2013 ECOSOC Annual Ministerial Review

Regional preparatory meeting for Western Asia

"Science, Technology and Innovation for Sustainable Development"

BACKGROUND NOTE

26 November 2012, 1:00 – 5:15 p.m.
Hashemite Auditorium in the Royal Scientific Society

ESCWA Technology Centre
El Hassan Science City

Amman, Jordan

Donors:

Executive Summary:

For the 67th session of the United Nations General Assembly (2012), the UN Secretary General report on *Options for a facilitation mechanism that promotes the development, transfer and dissemination of clean and environmentally sound technologies* gives a global background on innovation and available knowledge: "Over the past 20 years, the number of people in the emerging global innovation cluster has more than doubled. Communication and interconnection in this increasingly urbanized cluster has reached levels unimaginable just a few decades ago. All of this should, in principle, put humanity in a much better position to find solutions to sustainable development challenges."

The 17 Arab countries of Western Asia and North Africa are not socially or economically homogeneous. They can be categorized into 4 different groups based on similar socio-economic profiles. In all 4 groups, the roles of Science, Technology and Innovation (STI) in each society are interdependent, and interconnected to the higher education and research systems. STI is also critical – both directly and indirectly – for delivering social stability, environmental sustainability, and economic growth.

The population of the WANA region is overwhelmingly young, more so than any other region in the world. Based on a recent ILO report, over 60% of educated youth in the region are in neither school nor work. The region is also host to a number of paradoxes: its vast energy sources concurrent with frequent power outages; educated emigrants moving abroad alongside a great demand for imported products and labour; islands rich in natural resources in the midst of a degraded oceanic ecosystem; and selectively booming oases dispersed in an economic desert. The capacity is huge for over 300 million people given the region's available natural resources, strategic geographical location, and authentic rooted culture. The potential to improve industrial and agricultural productivity through STI not only improves wages and the quality of life for local people but also contributes to more effective, sustainable stewardship of resources.

Much has been invested in education and related infrastructure in the region. Yet, the returns on these investments have not always yielded the necessary returns on issues including job creation, poverty reduction, international migration, political stability, security and sustainability.

In this background note for the regional meeting on "STI for sustainable development," the state and present role of scientific research and innovation in the local society and economy will be explored. In addition, several recommendations will be proposed for the public regimes of these countries in order to improve the return on this societal investment towards improving the quality of life for current and future generations in the region.

This background note is organized as follows:

1- Introduction: the role of STI for sustainable development in WANA region

1. Introduction

Research and analysis on knowledge production and innovation in the Arab World has grown exponentially in recent years, as quickly as scientific investigations themselves. Research has grown rapidly as never before, not only in those countries that had invested in science and technology after their independence, but also from "newcomers" in science, particularly from the Gulf countries. There has been, closely linked to this growth, a growing consciousness about the importance of knowledge in society.

There is still a great need for improving the quantity of research and innovation activities. The dynamic of research and innovation is not a simple response to national policies and national frontiers. Rather it is a dynamic that is based upon the social actors that are directly or indirectly involved in the development of scientific activities: individual researchers, research groups, research institutions, universities and high educational institutions, research communities, enterprises, and public policies enacted by governments and inter-governmental programmes.

Perhaps prematurely, many Arab countries have wanted to be called 'knowledge societies' and appear driven by the need to become '*knowledge economies,'* a title that became popular after the 1999 World Development Report . This became a policy objective along with, and sometimes in contradiction of, the building of national innovation systems.

Things are different for innovation than research, since not all innovation is research-based. There are still margins for influencing the production of knowledge. The differences are more related to the presence of an enabling social and economic environment for companies that wish to introduce novel products and processes into the market. Innovation is always the result of a combination of investments, organization and technology, and individual success does not necessarily translate directly into economic indicators for all the economy.

Finally, it is important to emphasize that for research, as for innovation, the growth of activities follows a cumulative path. This path-dependency is particularly important because new research and innovation activities will always depend upon former investments, and former experiences. And, this is true both for research-driven activities as well as for innovation and technology generally. All technologies are constructed on prior experience, and this progressive technological learning builds paths made up of accumulated practices.

Since the Second World War, science has been thought of as a *national endeavour*, and as an expression of national sovereignty. This has been expressed by building institutions that have a national scope of activity and are closely related to areas of state power. Academic disciplines, areas of technological investments, domains of interests and objects of research were seen through the national lens. The view of collaboration was also seen as an inter-governmental and inter-national activity. This went hand in hand with the creation of national plans for science and technology, and of drawing national priorities.

As globalization becomes an economic and political norm, the national orientation has been strategically under threat. Areas such as nanotechnology or biotechnology developed in emerging countries despite low investments in other areas. Investments in a specific discipline thus become visible at a global level, and disciplines tend to be defined more and more internationally. This global view of research has been, paradoxically, constructed at the same time as national innovation systems were proposed as the objective of innovation policies. Thus global research and locally-based innovation have become the norm.

Part of the issues involved in resolving the riddle of under-investment in research and innovation in the Arab World are related to strategic choices such as solar energy, desertification, water resources, use of non-conventional sources of energy, uses of nanotechnology in low tech environments, orphan and geographically-specific diseases, as well as management of local institutional forces anddecision-making systems. All of these reflect, *in fine,* political choices and no technocratic decisions will help resolve them.[1] But, it is clear that some of the issues relate to the *way knowledge is created, used, and disseminated in the region*, that are independent of the topics that are to be chosen.

Aim at creating a discussion that is now very much needed:

(1) The growing gap in knowledge production between a few Arab countries and the rest.

(2) Various issues related to human capacity and scientific capital.

(3) Some observations on the special role of universities.

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[1] A good overview of issues for future research can be drawn from the topics of the Barcelona Conference that was organized by the European Commission. 2-3 April 2012.

2. Indicators in the Arab science system

The sources here are not so numerous. Most of the statistical information has been compiled by UNESCO[2], and by the OECD[3] for member countries of the Organization. COMSTECH[4] countries have gathered data also and there are no common definitions for manpower, or financial indicators and statistics. All these organizations rely on reporting by public authorities. It is understandable that national authorities provide data at the national level. But in most countries, the State has not given special interest to science and technology as part of their statistical administration.

Data on research and innovation can be simply divided into:

- Input data on resources
- Output data on results of research and innovation
- Relational data, showing networks and collaborations.

Given fear on unreliable data, policy makers and (more importantly) investors prefer to rely on indicators that are drawn out of opinion polls. Usually this method, used for example by the Competitiveness report or the Knowledge Reports of INSEAD, relies on what is considered "knowledgeable informants," persons who by their professional position have a good view of the research and innovation activities. This somehow mitigates the risks of false data but no one can be considered to have a global view of the sector in his own experience. A second possibility, which has been used by the World Bank, is to rely on more general indicators and transform the variables either into rankings or into marks, which permits the creation of somewhat more robust although less detailed figures.

There are two sorts of reliable sources of output: publications and patents. But both of these databases depend upon the social and economic system. In the case of scientific publications, it is the complex world of publishing that combines the scientists and the publishers, sharing scientific and economic considerations; in the patenting system, it is the economic and policy system that are the main drivers. Both are not value-free and depend upon strategies and a social organization. Thus publications and patents do not only reflect performance but they also show acceptance of the produced outputs by the specific social system.

Nonetheless, bibliometric indicators (the statistical uses of publications) are still considered the most reliable source on scientific activities, mainly because it cannot be manipulated by national authorities.

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[2] See UNESCO Institute of Statistics (Montréal).www.uis.unesco.org.
[3] See OECD Directorate of Science, technology and innovation. www.oecd.org/sti/
[4] COMSTECH is a Ministerial Standing Committee on Scientific and Technological Cooperation established by the Third Summit Islamic of the Organization of Islamic Countries (OIC). comstech.org/

A factorial analysis

The message delivered by this first analysis is that size indicators, dynamic indicators, and innovation indicators allow for a typology of Arab countries. Thus next to "size" we saw the importance of the variable of co-authorship: international collaboration plays a very important role in the explanation, and is closely related to the more rapidly growing countries. Those possessing high levels of co-authorship (Morocco, Tunisia, Lebanon, Jordan) are also rapidly expanding countries. In very recent years, Egypt saw a renewal of its production after many years of relatively sluggish production.

