the proportion of funding directed at basic versus applied science, though Al-Sherbiny estimates it is currently around 50-50. However, the aim is for 35% of funding to go to basic science and 65% to demand-driven research, to reflect Egypt's drive for knowledge-driven human and economic development.

20 SCImago Journal and Country Rank

Figure 1.4. Publications by Egyptian researchers by subject area 1996-2010



Source: SCImago (2007) *SJR — SCImago Journal & Country Rank.* Retrieved March 21, 2012, from http://www.scimagojr.com

55 These patents are broken down according to the International Patent Classification. For more information on what is covered by each category please see http://www.wipo.int/classifications/ipc/en/ Accessed 4 February 2011

56 Intellectual Property Corporation of Malaysia: Kuala Lumpur, Malaysia

57 Tourism Malaysia: Kuala Lumpur, Malaysia; Virtual Malaysia, available online at: http://www.virtualmalaysia.com

58 Baltakji E (2006). *'Islamic finance assets may rise to US$5 trillion', Moody says*. Bloomsberg Businessweek (April): New York, NY, USA

59 Bakri Musa M (2006). *Towards a competitive Malaysia: development challenges in the 21st century*. iUniverse Inc: Bloomington, IN, USA

1.7 Resistance to change

Given that one of the key demands of the revolution's leaders was a wholesale reform of the education system and the way universities are run, the policy-makers of the next administration should face far less resistance than their predecessors to the idea that Egypt must spend money on R&D to develop. But there is bound to be resistance to the reforms, indeed there already is, largely from those who have been in unassailable positions in management for years and who now feel threatened by a democratising process that will leave them more accountable and more vulnerable to competition.

"The dominant issue right now is democracy and how it is being implemented," says Al-Sherbiny. "We propose things for the good of the country, then people start arguing about how are we going to do that, and complaining that they are not used to that. The old generation does not want the new generation to come up. People are still educating themselves in this process." Inevitably, some students have been clamouring that everyone in academia associated with the old regime should be forced out. This is hardly practical, given that most academic appointments had to be endorsed by the regime and only a handful can claim no association whatsoever. Neither is it desirable, according to Al-Sherbiny and others, who argue that such a move would end up destroying the country's entire academic system for the sake of pleasing a minority of students.

The path to democracy, after 30 years of dictatorship, is bound to be difficult to navigate. "Inevitably there is a state of confusion, of not really knowing where we're heading," says El-Baz. But he is optimistic that the outcome will be positive. "I try to convey to the youth in Egypt – because I am a geologist – that a revolution is like an earthquake. After each earthquake you have the little shakes that follow. This is what we're living through. People need to realise that, and that these little shakes are not a threat to the revolution."

1.8 The way ahead

Egypt has made steady progress since 1980 in the UNDP's Human Development Index, which measures progress in a host of measures such as income, education, poverty, inequality, life expectancy, civil liberties, security and well-being – though it scores below the average for Arab states and beneath many countries in its region including Tunisia, Jordan and Algeria[21]. It has also gone some way towards meeting the UN's eight 2015 Millennium Development Goals, particularly on extreme poverty and child and maternal mortality.

21 Human Development Report 2010, United Nations Development Programme

Despite this progress, serious concerns remain over education (a third of those aged 15 and older are illiterate); gender inequality in employment, politics and education (nearly two-thirds of illiterates are female[22]); availability of water and security of food supplies, particularly in light of recent high food prices which affect the poor most; strained resources due to population growth, which despite a slackening recently is still expected to reach 91 million by 2015 and close to 105 million by 2025[23]; wide disparities in quality of life across the country, with Upper Egypt and rural areas significantly worse off than elsewhere[24]; and the high prevalence of Hepatitis C, a blood-borne pathogen which is spread by dental clinics, hospitals, barber shops and other public facilities and is among the leading causes of illness and death in some parts of the country, with up to 15% of people infected. Other health worries include diarrhoea in children caused by bacterial contamination of drinking water, and obesity, which according to the World Health Organization affects 24% of men and 44% of women in Egypt[25].

Science has a crucial role to play in dealing with these issues, and many of those interviewed for this report stressed the importance of directing Egypt's innovation strategy towards these critical areas. "The most important challenge we face is discovering what the demand [for research] is, what areas to target," says Helmy Abouleish, managing director of SEKEM and a former member of the STDF's board of directors. "Research in Egypt is still largely supply-driven, which always runs the danger of never being used."

It remains to be seen to what extent the new government's R&D agenda will reflect the political inclinations of its members – for example, will it nod to the Muslim Brotherhood's preference for greater self-sufficiency in agriculture, textiles and other industries? Whoever is making policy will do well to listen to the advice of Nazar Hassan, head of the science and technology unit at UNESCO's office in Cairo, who maintains it is crucial that the government identifies where the research gaps are before trying to fill them. "[The R&D system] has improved since 2006, but the funding is not being used optimally," Hassan believes that, "money is being spent on work that is already being done elsewhere." To address this issue, in 2011 UNESCO launched a regional initiative called NECTAR – the Network for Expanding Converging Technologies (nanotechnology, biotechnology, ICTs) in the Arab Region – which is intended to strengthen national innovation systems by promoting partnerships between academia, research and industry. It also aims to stimulate an entrepreneurial culture that links basic and new sciences and their conversion into wealth. NECTAR will identify regional STI priorities and help member countries fulfill them[26].

22 Information about literacy sourced from World Development Indicators 2010 and 2011 (World Bank)

23 World Population Prospects 1950-2050: The 2008 Revision (UN Department of Economic and Social Affairs, 2009)

24 For more on regional disparities see Egypt Human Development Report 2010, chapter 2 (UNDP / Institute of National Planning, Egypt)

25 Defined as having a body mass index of at least 30kg/m^2; data from the World Health Organization's Global Infobase 2011

26 See http://www.unesco.org/new/index.php?id=55922 for more details

National innovation systems are usually built on three pillars: education, R&D and the participation of the private sector. In Egypt, all three have been in an advanced state of erosion. The new administration is inheriting unenviable difficulties, yet there are many reasons for optimism, not least the flowering of the country's IT industry, the wealth of talent lying dormant within the research community across all sectors, and the first-rate work being done by researchers in centres of excellence that have managed – through brilliance or fortuity – to obtain sufficient funds. It is tempting to add a fourth reason: the country's scientific legacy. But the past is not always a helpful reference point. As Al-Sherbiny points out: "We are reminded every day by the pyramids that we were innovative a long time ago, but when we remind people of this they start to slow down. We have to believe that we can be innovative in the future."

2 People

Start a conversation about schools and universities in Egypt and you'll find that almost everyone agrees on two things: that the country's education system used to be world-class, and that today it is in dire straits.

Ismail Serageldin, Director of the Bibliotheca Alexandrina, is one of several distinguished academics whom the government has turned to for advice on how to improve the system and turn students into better innovators. "After I graduated from Cairo University in 1964 I went to Harvard, where I had people from all over the world next to me in the classroom, and I didn't feel at any disadvantage," he remarks. "That would not be the case with our graduates today."

Another of those rallying to the cause is Farouk El-Baz. He describes the education at Egypt's government-run schools as "incomparable" with the high standards on offer 40 years ago. Overhauling it, he says, should be the number one priority and is essential for the country's economic development. "If you want your children to be worthy of being Egyptian, to be the equal of children anywhere, then it has to be done through education. All countries that develop their economies start there."

2.1 South Korea – a model for Egypt?

El-Baz points to South Korea as an example of how investing in education can transform a country's fortunes. The country increased spending on education from 2.5% of GDP in 1951 to 17% in 1966 and is now reaping the economic and developmental benefits[27]. "South Korea is an excellent example for Egypt," he says.

Egypt has a long way to go before its commitment to education comes anywhere close to matching South Korea's in the 1960s. In 2009, the country's spending on education was an estimated 3.9% of GDP, having decreased almost every year from a high of 6% in 2002[28].

27 South Korea: Mass Innovation Comes of Age (Demos 2007)

28 Data from the Egyptian Academy of Scientific Research and Technology, UNESCO Institute for Statistics, and Higher Education in Egypt (OECD, 2010)

Table 2.1: Public expenditure on education in selected OIC and comparative countries (2008 unless otherwise stated)

Country	As % of GDP	As % of total Government expenditure
Algeria	4.3	20.3
Brazil	5.4	16.1 (2007)
Egypt	3.8	11.9
Finland	6.1	12.4
Iran	4.7 (2009)	20.9 (2009)
Korea	4.8	15.8
Kuwait	3.8 (2006)	12.9 (2006)
Lebanon	2.0	8.1
Malaysia	4.1	17.2
Morocco	5.7	25.7
Saudi Arabia	5.7	19.3
Tunisia	6.9	22.7
Turkey	2.9 (2006)	–
UAE	0.9	27.2

Source: UNESCO Institute for Statistics 2011

However, some of the lessons from South Korea have filtered through to those controlling Egypt's budget. In 2007 the Ministry of Education (MOE) introduced a LE2.6 billion five-year plan for pre-university education reforms, aimed at raising the quality of teaching, reforming the curriculum, decentralising the management of schools and improving access for those in poor or deprived areas, among other things (see section 2.6). The decision by Egypt's post-revolution interim government to increase the education budget by 16% to LE55.7 billion is further cause for optimism. But before looking in more detail at the reform strategy and its chances of success, it is important to understand why change is so desperately needed.

2.2 Bursting at the seams

Egypt's substantial and youthful population is often hailed as its greatest asset. With just over 80 million[29] people – up from 58 million in 1990 – it is the most populous country in the Middle East, and the third most populous in Africa. Yet this growth has proved an enormous challenge for the education system. Around 32% of Egypt's population is under 15 years old, and another 23% between the ages of 15 and 24[30]. Average class sizes are 44 in public primary schools, close to 40 in secondary schools[31], and the average ratio of pupils to teachers in primary schools is among the highest in the region (see Table 2.2).

Table 2.2: Average primary school teacher to pupil ratios in selected OIC and comparative countries

Algeria	23
Brazil	23
Egypt	27
Finland	14
Iran	20
Korea	24
Kuwait	9
Lebanon	14
Malaysia	15
Morocco	27
Saudi Arabia	11
Tunisia	18
UAE	16

Source: World Development Indicators 2011

The number of students entering universities or higher technical colleges has nearly doubled in the last 25 years. There are now around 2.5 million students in higher education, nearly 30% of the 18 to 23-year-old age group (Cairo University alone has some 265,000 students, according to the Ministry of Higher Education[32]). The ministry predicts this figure could rise to 40% by 2021, which according to current demographic projections would amount to nearly 3.9 million students[33]. Furthermore, with just 34 universities serving a population of 80 million, Egypt has a greater density of students in its higher education establishments – and fewer universities per head of population – than just about any other country in the Middle East and North Africa.

29 Central Agency for Public Mobilization and Statistics (CAPMAS) 2011

30 CAPMAS 2009

31 National Strategic Plan for Pre-University Education Reform in Egypt (Egyptian Ministry of Education, 2007)

32 This figure includes all types of students

33 CAPMAS 2009 and Higher Education in Egypt (OECD, 2010)

Table 2.3: Growth in Egypt's higher education system 1999-2009:

Indicator	1999	2009
Number of governmental universities	13	18
Number of private universities	2	14
Number of students enrolled in public universities	1,168,795	1,918,299
Number of students enrolled in private universities	-	59,852
Number of graduates at public and private high institutes and universities	262,551	425,931
Holders of master degree	5,142	8,976
Holders of PhD degree	2,812	4,480

Source: CAPMAS

Table 2.4 Students and graduates by university

University	No. enrolled	%	No. graduates (2007/08)	%
Cairo	189,948	13.29	30,865	10.99
Alexandria	175,379	12.27	30,187	10.75
Ain Shams	170,913	11.96	36,100	12.85
Assiut	71,096	4.98	13,271	4.72
Tanta	96,842	6.78	20,493	7.29
Mansoura	125,012	8.75	24,163	8.60
Zagazig	102,816	7.20	20,570	7.32
Helwan	100,401	7.03	18,401	6.55
Menia	47,454	3.32	11,548	4.11
Menoufia	73,279	5.13	17,626	6.27
Suez Canal	49,693	3.48	11,546	4.11
Ganoub el Wadi	44,099	3.09	9,066	3.23
Beni Suef	43,307	3.03	8,347	2.97
Fayoum	23,777	1.66	4,722	1.68
Benha	60,551	4.24	11,543	4.11
Kafr el Sheikh	25,204	1.76	6,228	2.22
Suhag	29,101	2.04	6,244	2.22
Total	1,428,872	-	280,920	-

Source: Supreme Council of Universities website, Higher Education Development Statistics, via Egypt Human Development Report 2010

2.3 Quantity over quality

No part of Egypt's pre-university or higher education apparatus was designed to cope with such numbers, and inevitably quality has taken a plunge, especially at primary and secondary levels. Industrialist Ahmed Bahgat, who is hoping to introduce a not-for-profit internet-based TV teaching service to Egypt to help raise standards[34], says "It is like a theatre: we have schools that look like schools but are not, we have students who look like students who are not students, we have teachers who look like teachers but who don't really teach anybody."

Many in academia and industry share this sentiment. Clearly parents share it, too, since a huge number of students – 64% in cities and 54% in rural areas[35] – receive private tuition to help them improve their grades. Spending on private education – most of it for tutoring – accounted for 3.7% of GDP in 2004/5[36], almost equivalent to the amount spent by the government. This has led to a hugely inequitable system, since students from poorer families who cannot afford private tuition find it hard to compete.

One of the commonest criticisms of school education is the standard of teaching, especially in the sciences. "In my day, the science teachers in primary and secondary schools were science graduates," says El-Baz. "They were knowledgeable and could tell you about science in a way you would appreciate. Today the teachers are all out of teacher training colleges, and the way they teach science is not good." A study by the Cairo-based think tank the Center for Future Studies (CFS), published in January 2010, found that uninspiring teaching was the main reason why the proportion of pupils majoring in science subjects at the end of secondary school had dropped from 69.2% in 1970 to 32.8% in 2008[37]. As Nahla El-Sebai, manager of the CFS's Research Unit, points out: "This is an important shift, especially given Egypt's need for science and maths-based disciplines to enable it to build a technological base and thereby increase its competitiveness."

2.4 Critical thinking

Another major concern is that students who do study science are not taught to think like scientists – to question orthodoxy, to analyse critically, to find their own ways of tackling problems, to appreciate the thrill of discovery. Instead, memorisation and rote learning dominate.

"Science lessons are about a teacher who is supposed to know everything standing in front of and imparting knowledge to a class who are supposed to know nothing," says Hoda El-Mikaty, Director of the Bibliotheca Alexandrina's Planetarium Science

34 This service, from US-based company TV2moro (www.tv2moro.com), would allow students to stream lessons and lectures onto their TV sets via the internet

35 Egypt Human Development Report 2005 (UNDP / Institute of National Planning, Egypt)

36 National Strategic Plan for Pre-University Education Reform in Egypt, Egyptian Ministry of Education, 2007

37 http://www.future.idsc.gov.eg/FutureCMS/workareas/a379143210327077260100000b7ad2db/apps/Publication/Building%20Egypt%E2%80%99s%20 Scientific%20Base_.pdf

Center, which aims to stimulate children's interest in science through entertainment and interactive learning programmes. "It is impossible to tell the teacher if you think they are wrong. This does not cultivate innovation, self-confidence or initiative-taking, and it sort of kills any potential the children could have."

Little wonder, then, that Egyptian universities complain they must spend considerable time "re-orientating" first-year science undergraduates in how to think and study like a scientist, skills they would ordinarily have expected to learn at secondary school[38].

Box 2.1 Seeds of learning

Outside the public system in Egypt, it is possible to find educational approaches to thinking and learning that many hope will eventually become standard in schools across the country – methodologies that encourage skills of critical analysis, creative thinking and problem-solving essential for research and innovation. One of these is in the schools of ***SEKEM***, a sustainable development enterprise encompassing communities, industries and farms that was started in 1977 by Ibrahim Abouleish in the desert sand 60 kilometres northeast of Cairo.

SEKEM promotes a sustainable approach to everything from growing food and manufacturing clothes to developing new medicines. Its schools – which cater to 650 children from surrounding villages and cover kindergarten, primary, secondary and vocational education – teach the basic curriculum of Egypt's public education system but are spectacularly different to them in several ways, notably in the close relationship they encourage between pupils and teachers and in the attention given to the training of teachers, who are all university-educated and who each day must attend an hour-long workshop in interactive learning. The aim, says Yvonne Floride, who helped found the SEKEM school system 22 years ago, "when there was nothing to see around here except desert", is to immerse the students in a "rich world of imagination and discovery" by integrating theoretical course work with practical application, rather than have them absorb endless facts which up to now has been the standard practice in many state schools.

Another initiative that encourages "learning by doing" is the ***Wadi Environmental Science Centre (WESC)***, a non-profit training centre that offers half-day or day-long field courses and workshops in basic and environmental sciences, industrial and agricultural ecology, renewable technologies and other disciplines for students aged 6 to 11 from public and private schools. The centre is based in the middle of an olive plantation off the desert road that runs between

38 From interviews conducted for this report

Alexandria and the Giza Pyramids and the courses are run almost entirely outside, which helps bring science alive in ways the students – and their schoolteachers, who accompany them on the trips – are unlikely to experience in the classroom, according to Lynn Freiji, WESC's energetic founder.

Freiji says she "wants to replace the stale, out-dated pedagogic methods that characterize science education in today's classrooms with a hands-on, child-centred approach that gets students out of their classrooms and into the world around them". Key to this, she says, is to get the schoolteachers on board. WESC puts a lot of energy into building up relationships with teachers over several years, helping them build the centre's activities into the standard school curricula. Freiji maintains the teachers find WESC's hands-on approach as inspiring as the students do, and often end up teaching it to their fellow teachers. The result, she says, is a substantial increase in the number of children enthusiastic about studying science subjects through secondary school and beyond.

Wadi Environmental Science Centre

2.5 The state of higher education

While the number of students graduating from Egypt's universities each year more than doubled over the decade to 2006, only around 20% of those additional graduates studied "practical" subjects (science, medical and engineering-based as opposed to arts and humanities)[39] (see Table 2.5). This is significantly below the average for the Middle East and North Africa of 34% and the OECD average of 40%. Indeed the proportion of graduates in many STI-based disciplines either declined or stayed flat over the decade, including engineering, agriculture and basic sciences. This is a worrying trend for a country that is trying to build a modern innovation-based economy in which science, engineering and technology should play crucial roles.

39 Higher Education in Egypt (OECD, 2010)

Table 2.5 Graduates by field 1996 and 2006

Study Orientation	1995/96 Persons	Share (%)	2005/06 Persons	Share (%)	Change 1995/96-2005/06 Persons	Change (%)
Theoretical						
Arts & Humanities	117,577	*13.5*	238,019	*12.7*	120,442	102
Domestic Management	4,588	*0.5*	3,638	*0.2*	-950	-21
Tourism & Hotels	3,514	*0.4*	12,162	*0.7*	8,647	246
Education	123,338	*14.1*	201,169	*10.7*	77,831	63
Dar El-Uloum	8,336	*1.0*	16,729	*0.9*	8,393	101
Quran Knowledge	152	*0.01*	1,070	*0.06*	918	604
Artistic Education	1,707	*0.2*	1,576	*0.08*	-131	-8
Musical Education	763	*0.1*	794	*0.04*	31	4
Social Service	11,360	*1.3*	24,422	*1.3*	13,062	115
Archaeology	1,939	*0.2*	3,919	*0.2*	1,980	102
Mass Communications	927	*0.1*	13,378	*0.7*	12,451	1,343
Sufficient Productivity Institute	10,037	*1.2*	4,992	*0.3*	-5,045	-50
Commerce	192,077	*22.0*	462,603	*24.6*	270,526	141
Law	110,891	*12.7*	208,800	*11.1*	97,909	88
Economics and Political Science	1,504	*0.2*	3,385	*0.2*	1,881	125
Sharia & Law	18,754	*2.2*	46,177	*2.5*	27,423	146
Languages (Al-Alsun)	3,102	*0.4*	10,099	*0.5*	6,997	226
Islamic Message & Theology	22,874	*2.6*	48,038	*2.6*	25,164	110
Islamic & Arabic Studies	34,388	*3.9*	106,194	*5.7*	71,806	209
Islamic Faculty for Girls	2,613	*0.3*	8,990	*0.5*	6,377	244
Arabic Languages	15,118	*1.7*	37,204	*2.0*	22,086	146
Languages & Translation	2,164	*0.2*	4,757	*0.3*	2,593	120

Study Orientation	1995/96 Persons	Share (%)	2005/06 Persons	Share (%)	Change 1995/96-2005/06 Persons	Change (%)
Special Type Education	0	*0*	30,339	***1.6***	30,339	n.a.
Kindergarten	0	-	3,192	***0.2***	3,192	n.a.
Azhar Girls	0	-	1,448	***0.08***	1,488	n.a.
Mubarak Police Academy	0	-	5,708	***0.3***	5,708	n.a.
Total Theoretical	696,839	*80*	1,516,353	***81***	819,514	118
Practical						
Medicine	25,530	*2.9*	62,934	*3.3*	37,404	147
Athletic Education & Physiotherapy	13,462	*1.5*	24,270	*1.3*	10,808	80
Fine & Applied Arts	9,167	*1.1*	10,376	*0.6*	1,209	13
Engineering	45,120	*5.2*	98,382	*5.2*	53,262	118
Agriculture	20,222	*2.3*	24,902	*1.3*	4,680	23
Pharmacy	15,070	*1.7*	45,143	*2.4*	30,073	200
Dentistry	2,950	*0.3*	10,220	*0.5*	7,270	246
Agricultural & Environmental Sciences	154	*0.02*	176	*0.001*	22	14
Petroleum & Mining	841	*0.1*	1,943	*0.1*	1,102	131
Sciences	28,681	*3.3*	46,240	*2.5*	17,559	61
Veterinary Medicine	6,985	*0.8*	16,047	*0.9*	9,062	130
Construction Planning	244	*0.03*	934	*0.05*	690	283
High Nursing Institute	5,340	*0.6*	9,521	*0.5*	4,181	78
Technology	1,519	*0.2*	13,018	*0.7*	11,500	757
Total Practical	175,222	*20*	364,107	*19*	188,885	108
Total All	872,061	*100.0*	1,880,460	*100.0*	1,008,339	116

Source: Ministry of Higher Education, Education Statistics, 2008, via Egypt Human Development Report 2010

The criticisms about passive learning and lack of critical thinking in schools apply as much to universities. The OECD's 2010 report on higher education in Egypt notes that most lecturers teach through recitation rather than interaction, telling students what they need to know rather than asking them for their interpretation of it. The authors blame this approach on "a narrow, content-heavy curriculum delivered to very large classes in poorly equipped facilities"[40].

All this could have serious implications for Egypt's future, since the degree to which a country's education system encourages critical thinking in part dictates its economic development. "You cannot build a country on people just repeating what they have been taught," observes Amir Wassef, Chairman of industrial equipment manufacturer UNITEL and adviser to the president of the new Egypt-Japan University of Science and Technology in New Borg El-Arab. The culture of non-criticism and passive learning in universities could partly explain why in the World Bank's Knowledge Economy Index, which measures how effectively knowledge is used in economic development, Egypt is placed 90th out of 145 countries and scores well below the average for the Middle East and North Africa[41].

Box 2.2 Engineering and technical education

Egypt has a surplus of engineering graduates. While they have helped establish the country as the leading producer of research in engineering and applied technologies in Africa[42]), the situation has done little to improve industrial development since the skills of most of these engineers are poorly adapted to the needs of the industrial system. At the same time there is an acute shortage of technologists in Egypt. This imbalance stems largely from the decision in the late 1970s to turn ten higher education institutes of technology, founded in 1965/66 to meet the growing need for workers with technical skills, into universities that granted BSc degrees instead of diplomas, thus defeating their original purpose.