There are four groups of Arab countries:

- Group I: Rather large research systems. Egypt, Morocco, Saudi Arabia and Algeria. Rather "rich" or comparatively large countries. Egypt is a case by itself, in this group (or any other) and its lack of natural resources (contrary to the other three) sets it apart. But the group is basically aggregating larger research systems, which also tend to certain inertia, growing rather slowly, consolidating their international collaborations.
- Group II: Small dynamic and integrated. Tunisia, Jordan and Lebanon: small and very dynamic research systems by all standards. These are the countries having the higher records in publications and growth of production. They are also small by any standard but have proportionally high figures of researchers, and of scientific production. Although they have low scores in innovation, these countries tend to have niches of innovative activities. Curiously, Tunisia is a very centralized science policy system, whereas Jordan and Lebanon are not. Had we had indicators to measure this centralization we would probably have had different results. But we know from recent work that Tunisia, Jordan, and Lebanon are engaged in an active pursuit of scientific research, and consolidate the evaluation systems inside their universities. Kuwait, which stands in between group I and II, could for analytical purposes be integrated in group II, because of its older strategy to support the university and research system.
- Group III. Very small and rapidly expanding. UAE, Bahrain and Qatar, very small and rich countries, with an active policy in developing technologies and universities, pursuing active "branding" strategies for their universities, and trying to make most out of their high-level resources.
- Group IV. All other countries. It is quite difficult to differentiate between them. They are rather small and less integrated research systems. Some universities seem to be developed but figures are low on many grounds. Iraq stands in this group since it still has not engaged in the reconstruction of its once well-known university system.

3. R&D and investment

Gross expenditure on research and development (GERD) has been low in Arab countries for almost four decades, and is lower than the world average at between 0.1% and 1.2% of gross domestic product (GDP). OECD countries devote about 2.2% of GDP to research and development (R&D). There are signs of change however.

As in the case of innovation, there is neither congruence between GERD and GDP nor GDP (per capita). The interest in research is indeed not linked to it in a simplistic, linear fashion. Some rich countries do not invest in the development of science. Much depends on the will and interest of the government, political system, and ambient values – especially in relation to religion, colonial history and international support. Many Arab scientists leave their countries, and therefore do not contribute to the GDP of their countries. However, the private sector also possesses part of the responsibility. For the most part, R&D centers in the region are relatively small, and generally focused on late-stage development, rather than "blue skies" research. (The Economist Intelligence Unit, 2011:4)

In brief, when we use the GERD as a measure of a state's scientific and technological advancement, the results for the Arab region are disappointing overall, despite the significant differences between countries. The annual share per Arab citizen of expenditure on scientific research does not exceed $10, compared to the Malaysian citizen's annual share of $33. Record levels are spent in small European countries such as Ireland and Finland, where annual expenditures on scientific research per capita reach $575 and $1,304 respectively. (UNDP, 2009:193)

4. Research Systems

Interest in S&T was kindled in the majority of Arab countries after the Second World War, when most gained their independence. Universities and research centers were founded principally by central governments from the 1960s onwards. National S&T policies would come much later. Jordan, for example, founded its main national university, the University of Jordan, in 1962 and its main industrial research centre, the Royal Scientific Society, in 1970, yet adopted a National Science and Technology Policy only in 1995. Saudi Arabia adopted its own national policy for S&T as recently as 2003 (Al-Athel, 2003). Today, many Arab countries still possess no national policies or strategies for S&T. However, they are in the process of taking this important first step. Where S&T policies do exist, they are either too ambitious or ambiguous. All Arab countries nevertheless have sectoral policies, such as those for agriculture, water resources, and the environment. (UNESCO, 2010: 255)

Table 1: General Descriptions of Research Systems in Various Arab Countries

Country	S&T Policy document	Permanent policy making bodies with national authority "Councils"	Ministry of S&T	Funding Agencies	Other Funding Mechanisms	Type of governance	GERD / GDP %
Algeria	**Yes**		**Yes**	ANRU,	PNR (Nat Progr of	Centralized	0,25 *

	(National Plan, 1998)		Min of state	ANRS, ANVRST	Res) + National Fund RTD + etc.		
Morocco	**Yes** (Vision 2006)		**No longer** (since 2004)	CNRST	Various Funds to support innovation: PTI, Incubators	Centralized	0,8 *
Tunisia	**Yes** (5th Plan & following Plans since 1977)		**Yes** Full Ministry	Nat Sc Res Foundation (since 1989) Et al.	Various Funds to support innovation: FRP, NPRI, PTI, Techparks	Centralized	1,0 *
Egypt	No	Formerly: Ac. Of Sc.	**Yes**	Several	Initiatives from various Ministries: Agri, Indus, Telecom, etc.	Centralized	0,2 **
Lebanon	**Yes** STIP (2006)		**NO**	CNRS Since 1962	Performers get contracts from all sorts of sponsors	De-centralized	0,22 *
Jordan	No	**Yes** HCST	**NO**	HCST since 1987	Performers get contracts from all sorts of sponsors	De-centralized	0,34 *
Syria	No	Just established(2007)	**NO**	No		De-centralized	0,12 **
Bahrain	_		**NO**	BCSR (acting as agency)		Trade oriented	0,04 **
Oman	_		**NO**	OCIPED Invest Promo 2002	Sponsors	Trade oriented	0,07 **
Emirates	_	Institutional research & strategic planning	**NO**		Sponsors	Trade oriented	0,2
Qatar	_		**NO**	Qatar Foundation	Sponsors	Trade oriented	0,6 **
Kuwait	_	Still in discussion	**Yes** Min High Edu &Sctf Res	KFAS Funding & coord since 1988	Sponsors	Trade oriented	0,2
Saudi Arabia		(KACST)		KACST since 1977			0,14 **

GERD / GDP as %.*Source*: Recent Monographs, especially from ESTIME project * or from Nour (2005). (Arvanitis and Hanafi, forthcoming)

Table 2: Four Institutional Models in Arab Countries

Type	**Countries**	**Main features**
Gulf model	Gulf countries	Decentralized trade-oriented governance Public universities open to foreign teachers/researchers Research based on international collaborations Foundations for research

Middle East model	Syria Egypt Iraq	Centralized type of governance Research in large public research centers and universities Large public universities
Machreq model	Lebanon Jordan	Decentralized governance Research concentrated in private universities
Maghreb model	Algeria Morocco Tunisia	Centralized governance Large public universities Research mainly in universities and public research institutes

Source: Arvanitis and Hanafi

In most Arab countries, scientific research agencies are attached to higher education systems, rather than to production and service sectors, as they are in industrial countries. This has contributed to the creation of a wide gap between education and research on the one hand and economic and social needs on the other.Table3 shows the rare effort of private sector (2.9%) in financing research.

Table 3: Scientific Research Sources of Financing in Arab Countries

Sources	Expenses in million dollars	Expenses in %
State budgets	840.9	61.5%
University budgets	217.3	27.8%
Private sector	12.6	2.9%
External funding	61.5	7.8%
TOTAL	1132.3	100%

Source: UNESCO (2009: 541)

Arab research centers at first focused on the basic sciences, but subsequently diversified their programs to include medical and agricultural sciences, among other applied specializations. During the last two decades, human, social, and environmental sciences have also been added. With regard to the structure of Arab research and development centers, they function through ministries of higher education and scientific research (eight countries), ministries of education (three countries), and a ministry of planning (one country), in addition to some specialized ministries (agriculture, health, industry). Five Arab countries (Lebanon, Kuwait, Bahrain, the UAE, and Qatar) show an exception to this trend, having assigned the task of research and

development to relatively independent councils and academies (Nabil ‘Abd al-MajidSalih, 2008, in Arabic) (UNDP, 2009:188).
Egypt currently has the largest number of research centers (fourteen specialised government research centers, 219 research centers under the auspices of ministries, and 114 centers at universities). In Tunisia, there are thirty three research centers comprising 139 laboratories and 643 branch research units. Technological research cities are few and are limited to Egypt, Saudi Arabia, and Tunisia (UNECA, 2008, in French). Other serious attempts exist in the Arab region, such as the Science and Technology Park that functions under the umbrella of the Qatar Foundation and sponsors numerous scientific and developmental studies in Qatar and worldwide. (UNDP, 2009:188).