As a result, many engineers fail to find jobs, since their skills are ill suited to the workplace (see section 2.5). An assessment of Egypt's higher education system by the World Bank in 2009 found that training offered by middle technical institutes (MTIs) was of poor quality and had little relevance to the needs of industry. It also found that only 50% of MTI students complete their degrees, and about 60% remain unemployed two years after graduation[43].

40 Higher Education in Egypt (OECD, 2010) March 2007. The World Bank: Washington, DC, USA

41 See http://info.worldbank.org/etools/kam2/KAM_page5.asp

42 Engineering: Issues, Challenges and Opportunities for Development (UNESCO, 2010), using data from Thompson Reuters Web of Science database

43 Egypt Higher Education Enhancement Project, report number ICR00001154 (World Bank, 2009)

Furthermore, engineers are being employed as technical experts without the requisite hands-on skills, a common scenario throughout the Arab world, where the majority of engineering graduates are employed as technologists. This is partly due to the fact that many engineering colleges do not adequately differentiate between engineering education (based on innovation and design) and technological support training.

Given that a nation's economic wellbeing is dependent on the quality of its education system, and of technical education in particular, it is critical that Egypt continues to expand and upgrade its vocational and technical institutes to provide a broad-based secondary vocational education and a technological education with a strong foundation in mathematics and science. The country has already made steps in this direction, notably through the Ministry of Higher Education's Egyptian Technical Colleges Project, which ran from 2005 to 2009 and helped develop MTIs to meet the needs of local and regional job markets[44].

The previous government began further reforms in this area, crucially by increasing the role and responsibility of industry in shaping education in technical secondary schools – which students can join at the end of grade 9 – and in higher education technical colleges. One idea, first rolled out in 2008, is a new model of technical education based around "industrial clusters" of schools and colleges located in the same area that feed off each other (see section 2.7). The importance of the participation of industry in vocational and technological education cannot be overemphasised. Industry is both the benefactor and the beneficiary. Without substantial involvement by industry no vocational and technical education programme can be completely successful.

This piece is updated from "The need for restructuring the education systems for technicians and technologists in developing countries", by Gamal A. Mokhtar, Asser E. Zaky and Mohamed M. El-Faham (Engineering Science and Education Journal, August 2002, p 153). Additional reporting by Rokia Raslan

44 see http://www.heep.edu.eg/et.htm

2.6 Preparing for the real world

One often-cited criticism of universities in Egypt is that they do not properly prepare their undergraduates for the jobs market, either because they offer an insufficient choice of subjects to cater to students' career preferences, or because large parts of the curricula are irrelevant to employers' needs. 41% of employers consider their young recruits poor at applying knowledge they acquired at school or university to the job in hand, according to a survey by the International Labour Organization[45].

Indeed, several graduates we spoke to complained that they were never properly taught how to apply scientific knowledge they learned in the lab to real-life scenarios – in effect, how to be a researcher. As Dina Khater, an undergraduate pharmacy student at Alexandria University, put it: "We are not taught how to think with a critical mind. I don't know how to determine whether scientific information I am taught is applicable or not, in particular information from chemistry. For example, how do chemical processes affect the effectiveness of a drug?" This suggests there is an urgent need to incorporate training in critical thinking and how to apply knowledge into undergraduate curricula.

UNESCO's assertion that higher education in Arab states "is succeeding only in producing bureaucrats with little innovative capacity to meet the needs of the private sector", resulting in "millions of young people with high expectations and no hope of fulfilling their dreams", seems at least partly true for Egypt[46]. Quality tends to come second to quantity: the OECD points to "a chronic oversupply of university graduates"[47]. A large proportion fails to obtain a job in the field for which they studied.

There is no question that the country produces some excellent science graduates, on a par with those from any top western university. But as Wassef remarks, these make up "a very small minority of naturally talented people who mostly train themselves. [Their success] is down to personal disposition rather than the system."

45 School-To-Work Transition Survey (ILO 2006)

46 UNESCO Science Report 2010

47 Higher Education in Egypt (OECD, 2010)

2.7 Road to recovery

Yousry El-Gamal has more reason than most to believe that things are about to get better. As Minister of Education from 2005 to 2010, he was one of the main architects of the current reforms to primary, secondary and technical schools, designed in association with UNESCO's International Institute for Educational Planning, whose implementation is still ongoing. Getting the changes through, says El-Gamal, was "very challenging", largely because they were resisted at almost every turn by teachers convinced that their top-down, rote-learning methods were best.

To shift such entrenched practices and to improve conditions for teachers themselves, the MOE introduced a training programme and an exam that all Egypt's 1.2 million teachers are obliged to take. If they pass they join a special cadre of educators, with a pay increase of up to 200%. The ministry has also established a professional academy responsible for awarding certification to teachers, who will be assessed continually throughout their careers. The hope is that changes will trigger a "paradigm shift" in the quality of education, with the emphasis shifting from the dissemination of knowledge to interactive learning and enhanced critical thinking skills[48].

Other modifications include reforming the curriculum so that it emphasises innovation and problem-solving and enables students to apply what they learn in the classroom to real life; introducing a performance-based accreditation system for schools; increasing the use of IT and communication technologies in teaching and management; building more schools to improve access for remote communities and reduce class sizes; improving – with the help of industry – the workplace skills of students at technical vocational schools so that they are more employable when they leave; and introducing a new model of industry-linked technical education known as "industrial clusters", consisting of a secondary technical school, a higher technical institute, a training centre and a college faculty of technology all in the same geographical area.

48 National Strategic Plan for Pre-University Education Reform in Egypt (Egyptian Ministry of Education, 2007)

2.8 A new university admission system

Perhaps the most far-reaching reform, one still at the proposal stage, is to overhaul the university admission system. Currently students are allotted a university place entirely on the basis of the score they obtain in the nationwide General Secondary Certificate exam (the Thanawiya Amma) taken at the end of secondary school. Since nothing matters except this score – not course work, not school attendance – it inevitably invites rote learning, and encourages those parents who can afford it to send their children to private tutors. If the proposed reform goes through, students would sit entrance exams in the discipline they were hoping to study at university, in addition to sitting the nationwide exam, and the scores from both will count, as well as their performance at secondary school.

"The nationwide exam was meant to provide equality for everybody, and it used to do that when the competition was not that tough," says El-Gamal. "But with the growth in private tutoring, which works against equality, it became necessary to change the whole system." As the OECD noted in its 2010 review, relying on a single nationwide exam for university admission results in students being assigned to disciplines that bear little relationship to their aspirations or abilities[49]. The new system would not only give students greater choice, it would also allow universities to select candidates according to their needs and resources.

2.9 The road ahead

Whether or not these changes equip Egypt's students with the tools to compete in a global knowledge-based economy – one of the MOE's stated aims[50] – will depend a lot on the new government's commitment to seeing them through. El-Gamal acknowledges that the previous regime did not come close to meeting the ministry's hoped-for target for public expenditure on education of 6% of GDP, always falling below 4%[51]. Yet many observers are optimistic. "The change has started and it is going in the right direction," says El-Mikaty. "It finally appears to have dawned on the decision-makers that [in terms of preparing students to do research and innovate] the system wasn't working, that we had hit rock bottom."

Box 2.3 Where the talent goes

With so few opportunities for graduates and so little money for research, it is hardly surprising that Egypt has lost so many scientists abroad, especially in engineering and IT. Yasser El-Shayeb, coordinator of EU programmes in higher education and scientific research for Egypt, estimates that during the late 1990s and early 2000s around 80 per cent of students who went overseas for their PhDs stayed there. Today he reckons one-third don't come back. Egypt has a harder job holding onto its skilled researchers than any other Arab country, according to the World Bank's Knowledge for Development indicators (see Table 2.6).

49 Higher Education in Egypt (OECD, 2010)

50 National Strategic Plan for Pre-University Education Reform in Egypt (Egyptian Ministry of Education, 2007)

51 UNESCO Institute for Statistics

Table 2.6: A measure of the extent to which Egypt loses its "knowledge workers" abroad

Human capital flight index

Country	Human capital flight (scale of 1-7)	Most migration
Egypt	2.1	
Algeria	2.3	
Syria	2.5	
Mauritania	2.5	
Jordan	2.8	
Morocco	3.1	
Tunisia	3.8	
Oman	4.4	
Bahrain	4.8	
Saudi Arabia	4.9	
Kuwait	5.1	
Qatar	5.5	
UAE	5.8	Least migration

One way to tackle the brain drain is to build up Egypt's research facilities so that researchers who go abroad to do their PhDs have a good reason to return. "When we provide a state-of-the-art place, researchers usually come back with no problem," says Maged Al-Sherbiny, President of the Academy of Scientific Research and Technology. Recently established or planned centres of excellence in nanotechnology, IT, renewable energy, biotechnology, medicine and microelectronics should help, as should a new "reintegration" grant scheme funded by the government's recently established Science and Technology Development Fund aimed at encouraging young researchers working abroad to return home.

There are also plans for a new joint venture model of PhD, whereby students spend two years at a foreign university and two years in Egypt, with half the money going towards their study abroad and half on infrastructure and equipment at home. This will ensure that money spent on Egyptian PhD students at foreign universities will also benefit Egypt. Nevertheless it will probably take a completely rejuvenated research landscape to persuade many top researchers that they are better off building their careers at home.

Source: World Bank Knowledge Assessment Methodology (KAM) 2008, via Mohammed bin Rashid Al Maktoum Foundation and UNDP Arab Knowledge Report 2009

Table 2.7: Egyptians studying for PhDs abroad

Country	2004/2005	2005/2006	2006/2007	2007/2008	2008/2009
Australia	0	14	0	0	0
Austria	0	2	1	2	0
Belgium	0	1	0	0	0
Canada	26	60	65	28	18
Denmark	0	0	0	0	1
France	8	14	167	0	15
Germany	0	15	172	56	40
Italy	2	1	6	11	0
Japan	23	51	55	21	13
Malaysia	0	0	1	2	1
Netherlands	1	0	0	3	0
Norway	0	0	0	0	2
Poland	0	2	0	0	4
Russia	0	0	0	0	4
Spain	2	0	0	3	0
Sweden	24	0	3	0	0
Switzerland	0	0	2	2	1
UK	65	77	27	104	55
Ukraine	0	0	0	2	0
USA	17	12	55	39	36
Total	168	249	554	273	190

Source: ASRT 2011

3 Business

Anyone who doubts Egyptians' appetite for innovation should try taking a drive in the streets of Cairo. There is something gladiatorial about entering the stream of traffic, though it often hardly moves. Drivers squeeze into impossible spaces and compete for imaginary lanes using techniques no driving school in the world could teach. The background conversation – the hum of engines and horns – is a constant reminder in this city that innovation is as much an art as a science; that it is not the tools that count so much as how you use them.

Embarking on a career as an entrepreneur in Egypt – especially in any of the sectors that depend on R&D – is a little like casting off into the Cairene traffic. There are obstacles at every turn, it can take ages to get anywhere, and generally only the skilled and persistent succeed. Although a 2008 report by the Global Entrepreneurship Monitor (GEM) ranked Egypt a respectable 11th out of 43 countries in its level of entrepreneurial activity – a measure of the number of people trying to start new enterprises or managing young ones[52] – the World Bank in its latest "ease of doing business" study puts the country 94th out of 183[53].

These figures point to a general appetite for entrepreneurship that is not being properly catered for. More worrying for the country's long-term development is the GEM's assertion that most nascent entrepreneurial activity is in the retail and service sectors rather than research-based industries; that financial support for R&D and the acquisition of new technologies is low; that the transfer of knowledge from universities and research centres to new enterprises is "extremely weak"; and that education in entrepreneurship skills is worse in Egypt than in any of the other 42 countries studied[54]. Consider also that just 1% of Egypt's manufactured exports are high technology goods, on a par with the world's least developed countries[55].

52 Egypt Entrepreneurship Report 2008 (Global Entrepreneurship Monitor)

53 Doing Business 2011: Making a Difference for Entrepreneurs (The World Bank and the International Finance Corporation)

54 Egypt Entrepreneurship Report 2008 (Global Entrepreneurship Monitor)

55 World Development Indicators 2011 (World Bank)

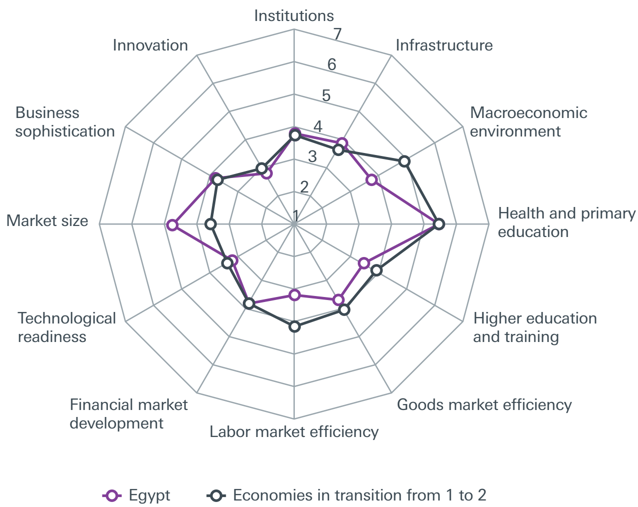
Figure 3.1. How competitive is Egypt?

Global Competitiveness Index

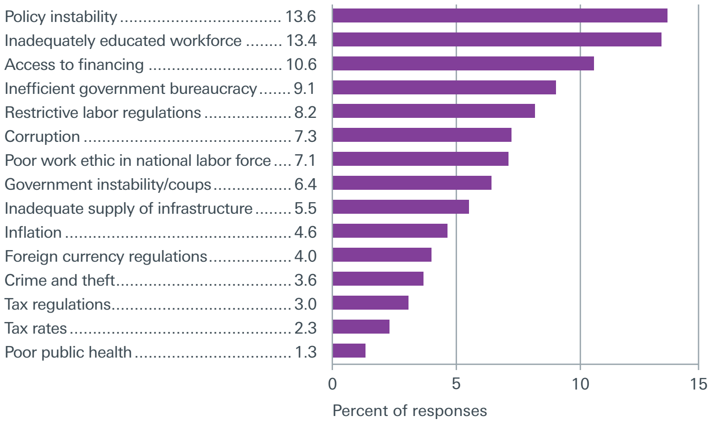
GCI 2011-2012	**94**	**3.9**
GCI 2010-2011 (out of 139)	81	4.0
GCI 2009-2010 (out of 133)	70	4.0
Basic requirements (44.2%)	**99**	**4.2**
Institutions	74	3.8
Infrastructure	75	3.8
Macroeconomic environment	132	3.7
Health and primary education	96	5.4
Efficiency enhancers (46.8%)	**94**	**3.7**
Higher education and training	107	3.4
Goods market efficiency	118	3.7
Labor market efficiency	141	3.2
Financial market development	92	3.8
Technological readiness	95	3.3
Market size	27	2.8
Innovation and sophistication	**86**	**3.3**
Business sophistication	72	3.8
Innovation	103	2.8

Stage of development

1	Transition 1-2	2	Transition 2-3	3
Factor driven		**Efficiency driven**		**Innovation driven**



The most probelematic factors for doing business



Note: From a list of 15 factors, respondents were asked to select the five most problematic for doing business in their country and to rank them between 1 (most problematic) and 5. The bars in the figure show the responses wighted according to their rankings.

Source: World Economic Forum 2011 *The Global Competitiveness Report 2011*

3.1 Foreign direct investment

Between 2000 and 2008, foreign direct investment (FDI) grew from $509.4 million a year to $13.2 billion a year, thanks in part to government reforms aimed at lowering barriers to entry, for example by streamlining the customs and corporate tax systems (see Figure 3.2)[56]. This led to an increase in the number of newly established companies from 926 in 2004/5 to 2690 in 2009/10[57]. The UN Conference on Trade and Development's World Investment Report 2010 ranked Egypt first among North African countries in its ability to attract FDI[58], and in the Middle East its FDI is greater than all except Saudi Arabia's, Turkey's and Qatar's[59]. The country's dependence on trade from the EU and the US led to a significant downturn in FDI during the global recession, falling to $8.1 billion in 2008/9 and to $6.8 in 2009/10[60]. Unfortunately, outside of certain sectors such as IT, Egypt's success at attracting FDI does not appear to have translated into significant technology transfer to domestic industries, nor to renewed investment in industrial R&D (see section 3.6 below).

56 Central Bank of Egypt / Ministry of Investment

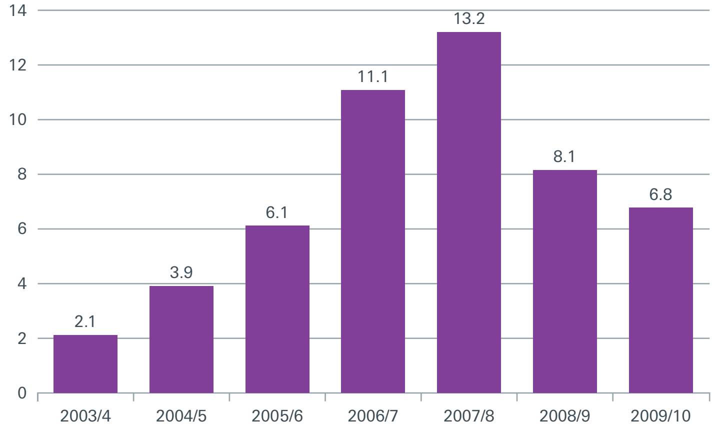
57 Central Bank of Egypt / Ministry of Investment

58 World Investment Report 2010 (UNCTAD)

59 World Development Indicators 2011 (World Bank)

60 Central Bank of Egypt / Ministry of Investment

Figure 3.2. Foreign direct investment in Egypt 2003-2010 (US $ billion)



Source: Central Bank of Egypt / Egyptian Ministry of Investment

3.2 The (lack of an) R&D culture in industry

One brutal statistic illustrates the root of the problem: out of Egypt's total investment in R&D, it is estimated that just 5% comes from non-governmental sources[61]. "The fundamental issue is that most Egyptian businesses do not seem to believe in the business model that centres on the engineering and development of their own products," says Ahmed Tantawy, Director of the new Egypt-IBM Nanotechnology Research Center, formerly Chief Technical Officer of IBM in its growth markets unit. Instead they opt for an easier and more lucrative model that involves trading imported goods or manufacturing products licensed from foreign companies. "Hence the lack of a real need for R&D in most Egyptian industries".

A survey of 3000 enterprises by the Ministry of Scientific Research (MOSR) in 2009 found that just 18% were actively investing in any kind of technological innovation, and that most innovation was being done by small businesses with between 6 and 49 employees[62].

61 Estimate by ASRT

62 Egyptian National Innovation Indicators Survey 2009 (Ministry of Scientific Research)

3.3 Innovation in pharmaceuticals

Take the drugs industry. Few of Egypt's 100 or so pharmaceutical companies invest in the development of new products, preferring to concentrate on making generic versions of existing medicines and formulations. Pharco Corporation, the country's biggest pharmaceuticals company, directs just 1% of its sales revenue into R&D for new drugs each year, around LE10 million[63]. American drugs companies, by contrast, consistently invest around 18-20%[64].

The Pharco-owned subsidiary European Egyptian Pharmaceutical Industries uses German-made equipment to churn out generic medicines assembled from raw materials shipped in from Europe, India and China. We asked Pharco president Sherine Helmy to explain why the industry is so innovation-shy. The main reason, he says, is bureaucracy. He would happily invest more in new drugs if there were fewer obstacles to registering them and bringing them to market – a situation he hoped would improve after the formation in 2010 of a new government committee responsible for regulating medical developments.

Maged Al-Sherbiny, president of the ASRT, acknowledges that the business climate for R&D could be improved. One reform under consideration is a change to Egypt's intellectual property laws so that foreign companies working on R&D in Egypt can more easily protect their innovations, a concern that has apparently discouraged pharmaceutical companies from carrying out research here.

Helmy has seen for himself how investing in R&D can pay off. His company has had some striking success with Egyptian-based research, such as the development of Mirazid, a treatment for schistosomiasis and facioliasis (parasitic diseases) with few side effects that still dominates the market nine years after its release; Aloreed, a cure for psoriasis (a skin condition) extracted from the aloe vera plant; and Pedyphar, an ointment used to heal diabetic foot infections. And it has several projects in the works, including an anti-cancer drug, an insulin supplement that can be administered orally, and a treatment for Hepatitis C derived from blue-green algae that has already won funding from the government's new Research, Development and Innovation (RDI) programme (see section 3.8).

63 From author interview with Sherine Helmy, president of Pharco Corporation

64 From research conducted by the Pharmaceutical Research and Manufacturers of America (PhRMA)

3.4 Appetite for innovation

Despite the fact that its financial commitment to research is one-twentieth that of most western pharmaceutical companies, Pharco is considered something of an R&D pioneer in Egypt. This says a lot about attitudes to innovation among the country's industrialists. With the exception of the IT sector, where business and academia are promisingly aligned (see section 3.10), investing in novel research or nascent technologies for long-term gain is simply not a priority for most businesses. "Egyptian companies are not good hunters," agrees Yasser Refaat, Acting Director of the City of Scientific Research and Technology Applications, a cluster of institutes set up by the government in 2000 to cultivate research relevant to industry.

Inevitably foreign investors are stepping in, happy to take the long view on fledgling ideas that local investors in search of quick profits may pass over. Refaat has first-hand experience of this: his research group has signed a memorandum of understanding with a US-based company for the production of a novel marker used to measure lengths of DNA[65]. How did the Americans hear about his innovation? "I was at an international conference, and they simply came over to ask what projects I was working on. That was the spark."

3.5 Venture capital

As general manager and chief investment officer of Nile Capital, one of just five venture capital funds operating in Egypt, Basel Roshdy has a front-row view of the country's entrepreneurial investment landscape. He is convinced that the environment for innovation is improving. "A few years ago I used to complain that you could find more entrepreneurs in Lebanon, which has 4 million people compared with Egypt's 80 million." Tunisia – population 10.5 million – has 37 venture capital funds, more than seven times the number in Egypt, and Jordan, with 6.5 million people, has 13 or 14.

Why do venture capitalists find it so hard to find fertile ground in Egypt? One reason could be that many entrepreneurs prefer to approach friends and family for money and thus remain invisible to institutional investors (the GEM's 2008 survey found that nearly two-thirds of "business angels" invest in projects run by close family, friends or neighbours[66]). Another reason, perhaps more significant because of how it reflects on Egypt's R&D culture, is that there is little to persuade researchers to leave their secure, government-funded (though usually low-paid) jobs at universities or research centres and strike out on their own or seek out partners in industry, however much commercial potential their ideas may hold. Yet there is good cause for optimism. The revolution has awakened interest in Egypt as a place to invest in nascent research-based projects, and several Egyptian expatriates have returned home to explore the opportunities in this area.

65 *Biotechnology*, vol 5, p 166 (2006), DOI: 10.3923/biotech.2006.166.172

66 Egypt Entrepreneurship Report 2008 (Global Entrepreneurship Monitor)

3.6 Academia and industry

The lack of entrepreneurial incentive among academics and the indifference to R&D shown by industrialists appear to share a common foundation: a lack of understanding between academia and industry that makes it almost impossible for them to serve each other's needs. The World Economic Forum (WEF)'s latest Global Competitiveness Report ranks Egypt 128th out of 144 countries on the extent to which universities and industry collaborate on R&D[67]. "Neither party trusts the other," says Essam El-Rafey, former Dean of the University of Alexandria's Institute of Graduate Studies and Research (IGSR). "This is hardly surprising. Why should businesses need us when we are concerned more about theoretical than applied research? It is easier for them to trust foreign consultants, who they know will solve their problems."