Foundations

A number of national funds for science, technology and innovation have been set up in recent years. These include the 2008 European Union-Egypt Innovation Fund, and three national funds: the Qatar Foundation, Mohammed bin Rashid Al Maktoum Foundation in the United Arab Emirates (2007), and the Middle East Science Fund in Jordan (2009) (Snaer & Steve, 2011). Among them, Qatar set the bar highest by calling for the allocation of 2.8 per cent of the general budget to support scientific research in mid of 2008.[5] The set-up of the European Union–Egypt Innovation Fund in 2008 supports projects for applied research on a competitive basis, with a special emphasis on innovation (Mohamed, 2008; cited by Mouton and Waast, 2009).

5. Scientific Production

Usually scientific production is measured by indicators based on two types of data: the number of the publications in refereed international scientific journals and books, and the citations received by the published articles. Studying the use of citations is only possible using the Web of Science (WoS) (Thomson Reuters), and SCOPUS.

A rapidly growing scientific production

The mere numbers of scientific articles is still low in the Arab Countries. A recent report underlies that in 2007, the level of Arab Scientific Publications (approx. 15,000 papers) was equivalent to that of Brazil and South Korea in1985 (Mrad, 2011). Moreover, the number of articles published per 100 researchers each year was only 2 in four countries, 6 and 38 in two further countries, and was around 100 in Kuwait. If the total number of Arab university teaching staff is calculated at 180,000 doctorate holding university professors, and if we add around 30,000 researchers working full-time in specialised centres, then the academic-scientific corps working in Arab research and development is estimated at 210,000 researchers. Yet this corps produces only 5,000 academic papers per year, equating twenty-four scientific papers per 1,000 university professors and full-time researchers (UNDP:2009:201).

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[5]Law N°24/2008 regarding support and regulation of scientific research.

This is a clear result of the general underinvestment in research that we have already mentioned in above. What is reassuring however is the fact that the growth pattern in the last twenty years is impressive. Growth rates are above the world growth rate in publications, and comparable to the three countries chosen as the “control group” (Chile, Thailand and South Africa). The main cause for this growth is the extremely strong growth of the Maghreb countries. Morocco has had a previously stronger and longer growth period which does not appear in the figures. Tunisia has quadrupled its publications (from 540 in 2000 to 2026 in 2008) with its world share reaching 2.05, while Morocco showed little progress (from 1041 to 1167 for the same period). However, Morocco experienced a very strong surge of production from 1998 to 2004. Algeria also underwent more recent rapid expansion. Jordan,Lebanon, UAE and Saudi Arabia have also shown rapid growth. After sluggish growth in the earlier part of this decade, Egypt’s production has surged in the last four years as the result of new science policy and funding for research..

In terms of book production, 20 Arab countries produce 6000 books per year, compared to 102 000 in North America (Lord, 2008, cited in UNESCO, 2010: 264). There are as many translations published in Greece in one year as in all Arab countries (Mermier, 2005). This relatively low production in the Arab World has been the topic of many discussions.

A marked specialization pattern in the Arab countries

When looking at the distribution by areas of science, we find a very particular mix of disciplines. We notice the especially small percentage for basic science (15%) while energy sciences (engineering mostly) occupied 47%, followed by the environment and agriculture (24%). Engineering in all senses is the dominant Arab disciplinary domain in most countries, with some notable exceptions (Tunisia and Lebanon). The research strength of Egypt, Morocco and Algeria lies in chemistry, with particular specialization in organic chemistry, chemical engineering and physico-chemical characterisations for specific materials. Clinical medicine is the research strength elsewhere in the region, including in Jordan, Kuwait, Lebanon, Oman, Saudi Arabia, Tunisia and the United Arab Emirates. Syria’s strength lies in plant and animal science, which is a result of the presence of ICARDA, an international institute belonging to the Consultative Group for International Agricultural Research Centres in Aleppo, which specializes in these fields. Qatar makes its mark in engineering (Naim and Rahman 2009, cited in UNESCO, 2010: 263).

Two exceptions can be noted: a relative surge of mathematics in Egypt as compared to the previous situation -- although this specialization concerns a very small number of articles -- and the relative growth in biomedical research in Tunisia. Contrary to the former case, the growth of production in the biological and biomedical research concerns the majority of scientific production Tunisia and thus makes Tunisia a regional leader in the biomedical domains. Research in Tunisia has not only grown in spectacular figures, it has also been oriented toward life sciences and biomedical research. Tunisia has thus become closer in its production profile to Lebanon. Most of the production of Lebanon is related to American University, Beirut (AUB) and its Medical Center which has a historical precedent in the region. Moreover, AUB has made great efforts in promoting the scientific production of its personnel, which shows in its staff's overall production figures. Jordan is also moving towards this pattern, although concentrated more in engineering research. It is now slowly broadening to include research connected to the medical sector. Nonetheless, the dominant research area in Jordan remains engineering-related areas of specialization.

This over-specialization in engineering might also partially explain the under-production of research in Arab countries. It is well known that Engineering sciences produce lower figures overall than do the biomedical and life sciences. Patterns of publication in Engineering are also lower as compared to basic sciences (chemistry, physics, biology). It is also true of Agricultural sciences which tend to patterns of production closer to engineering than to basic sciences.

Low Citations, low impact?

What is most striking is that citations received by publications from Arab countries remain still low in comparison to those published in other regions of the World. Whereas the average citation of a single paper from the USA is 3.82 and from South Korea 1.51, the average number of citations from the Arab region ranges from 0.99 for Lebanon to 0.60 for Egypt. The figure can be as low as 0.01 for other Arab countries. These very low levels of citations are not the result of language, since the data come from English-speaking material published and reported by the two databases that include citations (Thomson's WoS and Scopus).

Citations measure influence, if not impact. They are closely related to the distribution of prestige and reputation in the scientific community. Even though they do not measure the quality necessarily – as was usually defended by the inventor of the Citation measurement, E. Garfield – they do reflect the way in which the scientific community uses its publications. It should be noted that more than half of the world's science production in not cited at all. Since measures based on citations depend upon time, many indicators have been proposed to take into account this age factor.

Table 4: Production & H-index (1996-2010)

Country	Documents (citable docs)	Citations	Citations per Document	H index
Egypt	63 415	367 134	6,79	115
Saudi Arabia	35 161	200 216	6,42	106
Tunisia	25 780	116 113	6,37	75
Morocco	19 721	116 525	6,48	84
Algeria	17 288	71 453	6,01	68
Jordan	14 477	74 534	6,38	66
United Arab Emirates	12 372	68 035	7,02	72
Kuwait	10 723	69 937	7,06	71
Lebanon	9 319	69 103	8,98	82

Oman	5 488	30 617	6,64	52
Qatar	3 286	13 450	5,07	39
Iraq	3 147	9 345	4,24	31
Syrian Arab Republic	2 827	21 004	9,01	50
Sudan	2 693	17 692	8,5	45
Bahrain	2 304	9 257	4,72	33
Libyan Arab Jamahiriya	1 944	5 996	4,5	29
Palestine	1 787	9 374	7,34	35
Yemen	1 093	5 894	6,96	32
Eritrea	296	2 224	7,82	21
Djibouti	79	464	6,21	11
Somalia	42	233	7,82	10

Issues related to impact

The most famous indicator is the impact factor, which measures the mean number of citations received by a Journal on the total number of articles published. It is very different from one field to another, is not very robust (and thus easily varies), and has many statistical difficulties. There has also been strong controversy regarding the use of Impact factor for journals, an indicator that is regularly published by Thomson Web of Science (in its science citation index reports) (Monastersky, 2005). Finally, the impact factor is based on a generalization of the citations received by a journal, and can therefore be easily manipulated by an unscrupulous journal editor. The citations measures have encouraged a certain concentration of publication in journals that are registered in the WoS (formely ISI) database, which were once thought to represent “mainstream science”. This poses a real difficulty to countries that do not have a large history of science publication, since the game seems strictly limited to a very small number of players.

The real difficulty for Arab countries is that pressure for publishing in the handful of “internationally recognized” journals discourages production in local journals (Hanafi 2010). Arab science periodicals that are included in international databases number no more than 500, about a third of which are published by Egyptian universities and research centers. The rest of these are distributed among Morocco, Jordan, and Iraq. Arab science journals suffer from fundamental problems such as irregular publishing, lack of objective peer review of the articles accepted for publication, and the unedited publication of the proceedings of conferences and seminars. Additionally, some of these periodicals are not regarded as credible for academic promotion purposes, which makes many researchers and academics prefer to publish in international, peer reviewed journals. (UNDP:2009:200).

This is a very fundamental issue within academic publishing and therefore should be made the object of a more systematic analysis.

Another issue related to the measurement of impact is that impact is not related to citations. As a recent report for the EU mentions (MIRA White Paper 2011), the impact of scientific research can better be measured when it is done at the level of a project, but certainly not for a discipline as a whole and even less for a country as whole. Impact of science is a complex concept and relates not only to the disciplines but also to the structuring of the scientific community and its capacity to generate new and original research projects. To our knowledge, the region has had no exercises in measurement of impact of the research activities. Most exercises are related to using the data that we have presented above, and drawing attention to some inadequacies. Even the use of a more detailed scoreboard of the publications has not been implemented in any country (not even Morocco where the concept was born).

International Scientific Collaborations

As a result of the growing complexity of science, the ease of face-to-face contact, the Internet, and government incentives, S&T activities are being conducted in an increasingly international manner. The indicator most often used to capture the scale or intensity of international collaboration in S&T is co-publications of authors from two different countries. Co-publication analysis can tell us something about the relative importance of international collaboration that leads to tangible outputs (publications) and the nature of the cooperation in terms of countries and disciplines (see for instance (Glänzel 2001); (Adams, Gurney et al. 2007) (Schmoch and Schubert 2008)(Mattsson, Laget et al. 2008)).

As has been reported (Gaillard, Gaillard and Arvanitis, 2010), in 2006, for instance, 30% of the world's scientific and technical articles had authors from two or more countries, compared to slightly more than 10% in 1988. One-quarter (26,6%) of articles with U.S. authors had one or more non-U.S. co-authors in 2006; the percentage is more or less similar to the Asia-8[6]and slightly lower for China and Japan (NSF and OST, 2008). Between 2001 and 2006, international co-publications have increased in all countries except China, Turkey and Brazil. The higher EU-15 level (36% in 2006) partly reflects the EU's emphasis on collaboration among the member countries as well as the relatively small science base of some EU members. Other countries' high levels of collaboration (46% in 2006) reflect science establishments that may be small (e.g. developing countries) or that may be in the process of being rebuilt (e.g. Eastern European countries).

It is thus well known (Gaillard 2010) that developing economies have had high and growing co-authorship figures and the smaller the country, the higher this proportion of co-authorship. Co-authorships tend to be proportionally lower for larger countries that have a growing scientific community. Thus, China, Brazil and Turkey are the countries where the number of co-authorship has lowered (as percentage of total production), as a result of a very rapid growing scientific production and a diversification of its scientific community.

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[6] Asia-8 is composed of South Korea, India, Indonesia, Malaysia, Philippines, Singapore, Taiwan and Thailand.

Co-authorship has been extremely high for small producers (UAE, Syria, Qatar, Libya, Yemen, Sudan, Mauritania). It falls in middle ranges for larger producers. Egypt has an exceptionally low figure of co-publications. A small check with on-line data would show that the share of co-authorships is now growing also in Egypt as in other countries. About half of the production with co-authorship seems to be a standard situation.

Publishing outside the international journals: invisible knowledge

There is a tendency among all Arab public and private universities, to adopt the American promotion system, which emphasizes publication in refereed international scientific journals.

The evaluation of journals, where to publish by the use of the impact factor, is encouraged. This has consequences on the publications and prestige of universities. There is considerable production not reported in WoS, such as production that relates to local uses and local communities where researchers live. Perhaps this tendency (conscious and unconscious) to separate the university from community plays an important role in marginalizing the university or, rather, separating it from the local society.

Discussion

Many reasons explain the relatively low production in science in the Arab countries. The reports that have previously studied the subject mention many of these. We would like to recap some of the issues.

- The role of the university promotion system

Most researchers in the Arab world belong to higher education institutions. The promotion system used profoundly affects the professors' production. In the best cases, the recruitment and promotion systems mention the necessity to present a certain number of publications; in many cases, the system is not so clear and no such rule is made explicit. One issue worthy of notice is the type of documents required as evidence of production. Another issue is the balance between publications and other types of activities.

- The research policy of higher education institutions

Many professors would probably engage in more research if the universities relied on an explicit statement favouring research, which is rarely the case. Moreover a research policy congruent with international standards requires a certain analytical capability rarely found at universities in the region.

- The lack of good Arab science journals

Journals published in Arab countries and in Arabic are rare. Local periodicals of good scientific stature should be encouraged, not as academic department information papers, but as disciplinary relevant ventures. This would promote the image of science in society; it would help young researchers publish, and provide a venue for the diffusion of local scientific activity. These journals need to be of good quality and should avoid inconsistencies be such as irregular publishing, lack of objective peer review, and focus on irrelevant topics.

- Engage in a systematic analysis of impact of research programs

A notable effort is being made in creating observatories and indicators in science and technology in the region. An effort should be made to tackle the issue of impact of research.

From factor analysis and other indicators of the production of science and technology in the Arab countries, the first observation is that there are three categories of countries: (i) well established countries (Tunisia, Egypt and Morocco), (ii) emerging counties (SA, Lebanon, Algeria, Jordan and Qatar) and (iii) the "very small" science countries (the rest). For some output indicators, 20 Arab countries produce 6000 books per year, compared to 102 000 in North America (Lord, 2008, cited in UNESCO, 2010: 264)

6. Innovation

As mentioned in the introduction of this report, innovation is different from research, and not all innovation is research-based. This is why innovation needs special attention. Innovation policies have been developed and sustained quite firmly in the last years by some governments, for example in Algeria, Egypt, Turkey, Morocco and Tunisia. Other countries have also promoted specific schemes and measures for innovation (Jordan, Lebanon, and, to a lesser degree, Syria). Gulf countries have set-up also specific measures. It should be added that the European Union in the framework of the so-called "Barcelona process" (EU-Med cooperation) has also been suggesting more innovation-related actions for EU-Med cooperation in the hope of the set-up a "Euro-Mediterranean Innovation Space" (EMIS)(Pasimeni, Boisard, Arvanitis and Rodríguez, 2006). Many international organisations, bilateral donors and NGOs have participated in the need of the countries to transform their development models from low-cost into knowledge-based production: the EU, the OECD, UNESCO, UNIDO and ALECSO are only a few examples to name. Finally, the World Bank has actively promoted the policies in favour of knowledge and innovation (Reiffers, 2002).

Funding agencies and governments have put a specific emphasis on the development of techno-parks and industrial clusters (Saint Laurent, 2005). This policy shift toward innovation (rather than solely research support) was basically done through measures promoting innovation in the public sector and contacts between the public sector and the productive companies in many forms: engineering networks, promotion of technology transfer units, fiscal measures, promotion of start-ups and venture-capital funding. Finally, to varying degrees, all the MENA countries were profoundly affected by the EU, which served as an example by its own promotion of innovation and instruments used to measure it (such as the European Innovation Scoreboard).

In Western industrial countries and those with growing industrial economies, there is a positive correlation between the country's position on some 'innovation index' and the growth of their GDP. Arab countries, however, do not show such a positive correlation between GDP and innovation (Mouton, 2009). Despite the high GDP in oil-producing Arab countries, the ranking on the innovation and scientific research index of some of them remain low in comparison to other Arab countries with lower incomes.

Innovation is not yet part of S&T parlance in the region. This may be attributed to the weak linkages overall between private and public R&D, as evidenced by the low output of patents. However, recently many science parks were established in many Arabic countries, especially the Gulf monarchies (Qatar, Saudi Arabia, Kuwait, Bahrain, Oman and the United Arab Emirates). This represents a move towards partnerships in innovation between private and public R&D, and explains the relatively optimistic opinions from business executives on regional innovation captured by the World Bank Survey. Note particularly Qatar and SA, which were respectively ranked 11 and 21 over 142 countries. However, this indicator is analytically very weak as it depends on subjective criteria (opinion of the business executives). Science parks have been developed in Maghreb, mainly in Tunisia and Morocco. For Tunisia, it has been a systematic policy to promote technopoles (or technoparks). In Morocco, this has been a very recent move after some difficulties in setting-up successful technopoles. A first appraisal of this policy for Morocco and Tunisia concludes that it is rather too early to have conclusive observations {Arvanitis, 2009 #4845}. Nonetheless, undoubtedly, there has been the creation of new companies, in some cases of very successful medium to large companies. Most of these technoparks function as nurseries and incubators as well as technopoles.