Meanwhile academics either do not know how to approach industry with their ideas, or fear them being stolen. On a visit to Mansoura University[68], we listened as a group of frustrated researchers from a diverse set of disciplines including zoology, agriculture, medicine and veterinary science talked about their largely fruitless efforts to attract seed funding from local businesses, or even to build links with them. "They don't believe our research can lead to long-term [commercial] success," said Hassan El-Ghaffar, Professor of Clinical Pathology. Walid El-Sharoud, Associate Professor of Microbiology and focal point for the EU's FP7 funding programme, said that despite organising regular meetings between university scientists and local industry he couldn't think of any examples of long-term successful collaborations. By contrast, several of the researchers – in particular those working in pharmaceuticals and nutraceuticals – said they had established close relationships with foreign companies.

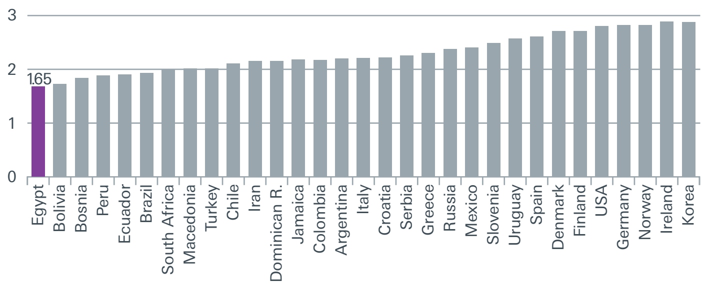
One manifestation of all this is the low rate of technology transfer between universities and research centres and businesses. The GEM's 2008 survey ranked Egypt last out of 31 countries on the level at which R&D and technology support is being provided to new and growing businesses (see Figure 3.3)[69]. There are few mechanisms in place to help firms get access to technologies that would help them flourish.

67 The Global Competitiveness Report 2012-2013 (World Economic Forum)

68 Date of visit: 7 November 2010

69 Egypt Entrepreneurship Report 2008 (Global Entrepreneurship Monitor)

Figure 3.3. How much access do businesses have to R&D?



Vertical axis shows extent to which new firms are thought by experts to benefit from R&D

Source: Hattab 2009 *Egypt Entrepreneurship Report 2008*. Global Entrepreneurship Monitor

Many people refer to the gap between academia and industry as one of "mindset", suggesting a deep-seated dissonance that will require considerable effort to resolve. The offers of support by the MOSR to help industry build its research capacity have largely not been taken up. For example, Al-Sherbiny says remarkably few businesses have taken advantage of the tax exemptions that apply on any expenditure related to R&D such as the buying of equipment. "They don't see that they will get greater benefit later on if they spend the money now."

Likewise, an appeal to private companies to link up with academics and apply for research funding from the ministry's Science and Technology Development Fund (STDF) went largely unheeded. "They were not interested, even though the funds would cover everything including salaries," recalls Abeer Shakweer, who worked for the STDF from 2008 to 2010 and is now science and technology adviser to the Misr El-Khreir Foundation.

Box 3.1 Innovation of the streets

You will be hard-pressed to find a better example of innovation in the community than the work of the Zabaleen in Moqattam village near the Cairo suburb of Manshiet Nasser, one of the poorest urban areas in Egypt. For some 80 years this community of Coptic Christians have assumed the role of the capital's rubbish collectors, gathering trash from throughout the city and bringing it back to their neighbourhood for sorting and recycling. Different families specialise in different materials – certain houses are packed with cardboard, others with plastic bottles or metals.

The Zabaleen are highly efficient: they recycle around 90% of the rubbish they collect and sell it on or reuse it. However they have begun to find new materials in the waste stream that are harder to process, in particular certain plastics – the detritus of the consumer age. It is a challenge crying out for a research partnership: the Zabaleen and a university chemical engineering department working together on a solution to a modern waste issue. Where is the mechanism that might bring these two disparate communities together?

3.7 Bridging the gap

What is being done to promote research that is more relevant to industry, and to encourage industry to talk to academics about what they need? Most universities and research centres have started programmes or opened knowledge transfer or investors' offices to help bridge the gap. For example, in 2009 Mansoura University created a fund worth LE2 million a year exclusively for scientists whose work has industrial value and who have found a business partner that might exploit it. Cairo University has established an Innovation Support Office, helped by a grant from the EU's TEMPUS programme, to teach researchers about innovation and help them build links with industry – though so far the university has been conspicuously slow in providing any additional funding beyond paying the office's rent. South Valley University has a TEMPUS-funded Knowledge Transfer and Innovation Centre with a similar mission (and a similar dearth of additional funds).

Most of these are nascent projects, but some are genuine success stories. Assiut University's Sugar Technology Research Institute, set up in 1994 to tackle challenges in sugar production, receives half a million Egyptian pounds a year in research funds from the sugar industry. Furthermore, some 90% of the institute's research students are on leave from sugar companies. The university's president, Mostafa Kamal, speaks of the "increasing confidence" in the university's relationship with industry in general – language that is rarely heard in this context anywhere in Egypt. He notes that the university's earnings from all industries, including sugar, fertilisers and cement, has increased from zero to LE5 million over the past five years.

What's the secret to this achievement? "Industry has had to be open minded, and as academia we have to make them feel we are capable of solving their technological problems," he says. The university is working on building a similar relationship with the cement industry. It is also receiving funding from the industrialist Ahmed Bahgat – one of the few businessmen in Egypt who consistently invest in R&D (see Box 3.2) – to produce a new lightweight, fire-resistant building material out of limestone and scrap aluminium. "I liked the idea," says Bahgat. "If I see a good idea I will fund it, if I have the money. It is important in Egypt for us to use our muscles and our brains to develop our own products."

Another initiative that is having considerable local success helping industry and academia speak the same language is the Institute and Industry Committee, formed in 2007 by Essam El-Rafey at the University of Alexandria's IGSR. The committee brings together heads of industry in Alexandria and representatives from several of the university's faculties who meet every month to build trust and discuss how best to tailor research to the needs of the business community. One of the outcomes is a new diploma course with a tailor-made curriculum for graduates seeking to work in the petrochemical industry. "Both sides sat down and talked about what sort of person the industry was looking to employ, what sort of knowledge should they have, what kind of practical experience," explains El-Rafey. "It is a good model for any faculty to follow."

A project at Cairo University has gone one step further. Students in the petroleum department can gain hands-on experience with the oil services company Schlumberger as part of their course, and on graduation 25 of them will have the opportunity to work for the company full-time. Such partnerships are bound to benefit both sides.

Box 3.2 Home-grown hero of R&D

Ahmed Bahgat is perhaps best known in Egypt for Dreamland, his self-contained mini-city eight kilometres west of the Giza pyramids which he built complete with schools, hospitals, mosques, hotels and a theme park. "I always say I live in Dreamland not in Egypt," he laughs. But real estate is not the only sector where Bahgat is trying to turn dreams into reality. He is a high-tech industrialist convinced that R&D is essential to long-term commercial success – an almost unique position among Egypt's entrepreneurs. The wide-ranging commercial interests of his company, Bahgat Group, include electronics, biomedicine, plastics, IT and satellite communications.

One of his most recent and perhaps his most progressive investment yet is in a cutting-edge R&D nanotechnology enterprise called Nano Tech, which specialises in adapting nano-materials for use in medical equipment, desalination technologies, photovoltaic cells and products such as detergents. He funded the acquisition of a $1 million high-resolution transmission electron microscope, one of only three of its kind in Egypt. Given the importance of instrumentation in nanotechnology, this is a crucial contribution to Egypt's progress in this field.

Bahgat's academic background is in electronics, communications and mathematics. He says he first understood the importance of R&D to business in the early 1980s when he made his first fortune designing a watch that provided Muslim prayer times. Nanotechnology will play a prominent role in Egypt's development, he says, especially in helping to solve its energy and environmental problems, since "it relies more than anything else on brain power, something this country has plenty of".

Why does he think so few entrepreneurs in Egypt invest in research? "It's lack of money and lack of interest. People don't really believe in R&D. They think it's easier and cheaper to buy in the products rather than invent them. I think differently. We have to use our muscles, our brains, to produce products ourselves. It will not be easy and it will not happen in a day or two."

3.8 Government initiatives to build innovation in industry

There are several government-backed schemes in place to promote industry-academia interactions and to boost Egypt's innovation culture. Foremost among these is the RDI programme, backed by EUR 31 million from the EU between 2007 and 2015 (the second phase, worth EUR 20 million, began in 2011)[70]. The RDI programme is designed to strengthen the links between the research sector and industry and – through its main component, the EU-Egypt Innovation Fund (EEIF) – support research that is useful to industry.

The EEIF funds research in the fields of energy, water, information and communication technology, environment, materials science, nano-technology, biotechnology, health, space science, manufacturing industries, food, agriculture and education. Grants are worth up to EUR 500,000, and to be eligible a project team must include a partner from both academia and business. "The aim is to enhance cooperation, encourage researchers to innovate, address the needs of industry and hopefully as a result have an impact on the Egyptian economy by making it more competitive," says Hamid El-Zoheiry, the programme's coordinator.

The response from researchers since the programme was established in 2007 has been impressive, with applications for funding exceeding the money available by some 10 times. Priority is given to projects that would enhance Egypt's sustainable development. Among the successful bids so far is a proposal by the Egyptian Company for Blood Transfusion Services and Al-Azhar University to create a universal blood type that would be safe to use in any blood transfusion; a scheme by Kaha for Environmental and Agricultural Projects and the National Research Center to make a building material out of rice straw, which farmers generally burn off after harvest causing extensive air pollution; and the proposal by the pharmaceutical company Pharco, in partnership with the City of Scientific Research and Technology Applications, to create an anti-Hepatitis C drug from blue-green algae.

In recognition that funding collaborative projects between academia and industry will not by itself transform the environment for innovative research, the RDI programme is awarding a number of smaller grants aimed at schemes that promote the idea of innovation in schools, universities, research centres and businesses, such as the Let Me Think programme of workshops run by the El-Sawy Culturewheel centre in Cairo that uses mind games to encourage 7 to 15-year-olds to think creatively. "We can put money on the table, but without changing the underlying culture it is not going to take us much further," says El-Zoheiry.

70 For further information on the RDI programme see official website at http://www.rdi.eg.net

The American University in Cairo

3.9 Teaching entrepreneurship

In the quest to improve the research community's relationship with industry and its capacity for innovation, one of the most pressing needs is to teach students entrepreneurial skills that will help them understand how ideas in the lab can translate into market opportunities. The GEM's 2008 entrepreneurship study found that the proportion of adults with any business training is lower in Egypt than in any of the 38 countries studied worldwide[71] (see Table 3.1).

71 Egypt Entrepreneurship Report 2008 (Global Entrepreneurship Monitor)

Table 3.1: Percentage of 18 to 64-year-olds who have received training in starting a business

	School - voluntary*	School - compulsory	School - any	After schooling - voluntary**	After schooling - compulsory	After-schooling - any	Any training
Factor-driven economies							
Bolivia	8.2	2.4	10.6	10.3	3.9	14.2	19.1
Bosnia & Herzegovina	12.7	0.8	13.5	8.1	2.5	10.6	19.9
Colombia	19.2	4	23.2	20.7	8.7	29.4	40
Ecuador	16.1	4.3	20.4	8.3	7.3	15.6	27.2
Egypt	**3.8**	**0.9**	**4.7**	**2.1**	**2.1**	**4.2**	**7.5**
India	3.3	1.7	5	3.8	7	10.8	13.1
Iran	8.9	6.6	15.4	9.2	10.3	19.5	28.9
Average	***10.3***	***3***	***13.3***	***8.8***	***6.2***	***14.9***	***22.2***
Efficiency-driven economies							
Argentina	6.4	3.2	9.6	7.3	3.6	10.9	17.4
Brazil	4.5	0.8	5.3	1.6	5	6.6	9.4
Chile	16.8	8.5	25.3	18.9	13.8	32.7	42.5
Croatia	8.6	11.1	19.7	8	7.6	15.6	27.6
Domincan Republic	4.7	0.6	5.3	1.9	2.1	4	7.7
Hungary	2.8	14.2	17.1	1.4	8.6	10	24.4
Jamaica	6.8	9.2	16	2.9	6.4	9.3	21
Latvia	6.1	8.4	14.5	9	10.1	19.1	28
Macedonia	10.3	2.3	12.6	7.2	3.7	10.9	19.1
Mexico	5.8	3.6	9.5	3.6	5.9	9.5	15.5
Peru	11.5	2.9	14.4	12.2	12.5	24.7	29.6
Romania	3.3	2.2	5.5	2.8	1.8	4.6	8
Serbia	1.5	1.5	3	2.6	4.9	7.6	10.2
South Africa	6.6	2.7	9.3	3.8	5.2	9	13.8
Turkey	1.9	0.6	2.5	1.9	2.3	4.2	6.3
Uruguay	9.7	1	10.7	9.5	8.9	18.4	24.1
Average	***6.7***	***4.6***	***11.3***	***5.6***	***6.3***	***12.3***	***19***
Innovation-driven economies							
Belgium	17.8	7	25	3	15.2	18.2	33.3
Denmark	2.4	7.1	9.5	2.1	11.9	14	22
Finland	10.1	7.8	17.9	19.6	20.8	40.4	47.9
France	5.3	4.9	10.2	5.9	6.6	12.5	18.1
Germany	10.3	2	12.3	8.4	4.7	13.2	21
Greece	5	1.2	6.1	6.4	6.5	12.9	17
Iceland	6.5	5.3	11.8	11.3	6.5	17.8	26.7
Ireland	8.1	5.8	14	9.9	7.6	17.5	26.1
Israel	4.1	1.7	5.8	4.5	4.1	8.6	12.8
Italy	6	4.2	10.2	5.3	3.7	9.1	16.5
Japan	2.8	2.1	4.9	10.1	5.6	15.7	17.4
Korea Rep.	2.7	3.2	5.9	3.8	5.4	9.2	13.6
Slovenia	13	11.3	24.3	10.3	12.3	22.6	35.7
Spain	9.5	3	12.5	7.9	6.8	14.7	21.9
United Kingdom	5.8	3.1	8.9	7.7	6.1	13.8	19.5
Average	***7.3***	***4.6***	***11.9***	***7.7***	***8.3***	***16***	***23.3***

Note: *'Voluntary' includes those reporting voluntary training or a mix of voluntary and compulsive training.
**'After schooling' means after primary or secondary schooling has officially ended.
Source: Hattab 2009 *Egypt Entrepreneurship Report 2008*. Global Entrepreneurship Monitor

One institution that has grasped the significance of this is the American University in Cairo (AUC), where science and engineering students are obliged to take courses in entrepreneurship, run in partnership with the university's school of business, to instil in them a strong sense of commercial awareness. The idea was introduced by Hassan Azzazy, Professor of Chemistry and Associate Dean for Graduate Studies and Research in the School of Sciences and Engineering, who is working with the government to help develop a national programme of entrepreneurship education.

"Our science students are very bright and knowledgeable in their subject but they lack confidence," says Azzazy. "They see opportunities in the lab that could be converted into a spin-off company or a patent, but they don't know how to do it or whom to contact." Azzazy is now seeking to introduce entrepreneurship into the "core curriculum" of language, philosophy, natural science, social science and humanities courses that every AUC student must complete, regardless of their major discipline. Other universities, such as Alexandria, are introducing similar programmes designed to improve undergraduates' "soft skills", such as communication, thinking and business awareness.

You don't have to travel far through Egypt's academic community to understand why such initiatives are so badly needed. The government's National Research Centre (NRC) in Cairo, which employs some 4000 scientists, a quarter of the government's research workforce outside of universities, earns an average of around LE4.5 million a year[72] from contract work with industry, a paltry amount for Egypt's largest multidisciplinary research establishment – though this is several orders of magnitude more than it earned before the establishment in 2003 of a special investors' office charged with marketing the centre's applied research.

Many of the NRC's scientists appear to lack an entrepreneurial outlook, with one junior researcher informing us that he and his colleagues were concerned only with the results of their research and not with any commercial potential it might have, since "we wouldn't know how to market the products", even though their particular project – the use of high-energy enzymes to break down contaminants such as oil in seawater – seemed to have obvious commercial potential.

3.10 How the government can help

Many in business and industry believe that the government's own legislation makes it hard for universities and research centres to commercialise their work and build up relationships with industry. For example, to accept funding from the private sector, research departments at government universities must be designated as "special service units" by the Supreme Council of Universities, which allows them to carry out contract work for businesses and other institutions.

72 This figure is for 2009, which also represents the average for the three years 2007-2009. Data taken from an NRC presentation 2010 supplied to authors by the NRC

These are managed and financed independently but must hand on a large proportion of their profits to the university administration, which inevitably restricts their scope for entrepreneurial activities.

At the same time, the government could do more to help potential investors reduce their risk, for example by offering matching funds. "If it is in the national interest for local businesses to innovate and build products, then the government should create incentives for industrial R&D that make the research-centred business model attractive," says Ahmed Tantawy, whose Egypt-IBM Nanotechnology Research Center is being set up as a new model for spearheading economic development through high-tech innovation, bringing together government, academia, multinationals and the domestic private sector.

One example of this kind of public-private research partnership is Nile University for IT-driven research, which is funded by the private sector but with infrastructure and land provided by the government (see section 3.12 below). Nile University was the first not-for-profit university to be established in Egypt, as recognised by a law passed in 2009 allowing for this type of institution. Its president, Tarek Khalil, calls it "a new experiment in higher education in Egypt". The future of Nile University is currently in the balance amid a row over the status of its planned new campus. Yet with government investment in research still low, the long-term success of Egypt's economy could well depend on the success of such experiments. Convincing the private sector that R&D leads to growth is surely one of the greatest challenges the country faces.

3.11 Egypt's IT success story

There is one area where Egypt has had considerable success at encouraging research-based business: information and communication technology (ICT). The number of ICT companies in Egypt has grown from 1,716 in 2005 to 3,972 at the beginning of 2011 and the number is increasing at a rate of around 13.5% a year[73]. The country's fast-developing IT infrastructure and growing number of tech-savvy graduates have attracted a host of foreign companies, including Microsoft, Ericsson, Vodafone, Intel and IBM. Spending in this sector is expected to increase from $1.4 billion in 2010 to $2.6 billion by 2014, making it one of the fastest growing IT economies in the world[74]. Much of this revenue has come from Egypt's outsourcing industry; the country was among the top five outsourcing destinations in 2010.

73 ASRT 2011

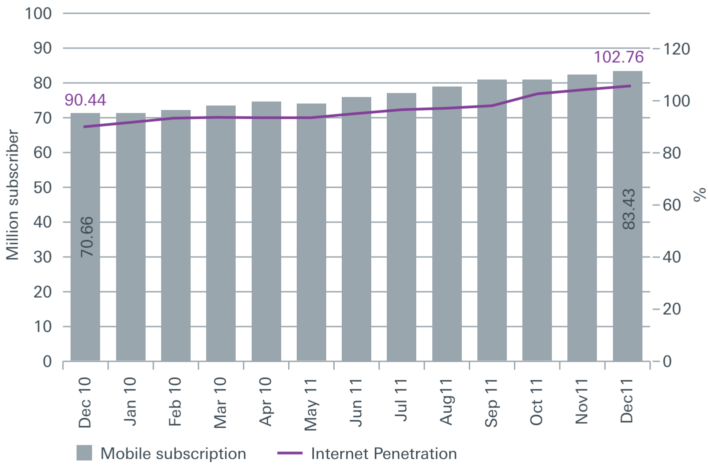
74 Egypt Information Technology Report Q4 2010 (Business Monitor International, October 2010)

Table 3.4 Mobile phone and internet growth in Egypt

Mobile Telephones

Indicator	Unit	December 2010	November 2011	December 2011	Monthly Growth Rate (%)	Annual Growth Rate (%)
Mobile Subscription	Million Subscription	*77.66*	81.70	*83.43*	2.12	18.06
Mobile Penetration*	%	*90.44*	100.79	*102.76*	1.97	12.32

Mobile Subscriptions



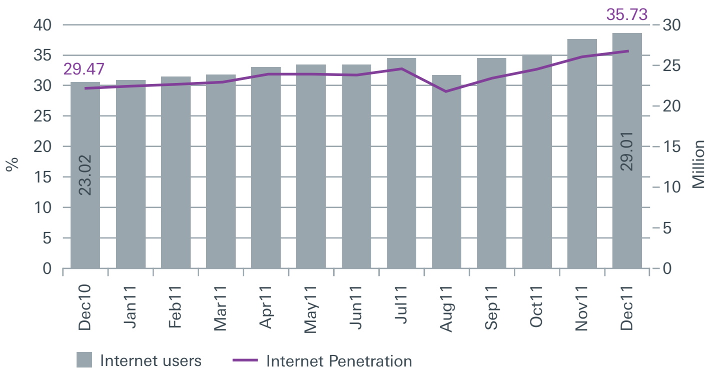
Source: Ministry of Communications and Information Technology

National Telecom Regulatory Authority – Telecom Egypt

Internet

Indicator	Unit	December 2010	November 2011	December 2011	Monthly Growth Rate (%)	Annual Growth Rate (%)
Internet Users	Million User	*23.02*	28.54	*29.01*	1.72	26.01
Internet Penetration*	%	*29.47*	35.19	*35.73*	0.55	6.27
International Internet Bandwidth	Gbps	122.30	185.74	185.74**	-	51.88
Proportion of Households Using Internet from Home*	%	32.19	36.44	37.32	0.88	5.13

Internet Users



Source: Ministry of Communications and Information Technology

National Telecom Regulatory Authority

*Growth rates are calculated as the difference between penetration rates or proportions in different time intervals

**November 2011

Many IT companies say they are drawn to Egypt primarily by its talent pool. "This was the number one thing that attracted us," says Tarek Elabbady, founder of the Microsoft Innovation Lab in Cairo and Director of Microsoft Innovation Labs in Europe, the Middle East and Africa. "In terms of numbers it's probably the biggest talent pool in the Middle East. We're talking 8000 to 9000 IT graduates every year, of whom 500 are good enough to hire." Ericsson is investing in Egypt for similar reasons. "We find the people here creative, innovative and extremely communicative," Carlo Alloni, president of Ericsson North East Africa. He points to the prodigious growth in Egypt of Facebook: around nine million people now use the social network, more than in any other country in Africa or the Middle East and twice as many as a year ago[75].

Another reason Microsoft decided to invest in Egypt, says Elabbady was "the government's clear commitment to IT and to using IT as a way to grow the country economically and socially, which has been consistent over the past 12 years". This commitment has been apparent in various ways, such as the creation in 1999 of the Ministry of Communications and Information Technology, which laid out a national plan for the development of an information-driven society[76]; the launch of the ICT Trust Fund by the ministry and the UNDP in 2002, aimed at exploiting ICTs to help Egypt's socio-economic development in health, agriculture and other areas[77]; the establishment in 2003 of Smart Village, a communication and IT park west of Cairo; the appointment of Ahmed Nazif, former minister of communications and information technology, as prime minister in 2004; and the government's ongoing mission to raise levels of IT use and computer literacy in schools.

3.12 Nile University – where research and industry meet

Nile University (NU), Egypt's first not-for-profit educational institution, faces an uncertain future because of a row over the rights to its proposed new campus. Its dismantling would be unfortunate, since it is a good example of the private sector's confidence that investing in IT R&D will pay dividends. Founded in 2007, its mission was to help push Egypt's development as an innovation-driven economy. Its graduate and undergraduate courses focus on areas that are most likely to be relevant to industry: computing engineering, electronics and communications engineering, wireless technologies, microelectronics system design, information security, intelligent transportation systems. All undergraduates take courses in entrepreneurship, and graduates are given training in business management and how to convert their technological ideas into successful commercial projects.