Table 5: Patents Granted to 13 MENA Countries by US Patent Office (1977-2009)

Appendix 1. Patents granted to 13 MENA countries by US Patent Office (01/01/1977–12/31/2009)

Country	Number of patents	% to total
Saudi Arabia	324	40.75
Kuwait	126	15.84
Egypt	97	12.20
UAE	77	9.68
Lebanon	58	7.29
Morocco	42	5.28
Jordan	24	3.01
Tunisia	18	2.26
Oman	8	1.006
Qatar	8	1.006
Algeria	5	0.628
Bahrain	5	0.628
Yemen	3	0.377
Total	795	100%

http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cst_all.htm

However, the most interesting example is King Abdulaziz City for Science and Technology (KACST). It is both the Saudi Arabian national science agency and its national laboratories. The science agency function involves science and technology policymaking, data collection, funding of external research, and services such as the patent office. KACST is a real science city with three components: research, innovation and service for the public and private sectors. In terms of research it has 15 research teams (Strategic Technology, Water, Oil and Gas, Petrochemicals Technology, Nanotechnology, Biotechnology, Information Technology, ECP, Space and Aeronautics, Energy, Environmental Technology, Advanced Materials, Mathematics and Physics, Medical and Health, Agriculture Technology, Building and Construction). In terms of innovation, KACST has three programs concerning industrial Property, Technology Incubator and Innovation centers, and finally a grant system to Encourage Excellence and Innovation. For that, KACST has a 2011 giant budget of around half billion USD ($491,713,692), offering research grants for 64 researchers/ research teams with ($16 m). It is interesting that only 23% is in basic science while the remaining is in applied science (31% in medicine, 27 in engineering and 16% in agriculture) (KACST, 2012: 105).

KACST understood that it is very important to provide an outlet for research output by subsidizing open access academic referee journals. KACST partnered with Springer to publish eight international journals to foster the development of key applied technologies, providing a forum for the dissemination of research advances and successes from the Kingdom of Saudi Arabia and the world. Their open access journals are: Applied Water Science, Journal of Petroleum Exploration and Production Technology, Applied Petrochemical Research, Applied Nanoscience, Biotech, Materials for Renewable and Sustainable Energy. All these journals have two chief editors: one westerner and other Saudi. What is compelling with the model of this Park that it is driven with local expertise, and contrary to what is happened in UAE and Qatar. Instead of parachuting foreign branches in their land, Saudi authorities opted for encouraging a model that is driven by local expertise, with the help of regional and international expatriates. The development of a “space for science” as socio-cognitive blocs can be an extra-terrestrial space of exception, in the sense that the law of the city does not necessarily apply to them, so they can have the freedom to be critical of their own society and culture, but also connect to society in the sense of responding to its needs.

Table 6: Opinions from business executives on innovation and S&T related factors (World Economic Forum 2011-2012)

	Brain drain	Company spending on R&D	Quality of scientific research institutions	University-industry research collaboration	Local availability of specialized research & training services	Firm-level technology absorption	Value chain presence	FDI and technology transfer	Capacity for innovation	Quality of management schools	Availability of scientists and engineers
Algeria	141	139	126	136	125	134	132	123	138	101	44
Bahrain	15	99	102	87	35	20	48	18	117	60	55
Egypt	122	106	113	128	83	78	68	67	83	133	40
Jordan	73	108	104	114	56	37	66	51	92	85	20
Kuwait	36	115	75	105	86	39	96	135	90	99	65

Lebanon	123	113	127	111	54	68	33	112	106	18	30
Mauritania	129	119	132	134	135	140	97	140	118	139	105
Morocco	62	104	96	102	49	74	79	54	108	51	36
Oman	21	45	62	56	90	49	58	46	57	97	99
Qatar	5	20	6	10	67	7	27	2	11	7	24
Saudi Arabia	9	18	36	28	29	23	22	8	21	42	26
Syria	110	136	125	133	110	70	106	106	134	108	63
Tunisia	51	42	52	58	34	50	25	25	44	31	8
UAE	10	24	40	37	28	16	18	10	32	38	18
Yemen	138	142	141	142	187	123	137	142	142	140	138

Source: World Economic Forum, Competitiveness Report 2011-2012. Rank over 142 countries

7. Scientific Capital: Universities and Researchers

Knowledge production cannot be understood without understanding the researchers behind the research. Thus a research system needs talented researchers. At the same time, it also needs effective management of research (incentives, door-to-door search for contracts, coordination of fundamental and applied research, liaison with other performers), and the ability to address national solicitations, propose novel courses or methods, and fill the gaps of unnoticed, promising niches (Mouton and Waast).

Preparing researchers starts with investment in higher education. This is demonstrated by state budgets for higher education. In the region, this ranges from from 0.8% from the GDP for Egypt and Algeria to 2.8% for Qatar. However, investment is actually larger as these figures do not include private and non-for-profit universities. In fact, only few of the latter play a significant role in research production: the American University of Beirut (AUB) and St Joseph in Lebanon; Université des Sciences et de la Technologie Houari Boumediène (USTHB) in Algiers.

All higher education institutions produce a huge number of students: approximately 1.8 million in Egypt and 750,000in Saudi Arabia, of which, respectively, 102,000 and 11,000 are graduate students.[7] The development of the number of faculty in Arab university has steadily been increasing since 1965, although 1995 marked the start of a particular increase in the Gulf and Egypt.

However, it is very difficult to draw an equation between the number of graduates or faculty and number of researchers, as we know many of them do not go into research. Only a small percentage of them would actively produce research at the international level through their publication in refereed journals counted in Web of Science or Scopus. The reason is related not

[7] In the Arab world, the number of students has increased considerably, from 5.4 million in 2000 to 7.3 million in 2008. In 2000, there were 1 907 students for 100 000 inhabitants. By 2008, this number had increased to 2185, according to the UIS. (UNESCO, 2010:68)

only to a lack of publications in the English language but also to the fact that many Arab universities are not research universities, even if a research focus is written in their bylaws. From 33,481 researchers in Egypt, statistics suggest that 13,941 estimates on full-time equivalents (FTE), but indeed only half of them will publish in referee journals. The FTE in Egypt certainly exaggerated, as we know it is rare for the actual research activity of teaching staff in government and most private universities to exceed 5 to 10 per cent of their total academic duties, whereas it forms 35-50 per cent of academic duties in European and American universities (UNDP, 2009:190). In a university like the American University of Beirut, which is a research university, our survey shows that around 40% of academics' time is spent in research. This is an average of two publications yearly for each FTE in AUB.

A recent study that relies primarily on government data from ten Arab countries (Nabil 'Abd al-Majid Salih, 2008) shows women accounted for 40 per cent of researchers in Egypt and Kuwait, 30 per cent in Algeria and Qatar, and 20 per cent in Morocco and Jordan. Their numbers fell to as low as between 14 and 4 per cent in Oman, Yemen, and Mauritania (UNDP, 2009:: 191).[8]

Where are these researchers located? While in social science they are located between the NGO status research centers and universities, in other sciences they are mainly in university or national Centers[9] (or state-sponsored science parks). Research has shown that the bulk of S&T research in the Arab world is carried out within the higher education system, even in Egypt where this represents 65% of R&D (IDSC, 2007) (UNESCO, 2010: 257). In 2008 $16.26 billion was spent in the region on higher education for 6.62 million students (Mrad, 2011). The issue that is raised by many researchers (Mouton and Waast 2012) is the dispersion and lack of critical mass in specific niches. The concentration of knowledge production in most countries has been well documented: a small number of establishments and scientists produce the bulk of results in most science systems. It has been well documented in "intermediary" countries (for instance in Morocco or Jordan) that even in leading establishments, there are no more than a score of successful research niches. Within each of these, there are usually no more than ten very active researchers, and a score of more episodic contributors (Kleiche and Waast, 2008). These persons very often do not collaborate with people outside their own institution (except for international collaborators), and the quality of national research remains fragile. There may thus be problems regarding the reproduction, updating and renewal of research methods, capabilities and subjects.

However, questions remain about how important the notion of critical mass is. TIt has not been proven that there is a 'right' critical mass at which point the construction of a scientific

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[8] If we take the number of faculty as indicator, we find that 30% of 125 000 university faculty members in Arab countries are women. Some researchers have put this figure at over 170 000 (Waast et al., 2008), but this could be due to the inclusion of faculty teaching at more than one university, meaning they would be counted more than once. (UNESCO, 2010:71)

[9] These centers are generally specialized in specific spheres of public interest (agriculture, nuclear and space technologies, health) with a continuum from basic to applied research. They are often favored by governments, which give priority to their funding because they contribute to (nationally) strategic areas and are commissioned to generate more practical outcomes.

community will be triggered. In fact, the concept of 'critical mass' has no empirical basis in the social construction of a research community. However, it is known that numbers count, and having 60 researchers in one area is certainly better than having one or two. But research can be the result of collaborations and these could very well be maintained by 'low-level' activity. What is decisive is not so much the number of researchers but rather the connection of the research activity with non-research activities, be they productive and economic or other. It is necessary here to understand that the researchers have multiple functions. They produce academic and scholarly work that is visible through their production in scientific journals, but they have other functions as well.

8. Brain drain and brain gain

Figures released by the National Science Foundation in 2000 reveal that there are thousands of Arab scientists and engineers living in the USA: 12 500 Egyptians, 11 500 Lebanese, 5 000 Syrians, 4 000 Jordanians and 2 500 Palestinians. Scientists from Morocco and Tunisia on the other hand, tend to head for Europe (Waast et al., 2008) (UNESCO, 2010: 271). The number of researchers in Lebanon is slightly larger than the number of Lebanese researchers employed in R&D in USA. This demonstrates the major phenomenon of brain drain.

Reproduction and brain drain are two chief concerns of the scientific community today. The proportion of students turning to scientific studies is declining (often on account of poor career prospects in their countries), and there is a crisis in their supervision. Positions have been frozen for long periods of time, professors have left their countries and were never replaced (as in the case of Palestine), those who stayed are getting old, and the best students turn to other fields. The need for new supervisors is not only a question of numbers, but also of quality. It is important that newcomers are well supervised, but also that they import new methods and cutting-edge science. The same is true for professionals, who should also be enrolled in topical research and periodically renew their knowledge. There is a lack of scientific life, and a need for upgrading teachers' knowledge. Many researchers have deskilled, or given up the activity. Some of them could probably be retrained, and restart in direct or indirect research tasks (for example, as advisors to government, liaisons with industry, gathering of funds,) (Mouton and Waast, 2009).

In a recent survey on brain drain, the results showed that significant proportions of scientists and scholars seriously consider leaving their universities and countries to look for employment elsewhere. Overall about 20 per cent of all respondents indicated that they plan to move to another country in the future.

The Arab region is considered one of the most active in terms of the export of highly qualified human capital equipped with university degrees. Indeed, human capital is among its major exports, possibly equalling oil and gas in value. The little data available on this indicates that 45 per cent of Arab students who study abroad do not return to their home countries. The Arab world has contributed 31 per cent of the skilled migration from developing states to the West, including 50 per cent of doctors, 23 per cent of engineers, and 15 per cent of scientists (Zahlan, 2004) (UNDP, 2009:208). For example, 34 per cent of skilled doctors in Britain are Arabs.

Over 200,000 PhD holders unable to connect with the local economy emigrate (representing 80% of Arab PhD holders) (Mrad, 2011). According to the NSF, very few scientists from the Maghreb are established in the USA. But scientists from the Maghreb are nevertheless heading for Europe (mainly France), and recently for Canada. A bibliometric study in the social sciences has just proved that 60 per cent of the 100 most productive social scientists from Algeria were now living and employed abroad (50 per cent of the 200 most productive, authoring more than 1/3 of the production in the last 25 years). The proportion of Moroccan authors living abroad is 15 per cent of the 100 most productive (Rossi and Waast, 2008).

According to the Algerian trade unions the number of Algerian scientists established abroad had increased from 2,400 in 1984 to 27,500 in 1994. Ninetyper cent of scholarship holders never came back from abroad in 1995. To this should be added the well-known exodus of "highly qualified persons" (among whom a number of leading researchers and academics) during the Civil War of the 1990s (Khelfaoui, 2004).

There is a range of opinions about brain drain. In many countries, emigrants might be viewed as traitors who prefer their own material well-being to their homeland's interests. Added to this is the claim that there is a deliberate "pirating of brains" by the wealthiest countries at the expense of the poor countries which bore the costs of their education (Mouton and Waast, 2009).

However, intellectuals are not the only ones fleeing some of these countries, and there is no reason for them not to emigrate if their skills can not be put to use at home. . Some recent studies have convincingly proven that most professionals' attitudes and behaviour concerning emigration depend on national science policies and the movements of international industry. The North African case has been well-documented. Brain drain is much lower in Algeria and Morocco, for instance, as the result of decent professional standards (status, income) and scientific life. Most students studying abroad return to these countries after completing a doctorate. (Gérard et al. 2008).

Another feature is noteworthy: ever since some multinational firms decided to invest in Morocco about three years ago (in high-tech production, and even in development research), the country has had to hastily develop a training plan to double the number of engineers it graduates. It has been able to do it because of the quality of its higher education system, which attracted the interest of said firms in the first place. The same is true in Tunisia.

Another interpretation is that there is no real brain drain, but rather a natural flow of scientists to the best places in which to exercise their talents. The "marketplace" of knowledge and know-how will organize their settlement to the best effect, each place in the world will have what it "deserves", and the task of governments is to offer the best conditions to retain the best researchers.

To overcome brain drain, the work conditions for researchers should be improved (in terms of having conducive environments to research and decent salaries). In Africa many studies show

how brain drain has been reversed by simply providing better conditions. Here we would like to provide three options for such reverse: the top-down initiatives in higher education, the temporary use of the diaspora expertise and networking with the diaspora.

Top-down initiatives in higher education

Three regional initiatives exemplify recent top-down initiatives in higher education: Qatar's Education City; the Masdar Institute in Abu Dhabi, and the King Abdullah University of Sciences and Technology in Saudi Arabia. These initiatives are likely to staunch brain drain in Arab countries like Algeria and Egypt, which have been hit by an exodus of talent (UNESCO, 2010: 71).

Tunisia has made great efforts, and some Gulf countries are now offering excellent facilities to international enterprises and universities, in order to attract and territorialize them. For instance the University of King Abdel Aziz attracted 20 scientists from the UK in 2012 by providing each one million dollars for their research. So far, however, it has not found niches of excellence.

Qatar's Education City: Hamad Bin Khalifah University

Qatar Foundation offers branch campuses of eight strategically selected elite international universities, delivering world-class programs chosen to ensure Qatar is equipped with essential skills and specialism: Texas A&M University at Qatar, Weill Cornell Medical College in Qatar, Georgetown University School of Foreign Service, Virginia Commonwealth University in Qatar Carnegie Mellon University, Northwestern University in Qatar, HEC Paris, University College London Qatar. The city is also home to educational institutions for children and teens, and research institutions (i.e., RAND-Qatar Policy Institute, Qatar Science & Technology Park, Qatar National Research Fund). Education City is also the home of the Qatar Music Academy/Qatar Symphony Orchestra.

The temporary use of the diaspora expertise

While connectivity between the diaspora and the homeland is an important factor in fostering physical return, a temporary physical return remains possible for skilled expatriates, a category whose participation is vital to the construction of the Arab world, especially in the post Arab Spring Era. In this case, is it possible for a voluntary facilitator role to be assumed by the Arab governments or the international community to harness this group and facilitate the transmission of expertise by the migrant community towards the homeland? As Meyer et al. (1999) argues, there are two possible policies for developing countries to tap their expatriate professional communities: either through a policy of repatriation (a return option), or a policy of remote mobilization and connection to scientific, technological and cultural programs at home (a diaspora option).