75 Figures from http://www.socialbakers.com/facebook-statistics/egypt

76 See Arab Knowledge Report 2009 (UNDP / Mohammed bin Rashid Al Maktoum Foundation)

77 See www.ictfund.org.eg

Students at Nile University

The university's president Tarek Khalil explains that he recruited NU's faculty largely from Egyptian professors working overseas so that the university could benefit from their links with industry and their former institutions. The strategy seems to have convinced industry: NU won funding from or signed agreements with several multinationals including Intel, Microsoft, Philips and Qualcomm. Khalil has been trying to persuade industry to incubate a clutch of spin-off enterprises in wireless technology, bioinformatics and nanoelectronics that have emerged from the university's research centres. "A primary lesson I have learned is that you cannot establish research centres in a vacuum," says Khalil. "You have to link them with industry somehow. Research centres that do not have that commitment to productivity are not going to give you a return on your investment."

For the past four years, NU has been based in cramped offices and labs at its temporary premises in Smart Village. The plan was to move it to a brand new campus northwest of Cairo. One possibility now is that it will share this space with – or be subsumed into – a $1 billion science and technology park being planned by Nobel laureate Ahmed Zewail, which will house research centres, incubators, entrepreneurship hubs and universities. "Zewail City" will be a non-profit organisation and geared towards the promotion of Egypt's strengths in science and technology, in particular energy and water resources, genetic medicine, nanotechnology and IT.

3.13 Fostering IT entrepreneurship in Egypt

In 2010, the Ministry of Communications and IT launched a new agency that aims to turn Khalil's philosophy into reality across Egypt. The Technology, Innovation and Entrepreneurship Centre (TIEC) is helping establish a suitable business environment for innovations in IT and promote a culture of entrepreneurship among researchers.

One of its first tasks has been to establish a national ICT incubation programme for Egyptian start-up projects from the private and public sectors[78]. The Technology Incubation Program (TIP) provides training, equipment, office space and financial support of between $50,000 and $250,000. TIP projects currently in incubation include 3Dvelopers, which makes virtual reality software for use by estate agents; Smart ID Systems, which provides biometric security and identification services; Damlag, which operates the largest Arabic movie database; and Apricot, which has developed a tool to allow 3D characters to talk in Arabic with full lip synchronisation and facial mapping.

TIEC is also working on another incubator programme with Plug and Play, a community of technology start-up companies, entrepreneurs and investors in Silicon Valley[79]. Plug and Play Egypt[80] will provide mentorship, funding and support for up to 80 start-ups over five years, tapping into the extensive network of venture capital funds and technology companies of its parent company in the US. All this should help realise one of the main aims of the Ministry of Communications and IT: to rebrand Egypt as a leading regional hub for ICT-based innovation and entrepreneurship by 2014[81].

78 See http://www.tip-eg.com

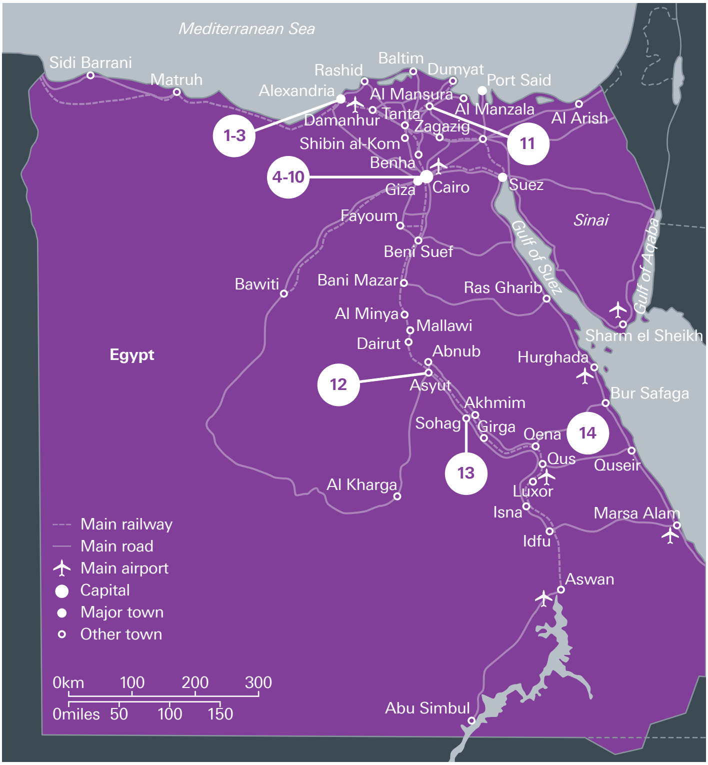
79 http://www.PlugandPlay TechCenter.com

80 http://plugandplayegypt.com

81 Technology, Innovation and Entrepreneurship Strategy 2011-2014 (Technology, Innovation and Entrepreneurship Center, 2011). Downloadable from http://www.tiec.gov.eg

4 Places

Figure 4.1. Landmark institutions in Egypt



Map based on figure in: Economist Intelligence Unit 2010 *Egypt Country Report.* The Economist Intelligence Unit Limited: London, UK

1 Alexandria University
2 City of Scientific Researches and Technology Applications
3 Bibliotheca Alexandrina
4 Desert Development Centre, AUC
5 CULTNAT, 6- Cairo University
7 Nile University
8 Smart Village
9 Wadi Environmental Science Centre
10 American University in Cairo
11 Mansoura University
12 Assiut University
13 Sohag University
14 South Valley University

More than 5000 years have passed since the separate kingdoms of Upper and Lower Egypt were united under one ruler, but many disparities remain between the two regions. Historically these are largely due to the geography of the Nile: south of Cairo the upper reaches of the river are confined to a narrow valley a few miles wide and bordered by cliffs, while to the north it fans out into a broad delta rich in fertile soil – the so-called breadbasket of the Roman Empire. The socio-economic implications of this natural history are palpable: Upper Egypt lags behind Lower Egypt on just about every development indicator, including life expectancy, adult literacy, infant mortality and GDP per capita (though the gap is decreasing) (see Table 4.1)[82].

It also lags behind on many scientific indicators. Its universities and research centres tend to attract less funding, publish fewer papers (see Table 4.3) and win fewer patents relative to their size than those in the north. Inevitably the Cairo metropolitan area contains the greatest concentration of research institutions, both public and private, and they tend to be among the best resourced. The further you are from Cairo, the less likely funding opportunities will come your way – this, at least, is how many academics far from the capital see it. Even researchers at Mansoura University in the Nile Delta, one of the country's leading research institutions, complain that they are "not given the same attention" as Cairo or Alexandria.

82 Egypt Human Development Report 2010 (UNDP / Egyptian Institute of National Planning)

Table 4.1: Regional disparities in human development

		Households with access to:					Households with:		
	Life expectancy at birth	Piped water (%)	Sanitation (%)	Literacy rate (15+) (%)	Combined basic and secondary enroll. (%)	GDP per capita (L.E.)	Electricity (%)	Radio (%)	Television (%)
	2007	2008	2008	2007	2008/2007	2008/2007	2008	2008	2008
Cairo	71.3	0	0	80.7	82.2	7726.4	0	0	0
Alexandria	72	0	0	80.5	93.6	8978.3	0	0	0
Port Said	72.7	0	0	83.6	92.1	10549.7	0	0	0
Suez	72.3	0	0	82.9	98.1	8745.8	0	0	0
Urban Govs	72.2	99.9	96.8	0	71.5	8282.4	99.9	81.7	96.7
Damietta	72.6	0	0	77.6	101.5	7883.5	0	0	0
Dakahlia	71.8	0	0	72.1	96.6	9111.5	0	0	0
Shrkia	71.2	0	0	67.8	97.5	8700.4	0	0	0
Kalyoubia	72.7	0	0	72.5	91.7	8134.4	0	0	0
Kafr El Sheikh	70.6	0	0	65.7	99.6	8927.9	0	0	0
Gharbia	72.3	0	0	74.1	96.5	8799.6	0	0	0
Menoufia	71.5	0	0	72.6	95.6	9854	0	0	0
Behera	71.5	0	0	63.4	99	9451.6	0	0	0
Ismailia	70.9	0	0	77.2	97.4	8970.2	0	0	0
Lower Egypt	71.5	98.6	64.6	0	80.2	8934.8	99.8	78.1	96.7
Urban	0	99.8	93.1	0	0	0	99.9	81.3	97.7
Rural	0	98.1	52.6	0	0	0	99.8	76.8	96.3
Giza	69.5	0	0	80.3	98.2	8242.8	0	0	0
Beni Suef	71.6	0	0	59.5	88.7	8857.4	0	0	0
Fayoum	69.5	0	0	59.1	86.2	8433.7	0	0	0
Menia	69.3	0	0	58.7	88.5	8655.9	0	0	0
Assiut	70.7	0	0	60.9	88.5	8019.6	0	0	0
Suhag	70.5	0	0	61.5	94.7	7329.7	0	0	0
Qena	70.5	0	0	65.2	96.2	6387.5	0	0	0
Luxor	69.8	0	0	72.2	105.5	9105.6	0	0	0
Aswan	71.2	0	0	77	97.1	7057.4	0	0	0
Upper Egypt	70.2	96.9	37.2	0	77.4	7978.9	99	62.4	90.8
Urban	0	100	76.5	0	0	0	99.8	76	96.1
Rural	0	95.1	13.5	0	0	0	98.5	54.1	87.5
Red Sea	71.2	0	0	87.3	96.3	8460.7	0	0	0
New Valley	71.2	0	0	81.8	100	12682.2	0	0	0
Matrouh	71.1	0	0	64.9	87.1	10346.1	0	0	0
North Sinai	71.2	0	0	75.8	91.6	8884	0	0	0
South Sinai	71.1	0	0	88.4	84	12454.6	0	0	0
Frontier Govs	71.1	88.4	42.8	0	78.2	10116.1	98.6	70.8	92.1
Urban	0	0	0	0	0	0	0	0	0
Rural	0	0	0	0	0	0	0	0	0
EGYPT	71.7	98	56.5	70.4	77.6	10246.1	99.6	73.7	94.7
Urban	0	99.8	89.8	0	0	0	99.6	80	96.8
Rural	0	96.7	37	0	0	0	99.3	67.8	92.8

Source: Handoussa 2010 *Egypt Human Development Report 2010*. UNDP and Institute of National Planning, Egypt

4.1 Who gets the money…

Such concerns are well founded. In a country so lacking in R&D money, a university's ability to win funds from the various limited sources available will largely determine its success in research. One of the most striking observations from our visits to some of Egypt's 19 government-run and 15 private universities was how dramatically they vary in their capacity to attract resources and exploit the government's new funding streams. Cairo University's annual research budget has increased 20-fold in the past five years to more than LE120 million, much of it coming from sources outside the university such as the Science and Technology Development Fund (STDF) and the Research, Development and Innovation (RDI) programme, according to Hussein Khaled, vice-president for graduate studies and research. The university has won some 50 grants from the STDF alone.

Alexandria University has been similarly successful, earning around LE44 million in Egyptian government grants during 2009/10 and a similar amount from EU and US sources. The day we visited in late 2010, staff were abuzz with the news that Alexandria had achieved a very respectable 147th place in the Times Higher Education World Universities Rankings 2010, the first time an Egyptian university had made the top 200, largely on account of the quality of its research in mathematics and theoretical physics[83].

Another Egyptian establishment that has scored highly in global higher education rankings is the privately funded American University in Cairo (AUC), which features among the top 600 in the 2010 QS World University Rankings[84]. At its $400 million new campus in New Cairo – 260 acres of courtyards, fountains, lawns and sandstone buildings complete with immaculate Arabesque trellising and Mashrabiya window screens – members of the science faculty are striving to make the university a centre of excellence in research as well as teaching. Central to this mission is a state-of-the-art nanotechnology centre set up in 2003 with an $8 million donation from Saudi Arabian businessman Yousef Jameel, where researchers are exploring a range of disciplines including biotechnology, surface chemistry, nano-structured materials and novel diagnostics.

4.2 …and who does not

Such opportunities can revolutionise a university's research capacity, but they are rare. Most public universities struggle to get by principally on what they get from the government, and once the staff's (generally meagre) salaries have been paid there is often little available for research. In the wide, unadorned corridors of Sohag University, 500 kilometres south of Cairo on the east bank of the Nile, researchers remark that their chemistry labs are "less well equipped than those at the National Research Centre" – a reference to the notorious lack of funding at the

83 see http://www.timeshighereducation.co.uk/world-university-rankings/2010-2011/top-200.html

84 see http://www.topuniversities.com/institution/american-university-cairo/wur

government's flagship research institute in Cairo. The most important instrument in the university's central lab – a nuclear magnetic resonance (NMR) spectrometer used daily to understand chemical structures – dates back to 1984 and has a resolution at least ten times as low as that of modern machines. The newest piece in the room – a Fourier transform infrared spectrometer – was acquired five years ago. Most of the equipment is around 25 years old.

Fayez El-Hossary, dean of Sohag's faculty of sciences, says a new NMR spectrometer would cost up to LE1.2 million, close to the university's basic annual research budget. He maintains that with very little income from industry, the university desperately needs more funding from the government to entice researchers to stay. "We have good scientists who have proved themselves at institutions in the US and Europe, but without good facilities and salaries they end up looking for opportunities abroad. We lose many people this way."

4.3 The challenges of the new grant system

Unquestionably, the competitive sources of funding that the government introduced in 2007 and 2008, such as the STDF (which has distributed LE500 million so far with another LE200 million earmarked for 2011/12) and the RDI programme (worth 31 million Euros to 2015), have helped, giving hope to cash-starved researchers everywhere. "The launch of the STDF was a bright spot as it was the first time the government realised that something needed to be done," says Tarek Khalil, Nile University's President. "It is helping a lot of institutions." Scientists at Assiut, South Valley and other universities spoke to us of their pride at winning STDF grants – a sign that the government's competitive funding strategy is working.

Still, the universities and research centres that benefit most from the STDF tend to be those that are better resourced or nearest to Cairo (see Table 4.2). An STDF report published in June 2010 noted that 70% of successful proposals were submitted by researchers affiliated to institutions in greater Cairo, with the National Research Centre and Cairo University the most dominant[85]). Up to 2011 Sohag University, for example, had had only one proposal accepted in three years of trying, which leads El-Hossary to speculate that those awarding the grants "are biased to certain universities. They don't trust us in Upper Egypt to complete projects successfully."

85 Indicators of STDF Achievements (STDF, 2010).

Table 4.2: Numbers of grants awarded by the STDF (up to mid-2011)

Contracting Institution	No. of funded Projects	Contracting Institution	No. of funded Projects
National Research Center	95	Electronics Research Institute	4
Cairo University	59	Tanta University	4
Agriculture Research Center	45	Kafr El Shiekh University	3
Alexandria University	33	National Institute of Oceanography & Fisheries	3
Ain Shams University	24	Sohag University	3
Central Metallurgical R&D Institute	20	Atomic Energy Authority	2
Menofia University	19	Fayoum University	2
Mansoura University	17	National Hepatology and Tropical Medicine Research	2
City for Scientific Research and Technology Applications	17	VACSERA	2
Assiut University	14	Al-Ahram Centre for Sociological and Historical Studies	1
Suez Canal University	10	Children's Cancer Hospital 57357	1
German University in Cairo	7	Coastal research Institute, Alexandria Ministry of Water Resources & Irrigation	1
Nile University	7		
South Valley University	7	Desert Research Center	1
National Authority for Remote Sensing & Space Sciences	6	Egyptian Meteorological Authority	1
Banha University	5	Heliopolis Academy	1
Helwan University	5	Horticulture Research Center	1
Menia Univeristy	5	Housing and Building National Research Center	1
National Research Institute of Astronomy and Geophysics	5	Ministry of Investment	1
Theodor Bilharz Research Institute	5	Ministry of Water Research & Irrigation	1
Zagazig University	5	Misr University for Science & Technology	1
Al Azhar University	4	National Center for Radiation Research and Technology	1
Bani Swief University	4	National Gene Bank	1
British University in Egypt	4	National Institute of Standards	1
Egyptian Petroleum Research Institute	4	National Water Research Center	1
		Totals	**466**

Source: STDF Annual Report 2011

One of the problems is that prior to the existence of the STDF and the RDI programme, few researchers in Egypt had any experience competing for funds or filling out detailed grant proposals with budgets and progress reports – something the Ministry of Scientific Research is striving to address by ensuring that applicants are shepherded through the proposal process.

"Before the creation of the STDF it used to work this way: if you wanted money you would call someone from the academy, have a coffee with him, tell him about your super project and you would get the funding immediately," says Aly El-Shafei, former Executive Director of the STDF. "A competitive environment is something people are not used to and do not trust." He recalls visiting Mansoura University where someone came up to him and thanked him for a grant they had received from the STDF. "I asked him why he was thanking me and he said, you don't know me so why should you give me money! This is how people think. It is a different culture and it will take time [for people to adjust]."

The funding inequalities are reflected in the huge disparities in scientific output among Egyptian universities, with the most prolific producing at least ten times as many papers as the least (see Table 4.3).

Table 4.3: Regional disparities in output – international publications per university

University	2007	2008	2009	2010
Ain Shams	605	673	856	916
Al-Azhar	227	276	358	413
Alexandria	506	572	632	637
Al-Fayoum	34	49	52	67
Assiut	263	298	396	433
Banha	108	120	172	202
Beni Suef	77	81	84	107
Cairo	888	463	1,378	1637
Helwan	162	181	204	218
Kafr Ashaykh	33	44	74	91
Mansoura	511	574	693	767
Minia	140	150	163	217
Minufiya	202	229	296	326
Port Said	-	-	-	20
Sohag	54	100	120	130
South Valley	89	130	155	215
Suez Canal	258	292	323	319
Tanta	177	216	237	312
Zagazig	182	247	287	379

Source: SciVerse Scopus database

4.4 Egypt's Centres of Excellence

An observation widely held within Egypt's academic community is that the best of the country's scientists can compete with any on the world stage. Despite the general lack of funding and low salaries, first-class science is being done in research centres and universities around the country that is likely to have a significant impact on Egypt's development. Here we give brief outlines of some of the most exciting projects and centres of excellence so that others might learn from their success.

Egypt's Silicon Valley: Smart Village

Smart Village is a communication and IT business park in the western suburbs of Cairo – not a centre of excellence so much as an innovation hub, home to a cluster of 130-odd multinational and local companies, including Ericsson, Hewlett Packard, IBM, Intel, Microsoft, Mobinil, Telecom Egypt, Vodafone and – underlining the government's commitment to the whole venture – the Egyptian Ministry of Communications and IT. Owned jointly by the government and by the companies that are located there, it boasts state-of-the-art infrastructure, a conference centre, a school, restaurants, meeting rooms and an on-site shuttle service, as well as artificial lakes, fountains, irrigated lawns and palm trees – all of which help offset the inescapable impression on arrival at Smart Village that you have arrived at an airport terminal. Two more Smart Village business parks are being planned at Damietta and Alexandria on the Mediterranean coast, and a similar investment park opened in the Cairo suburb of Maadi in 2010. Smart Village currently employs more than 40,000 people, and that number is expected to grow to 100,000 by 2015.

Smart Village

In pursuit of a killer: The Cancer Biology Research Laboratory, Cairo University

Mona Mostafa Mohamed runs Egypt's first lab dedicated to tackling inflammatory breast cancer, a particularly aggressive variation that affects at least 15% of breast cancer patients in North Africa, compared with 1-5% in the US. She and her team of nine students at the Cancer Biology Research Laboratory in Cairo University's Department of Zoology, which opened in February 2009, are studying samples of mutated tissue donated by women undergoing treatment for the disease to try to find out why the incidence is so high in this region and how breast cancer cells behave in different environments, as well as looking for improved diagnostic and therapeutic techniques.

The project stems from a $160,000 scholarship that Dr Mona won from the Avon Foundation's American Association for Cancer Research International Scholars-in-Training Program, which funded her from 2005 to 2007 at Wayne State University School of Medicine in Detroit and then enabled her to transfer her work to Cairo. A major purpose of the Avon scheme is to ensure that scholars return to their home countries to continue their research, which suited Dr Mona fine. "I believe I have a mission here," she says.

Her mission would have been difficult, however, without the Avon funding and without other grants that followed, including $75,000 from the US National Institutes of Health and LE648,000 from the STDF. Cairo University awarded the lab LE200,000. The additional funding is essential, not only to cover the day-to-day running of the lab and to buy equipment and chemicals but also to make it worthwhile for her staff to stay. "If we didn't have a place like this I would have left Egypt," insists Mona Seif, a masters student in Dr Mona's lab and winner in 2009 of a Scientists for Next Generation award, presented to promising young researchers by the Academy for Scientific Research and Technology.

The team has had papers published in several international and Egyptian journals[86]. Their main challenge at the moment is not so much funding as obtaining antibodies, reagents and other chemicals necessary for their research. Most of these have to be imported, which can take months, delaying crucial experiments. "I'm often tempted to just bring them over in my bags from a trip abroad," says Dr Mona.

86 See *Journal of Translational Medicine*, vol 9, published online (January 2011), doi: 10.1186/1479-5876-9-1; *Biological Chemistry,* vol 389, p 1117 (August 2008), doi: 10.1515/BC.2008.117

Assiut University

"Funding is not a problem here": Analytical Chemistry Unit, Assiut University

The very first entry in the visitor's book at the entrance to Assiut University's Analytical Chemistry Unit makes it clear this lab has high aspirations: the signature belongs to Ahmed Zewail, the Nobel prize-winning chemist, who inaugurated the place on 22nd December 2007. Although the main business of the lab is chemical analysis rather than R&D, its success as a designated special service centre – which allows a state lab to take work from industry so long as profits are channelled centrally – is a fine demonstration of the business potential in university research.

Everything about the unit is cutting-edge, from the fingerprint scanners that open the door and log the staff's working hours to the state-of-the-art spectrometers and analysers in the main lab. The equipment is key: there's a gas chromatography-mass spectrometer, the gold standard of chemical identification, used in many applications such as to determine the pesticide content of wastewater or the combination of hydrocarbons in gasoline; a high performance liquid chromatograph for separating out compounds in a mixture; a differential scanning calorimeter for calculating the calorific value of biomass such as rice straw; and a voltammetric analyser for measuring concentrations of heavy metals. Several empty spaces on the benches await the arrival of new instruments.

The lab cost LE6 million to set up, and around LE2 million has been spent on equipment since then. The money has come partly from the university (which also pays the salaries of the PhD and Masters students working in the lab) and partly from various government funds such as the Higher Education Enhancement Project (HEEPF), designed to improve the competitiveness of universities and technical colleges. Income from clients – which include CEMEX (cement), T3A

Pharma and Sigma (pharmaceuticals), Petrojet (petroleum), Coca-Cola, sugar producers, hospitals and other labs within the university – has been modest so far (LE121,000 between July 2009 and September 2010, for example), but this is likely to increase now the unit has accreditation from the American Association for Laboratory Accreditation (A2LA).

"Funding is not a problem here," remarks the dynamic manager Nagwa El-Maali. "You won't find many labs even in the US with more facilities than ours" – a fairly remarkable statement uttered in a science faculty of a government university. El-Maali shows us around her lab like a skipper showing off her boat. She is as "hands on" as managers get, with a live CCTV feed from the labs into both her office and her home enabling her to keep an eye on her staff at all times. With equipment like that to watch over, who can blame her?

Science for industry: City of Scientific Research and Technology Applications (formerly Mubarak City)

With its pink pyramidal buildings, and fire escapes that resemble giant penne tubes, this "research city" looks a bit like some futuristic theme park. But there's nothing fantastical about its mission. The idea behind this cluster of government-funded research institutes, established by presidential decree in 1993 and opened in 2000, is to develop innovations that will serve the needs of industry – hence the decision to site it in Borg El Arab near Alexandria, where 40% of the country's industries reside.

The City houses four institutes, covering genetic engineering and biotechnology, advanced technologies and new materials, arid land and agriculture, and IT. Most of the research is focused on technologies likely to boost Egypt's development. Current projects include new irrigation techniques for desert-based agriculture; a 10cm by 10cm quantum dot solar cell with 10% sunlight to electricity conversion efficiency; a combined 1MW solar power and desalination plant, the first of its kind, developed with the Italian National Agency for New Technologies, Energy and Sustainable Economic Development; and the use of cloud computing and other information technologies to recreate Egypt's cultural heritage online, including a "virtual tour" of the Pyramids and other major tourist attractions made with data collected by a 3D laser scanner.

To encourage industry to get involved in such research, the government has designated part of the City's grounds as a "technology investment zone". Businesses will be invited to build incubation or research centres, taking advantage of the R&D expertise within the existing institutes and using their facilities to build prototypes for new products. Yasser Refaat, Acting Director, says several high-tech companies have already signed up.

A clinic for the 21st century: The Aswan Heart Centre

The Aswan Heart Centre opened in April 2009 with the purpose of treating patients in Upper Egypt who are suffering complex cardiac diseases and who would usually not have access to such advanced treatment. Plans are in train for an additional facility, mainly for clinical research to help doctors study the heart before and after surgery. It will be equipped with the latest MRI and CT imaging equipment and will be run in collaboration with Zewail City of Science and Technology and the Qatar Heart Research Center in Doha. A third phase – a lab-based research unit that will also carry out extensive epidemiological studies – is in the design stage.

As well as treating patients and teaching cardiologists and biomedical engineers, the Aswan Heart Centre aims to carry out research on the genetic basis of common cardiac diseases in Egypt, such as rheumatic heart disease, atherosclerosis and dialectic cardiomyopathy. Scientists linked with the centre have already started to sequence some of the crucial genes behind these conditions.

The centre's founder, the Magdi Yacoub Heart Foundation, based in Cairo, is currently raising money to build a new hospital and research centre overlooking the Nile in Aswan. The funding will come mainly from private enterprise in Egypt. The Foundation has so far raised more than $35 million from donors including the Qatar Foundation, the Misr El-Kheir Foundation, the Sawiris Foundation for Social Development and Magdi Yacoub's own Chain of Hope charity. "Ultimately it will be a $100-150 million project," says Yacoub, who is Professor of Cardiothoracic Surgery at Imperial College London.

While the Aswan Heart Centre is leasing the land for its buildings from the government, it receives no state funding and runs its hospitals – which currently do not charge patients – independently.

Thinking small, acting big: Egypt's nanotechnology revolution

Before the revolution, in most offices in Egypt you would inevitably find hanging above the desk a portrait of Hosni Mubarak, generally looking younger than was credible. The portrait that hung – is still hanging – above Mona Bakr Mohamed's desk in the offices of her company ***Nano Tech*** is of someone of a very different ilk: Ahmed Bahgat, one of the country's most successful businessmen (see profile of him in Business chapter).

Nano Tech is part of Bahgat's industrialist group and is based in his residential development park Dreamland, west of Cairo. The company specialises in adapting nano-materials such as graphene and carbon nanotubes for use in biomedical imaging, drug delivery systems, solar desalination technologies, quantum dot photovoltaic cells and new consumer products such as detergents and disinfectants, some of which will soon be fit for market. Bahgat's initial defining contribution to Dr Mona's research – which is also being funded by UNESCO, the STDF and the Industrial Modernisation Centre – was the acquisition in January 2010 of a $1 million high-resolution transmission electron microscope capable of a spatial resolution down to 0.14 nanometres.

This gold standard of nanotechnology instrumentation stands a metre high and is capable of discerning structures several million times thinner than an average human hair. “This is my eye, I wouldn’t be able to build much in the lab without it,” says Dr Mona. “It allows me to see how atoms are organised and how the lattice is formed. I can characterise the chemical composition of individual particles, as well as their shape, size and other properties.” Only two other places in Egypt own a microscope this powerful: the Central Metallurgical Research and Development Institute in Helwan and the Egyptian Petroleum Research Centre in Cairo.

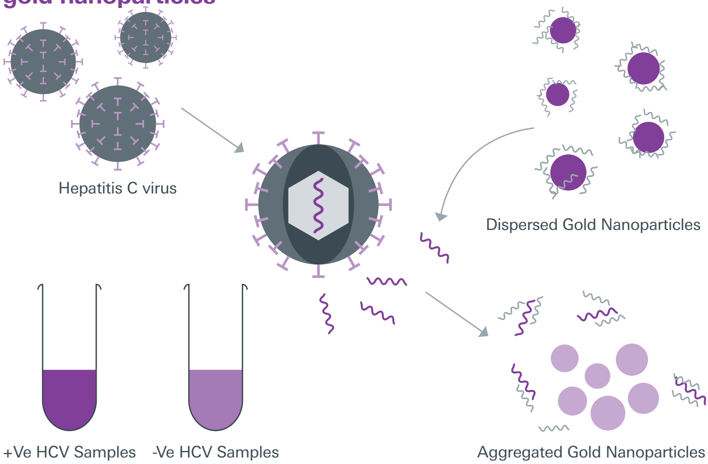
On the roof of Nano Tech’s Dreamland office, Dr Mona shows us the prototype solar desalination device that she has built with some of her 34 PhD students (13 of whom are employed full-time at the company). Its key ingredient is a thin oil-based film of nano-material that floats on top of the water and absorbs the sun’s energy with super-high efficiency, converting it to heat and driving evaporation at 12 times the normal rate. The evaporated water is collected after condensing and is free not only of salt but also of microorganisms and other contaminants. “I’m trying to spread awareness among high school and university students that you can do a lot of things using nano-materials at low cost, you don’t need huge facilities.” Some of that awareness-spreading takes place at Nano Tech itself, where each summer Dr Mona trains 30 students who she recruits from every engineering faculty in the country.

Nanotechnology holds great promise for developing countries because of the huge range of potential applications. By manipulating atoms and molecules, scientists can change properties of matter such as colour, strength, hardness, electrical conductivity, elasticity and heat tolerance, leading to new materials and technologies for use in medicine, construction, energy production and storage, sanitation, agriculture and other industries. While Egypt’s share of the global nanotechnology market is still miniscule, the field is fast becoming a highly promising area of Egyptian science, in both the private and public sectors.

One of the sectors most likely to benefit is medicine. At the ***National Research Centre*** in Cairo, researchers are using gold nanoparticles to destroy cancer cells, coating the nanoparticles with antibodies to guide them to the tumour and then blasting them with a laser – the cancer cells attached to the nanoparticles absorb heat from the laser more effectively than healthy cells. The team behind this technique – which is currently undergoing animal toxicity tests funded by the non-governmental Misr El-Khreir Foundation – is advised by Mostafa El-Sayed, professor at the school of chemistry and biochemistry at the Georgia Institute of Technology in Atlanta and Mona Bakr’s PhD supervisor when she studied there. El-Sayed says the success of such projects depends largely on equipment. “Without the correct instrumentation, the quality of research will always be limited”.

Gold nanoparticles are the focus of a project run by Hassan Azzazy at the AUC’s ***Yousef Jameel Science and Technology Research Center*** to improve diagnosis of hepatitis C (HCV), a blood-borne virus that has infected at least 10 million people in Egypt and is a research funding priority for the government. In a new blood test developed by Azzazy’s group, gold nanoparticles are attached to a short DNA sequence that can recognise and target HCV. In a positive specimen, this DNA sequence binds to the HCV's RNA, which then aggregates and change colour (see Figure 4.2). "Gold nanoparticles have a fantastic property," says Azzazy. "When they are suspended in solution they are a bright red colour, but if you force them to aggregate they give you a nice blue." The test – which is still a prototype – is a lot quicker than those currently used and at LE35 is a tenth of the price[87]. The team has applied for international patents and is setting up a spin-off company to market the technology.

Figure 4.2. Direct detection of active hepatitis C virus infection using gold nanoparticles



Source: Professor Hassan Azzazy, Novel Diagnostics & Therapeutics Research Group, American University in Cairo

87 See paper in *Clinical Biochemistry*, vol 43, p 1163 (September 2010), doi: 10.1016/j.clinbiochem.2010.07.001

88 More information at http://www.egnc-ibm.gov.eg

The Egyptian government has been swift to recognise the potential benefits of nanotechnology. By 2012 it hopes to open the ***Egypt-IBM Nanotechnology Research Center***, an R&D facility founded with $60 million seed money from the STDF and the Information Technology Industry Development Agency, part of the Ministry of Communication and Information Technology[88]. IBM is the strategic partner. The company is currently providing training and development for the first 10 Egyptian researchers at its labs in Zurich and Yorktown in New York State while the centre's premises at Cairo University's Sheikh Zayed City campus are finished.

The centre's research will focus on developing renewable energy technologies such as thin-film photovoltaic cells, graphene electrodes for photovoltaic cells and a combined thermo-electric desalination system that uses waste heat, as well as algorithms and modelling software that can be used in the adaptation of nano-materials. "The key will be to focus on innovation that benefits Egypt and that is relevant to industry, rather than doing research for its own sake," says the Director Ahmed Tantawy. He points out that the funding behind the centre is relatively large by Egyptian standards, and researchers will be working with expensive equipment and materials. "The expectation is that it should have an impact year on year and justify the cost."

88 More information at http://www.egnc-ibm.gov.eg

5 Culture

"There is no turning back now. Nobody can say anymore that science and technology is not important." This confident assessment by Maged Al-Sherbiny, President of the ASRT, reflects a widespread optimism among academics that science and technology will at last play a prominent role in the country's economic and social development.

"The biggest thing of the revolution was the glimpse that we can change things, and that nothing is going to get fixed if you don't go out onto the streets," said Ramy Aziz, a lecturer in the faculty of pharmacy at Cairo University and a well-known science blogger[89]. "It is a similar thing with science and technology. People who had ideas before and were disappointed are starting to stand up. Now is the time for initiatives. We have to ride this wave now otherwise it will fade and people will go back to the same as before."

Others have spoken of a remarkable change in attitude on campuses, with lecturers choosing to spend more time with their students, and researchers "seeking to do research for the benefit of Egypt, whereas in the past it was more for their own promotion". There are high expectations for the future – that institutions will be free of bureaucracy, that researchers will have more time for research, that academic salaries will increase, that science curricula will be overhauled.

Turning all these dreams to reality will require not only a sustained commitment by the new administration, but also a marked change in how the public values scientific research and its role in development, and also an end to some of the rigid hierarchical structures that continue to suppress innovative thinking in universities and research centres – in short, a cultural transformation.

5.1 A waning appetite for science?

When the Nobel-prize winning chemist Ahmed Zewail visited the Bibliotheca Alexandrina in the city where he graduated to make a speech about educational reform in July 2010, he was mobbed by hundreds of admirers desperate for a glimpse of Egypt's star scientist. Zewail has been based at the California Institute of Technology since 1976 and in the US since 1969, but his role as one of President Obama's science envoys to the Middle East and his involvement in several initiatives in Egypt before and since the revolution have meant he is a regular visitor. He is feted whenever he comes.

He is not the only Egyptian scientist who is treated as a celebrity in his home country. When expats such as cardiothoracic surgeon Magdi Yacoub and remote sensing expert and former NASA scientist Farouk El-Baz give lectures at Egyptian

89 See http://microbes.wordpress.com

universities, the halls are invariably packed. In November 2010 at a conference on sustainable development at the British University in Egypt we watched as El-Baz walked down some stairs into the lobby and was besieged by scores of students seeking to be photographed with their hero, all of whom he accommodated with patience and a smile.

Despite this clearly heartfelt appreciation of scientific achievement, public interest in science in general in Egypt appears to be at a low ebb. The proportion of pupils majoring in science subjects in secondary school has more than halved over the last four decades, according to a report by the Center for Future Studies, an Egyptian government think-tank[90]. "There is little popular appetite for science," says Mohammed Yahia, Editor of *Nature Middle East*. "Many people on the street do not see science as playing a pivotal role in development or in improving their livelihoods. Curriculum science courses are still uninspiring, and there is no outside influence to get children to love science."

Egyptians over a certain age recall with fondness how during the 1980s families in their tens of thousands across Egypt gathered around their TV sets on Monday evenings to watch Moustafa Mahmoud's captivating science documentary series *Science and Belief*. It was one of the most popular shows of that era, lasting for some 400 episodes. Today Egypt has a satellite channel dedicated to scientific research but it is invariably described as "boring" and is watched by relatively few.

5.2 Reviving public interest in innovation

Several efforts are underway to revive public participation in science and innovation, including competitions such as FameLab, hosted by the British Council and the Egyptian government's RDI programme, in which contestants have to talk entertainingly on a scientific subject for three minutes in front of a live audience (the winner goes on to compete in the international finals in the UK); Stars of Science, tagged as the "first pan-Arab reality TV programme dedicated to innovation", currently in its third season; the Young Innovators' Awards, run by the NGO Nahdet El Marousa and the Industrial Modernisation Centre, designed to stimulate an R&D culture among young researchers; the Intel Bibliotheca Alexandrina Science and Engineering Fair, a competition to encourage creative thinking and innovation among 14 to 18-year-olds; and ScienceBook, Egypt's Facebook type social network for scientists set up by the Ministry of Scientific Research (MOSR) in 2009[91].

Yet clearly more could be done to boost people's interest and – a harder but no less important challenge – to get across the message that research is vital for development. "We have to make the case that research is important for the alleviation of hardship," says Alaa Adris, Chairman of the scientific research committee of the Misr El-Kheir Foundation, which distributes charitable donations

90 Download report here: http://www.future.idsc.gov.eg/FutureCMS/workareas/a379143210327077260100000b7ad2db/apps/Publication/Building%20Egypt%E2%80%99s%20Scientific%20Base_.pdf

91 http://www.estc.sci.eg

to projects that alleviate poverty and disease. He says he regularly encounters donors who doubt whether spending money on, say, stem cell research or nanotechnology can help the poor. "There aren't even enough believers [in the importance of research to development] in the academic community itself."

5.3 The role of the media

The media could do much to help, especially since many issues of national concern such as water resources, energy and food are science-based. "They need to play a role in increasing people's informal science education, encouraging them to go to museums, getting children impassioned by science, so they become convinced this is the future," says former Minister for Higher Education and Scientific Research Hany Helal.

How effective is Egypt's science media? Nadia El-Awady, who used to cover science at IslamOnline.net and helped launch the Arab Science Journalists Association (ASJA) in 2006 to improve the professionalism of science reporting throughout the region[92], says that while many newspapers publish science or technology sections and job prospects for science journalists remain buoyant, the quality is often poor. "Basic journalism skills, such as fact-checking and using multiple sources, are just not there. There is little critical analysis. That applies to journalism as a whole."

Media coverage of the H1N1 crisis in Egypt in 2009 was generally substandard, she says. This was partly because the government issued statements and policies that were unscientific and scaremongering – such as the order to slaughter all pigs despite no evidence of them carrying the virus – which journalists then reported without checking them with experts; in another instance, a journalist writing in a government-owned publication claimed people could "catch" certain behaviours of pigs by eating pork[93]. Another example of a worrying lack of analysis came after a spate of shark attacks along the Sharm El-Sheikh coastline in December 2010, when several papers uncritically reported the unsubstantiated claim by a University of Cairo researcher that the sharks' frenzied behaviour could have been triggered by nuclear tests under the Gulf of Aqaba[94].

One problem is the lack of training courses in science journalism, though organisations such as the ASJA and the World Federation of Science Journalists are attempting to address this with workshops and mentoring programmes. Another is that many journalists are also politically active or keen to promote a particular ideology, which can make it hard for them to remain report objectively. Furthermore, universities and research centres do not readily talk to reporters and are often mistrustful of them. "It can be very hard, near impossible sometimes, to reach researchers or officials to get them to comment or explain something," says Yahia. He recalls that when he worked in an office opposite the National Research

92 To join the Arab Science Journalists Association or find out about its training courses visit http://www.arabsja.org

93 El-Awady N (2009). *Media and government to blame for Egypt swine flu chaos.* SciDev.Net, 15 May 2009.

94 For example see "Nuclear emissions frenzied sharks: Egypt expert", *Al Arabiya* news channel, 8 December 2010, http://www.alarabiya.net/articles/2010/12/08/128884.html

Centre "it was much easier to get information about a piece of research in the US than to find out what was happening inside the NRC". A useful step might be for research to be better reported on institutions' websites, and communicated to journalists through university media offices.

By contrast, eminent Egyptian scientists such as Ahmed Zwail, Farouk El Baz, Magdi Yacoub, Mostafa Alsayed and Mohammed Ghonaim are treated as stars in the Egyptian media, frequently appearing on television explaining how scientific achievement can contribute to a better future for Egypt. The Egyptian media has also been very supportive of some national programmes suggested by the scientists, such as the Zewail City for Science and Technology. Furthermore, media interest in science and technology has increased significantly following the revolution.

5.4 Science and religion

In searching for explanations for the decline of science in recent decades, some have asked whether there is anything in modern Egyptian culture that discourages innovation. This is commonly framed as a question about Islam's receptiveness to new ideas, which for most Egyptian scientists is a question hardly worth asking. You don't have to spend long in the halls of Egypt's universities and research centres to see how religious belief and scientific endeavour co-exist without argument (with one notable exception, discussed below). When we visited the temporary Smart Village campus of Nile University, a place dedicated to cutting-edge IT, students were kneeling for midday prayers in a corner of the corridor just outside the incubator room where new projects are nourished, an appropriate metaphor for Ahmed Zewail's assertion that "there is nothing in the cultural DNA of Islam that makes it resistant to assimilating new ideas"[95].

There are fears, however, that fundamentalist voices are having an impact in all areas of public discourse including science – though this is nothing yet on the scale of that in the US where policymakers have had to bow to conservative Christian opinion on issues such as embryonic stem cell research. Ismail Serageldin, Director of the Bibliotheca Alexandrina, predicts increasing ideological confrontation with religious zealots and warns that rationalists in Egypt must be prepared to "fight for the values of science" and reject bigotry, fanaticism and xenophobia[96]. "The defence against extremism is not by censorship or autocracy; it is by embracing pluralism and defeating ideas with ideas."[97]

Some academics are wary of the Muslim Brotherhood's ambitions for an Islamic state, which they see as incompatible with free enquiry. The group does appear to be pro-science and has even stated in the past that it would seek to boost R&D

95 "The US needs a new soft era" by Ahmed Zewail, *The Guardian*, 11 July 2010

96 From author interview and an editorial in *Science*, vol 321, p 745 (8 August 2008), DOI: 10.1126/science.1162825

97 From acceptance speech at the award of the US National Science Foundation's Public Welfare Medal, Washington DC, 1 May 2011

spending to western levels. Its Freedom and Justice party has said it does not envision a theocracy and seeks only an "Islamic frame of reference". However some of the Brotherhood's previously stated development policies – such as to push for complete self-sufficiency in agriculture and other industries[98] – run counter to moves by previous governments to instead aim for self-reliance through international trade due to the constraints posed by Egypt's limited land and water resources.

5.5 Evolution – where science teachers fear to tread

Many moderate Muslims find evolutionary theory a challenge to the Islamic account of creation. (Perhaps not surprisingly, so do the Muslim Brotherhood. Interviewed for this report, Sherif El-Magd, a spokesman for the group and head of the department of civil engineering at Helwan University, described Darwin's theory as "without proof"). A 2007 study of religious attitudes in Indonesia, Pakistan, Egypt, Malaysia, Turkey and Kazakhstan found that just 8% of Egyptians believed Darwin's theory of evolution was true, fewer than in any of the other countries surveyed (see Table 5.1)[99] .This figure was corroborated by the British Council's 2009 global survey of views on evolution[100].

Other studies have suggested that many Egyptian students have misconceptions about evolution and how it relates to their religion that lead them to reject it[101]. Yahia, who has taught science in a private school in Cairo, says in his experience a lot of teachers tell their students that there is no scientific basis for Darwin's theory and that it is anti-religious. These messages pose a challenge to the successful teaching of science in schools.

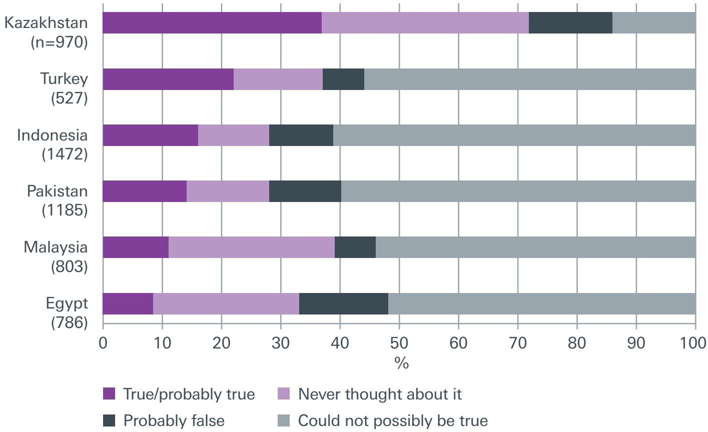
98 In author interview with Sherif Abou El-Magd, 2 December 2010. For further reading on differing Islamic attitudes to scientific ethics see "Islam and Science: an Islamist Revolution" by Ehsan Masood, *Nature*, vol 444, p 22 (2 November 2006), doi:10.1038/444022a

99 "On Being Religious: Patterns of religious Commitment in Muslim Societies", Riaz Hassan, *Muslim World*, vol 97, p 437 (July 2007), DOI: 10.1111/j.1478-1913.2007.00190.x

100 See http://darwin.britishcouncil.org

101 See papers by Jason Wiles (Syracuse University), Saouma BouJaoude (American University of Beirut), and others. Eg. "Muslim Egyptian and Lebanese Students' Conceptions of Biological Evolution", *Science and Education*, published online 26 February 2011 (DOI: 10.1007/s11191-011-9345-4); see also the Hampshire College Center for

Figure 5.1. Acceptance of Darwinian theory in Egypt and other Muslim countries



Acceptance of evolution in six Muslim countries. The data were gathered from 1996 and 2003, as part of a study of religious patterns in Muslim countries (8). The number of participants for each country is given in parentheses.

Source: Hameed 2008 *Bracing for Islamic Creationism*. Science 322, 1637-1638

While the distortion of science in the face of cultural or religious taboos is always worrying, the controversy over evolution does not seem to reflect a wider anti-rationalist sentiment in Egypt, though scientific advances in fields such as biotechnology and reproductive biology will inevitably throw up particular ethical dilemmas just as they have in Europe and the US. In anticipation of this, the Higher Council for Science and Technology has held consultations on setting up a cross-disciplinary National Bioethics Commission to advise policy-makers on the use of new technologies and applications and other issues such as how to protect people's genetic privacy, a move many claim is long overdue.

the Study of Science in Muslim Societies website: http://www.hampshire.edu/academics/SSiMS.htm
For further discussion of evolution and Islam see Ihsanoglu 2011 *Modern Islam*. In: Hedley Brooke and Numbers (Eds) *Science and religion around the world*. Oxford: Oxford University Press Ch. 6

5.6 Egypt's rigid university system and how it is strangling innovation

Of more concern is the culture of conservatism within the scientific community itself – though since the revolution this has at last begun to unravel.

As they stand, Egypt's higher education regulations make it very hard for academics to move between universities. A researcher is more than likely to retire from the same faculty at the same university from which he graduated. As Hany Helal put it: "You are admitted to a particular faculty, you will graduate from this university, you will become teaching assistant at this university, you will be promoted to research assistant, to lecturer, to assistant professor or professor, and maybe you will die in the same department." This ensures a deeply hierarchical system in which it is difficult for younger people to question their superiors, since they will be their superiors for life, and in which promotion is determined largely by seniority rather than, say, success at obtaining patents. "It kills creation and innovation."

New legislation introduced by the interim government should help change this by making the system for appointing senior university staff more flexible and democratic. University presidents and deans of faculties will no longer be directly appointed by the Ministry of Higher Education and Scientific Research as before, but instead chosen by committees made up of two people elected from each faculty at the university, plus a student representative. The committee puts forward three possible candidates to the minister, who then makes the final selection. Currently applications are open only to candidates from within the community of the particular university; in future they will be open to everyone, which will encourage people to move between universities.