The TOKTEN (Transfer of Knowledge through Expatriate Nationals) concept has been an interesting mechanism for tapping national expatriate human resources and mobilizing them to undertake short-term consultancies in their countries of origin. The United Nations Development

Program (UNDP), which implemented TOKTEN, demonstrated that specialists (who had migrated to other countries and achieved professional success aboard) were enthusiastic about providing short-term technical assistance to their country of origin. Often these individuals returned and settled permanently. This program has been applied over the past 22 years in some 30 different countries, resulting in the application of thousands of technical assistance missions by expatriate professionals to their home country (UNDP, 1996). One of the main catalysts in the creation of the TOKTEN program was the growing necessity of counteracting the so-called 'brain drain' from developing countries to the first world. The program has created databases of highly trained and experienced expatriate experts and in the 1990's assigned more than 400 of them per annum on a volunteer[10] basis to their countries of origin for periods ranging from one to six months. TOKTEN volunteers have served in governmental, public and private sector, academic and NGO sector capacities.

The TOKTEN program in the Palestinian Territories is considered one of the most successful with more than 178 Palestinian experts who have contributed to Palestinian development under the TOKTEN modality. Palestinian TOKTEN consultants, for example, have helped reform the treatment of kidney disease in Palestinian Territories and have guided the development of macro-economic frameworks and planning. TOKTEN skills also have been brought to bear in the realm of computer and information technology, on city planning, on university curriculum development and academic networking, on the upgrading of film and television capacities, on cultural preservation including the Bethlehem 2000 project. The lack of expertise in some sectors where people have volunteered under TOKTEN has generated some genuine success stories in Palestine, such as the construction and opening of the international airport in Gaza. In this case, 9 TOKTEN consultants have stayed on and presently constitute the backbone of the airport's operations (UNDP, 1999: 1-2).

Finally, the TOKTEN program raises questions concerning the nation-state framework's capacity to deal with issues of brain drain. In an increasingly globalized skill and labor market developing countries are rarely able to compete with developed countries which offer far higher wages. In such a case, TOKTEN can be considered a mechanism by which recipient countries (usually western) compensate countries of origin.

9. Conclusion: Three socio-cognitive challenges facing research and innovation

We identify here three major challenges: the model of development the Arab world wants to adopt; trust in science; and the social environment conducive to the development of science.

Models of development in the Arab world

Some of the Arab countries' reliance on income from natural resources (for example, oil economies or phosphate in Jordan and Morocco), or from the development of services (Tourism in Lebanon), might mean that they do not really need science and research. They may maintain

[10] - In the Palestinian Territories, TOKTEN consultants receive $2,000 US Dollars, if junior, and $3,000, if senior in addition to paid travel expenses and miscellaneous expenditures.

universities, invite topflight teachers, and support the research they pursue for their own career and the prestige of sponsors (as in some Gulf countries until recently), but their commitment is unclear.

There is a clear link between the development of science and industrialization. The nationalist governments that tried to develop import substitution, even when they failed in that plan, generally established a science base which remains a national asset for the country (see Egypt for some time, and the Maghreb countries). It must be stressed that the (re)building of a science base is slower and more difficult than its demise, and that the tribulations of a "to and fro" strategy in support of science leave clear, long-lasting scars.

Trust in science

> « Le discours sur la science a été partout légitimé, la pratique de la science, elle, ne l'a pas été »
>
> Jean-Jacques Salomon (Khelfaoui, 2000: 5)

There must clearly be some pact (at least an implicit one) between science and society. However, as Jean-Jacques Salomon suggested in this excerpt that the discourse on science is easily legitimized but the *practice* of science is not always.

Since the Second World War, the general view of science has been one that sees science as a benefit to people, generating new, essential technologies. This was the main result of the *Comparative Study on National Research Systems: Findings and Lessons*, which considered science as a source of progress for humankind. Its support was the duty of the state, and its results should be public goods. This applied to the developing world, too, and free of colonization, its governments entered higher education institutions and research centers with the support of international cooperation and funding as well asgreater or lesser ambitions (enlightening minds versus harvesting rapid, useful results). Gradually, a more liberal way of thinking changed things, and well-being was no longer sought from the state but from enterprises; progress no longer from science but from innovation.

The social

The social environment of science is an important component of the motivation of scientists. The trust of their employer (often the government) is part of it. But social values all around are yet another dimension; some nations have traditionally held science in high regard, such as Egypt. Others have not had such traditions or they have another understanding of what valuable knowledge is. Political power or material wealth may supersede all other aspirations in imparting a certain kind of status on science. Religious beliefs, values related to aristocratic ancestry or to the family may also override all other considerations. These tendencies may well interfere with a commitment to science and its standards.

Among others, Jordan is a well-documented example of self-censorship for partially religious or political reasons, and of family duties superseding professional obligations. In many places, this may reach the point where practicing research has no other meaning than fulfilling the formal requirements of building one's career.

This is why a number of scientists in the developing world seek work in research centers, where they believe they will escape a heavy burden of teaching and many additional professional demands. At a minimum, this situation calls for a debate on the interest of promoting local (or regional) "Centres of Excellence", dedicated to science and with sustainable support, high standards and a relevant focus.

10. Recommendations: A vision for the future

Over the last 10 years, scientists and policy-makers in charge of science in the region have been trying to transform their research systems. Interest in research by the specific policy-makers is thus not so much related to the national pride as to the defence of competitive advantage. Moreover, some countries, such as Brazil, Chile, Malaysia, Tunisia, Turkey and South Africa have shown that a spectacular increase in the level of spending on science in a very short time is possible. . Is the region ready for such a major overhaul?

Some recommendations and a sort of a vision for the future, taking into account some challenges to be faced:

Fixing the cycle between research, university and society

Arab countries have small patenting figures. This is often used as a reason to conclude that more patenting should be encouraged. Policies have been designed that are supposed to promote the development of research into patents. But this is only a small part of the more general issue of the relation of research with the economy and society. As we have mentioned earlier when talking of the various functions of research, there is an insufficient appraisal of all the activities that are not directly linked to production of scientific articles and books. More generally there has been a broken cycle between research, university and the society.

One of the most important aspects has been the working conditions of researchers in their institutions. Since most of the researchers in Arab countries belong to universities, this relates very much to the way universities are supporting research. There will be no real progress if universities do not promote actively research in their own teams, departments, and faculties. Action here will require greater internal funding opportunities for both individual and team work. The use of external funding should be promoted to help provide administrative support for the development of research activities.

Also, in many universities, the vast majority of faculty are absorbed by heavy load of teaching and capacity building for the institution where they work. Faculty who are able to produce good research are those who receive support from their own institutions. In the absence of this institutional support, research will always be a marginal activity.

Moreover, research has been too narrowly related to the individual promotion of professors. 'Research' has a distorted sense in this case since it only relates to the reception by the colleagues and the administration of the university and only for a specific person. On the contrary, research should be promoted as part of a collective endeavour as part of shared activities and common working plans.

Another important aspect that relates to the institutional capability to support research is the existence of post-doctorate fellowship and grants. These are important yet rare in the Arab world. Many Arab universities give grants for research only to full professors, i.e. generally those aged 50 and older. Young faculty do not get easy support and there is a lot of room to increase the support to young faculty by promoting fellowships in accordance with university authorities. None of these measures can be of any success if both funders and employers (in this case university administration) are not involved in a common negotiation.

Finally, in universities a large part of the research activity needs to be included under the general frame of the Masters and PhD programmes. These need to be designed in such a way as to lead to research, in particular PhD programmes. There will be no research-efficient faculty if it cannot relate the teaching activity in PhD seminars to research orientations. Moreover, the use of cooperative or shared doctoral programmes with foreign universities could be a lever for more research inside the university. Research institutions need ensure a good ratio balance of researchers, research assistants, employees supporting research, PhD. candidates and post docs.

A difficult issue relates to evaluation systems and the way the academic institutions measure their own performance. There is a low correlation between research output – even when restricted to academic publications – and the number of academic/research personnel. There is very small elite of researchers who will publish a lot and a large number of persons who publish much less; figures show a large quantity of teaching personnel with less than one article per year. This might not necessarily be a default considering that academic activity is not restricted to research. As we said before, even research has a multiplicity of forms. Evaluation systems should not be limited to measuring papers in journals. This leads to a certain dis-embeddedness of science from society and even the market.

Patenting might not be the right tool to measure applied research (in fact it is not a good tool since it relates to commercial considerations as much as technical ones). Nevertheless, here are too few patents in the region. Here again the issue is not measuring patents but giving support to academics that have inventions that need to be patented. Patenting might be expensive, uneasy or not worth the risk as compared to other strategies (secrecy in relating to an actual enterprise, common business plans, exchange contract between the university and the company, creation of start-up), but it should in any case be examined by a support and technology transfer unit. This unit needs a high degree of institutionalization.