The new rules are unpopular with some students who would like to see presidents and faculty staff appointed by completely open elections, rather than by committee. However, the MOSR and the Academy of Scientific Research and Technology (ASRT) have strongly resisted this, maintaining that such a system when it was tried in the past in Egypt encouraged political-style campaigning and was divisive and destructive.

They have also resisted populist calls to "wipe the slate clean" and sack any faculty leaders who were in any way associated with the Mubarak regime – a somewhat impractical move since before the revolution almost every faculty appointment had to be approved by the ruling National Democratic Party. "You wipe the slate if there is dirt all over the place, but there is not," says Al-Sherbiny. "We should not do something just to please people that destroys the country's academic system."

They face opposition from the other direction too. Many who have been in academia for years feel threatened by the new system. As one professor told us: "People here do not like competition. We are not used to it."

5.7 The need for more interdisciplinary research

The deleterious effects of Egypt's rigid academic culture are apparent in the lack of cross-fertilisation not only between universities, but also between different faculties at the same university. Faculties tend to work independently; interdisciplinary research is rare. Some institutes have started to encourage scientists to work across their traditional academic boundaries.

At the new engineering-oriented Egypt-Japan University of Science and Technology (E-JUST), a partnership between the Egyptian and Japanese governments based in Borg El-Arab, founding President Ahmed Khairy has insisted that students are recruited from basic science as well as engineering faculties. Alexandria University's Institute of Graduate Studies and Research (IGSR) is now geared almost exclusively towards multidisciplinary work, which it claims is more relevant to the community. In the Environmental Studies Department, for example, you can find engineers and chemists working alongside pharmacists and economists.

Sherif Kandil, Professor of Materials Science at IGSR, thinks this collaborative approach produces "a unique hybrid of scientist", one more able to apply science to the needs of industry. How so? "I'll give you an example. I trained as a chemist. I was taught to think about the chemical reaction, how electrons move from one atom to another, that sort of thing. I was looking at the micro, never at the macro. Today, working with engineers within my department, I can see how a chemical reaction can affect the design of an entire bridge and even make it collapse. That's a completely different vision."

UNESCO's new NECTAR initiative, mentioned in section 1.8 above, should help promote this kind of thinking. One of the objectives of this regional network is to intensify the use of new technologies in all economic sectors and thus encourage innovation and the commercialisation of new products. This will be achieved by improving science education and R&D in nanotechnology, biotechnology, communication and IT, and all basic sciences associated with these technologies (chemistry, physics, biology and mathematics)[102].

102 See http://www.unesco.org/new/index.php?id=55922 for more details

5.8 More power to the universities!

Many Egyptian academics believe that public universities would be more likely to break down cultural norms that are hindering innovation if they were given more administrative and political autonomy. Though defined in law as independent entities, in practice much of what state universities can do – including how they structure their councils, faculties and departments, appoint their teaching and research staff and set their curricula – is directed by the Ministry of Higher Education and Scientific Research and other governmental bodies. The OECD's 2010 report on higher education in Egypt maintains that Egyptian law "places severe limitations on public universities regarding employment, promotion, and dismissal of academic staff"[103]. All of this makes it hard to implement a real culture of innovation.

The revolution heralded the end of the constant meddling by the regime's security apparatus that on occasions resulted in researchers being denied a post on account of their political affiliation (or, according to some Coptic Christians, their faith). Mohamed Aboulghar, Professor of Obstetrics and Gynaecology at Cairo University and leader of the new Egyptian Social Democratic party, recalls that before January 25th the chances of anyone with a history of political activism or loyalties to a party other than the NDP winning a post were "almost zero". Abdel Gelil Mustafa, Professor of Medicine at Cairo University and Coordinator-General of the National Association for Change reform movement, agrees. "They didn't choose the best people for these academic responsibilities. They chose those who were obedient and loyal and very frequently they were unfit scientifically."

Today campuses are largely free from such meddling. "We already have more freedom and I am much more optimistic," says Aboulghar. "Inevitably there is some chaos now, but once there is stability and a new administration it should be possible to achieve more autonomy for universities." It is a hope that appears to be shared by many faculty members. As Aya Diab, Assistant Professor in engineering at Ain Shams University, puts it: "The dictatorship is still present in the education system. We need a revolutionary way of thinking here, to relieve ourselves of these stiff structures that slow decision-making, increase bureaucracy and prevent innovative ideas from surfacing."

103 Reviews of National Policies for Education: Higher Education in Egypt (OECD, 2010)

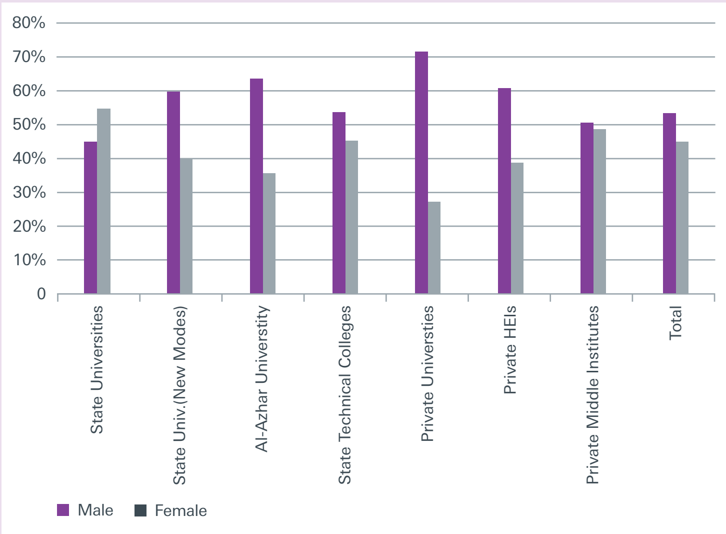
Box 5.1 Gender disparities in Egyptian science

"When a man is educated, an individual is educated; when a woman is educated, a family and a country are educated." Mahatma Gandhi

Women are significantly underrepresented in the scientific community in Egypt, and especially in leadership positions, despite progress in recent years. The country has female ministers – including the current minister of scientific research, judges, lawyers, researchers, doctors and scientists (including the leaders of three of Egypt's most promising research centres – see Section 4.4), yet the big picture is discouraging. For example, all but three of Egypt's 34 university presidents are men.

Access to education has much to do with this. While 55% of students at state universities are girls, this figure is significantly lower for private universities and other institutions (see Figure 5.2). Furthermore, more women than men drop out of higher education.

Figure 5.2. Enrolment by gender in different types of higher education institutes (2006/7)



Source: Country Background Report, Egyptian Ministry of Higher Education, 2008

Only 43.4% of women over 25 have had at least secondary education, compared with 61.1% of men[104]. As a result, adult literacy rates are far lower for women (58%) than for men (75%). However the picture is more encouraging for today's youth: 82% of women between 15 and 24 years old are literate, and 88% of men[105].

Cultural attitudes are another important reason why women are underrepresented in science (and in other areas). Men are widely seen as more suited to certain academic professions. As Aya Diab, assistant professor in engineering at Ain Shams University, puts it, some people believe that if a woman "grows up to be a scientist she will be the nerd".

At a roundtable discussion in May at the Bibliotheca Alexandrina on the future of research in Egypt, organized for this report, it became clear that some lab managers – female and male alike – prefer to hire men because they fear that women's commitments at home might limit their "passion" for their work and the hours they can spend in the lab. Mohammed Yahia of *Nature Middle East* suggested this might have to do with a "general understanding that a man's life is built around his career while a woman's life is built around her family, so she is very likely to leave her work if it conflicts with her personal life" – but, he added, such decision-making was very obviously biased against women.

Cultural attitudes and educational disadvantage have made it harder for women to enter the labour force in Egypt in all professional fields. In 2008, 24.4% of women had jobs, compared with 76.4% of men[106]. The picture is even more skewed among young people, according to a 2009 survey, which found that just 13.4% of 15 to 29-year-old women were in work, compared with 61.4% of men[107].

Gender disparities tend to be worse in Upper Egypt. Girls make up only 34% of students in the governorate of Assiut, for example, according to the OECD's 2010 report on higher education in Egypt[108]. In rural areas there is a marked gender gap in enrolment in education. The principal reason for this is economic pressure: families living in poverty force their children – and particularly their daughters – to leave school early to work and provide additional income.

Some non-governmental organizations have been working hard to change stereotypes and promote the importance of their role in society. As Figure 5.3 shows, there has been incremental progress in recent years in addressing gender disparities.

104 Human Development Report 2010, United Nations Development Programme

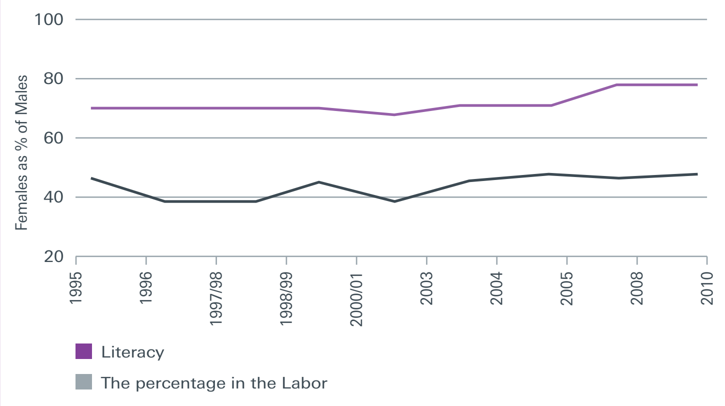
105 World Development Indicators 2010 (World Bank)

106 Human Development Report 2010, United Nations Development Programme

107 Survey of Young People in Egypt (Population Council, 2010)

108 Higher Education in Egypt (OECD, 2010)

Figure 5.3. The struggle to close the gap between men and women



Source: Handoussa 2010 *Egypt Human Development Report 2010*. UNDP and Institute of National Planning, Egypt

One area this is most evident is the increased participation of women in political life (see Table 5.1).

Table 5.1: Women in politics

Indicator	1999	2009
Political rights		
Women representation in Shura Council 1980-2007	3.3%	7.9%
Women representation in local councils	1.8%	5%
Women percentage as members in trade unions	32%	37%
Recruited women percentage senior management jobs	15.3	24.1

Source: CAPMAS

To counter the bias against female scientists, Egypt urgently needs more flexible learning programmes to allow women to study without having to sacrifice their other commitments, and a more flexible research environment to allow them to pursue their careers without fear of discrimination. This cannot be achieved without adequate support from the entire Egyptian society. More female role models would clearly help. One of those most often named as someone female science students might look up to is Sameera Moussa, the nuclear scientist who helped pioneer affordable nuclear technology for use in medicine who died in 1952.

Riham Khattab

6 Sustainability

Anyone interested in catching a glimpse of the future of agriculture in Egypt should take a trip to the desert town of South Tahrir, 150 kilometres northwest of Cairo. Here for the past three decades researchers from the American University in Cairo's Desert Development Center (DDC) have been helping Egypt's farmers build an alternative agricultural reality based not on traditional cereal crops but on fruit.

Desert Development Center

From the desert soil they have conjured some 575 acres of oranges, limes, mandarins, mangoes, peaches, grapefruit and other fruits, shielded by lines of tall Casuarina evergreens to protect them from the wind and watered by the Nile via a canal. It is an exercise in adaptive research: the fruit trees start off in large netted greenhouses where seedlings of different varieties are hand-grafted onto existing rootstock. The aim is to find appropriate rootstock and fruit combinations that work best in the desert conditions, the most successful of which the centre then sells on to small-scale farmers.

The strategy has had considerable success. More than 80% of Egypt's orange production comes from two cultivated varieties of Navel and Valencia oranges developed at the DDC station. With agriculture contributing around 14% to the country's GDP[109], it is the kind of agricultural innovation that is crucial to the country's economic development.

109 World Development Indicators, World Bank

6.1 Beyond self-sufficiency

Wheat is still Egypt's most important crop: the country produced 8.7 million tonnes in the 2011 harvest[110] and Egyptians are the highest per capita consumers in the world. But despite impressive gains in yield – to close to 10 tonnes per hectare in 2012[111] – the country produces only around 60% of the wheat it requires[112]. The aim of the previous administration was to raise this to 75%, but it had long abandoned the idea of self-sufficiency in food production (Egypt is now among the top importers of wheat in the world), striving instead for "self-reliance", whereby the country would grow enough cash crops for export to enable it to buy in the extra wheat it needs. The government has spoken of the need for Egypt to become self-sufficient at least in the wheat it grows for bread.

Many experts agree that with an expanding population, growing demands for water and the many threats posed by climate change, self-reliance is the best course for Egypt. "It is more achievable," says Fawzi Karajeh of the International Center for Agricultural Research in the Dry Areas (ICARDA). "It doesn't make sense to produce a kilogram of wheat for $1 when it is available in the international markets at 30 cents. The concern, of course, is what happens when there aren't resources available to buy, as happened two years ago."

Table 6.1: Changing agricultural patterns in Egypt 1960-2005

Item	1960/61		1970/71		1986/87		2005	
Food commodities	Per capita Kg/year	%	Per capita Kg/year	%	Per capita Kg/year	%	Per capita Kg/year	%
Creals & starchy Group	202.3	44.1	279.0	49.1	330.8	45.0	309.0	39.3
Legume group	10.9	2.4	9.5	1.7	7.4	1.0	9.8	1.2
Oil crops and vegetable oils	5.1	1.1	5.3	0.9	12.0	1.6	22.4	2.8
Sugary crops	11.4	2.5	7.0	1.2	32.8	4.5	39.5	5.0
Fruit & nut group	37.9	8.4	53.3	9.4	78.0	10.6	106.9	13.6
Vegetable group	129.7	28.2	146.3	25.8	199.0	27.1	168.9	21.5
Group of animal protein and fish products	61.4	13.4	67.4	11.9	75.3	10.2	130.5	16.6
Total	458.9	100	567.8	100	735.3	100	787.0	100

Source: Ministry of Agriculture and Land Reclamation / CAPMAS

110 Data from USDA Foreign Agricultural Service at www.fas.usda.gov/psdonline

111 USDA Foreign Agricultural Service at www.fas.usda.gov/psdonline and UN Food and Agriculture Organisation Statistical Yearbook 2012

112 Data from ICARDA, ARDF and other sources

6.2 Egypt's agricultural master plan

Egypt's basic challenge in agriculture in the coming decades is to improve yields on the roughly 3% of the country's land area that is naturally suited to productive farming and to make better use of the 97% that is less so, including converting some of it into farmland.

To decide how best to do that, the government's Agricultural Research and Development Council (ARDC) commissioned 70 Egyptian experts in 2009 to plot the country's sustainable agricultural development strategy to 2030, in consultation with the World Bank, the UN Food and Agricultural Organization and the International Fund for Agricultural Development[113]. The aim is two-fold: to achieve food security, and to improve the livelihoods of rural people, a crucial aspect of agricultural policy-making in a country where more than half the people depend on farming, and where the vast majority of farms are smallholdings.

Key objectives of the sustainability plan include raising the efficiency of irrigation systems across 7 million out of Egypt's 8.6 million acres of agricultural land, both in the Nile Valley, where 50% of irrigation water is lost to evaporation and other wastage, and in newly reclaimed desert areas; preventing the degradation of agricultural lands; creating job opportunities and bolstering support for small rural industries; increasing the production of milk, poultry and marine fish; using biotechnology to develop crops that can tolerate salinity, drought and heat; promoting water-efficient semi-arid crops such as olives, figs, dates and pomegranates; developing strategies to tackle the effects of climate change on yields; and expanding the area of desert land under cultivation, in particular for fruit and vegetable cash crops.

6.3 Research is the key

To achieve these objectives, agricultural R&D has been made a top spending priority. "Intensifying our agriculture has to be done in a sustainable way, otherwise we will destroy the natural resources we depend on such as the soil and water," says Adel El-Beltagy, Chairman of the ARDC. Research and innovation is very important for that." The person largely responsible for directing how Egypt's agricultural research funds are dispensed is Magdy Madkour, Chairman of the technical committee of the Agricultural Research for Development Fund (ARDF), which is worth LE1 billion and distributes loans to farmers as well as LE40 million a year in research grants.

The ARDF works in a similar way to the STDF: researchers compete for funds by submitting proposals in areas that will contribute to the agricultural development of Egypt. Typical projects might include the genetic engineering of crops that can endure drought, salinity and fluctuating temperatures, an assessment of the effects

113 Sustainable Agricultural Development Strategy Towards 2030, Ministry of Agriculture and Land Reclamation, Agricultural Research and Development Council, 2009

of pesticide use on reclaimed land, and a search for alternative sources of animal protein to cattle, which are grain-intensive and expensive. "The funds are designed for research that can be applied, that farmers can make use of," says Madkour.

The use of new technologies to improve productivity has been led by the government's Agricultural Research Center (ARC). The ARC is also responsible for providing extension services to ensure that new technologies are transferred to the farming community and properly adopted. This is done through 7000 special advisers, all of whom are specialists in their particular field, for example in citrus or mango horticulture, or wheat agriculture, or the management of large ruminants. "Extension and advisory services are the link between research and the end user," says Atef Swelam of ICARDA. "They are extremely important since any technique developed through research is worthless if it is not used by farmers on their own holdings."

Non-state organisations are playing an important role in rolling out new agricultural technologies. ICARDA, which is based in Aleppo, Syria, with a regional office for the Nile basin and sub-Saharan Africa in Cairo, is running several projects of direct relevance to Egypt. These include the development of high-yielding varieties of wheat (Misr-1 and Misr-2) that produce 9 tonnes per hectare compared with the 6.5 t/ha of local varieties – the use of these varieties is one of the main reasons for the bumper harvest in 2011; the identification of wheat strains resistant to Ug99, a virulent wind-borne stem rust fungus that emerged in Uganda in 1999 and has spread to the Arabian Peninsula and west Asia; the promotion of raised bed and furrow irrigation techniques, which channel water to the plants via capillary action and thus reduce water consumption by 30% with no loss of yield; and a 25% improvement in the efficiency of fertiliser use, which has increased farmers' income by 20%.

6.4 Turning desert into farmland

Over the last 30 years, Egypt has reclaimed some 2.8 million acres of desert land for agricultural development. The ARDC's target is to reclaim another million acres by 2017, and up to two million acres by 2030. For two decades, the government has been enticing graduates to start new farms in arid areas, offering low prices (and a long pay-back period) for a house and five acres and modern irrigation system, with the proviso that they cannot sell the land for 30 years – though to encourage potential farmers to get agricultural qualifications this scheme is now open only to those with degrees in agriculture. In 2011 the Egyptian and Sudanese governments announced a land reclamation agreement that could soon give Egyptian graduates and private companies the option of reclaiming and farming desert land in Sudan.

6.5 The desert development corridor

In April 2011, Prime Minister Essam Sharaf gave a tentative green light to a controversial $23.7 billion north-south “corridor of development” west of the Nile linking the Sudanese border to the Mediterranean coast, which would make it easier to export agricultural goods from the south of Egypt to Europe (see Figure 6.1).

Figure 6.1. Map of desert development corridor

Source: Professor Farouk El-Baz, Centre for Remote Sensing, Boston University

The scheme was proposed more than two decades ago by Farouk El-Baz, Director of the Center for Remote Sensing at Boston University, and is the subject of heated debate between geologists, urban planners, engineers and others. It would involve building a superhighway and railway through the desert, with 12 highways running east-west linking the corridor to the population centres of the Nile Valley. El-Baz maintains it would open up new land for urban development and agriculture, as well as boosting tourism and trade and creating hundreds of thousands of jobs.

"Every year Egypt is losing 30,000 acres of agricultural land to urban growth," he says. "If we continue at the same pace, all the fertile land in the Nile Valley and Delta will disappear in 183 years. We urgently need to stop urban growth on agricultural land, but you cannot do that unless you offer people some additional land somewhere."

Drinking water for new urban centres would be piped in from the Nile, and water for agriculture would come from aquifers beneath the corridor that El-Baz says are constantly fed by Nile water that seeps through the underlying soil and rock. "This is a sustainable source, so long as the Nile runs." It is unclear how the scheme would be funded, though El-Baz has suggested that all costs could be met by the Egyptian people and by the private sector through a public share offer[114].

6.6 Water – will there ever be enough?

Desert reclamation projects face considerable challenges since, as the DDC's Director Richard Tutwiler puts it, "you have to bring in pretty much everything". Most of all they depend on the availability of water – perhaps the defining issue in Egypt's future agricultural and sustainable development. Mostafa Tolba, former Executive Director of the UN Environment Programme, describes water scarcity as "one of the most significant challenges" to all Arab countries (see Table 6.2)[115]. The issue is particularly acute in Egypt because 95% of its water comes from the Nile, from which it extracts 55.5 billion cubic metres a year in line with historical agreements that grant Egypt and Sudan the right to the entire flow – a situation now being challenged by Uganda, Ethiopia and other upstream states. The remaining 5% is supplied by deep aquifers and rainfall.

Table 6.2: Precipitation in Arab countries, annual average per capita

Country	Precipitation in cubic metres per capita	Country	Precipitation in cubic metres per capita	Country	Precipitation in cubic metres per capita
Mauritania	31,099.60	Saudi Arabia	5,355.00	Lebanon	1,701.50
Sudan	27,678.10	Morocco	4,918.60	United Arab Emirates	1,536.80
Somalia	21,322.30	Yemen	4,064.40	Qatar	987.4
Libya	16,311.60	Tunisia	3,554.50	Kuwait	830.9
Oman	10,446.40	Comoros	3,259.40	Egypt	693
Algeria	6,341.60	Syria	2,406.30	Bahrain	79.8
Djibouti	6,230.80	Jordan	1,793.00		

Source: United Nations Development Programme 2009 *Arab human development report 2009*

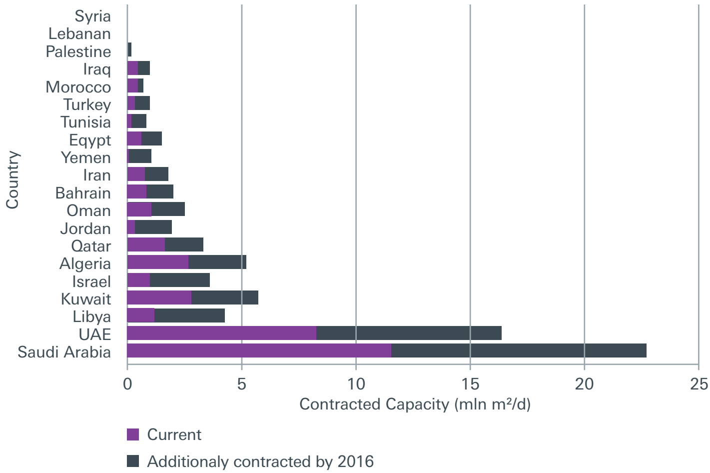
114 http://faroukelbaz.com

115 Mostafa Tolba writing in the Arab Human Development Report 2009, p 34 (UNDP)

Annual water use in Egypt exceeds availability by some 20 billion cubic metres, the difference being made up by large-scale recycling of agricultural drainage (up to 5 billion cubic metres a year, which is mixed with freshwater before being reused); abstraction of water from shallow Nile-fed aquifers; and treatment of municipal sewage. Agriculture is by far the biggest consumer, accounting for around 80% of supplies[116].

How can Egypt meet the water needs of its growing population and irrigate its new agricultural lands when it is already close to the limit of what it can supply and faces acute pollution problems from over-extraction and industrial development? The government's National Water Resources Plan 2017[117], which lays out how Egypt aims to manage its supplies for the future, focuses strongly on how the country could make better use of existing resources, but it also considers ways to generate new supplies, such as desalination (capacity is due to rise from 650,000 to over 1.5 million cubic metres a day by 2016[118]), rainwater harvesting and the greater use of deep aquifers in the western desert (see Figure 6.2).

Figure 6.2. Desalination capacity in Middle East and North African countries



Source: Global Water Intelligence 2009 *Water Market Middle East 2010*

116 Second National Communication of Egypt to the UN Framework Convention on Climate Change, May 2010

117 Water for the Future: National Water Resources Plan 2017, Ministry of Water Resources and Irrigation, 2005

118 Desalination Markets 2010, Global Water Intelligence

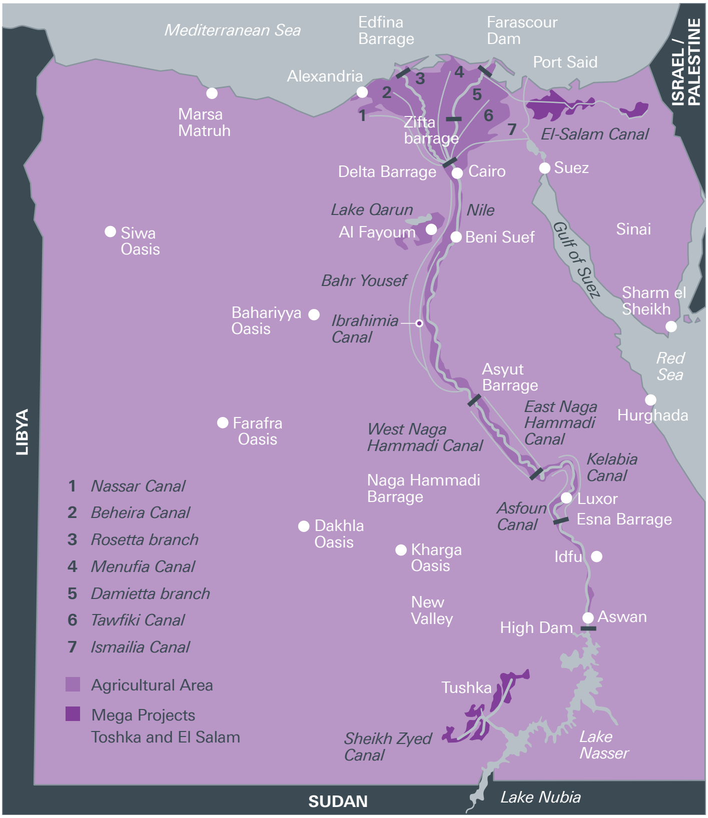
El-Baz, who has used space-borne radar to trace ancient water channels in the Sahara, believes there are "plentiful" reserves of groundwater beneath Egypt's deserts, pointing out that resources found in the East Uweinat region in the southwest are sufficient to support agriculture on 150,000 acres for at least 100 years[119]. Understandably, the government is nervous about relying on non-renewable sources of water and has started taking drastic measures to reduce consumption, such as banning the production of water-intensive crops like rice in certain areas – though as Tutwiler points out, growing rice in the Nile Delta make some sense, since the high water levels from irrigation help prevent seawater from pushing inland. It has also begun a collaboration with the Australian government and ICARDA to develop, test and promote water-efficient agricultural technologies in the Nile Delta and in newly reclaimed lands.

The rising salt water table in the delta is a major concern. Experts believe it has several causes: over-extraction upstream resulting in a reduced flow of water into the delta, reduced flow of sediments downstream of the Aswan High Dam, causing the delta to sink[120], and sea level rise due to climate change.

119 From author interview and in "Remote Sensing: Generating Knowledge about Groundwater" by Farouk El-Baz, in Water: Sustainable Management of a Scarce Resource, Arab Forum for Environment and Development, 2010

120 See Science, vol 327, p 1444 (19 March 2010), DOI: 10.1126/science.327.5972.1444

Figure 6.3. Map of Egypt's water resources



Source: Water for the Future – Egypt National Resources Water Plan 2017 (Ministry of Water Resources and Irrigation)

Box 6.1 Turning desert sand into fertile soil

One of the most progressive agricultural research programmes in Egypt is run by SEKEM, a sustainable development and educational initiative that encourages low-impact, self-sustaining biodynamic agricultural methods through its network of hundreds of farmers. "Organic farming presents hundreds of challenges: how to preserve genetic resources, turn desert into fertile soil, develop seeds, achieve the highest fertility, manage pests," says SEKEM's founder Ibrahim Abouleish, who has been pursuing his holistic vision for Egypt since 1977 and with his company was awarded a Right Livelihood Award in 2003, known as the "alternative Nobel Prize". Scientists at SEKEM's Heliopolis Academy are exploring how best to manage soil, rotate crops and control pests sustainably under particular conditions, as well as adapting new plant varieties to Egypt's arid environment and conserving and domesticating wild medicinal and aromatic species. "There is no sustainable development without research," says Abouleish.

Visitors to SEKEM's farm in the desert 60 kilometres northeast of Cairo, where fields of organic clover, fruits, vegetables, herbs, spices and cotton thrive on what used to be arid scrubland, quickly get a sense of the huge efforts involved in transforming desert into arable land – a key ingredient in the Government's national agricultural strategy. Heaped piles of compost of myriad hues and levels of maturity stretch across the fields outside the farm's soil and microbiology lab. This is the raw material that desert farms are founded on: some 10 tonnes of compost must be added to each acre of sand over the first year, and decreasing amounts thereafter, to keep it sufficiently fertile for crops. In the lab, manager Ramy Ramadan explains how cow manure and rice straw are converted to soil using wind, worms and even oxygen to hasten the work of bacteria that break down the organic waste into a humus rich in nitrogen, potassium, zinc, iron, boron and other nutrients. Under the African sun the process takes just six to eight weeks; it can take twice as long in northern Europe. At SEKEM they make 3000 tonnes of compost every three months.

6.7 The effect of climate change on productivity

Sea level rise is one of many serious threats that Egypt faces from climate change, a prospect that makes the country's need for sustainable development all the more urgent. The most recent study from the UN Intergovernmental Panel on Climate Change predicts an increase in global temperatures of between 1.8 °C and 4.0 °C by the year 2100[121]. While there is no model specifically for Egypt, climate experts suggest minimum temperatures will rise by up to 0.1 °C a year in the south of the country in coming decades[122].

This is likely to have a significant effect on livestock productivity and on crop yields. Yields of wheat and maize, two of Egypt's most important crops, could fall by 15% and 19% respectively by 2050, according to the latest report by the Egyptian Environmental Affairs Agency to the UN Framework Convention on Climate Change (see Table 6.3)[123]. The losses are attributed to the harmful effects of higher temperatures, rising salinity, disease, pests and stress caused by lack of water – the water requirements of cereal crops in Egypt are expected to rise by between 6 and 16% by 2100.

Egyptians had a taste of what such a world might be like in 2010, when a fall in tomato yields – thought to be because of a temperature spike during the flowering season – caused prices to quadruple. Furthermore, the emergence of animal diseases such as rift valley fever and blue tongue disease are believed to be due to higher temperatures allowing the northwards spread of the mosquitoes and midges that carry them. As Mostafa Tolba states: "All available models point to a reduction in resources in Egypt." That goes for the entire region. A 2007 study predicted that the number of undernourished people in the Middle East and North Africa will increase by 50% by 2080 compared with 1990, and in sub-Saharan Africa by 200%[124].

121 IPCC Fourth Assessment Report: Climate Change 2007

122 Adaptation to Climate Change in the Nile Delta through Integrated Coastal Zone Management, UNDP / Egyptian Ministry of Water Resources and Irrigation / Coastal Research Institute / Egyptian Shore Protection Authority, 2009

123 Second National Communication of Egypt to the UN Framework Convention on Climate Change, May 2010

124 Francesco Tubiello and Gunter Fischer, *Technological Forecasting & Social Change,* vol 74, p 1030 (2007), doi:10.1016/j.techfore.2006.05.027

Table 6.3: Projected changes in crop production for some major crops in Egypt under climate change

Crop	Change %		Reference
	2050s	2100s	
Wheat	-15*	-36*	(Abou-Hadid, 2006)
Rice	-11		(Eid and El-Marsafawy, 2002)
Maize	-19		(Eid, El-Marsafawy, Ainer, El-Mowelhi, El-Kholi, 1997)
	-14	-20	(Hassanein and Medany, 2007)
Soybeans	-28		(Eid and El-Marsafawy, 2002)
Barley	-20		(Eid, El-Marsafawy, Ainer, El-Mowelhi, El-Kholi, 1997)
Cotton	+17*	+31**	(Eid, El-Marsafawy, Ainer, El-Mowelhi, El-Kholi, 1997)
Potato	-0.9 to -2.3	+0.2 to +2.3	(Medany and Hassanein, 2006)

* 2°C increase in temperature **4°C increase in temperature

Source: UNFCCC 2010

6.8 The front line of climate change

The effects of climate change will be felt most keenly in the low-lying Nile Delta. "The delta is one of the most vulnerable areas in the world to climate change and, along with the Bangladesh and Vietnam deltas, one where you are likely to see the heaviest impact," says Salah Soliman, Professor of Pesticide Chemistry and Toxicology at Alexandria University and Deputy Chairman of the National Agricultural Pesticides Committee. "The intrusion of salt water is already affecting soil salinity far to the south and is making much soil unsuitable for agriculture."

Since much of Egypt's prime agricultural land and infrastructure is concentrated in the delta and adjoining coastal region, sea level rise will have a critical impact on the entire economy. Studies indicate that a rise of 0.3 metres – in line with the IPCC's more conservative forecasts for 2100 – would flood large parts of Alexandria, displacing more than half a million inhabitants and causing billions of dollars of damage to infrastructure[125].

Ibrahim El-Shinnawy, Director of the Coastal Research Institute in Alexandria, has used measurements from tidal gauges from the last three decades to calculate the rate of sea level rise in different parts of the delta, estimating that without concerted mitigation efforts climate change could flood up to 11.75% of the area, some 2938 square kilometres[126]. A report published in 2010 by geologist Khaled

125 Adaptation to Climate Change in the Nile Delta, UNDP / Egyptian Ministry of Water Resources and Irrigation / Coastal Research Institute / Egyptian Shore Protection Authority, 2009

126 "Coastal Vulnerability to Climate Changes and Adaptation Assessment for Coastal Zones of Egypt" (2008) in support of the Second National Communication of Egypt to the UN Framework Convention on Climate Change

Ouda at Assiut University is even more pessimistic: based on topographical data taken from high resolution satellite images, it warns that 4000 square kilometres could be lost to the sea by the end of this century[127].

6.9 Adaptation and mitigation

What can Egypt do to offset or adapt to these dramatic changes? A science-based approach seems crucial. Agricultural researchers are already experimenting with alternative cropping patterns and sowing dates, and selected varieties of plants that are tolerant to heat, salinity and pests. For example, a simulation study published in 2006 showed that delaying the planting of wheat in the northern delta might alleviate the harmful impact of climate change on yields by 10%[128]. Changing practices might be supplemented by a system that gives farmers the most up-to-date information – for example, using mobile ICTs to inform farmers about the impact of rising temperatures on various crops or about best practice for cropping patterns, planting new cultivars or other innovations.

In coastal regions, the preservation and creation of wetlands and sand dunes should act as a buffer against the sea, says Shinnawy, who also recommends building a sea wall beside the road that runs along the northern coast as a second line of defence. Above all, maintains Tolba, any adaptation policies should be based on empirical studies carried out by multidisciplinary research teams with responsibility for solving specific issues.

6.10 Making the most of the sun and the wind

Egypt's geography may make it vulnerable to climate change, but it favours it in another way: the solar radiation in its western desert is among the highest in the world, making it a prime site for the production of solar energy. "In Europe a solar plant will use perhaps 15% of its capacity, in Egypt it will use 90%," says Salah Soliman at Alexandria University. The country has been slow to realise this potential, with just one plant in operation – a hybrid gas/solar station at Kuraymat 90 kilometres south of Cairo generating 20 megawatts of solar power and 120 megawatts of gas-generated power, which came on line in 2011. A bigger plant with 100 megawatts of solar capacity is planned for completion by 2017 at Kom Ombo near the Aswan High Dam. At the other end of the scale, the non-governmental group Solar CITIES has been installing small-scale solar hot-water heaters on rooftops in the Cairo suburb of Manshiet Nasser and training local residents how to construct them for themselves[129].

Egypt is blessed with another natural resource: wind, which along the Red Sea coast blows from the northwest at 9.5 metres a second almost constantly. "These conditions are optimum for producing energy," says Essam El-Rafey, former Dean of the University of Alexandria's Institute of Graduate Studies and Research. Egypt's

127 "Atlas of Risks of Climate Change on the Egyptian Coasts and Defensive Policies", Assiut University, 2010

128 "Assessments of impacts, adaptation and vulnerability to climate change in North Africa: food production and water resources", Abou-Hadid, A. F., report submitted to Assessments of Impacts and Adaptations to Climate Change, Washington DC, 2006

129 For more information on Solar CITIES see http://solarcities.blogspot.com

wind capacity currently stands at 550 MW, though a new $796 million wind power development project financed by the World Bank, the European Investment Bank, the German development bank KfW and other donors to build up infrastructure and develop business models should raise that to 7200 MW by 2022.

All this will nudge Egypt towards its objective of providing 20% of electricity from renewable sources by 2020 – though most experts consider this target over-ambitious. The biggest problem is the considerable capital expenditure required for new plants: the planned solar power station near the Aswan High Dam will cost in the region of $700 million.

It would be considerably cheaper if Egypt produced its own photovoltaic cells, an option that seems reasonable in the future given the number of nanotechnology research teams working in this field (see Places chapter). Researchers are hoping such innovation will get an added boost with the establishment of a centre of excellence in solar energy, an idea being promoted by Zakya Kafafi, Director of the US National Science Foundation's materials research division. What's needed above all is private investment. The Egyptian government has been finalising a draft law designed to encourage private companies to enter the renewables market. It is due to come into effect in 2012 and offers incentives such as feed-in tariffs and guaranteed access to the grid, customs exemptions on equipment for renewable plants, and the free use of land for renewable projects for 99 years. Such incentives seem crucial, since there is little chance of Egypt making the 20/2020 target without the private sector on board.

6.11 Public apathy

While the government appears to be taking climate change seriously, Egypt is a long way from being prepared. A major reason for this is the worrying lack of public appreciation of the seriousness of the threat. "I have the feeling that the man in the street knows nothing about climate change," says Tolba. "The only way to change that is to have a really strong awareness campaign. We need to address people through songs or films, not just serious newspapers."

So far, public awareness campaigns have been relatively low-key. The Ministry of Education has been running training courses for teachers on how to simplify the climate change message for children. Several newspapers publish regular environmental features. Various NGOs are attempting to get the message across through education. For example, sustainability is a core part of the curriculum at SEKEM's kindergarten, primary, secondary and technical schools, and at the innovative Wadi Environmental Science Centre off the Alexandria-Cairo desert road, which runs field-based courses for children from public and private schools. Bibliotheca Alexandrina has several initiatives aimed at raising environmental awareness, such as the Youth for Environmental Sustainability and Better

Understanding programme (YESBU) for 13 to 17-year-olds, attended by more than 8000 students since it began in 2002[130]. The Bibliotheca is also a partner in the Educamp project, funded by the EU's TEMPUS programme, which promotes sustainable development in Egyptian society by targeting university professors, undergraduate students, schoolteachers and children[131].

Such programmes and initiatives set an encouraging precedent, but they will need to be replicated many times across Egypt. The country is as vulnerable to the effects of climate change as any in the world – unfairly, given its disproportionately low per-capita contribution to human-induced global warming. Coping with the consequences will require action from all sectors of society.

Box 6.2 Where Bedouin fear to tread

In Egypt's beautiful northwest Mediterranean coastal zone between Alexandria and Mersa Matruh, the country is struggling with a legacy of the Second World War that not only continues to threaten lives but is also holding back its agricultural development. Some 17 million landmines left by German and Allied forces after the Battle of El-Alamein in 1942 lie scattered over several hundred square kilometres of potentially highly fertile land. Anyone planting a foot on it risks having it blown off, a fate that has befallen several hundred Bedouin over the decades. "This is the only area in Egypt where it is worthwhile and cost-effective to grow wheat, where it could be watered by rainfall rather than expensive irrigation schemes," points out Magdy Madkour of Egypt's Agricultural Research for Development Fund.

The Egyptian army has cleared small areas, but appeals to the British, Italian and German governments for assistance have largely been ignored. The UK government argues that it directs help for mine clearance only to countries that have signed the Ottawa Treaty that prohibits the use and production of land mines, which Egypt has so far refused to do. "This region was part of the cereal basket of Europe in Roman times," says Madkour. "It has some of the highest precipitation rates in Egypt. There are huge areas that could be cultivated, but nobody dares, it is too risky." As Farouk El-Baz points out, the Alamein area will also be crucial to the proposed desert development corridor linking Sudan with the Mediterranean (see section 6.5), since it is the ideal location for a badly needed new port that would be the principal gateway for all products leaving and entering Africa via the Mediterranean.

130 http://www.yesbu.org

131 http://www.educamp.eu

7 Collaboration

The Egypt-Japan University of Science and Technology (E-JUST), established in May 2009 in Borg El-Arab City near Alexandria, is considered a model of international cooperation in education and industry-orientated research. It is a product of 150 years of partnership between the two countries that has seen 2000 Egyptian students obtain degrees from Japanese universities over the past 50 years. Its founders believe it will bring Japanese expertise in engineering and innovation to the entire Middle East and North African region.

That assessment rings true, but for E-JUST's President Ahmed Khairy the experience of setting up the institute was at times as painful as it was satisfying. "The Japanese have a very different way of thinking to us," he says. "It was very difficult to start with. Over the course of a year they sent about five delegations, asking all kinds of detailed questions, like what kind of paint we should use in the rooms and what dimensions the labs should be. I nearly quit twice because I didn't think they could be serious, asking these kinds of questions." Some months later they told him it was all part of a strategy to test his patience. We cannot be involved in a partnership with people who cannot understand our way of repeated and persistent work, they said. "They look at things from different levels, from the macroscopic to the minute details," says Khairy. "This is a positive thing they have brought to the project."

7.1 University for the national good

Since it opened, E-JUST has been based in temporary premises in the City of Scientific Research and Technology Applications (its new campus should be complete in 2012). It is already running courses for PhD and masters students in seven multidisciplinary engineering-based disciplines: electronics and communications, mechatronics and robotics, energy and environment, computer science, industrial and manufacturing, chemicals and petrochemicals and materials science. Japan is supplying equipment, technical help and 35% of the staff, and has a strong influence over the educational approach, which is geared towards lab-based learning, problem solving and teamwork. All programmes are aimed at meeting industrial and societal needs, and Khairy has insisted that a certain proportion of students are from science faculties "to break down the culture of engineers working only with each other".

The university is unique in Egypt in another way: it is a partnership between two governments, rather than two institutions, and is subject to a special legal status that has enabled it to bypass much of the regulation that previously has weighed down novel academic enterprises in Egypt. This says much about the value its founders place on bi-lateral collaboration: they consider it too crucial to risk having it undermined by bureaucracy.

Most Egyptian academics would concur. For Ismail Serageldin, director of the Bibliotheca Alexandrina, intensifying research collaborations with the west is one of the best ways Egypt can accelerate its development. Yasser El-Shayeb, who coordinates Egypt's involvement in the EU's TEMPUS programme that promotes the modernisation of higher education in EU-neighbouring countries, says accessing the academic networks that collaborative ventures bring is "a good way to acquire quality – to know what others are doing". The TEMPUS programme sponsors joint projects that are based around consortia of six universities, three from Egypt and three from the EU. In 2010, seven Egyptian universities – Cairo, Alexandria, Ain Shams, Zagazig, Helwan, Suez Canal and Fayoum – participated in TEMPUS projects, with funding worth some 4.2 million Euros. Building links through consortia, says El-Shayeb, allows the institutions to develop new curricula and teaching methods, improve the way they are governed and enhance their contribution to society[132].

7.2 Egypt's landscape of collaboration

Egypt's main collaborative partner country is the US, which is the case for almost every Middle Eastern country (see section 7.4). Regionally its most important partner is Saudi Arabia, which collaborates more with Egypt than with any other country (see Table 7.1). This is partly to do with the large number of Egyptian researchers working in Saudi Arabian institutions. Indeed Egypt is a leading supplier of human capital to Arab nations.

132 For more on the EU's TEMPUS programme see http://www.tempus-egypt.com

Table 7.1: Egypt's top 20 collaborating nations (co-authored publications, 2008)

United States	1692	Italy	244	Austria	145
Saudi Arabia	1095	United Arab Emirates	208	Belgium	140
Germany	996	China	195	India	135
Japan	703	Spain	195	Switzerland	135
United Kingdom	687	Netherlands	194	Sweden	110
Canada	432	Korea, Republic of	185	Turkey	98
France	274	Kuwait	175		

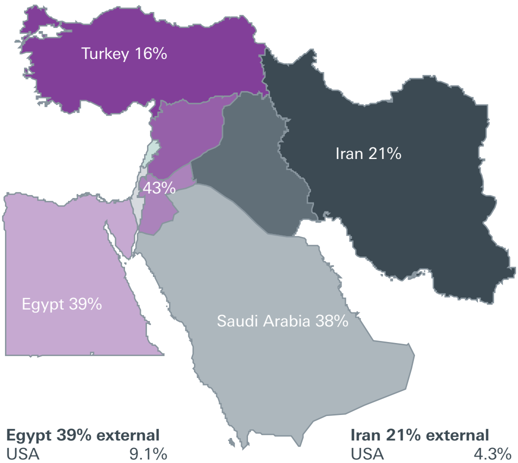
Source: Data provided by Elsevier

Egypt plays a critical linking role in the Middle East and North Africa region, co-authoring on average 10 papers a year with UAE, Kuwait, Lebanon, Qatar, Jordan, Oman and Libya[133]. It is also a partner in SESAME, the international synchrotron light source in the Middle East, based in Jordan and managed under the auspices of UNESCO; a founding member and sponsor of the Regional Centre for Renewable Energy and Energy Efficiency in Cairo, which acts as a platform for regional discussions about policy and technological issues; and host of the new Singhor University, which aims to help development in 22 French-speaking African countries by offering potential policy-makers masters degrees in management, culture, public health and the environment.

Further afield, and aside from the US, Egypt's other main research partners are Japan and the EU countries, particularly Germany and the UK. Since 2007, Egypt has tripled the number of grants it wins each year from the EU's FP7 research funding scheme, and its success rate at getting proposals accepted has increased from 6 to 18%, largely because of the expertise gained from partnerships with scientists in Germany, Italy and France over the past four years (see section 7.3 below). Meanwhile, in July 2011 the Egyptian government began a collaboration with the Australian government and ICARDA to develop technologies to increase water productivity in Egyptian agricultural lands (see section 6.6).

133 Data provided by Elsevier

Figure 7.1. Collaborative research in the Middle East
Top collaborating partners for the five most prolific research publishing nations in the Arabian, Persian & Turkish Middle East. Colour intensity reflects research output volume, with deeper colours corresponding to greater output. The numbers in each country refer to the percentage of national output that has an International co-author. Note that the figure of 43%, near the centre of the map, refers to Jordan (table at top of map).



Turkey 16% external	
USA	6.5%
Germany	2.0%
UK	2.0%
Italy	1.0%
France	1.0%

Jordan 43% external	
USA	14.2%
Germany	7.0%
UK	5.5%
UAE	2.8%
Canada	2.7%

Egypt 39% external	
USA	9.1%
Saudi Arabia	5.9%
Germany	4.9%
UK	3.9%
Japan	3.5%

Iran 21% external	
USA	4.3%
UK	3.3%
Canada	3.1%
Germany	1.7%
Australia	1.6%

Saudi Arabia 38% external	
Egypt	12.8%
USA	9.2%
UK	5.4%
Canada	3.1%
Germany	2.3%

Source: Adams et al 2011 *Global Research Report Middle East*. Thomson Reuters

7.3 Decade of Science

Egypt's collaborative research with developed countries received a significant boost in 2007 with the launch of the government's Decade of Science initiative, which will see Egypt build a research partnership with a different country every year until 2016. It began with Germany, followed by Japan (2008), Italy (2009), France (2010), the US (2011), China (2012) and Australia (2013). The US is the partner for 2011. "The idea is to benefit from each country's experience, to build viable networks and establish links," says Maged Al-Sherbiny, President of the Academy of Scientific Research and Technology, which is helping coordinate the bilateral programmes.

The Decade of Science has already proved productive. Germany, Italy and France are now Egypt's three most important partners in the EU's FP7 research funding programme as a direct result of collaborations established during their partnership years. The year with Germany resulted in a new bilateral grant scheme, the German Egyptian Research Fund, run jointly by the STDF and the International Bureau (IB) of the German Federal Ministry of Education and Research, for projects in agriculture, basic sciences, engineering, material sciences and medicine. The fund was worth 600,000 Euros in its first year, with the STDF and the IB paying half each. Due to the number and quality of proposals both sides have agreed to increase it to 2 million Euros a year.

There is also a new mobility programme, run by the German Academic Exchange Service in Cairo, to encourage partnerships and technology transfer between German and Egyptian scientists, and a jointly financed scholarship programme to give Egyptian graduate and postdoctoral students the opportunity to spend up to six months in Germany on research visits. Similar initiatives, joint funds and exchange programmes have been established with Japan (focusing on biotechnology, nanotechnology, medicine and ICT), Italy (renewable energy, physics, astronomy, engineering, architecture) and France (ICT, sustainable development, space and nuclear energy).

7.4 The US-Egypt special relationship

The 2011 programme with the US will strengthen cooperation that began decades ago, but which has been particularly productive since 1995 when the two governments established the US-Egypt Science and Technology Joint Fund for projects involving Egyptian and American scientists working together. Since 2007 the fund has been managed by the STDF, and in 2010 the two governments agreed to double its value to $8 million a year.

Other US-Egypt projects include a collaboration between the US Agency for International Development (USAID) and the Egyptian Ministry of Education to develop specialised secondary schools that focus on the teaching of science and maths; a series of "expertise-sharing" public lectures from 12 eminent American scientists including Ahmed Zewail, biotech pioneer Roger Beachy, astronaut Mae Jemison and technology entrepreneur Taher El-Gamal; summer science camps for students developed with the John Hopkins Center for Talented Youth; and the two-year $5 million Global Innovation Through Technology initiative in support of innovations based on sustainable technologies in Egypt and the broader region[134].

134 For more details see http://egypt.usembassy.gov/sy.html

7.5 Building partnerships for the future

As Al-Sherbiny points out, the fruits of international collaboration tend to grow over time, as academic partnerships develop and funding translates into viable projects. He points to a string of future bilateral developments, such as a German-Egyptian microelectronics research centre and a technology commercialisation programme proposed by the STDF that will build on a pilot project carried out with the IC2 Institute at the University of Texas[135].

In the Middle East and North Africa region, Egypt is well placed to lead in several areas in collaborative research, notably in renewable energy, nanotechnology, biotechnology, agriculture, water resources and pharmaceuticals. However, Al-Sherbiny says regional collaboration is being held back by the lack of a single comprehensive collaborative research funding mechanism along the lines of the EU's FP7 programme. "Currently Islamic countries work individually, but if we had something like the FP7, the picture would look very different. Islamic countries have common borders. Most of them speak the same language. They face the same problems with deserts, agriculture, scarcity of water, climate change and so on. Some of them have no energy resources, some of them have no water resources. They face common challenges. But there is no formal system for them to share expertise."

Further afield, Egypt is working with a United Nations Volunteer programme called Transfer of Knowledge Through Expatriate Nationals (TOKTEN), which allows expats with particular skills to return to their country of origin for short periods from two weeks to three months to lend their skills and expertise. This is hardly long enough to have an impact, so the Ministry of Scientific Research is negotiating with several countries to allow expatriate professors to return to Egypt for sabbaticals of up to two years.

7.6 Progress in figures

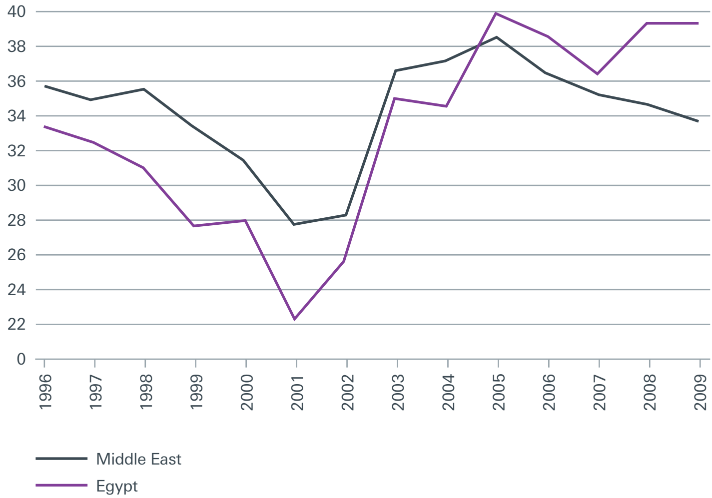
Egypt's progress in international collaboration is reflected in its scientific output over the last decade. The number of papers published by Egyptian scientists with international collaborators rose from 687 in 2001 (22.38% of the total output) to 2906 in 2009 (39.21% of total output), an increase of 266%, according to figures gathered from the SCOPUS database[136]. Since 2005, the share of Egypt's publications co-authored by an overseas researcher has been above average for Middle Eastern countries (see Figure 7.2)[137]. Only Jordan is more collaborative (see Figure 7.1).

135 See more on the IC2 Institute's programmes on entrepreneurial wealth creation at http://www.ic2.utexas.edu

136 Data from the SCImago Journal and Country Rank portal based on the SCOPUS database, www.scimagojr.com

137 Data from the SCImago Journal and Country Rank portal based on the SCOPUS database, www.scimagojr.com

Figure 7.2. **Percentage of publications with overseas researchers, Egypt v. Middle East**



Source: SCImago (2007) *SJR — SCImago Journal & Country Rank.* http://www.scimagojr.com

7.7 Future obstacles

Egypt's overall collaborative output should increase as the partnerships resulting from the Decade of Science take effect. However, there is a danger that Egypt's somewhat rigid higher education system could hold things back, particularly since bilateral academic arrangements demand flexibility.

One problem is that many Egyptian universities do not always fully recognise foreign degrees. For example, if a student completes a masters in engineering at a European university in five and a half years, when they return to Egypt – where a masters might take up to seven years – they are sometimes obliged to justify their foreign degree by studying the additional semesters. "We think this is absurd," says El-Shayeb, who is seeking to harmonise the system so that credits earned in a foreign university are accepted in Egypt without question. He is also trying to persuade more universities to establish joint degrees, which are fully recognised by the Egyptian and foreign institutions that award them. "With joint degrees everything is transparent. They also help reduce the gaps between Egyptian and other universities."

Another problem is that Egyptian institutions are sometimes wary of allowing their researchers to study abroad on temporary contracts for fear they won't come back.

Take the case of Mohamed Elmasry, now an Associate Professor and vice-dean of graduate studies at the Arab Academy for Science, Technology and Maritime Transport in Alexandria. Elmasry obtained his PhD on the structural monitoring of bridges – how they respond to moment-to-moment to vibrations caused by wind, traffic and other sources – at the University of South California (USC) while he was an assistant lecturer at the Academy, and later returned to USC for a short period on a research fellowship funded by the Bibliotheca Alexandrina's Center for Special Studies and Programs[138]. He was then offered a year-long postdoctoral position at USC – a move that would undoubtedly have benefited him – but was unable to accept it because the Academy wanted him to fulfil his teaching obligations. "They were itchy about why I would want to return to the US for another year, as if I might be abusing my job somehow. It was as if diplomacy had beaten research."

This highlights one of the major tasks of the new administration: to build up Egypt's research infrastructure so that scientists studying abroad have a good reason to return, and – just as important – so that university administrators have sufficient confidence in their capacity to draw them back to allow them the flexibility to make the most of any collaborative ventures that come their way.

There is also a message for the international community, especially Europe. "Now is a very good time to form research partnerships with Egypt," stresses Al-Sherbiny. "In 20 years Europe as an ageing society will require more young people. European countries will find qualities in Egyptian researchers that suit them. We are open and we understand the demands of others. We are very close across the Mediterranean. Europe will do better to seek research partners in Egypt than in totally different cultures such as China and India."

138 For further information about this fellowship scheme see http://www.bibalex.org/cssp/researchs/index.htm

8 Summary and recommendations

Egypt's revolution has presented a big opportunity to revive the country's STI system and put research and innovation at the forefront of economic and technological development. Overturning three decades of neglect will take time and commitment, and turning the tide will require substantial change at many levels – in schools, in the private sector, in universities and research centres, and in cultural and political attitudes.

However, new initiatives are already taking shape and the sense of optimism and hope is palpable. Many researchers have underlined the need for the new administration to catch the mood and act fast. Here we summarise the main strengths and weaknesses of Egypt's STI system, as uncovered by our analysis, and make some recommendations for change that could help accelerate the country's transition to a knowledge-based economy. As Maged Al-Sherbiny, President of the Egyptian Academy of Scientific Research and Technology, says: "We understand very well that there will never be development and progress in Egypt unless we are able to be internationally competitive in science."

8.1 Strengths

Human capital

Egypt has a large pool of researchers and science students that harbours great talent, as well as a powerful and active diaspora. Several Middle Eastern countries, notably Saudi Arabia, use significant numbers of Egyptian scientists and technicians in their universities and research centres. The best of the country's scientists can compete with any on the world stage.

Collaboration

Egypt plays a critical linking role in research in the Middle East and North Africa region. Egyptian researchers co-author on average 10 papers a year with collaborators in UAE, Kuwait, Lebanon, Qatar, Jordan, Oman and Libya. Further afield, new collaborative initiatives have led to significant research partnerships with Germany, Italy, France and Japan. The new Egypt-Japan University of Science and Technology (E-JUST) near Alexandria is considered a model of international cooperation in education and industry-orientated research.

Foreign investment

The UN Conference on Trade and Development's World Investment Report 2010 ranked Egypt first among North African countries in its ability to attract foreign direct investment, and in the Middle East its FDI is greater than all except Saudi Arabia's, Turkey's and Qatar's.

Information and communication technology (ICT)

The number of ICT companies in Egypt is increasing at a rate of around 13.5% per year. The country's fast-developing IT infrastructure and growing number of tech-savvy graduates have attracted a host of foreign companies, including Microsoft, Ericsson, Vodafone, Intel and IBM. Spending in this sector is expected to increase from $1.4 billion in 2010 to $2.6 billion by 2014, making it one of the fastest growing IT economies in the world.

Mathematics

This is another strength area on a global scale. Egypt exceeds the world average in citation impact for mathematics papers. Furthermore, Alexandria University came 147th in the Times Higher Education World Universities Rankings 2010 – the first time an Egyptian university had made the top 200 – largely on account of the quality of its research in mathematics and theoretical physics.

Natural resources

Egypt's geography makes it vulnerable to climate change, but it favours it in another way: the solar radiation in its western desert is among the highest in the world, making it a prime site for the production of solar energy. Egypt is blessed with another natural resource: wind, which along the Red Sea coast blows from the northwest at 9.5 metres a second almost constantly.

8.2 Weaknesses

Lack of research funding

Lack of money for research, and the scant pay of researchers, has been a constant struggle for scientists across Egypt. This is especially true for those in public universities who until recently had to rely almost exclusively on the government's meagre annual funding allocation. The various competitive grant initiatives introduced in 2007 have helped, and recently the government introduced several new proposals to increase funding and salaries. Raising the proportion of GDP spent on R&D from the current level of 0.4% to the 1% suggested by the Organisation of the Islamic Cooperation or the 2% suggested by the Egyptian Academy of Scientific Research and Technology will be critical for the country's economic development.

The education system is letting students down

Egypt's rapid population growth has proved an enormous challenge for its education system. Average class sizes are 44 in public primary schools, close to 40 in secondary schools, and the country also has fewer universities per head of population than just about any other country in the Middle East and North Africa. One of the commonest criticisms of school education is the standard of teaching, especially in the sciences. Students who study science are not taught to think like scientists – to question orthodoxy, to analyse critically. Instead, memorisation and rote learning dominate. All this could have serious implications for Egypt's future, since the degree to which a country's education system encourages critical thinking in part dictates its economic development.

Graduates need more business skills

One often-cited criticism of universities in Egypt is that they do not properly prepare their undergraduates for the jobs market, either because they offer an insufficient choice of subjects to cater to students' career preferences, or because large parts of the curricula are irrelevant to employers' needs. 41% of employers consider their young recruits poor at applying knowledge they acquired at school or university to the job in hand, according to a survey by the International Labour Organization. Another report found that education in entrepreneurship skills – such as understanding how ideas in the lab can translate into market opportunities – is among the worst anywhere.

Private enterprise has little faith in R&D as a business model

Out of Egypt's total investment in R&D, just 5% comes from non-governmental sources. This is among the lowest contributions anywhere. With the exception of the IT sector, investing in novel research or nascent technologies for long-term gain is simply not a priority for most businesses. A major reason appears to be a lack of trust and understanding between academia and industry that makes it almost impossible for them to serve each other's needs. Furthermore, too much university research is not geared to the needs of the community.

There is little public appetite for science

Public interest in science in general in Egypt appears to be low. The proportion of pupils majoring in science subjects in secondary school has more than halved over the last four decades. Furthermore, people do not generally see science as playing a pivotal role in development or in improving their livelihoods. This makes it harder for government to justify spending large amounts of public money on research.

The rigid academic culture holds back creativity and innovation

Egypt's higher education regulations make it difficult for academics to move between universities. This ensures a deeply hierarchical system in which it is difficult for younger people to question their superiors, since they will be their superiors for life, and in which promotion is determined largely by seniority rather than, say, success at obtaining patents. The deleterious effects of this and other aspects of the rigid academic culture are apparent in the lack of cross-fertilisation not only between universities, but also between different faculties at the same university. Faculties tend to work independently; interdisciplinary research is rare. Furthermore, women are significantly underrepresented in the scientific community in Egypt, and especially in leadership positions, despite progress in recent years.

8.3 Recommendations

National research policy

- Devise a mechanism that can help forge partnerships between academic institutions, research centres and the production sector so that research output more effectively meets the needs of the community and of industry.
- Ensure that research funding is used more efficiently and in line with national research priorities. Too often research institutes duplicate work that has previously been done by others. It is important that government identifies the research gaps before trying to fill them, so that research money is used optimally.
- With other partners in the Islamic world, Egypt should seek to build a comprehensive Islamic-world collaborative research funding mechanism, along the lines of the EU's FP7 programme, that could direct funding to research areas that are crucial to the whole region, such as water resources, renewable energy and agriculture.

Education

- Upgrade school and university curricula and teaching methodology to ensure they reflect the needs of the marketplace, with greater emphasis on problem-solving, critical thinking and communications skills. Revise science curricula to make them more interdisciplinary and to incorporate knowledge about new technologies.
- Increase the emphasis on vocational and technical education, whose critical role is too often downplayed or considered socially inferior to that of higher education.
- Introduce entrepreneurship courses into university degrees and vocational and technical training courses, and encourage more students at universities and research centres to start up their own businesses.

University research

- Dismantle the hierarchical academic culture that restricts the mobility of faculty members within and between universities and inhibits innovation. Discourage universities from solely hiring faculty members who were awarded their PhD by the same institution.
- Grant more autonomy to universities so that they become to a certain extent self-governing, allowing them greater administrative control and greater control over their academic programmes and curricula. Furthermore, encourage the establishment of a single administrative body within each university to supervise the management and operation of all research facilities and their use by researchers.
- Change the merit system by which university officials and faculty members are evaluated so that it takes account not only of published work but also of the extent to which they are involved with or funded by industry – so that building links with industry becomes integral to a researcher's role.
- Introduce flexible learning programmes in universities to enable women to study without having to sacrifice their other commitments, and a more flexible work environment in universities and research centres.

Business and industry

- Offer more incentives to encourage businesses to invest in R&D in areas that will benefit the country – for example, the government could provide matching funds, infrastructure or tax incentives. In addition, provide the right regulatory environment to encourage more venture capital and private equity funds to invest in young innovative enterprises.

Sustainable development

- As part of Egypt's climate change adaptation strategy, develop a system that gives farmers the most up-to-date information – for example, using mobile ICTs to inform farmers about the impact of rising temperatures on various crops or about best practice for cropping patterns, planting new cultivars or other innovations.
- Launch a national awareness campaign to preserve Egypt's water supplies, encouraging the efficient use of resources and their protection from pollution. This should become part of formal school and university education.

Appendix 1

List of individuals interviewed

Dr Wael Abdel-Aal, Tele-Med International

Dr Ghada Abdelhady, German University in Cairo

Professor Elsayed Abdel-Khalek, Vice President, Mansoura University

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Helmy Abouleish, Managing Director, SEKEM

Professor Ibrahim Abouleish, Founder, SEKEM

Professor Tarek Abou-Zekry, Consultant Architect/ Department of Architecture, Zagaziq University

Dr Alaa Adris, Chair of Scientific Research Committee, Misr El Kheir

Dr Hassan Ahmed, Knowledge Transfer and Innovation Centre, South Valley University

Dr Amr Al-Gashef, Junior Researcher, National Research Centre

Dr Mohamed Youssef Ali, Associate Professor, Geology, South Valley University

Carlo Alloni, president, Ericsson (Northeast Africa)

Dr Rehab Amin, National Institute of Laser Enhanced Science, Cairo University

Professor Maged Al-Sherbiny, President, Academy of Scientific Research and Technology

Dr Ramy Aziz, Faculty of Pharmacy, Cairo University

Dr Hassan Azzazy, Associate Dean, Graduate Studies and Research, American University in Cairo

Dr Ahmed Bahgat, Bahgat Group

Dr Hala Barakat, Deputy Director, Cultnat

Professor Mohamed Bayoumi, Vice-President, Postgraduate Studies, Assiut University

Dr Hoda Dahroug, Deputy Director, Egypt ICT Trust Fund

Dr Aya Diab, Faculty of Engineering, Ain Shams University

Dr Ali Douraghy, USAID

Dr Tarek El-Abaddy, Director, Microsoft Innovation Lab, Cairo

Nadia El-Awady, World Federation of Science Journalists

Professor Farouk El-Baz, Centre for Remote Sensing, Boston University

Dr Hussam El-Behiery, Military Research Center (Air Defence Forces)

Professor Adel El-Beltagy, Chairman of the Agricultural Research and Development Council

Dr Tamer El-Degheidy, Experimental Medical Research Center, Mansoura University

Dr Mohamed El-Fattah, City of Scientific Research and Technology Applications

Shereen El-Feki, Presenter and health and social welfare expert

Professor Yousry El-Gamal, Chairman of Board of Trustees, E-JUST (former Education Minister)

Professor Hassan El-Ghaffar, Professor of Clinical Pathology, Mansoura University

Dr Ahmed El-Gharably, Faculty of Agriculture, Assiut University

Yousry El-Ghitany, Entrepreneurs Business Forum

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Professor Hany El-Husseini, Science Faculty, Cairo University

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Dr Sherif El-Maged, Head, Civil Engineering Department, Helwan University

Dr Mohamed Elmasry, Arab Academy for Science, Technology and Maritime Transport

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Professor Mohammed El-Missiry, Professor of Physiology, Mansoura University

Professor Ahmed El-Moneim, Vice-Dean, Community and Environmental Development, Sohag University

Professor Essam El Rafey, former Dean, Institute of Graduate Studies, Alexandria University

Dr Amr Elsadr, Tele-Med International

Professor Mostafa El-Sayed, Biochemistry Faculty, Georgia Tech University, USA

Ahmed El-Serafy, KPMG Advisory

Professor Aly El-Shafei, Executive Director, Science & Technology Development Fund (STDF)

Sherif El Shamy, Esevier

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Dr Yasser El-Shayeb, TEMPUS-EGYPT

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Appendix 2

The Bibliotheca Alexandrina

The Bibliotheca Alexandrina (BA), or the new Library of Alexandria, is a revival of the concept of the ancient library of Alexandria of the third century BC. Inaugurated in October 2002, it was created as an Egyptian national project through cooperation between the Egyptian Government, United Nations Educational, Scientific and Cultural Organization (UNESCO) and United Nations Development Programme (UNDP) for the benefit of Egypt, the region and the world. The principal objective was to establish a comprehensive public research library, which the BA pursues by creating interlinked cultural programmes in four main areas: science and technology, humanities, art and culture and development, with special concern for environment and gender.

However the BA is more than a library. It contains a reading area with space for eight million books, an Internet Archive, seven specialised libraries and 133 study rooms. It also houses four museums, a planetarium, an Exploratorium, nine academic research centers, 15 permanent exhibitions of contemporary visual arts, personal collection and heritage collection, a conference centre, art galleries for temporary exhibitions, and the Culturama – a cultural panorama with over nine screens, the first ever patented nine-projector interactive system. Other facilities include the VISTA, an interactive virtual reality environment that allows researchers to transform two-dimensional data sets into 3-D simulations.

Since the beginning of 2004 BA's Center for Special Studies and Programs (CSSP) has been offering annual research grants for outstanding young Egyptian postdoctoral researchers below the age of 35 who have completed their PhD within the past 5 years, or are expecting to complete it within a year of submitting their application. This programme aims to support Egyptian R&D and to decrease the widening achievement gap between local scientists and their peers in developed countries. It seeks to provide funding while at the same time evading the bureaucracy usually faced by researchers in search of grants. Selection is based on research excellence and not seniority, thus ensuring equal opportunities for all applicants. The CSSP hopes to act as a focal point, creating and sustaining networks of international collaboration through its grants, which are designed to cover research in natural sciences, mathematics, pre-university education and IT.

Ismail Serageldin, the BA's director, says the Library aspires to be "the world's window on Egypt, Egypt's window on the world, a leading institution of the digital age and a vibrant center of dialogue and understanding", thus working towards one of the main aims of the ancient library to serve the knowledge-seekers of the world. The building's symbolic design, by the Norwegian architectural office Snohetta, reflects its broad mission: a state-of-the-art "intelligent" construction representing the rising sun, with the bridge signifying the horizon and the planetarium as the moon. A granite wall surrounds it carrying inscriptions of various languages and scripts.

The Bibliotheca Alexandrina

The BA has attracted its share of criticism. Many claim it is a white elephant impossible for modern Egypt to sustain, and served as little more than a vanity project for the former Egyptian government. Others argue that a developing country such as Egypt should spend its money on more basic needs. Yet its value to many Egyptians seemed clear during the revolution, when residents of Alexandria joined hands with BA staff to form a human chain to protect the library from potential vandals and looters.

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- Dr Atef Swelam, ICARDA
- Professor Magdi Yacoub FRS, Imperial College London

It is not often that a country is faced with the prospect of rebuilding from the ground up. Egypt's recent revolution – notwithstanding the many and inevitable challenges it presents – has ushered in an era of unprecedented hope and expectation. This report assesses the current state of Egypt's science, technology and innovation (STI) systems, their strengths and weaknesses, as well as the many ideas under consideration and programmes already in place for improving them. It is designed as an accessible guide for anyone interested in Egypt's future development at this vital time.

The research for this report was conducted as part of a multi-partner project entitled *The atlas of Islamic-world science and innovation*. Bringing together partners from across the Islamic world, Europe and North America, the aims of this project are to explore the changing landscape of science and innovation across a diverse selection of countries with large Muslim populations.

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