Making innovation a clearly stated objective of public policy

Business incubators, technoparks and technopoles or industrial clusters in high-tech are not necessarily a panacea, or at least will probably be less of a solution than was initially thought. At the same time this is not to say that these efforts should be abandoned. On the contrary, these initiatives should be promoted and supported. Technoparks and the like are also parts of regional economies, and they can only function with economic and social entities nearby. Thus, they should be included in regional development considerations and economic programmes that support local businesses and not limited to purely academic initiatives.

It is often declared that the industry demands little from the local university and research community. This is only partially true. Innovation surveys done so far show that there is innovation occurring in ways that are difficult to measure. More than half the enterprises actually develop innovative projects but usually away from the university. This innovative activity of course depends upon the size and the sector of the companies. It should be noted that the national companies are more innovative than the branches of multinationals (even in sectors such as pharmaceuticals, chemistry, and electronics). Success stories of companies show that innovation is to be found in "medium-sized" companies, around 300 employees, based on a long technical expertise that can be fed by continuous improvement in actual markets and interactions with clients and providers.

The same is true for universities. There is an abundant anecdotal material in various universities showing strong linkages between research teams and companies, based on long-term relationships and expertise. In Egypt, in the ICTs there has been a group of companies that have developed their technological learning based on university expertise. Innovation surveys indicate that this effort can still be developed and it is not that the innovation is failing but rather that the support is not provided. Less that 10% of companies know of the support schemes offered by the government in any of the countries where similar surveys have been done (Egypt, Morocco, Tunisia). It might be that they will develop in the future – as is hoped, for example, with the plan "Maroc Innovation" launched in Morocco in 2011.

The situation today is a sort of a paradox. On one hand, there is growth of innovation activities, in all kind of companies and even firms that were not interested in this activity some years before; on the other hand, innovation surveys indicate a low level of interest in innovation from companies with public support. Many reasons are mentioned by companies in the surveys, but mainly two arise: poor knowledge of the support schemes, little involvement in them, and little previous experience. One aspect is mentioned often: companies show a low level of confidence when the state is involved. A way to re-establish this confidence would be to channel the public support through market-based entities, such as companies with close working relations with public entities. By and large, the state should then show that its interest is not the 'business as usual' approach and that technological development will benefit from exceptional support measures. A preference should be given to collaborative work between technical entities (labs, centres, research teams) and the companies as well as some preference should be given to companies that wish to develop internally R&D activities.

Entrepreneurship is often said to be lacking in the region, which is considered one explanation for low levels of innovation. We believe this not to be the case in either the more market-oriented economies in the region or those with stronger, centralized states. In fact, entrepreneurship is one of the region's most abundant resources. What seems to be more difficult to secure is regular market support and continuing expansion. The initial investment costs in R&D consists of less "R" than "D" and the support schemes should provide for more than "one shot" support. Such an effort would need a more concerted action between the public entities involved in promoting economic activities. Single support schemes will always be short-term. Sustainable development of enterprises based upon innovation, R&D and technological development should be considered special areas of interest of the state.

Research systems

What kind of science systems are needed in the Arab world? The fact that the research landscape in each Arab country is fragmented and small-scales means it can be difficult to talk of a science "system" in much of the region (Mouton and Waast 2009). Institutions are not typically aligned through input, process and output flows, and there is no systemic behaviour in response to external changes and demands. Rather, the image of an "assemblage" of fragile, somewhat disconnected and constantly under-resourced institutions is perhaps a more apt metaphor to describe the science arrangements in most of these countries. Here two issues are raised for the future: the centralized vs. diversified model and the issue of the autonomy of the research.

Among the research units, there are a variety of research activities that can be developed. Up to a certain point, all countries experiment and as an increase inresearch activity often results in diversification. What can be found in a good research system is usually a wide range of specialists. In all areas, you would then find one –more rarely two – specialists. Small research systems then have to confront this situation and it will be difficult to create larger teams.

The institutional complexity of a research system is always a challenge. As a way to offer a sound proposal for discussion, one should examine the type of funding that would be drafted according to priorities. "Priorities" is not a very good term since it calls back to the seventies, when national planning was *en vogue*. Moreover recent exercises in priority setting in Arab countries usually produce a catalogue, which is possibly relevant but not feasible with local resources. An alternative way of tackling the funding issue would be to raise a catalogue not on the basis of declared priorities only (whatever the forecasting exercise be used) but by combining these declared priorities with actors funding them. A possible differentiation would be the following one:

1) *Few strategic funding programmes with strong linkages with productive sector*. The pursuit of some programmes, which imply strong support from the state in areas considered "strategic", and applied research where the public authorities promote active collaborations or "clusters" with dynamic firms. Funding would then be given in priority when the alliances and collaborations are made. The areas for funding would include water, desertification, renewable sources of energy and agro-food, among others. The "knowledge economy" areas could be among those programmes. The main evaluation criteria here would be relevance to local economy and intensiveness of linkages with the productive sector.

2) *Promotion of some research areas with clear socio-economic objectives that are specific to the country, where users and social actors are present, and where the economic interest is not the first objective, such as health for example*. What is needed is some support to these areas which are not immediately profitable but where interaction with

final users is paramount. Consider for example, the construction industry which has considerably developed its new building materials based upon intense exchanges between the companies that build, those producing the material and designers and architects. These areas related to users, real users, not users that are imagined by the promoters of the projects, could also be recollecting and using local knowledge, for example in agriculture, medicine, pharmaceutics, fisheries and the like. ‘Traditional knowledge’ is better introduced into research and new developments when it is linked to communities using this traditional knowledge. The main criteria here would be relevance to social needs and creation of strong teams.

3) *Areas of basic sciences, where collaboration with foreign colleagues is active and in which the objective is neither socio-economic nor innovation driven*. The rationale for such programmes is that a country, whatever its size, needs to have an eye open to developments elsewhere. If C. Wagner[11] is right, the smaller the country the more beneficial its linking to foreign research. Doctoral students are a good investment if interesting employment schemes are devised for them after completion of their studies. But we should add to the “Wagner” proposal of a linking strategy, that this should be related to domains that are not necessarily those with a local productive base or practice base (such as hospitals, or other economic activity). Excellence and novelty should be the main evaluation criteria.

All these types of funding need money that can be distributed along many different schemes: scholarships to students working into companies, funding of collaborative projects, direct subvention to research projects.

Consolidating teams

Naming “clusters of activities” is not a sufficient manner to induce the creation of strong teams around specific objectives. One needs a mechanism that would guarantee regular funding in the medium-term and not exclusively from outside sources. The Tunisian experience here could be examined more in detail. It needs to be driven by both universities and central state institutions, or at least recognized instances that can guarantee the validity of the “team projects”.

Research in a social and economic environment that appears to have little interest inresearch is still possible. The AUB in Lebanon is a good example of this. In Lebanon, there have been very fewincentives for research. Historically, the National Council for Scientific Research has supported already existing research areas rather than promote new ones. Usually, the original areas of research have been developed by academics returning from France or the USA and developing the research activities with their former European or American colleagues locally. International cooperation is thus the main tool of consolidating a competence. Biomedical research at AUB grew in this manner and with its intersection with the medical practice offered by the hospital. Thus, professionalization of medicine entails conducting research.

In short, the most accurate depiction of the current situation in many Arab countries is as follows: a series of islands of competence with niches of peculiar expertise which have been built or are being built. These “islands” are relatively independent from each other and not interlinked, even in similar domains; local networking is generally avoided. They will objectively seek the best expertise and avoid local competition.

Interacting with others: international, regional and local networking

All the studies and interviews show that there are very few synergies between different scientific institutions at the national or regional level. Joint research projects among Arab scientific research institutions working in similar fields remain extremely rare, even within the same country.

It is clear that scientific networks at the level of sub-disciplines could be promoted and that the resources form Gulf countries would be useful in that effort. The European Union offers a useful example in this regard. EU funding came in the form of project-based funding organized through competitive calls, whereas most European countries were funding research by regular budgetary provisions to research institutions. Nonetheless, the EU “framework funding” came handy and worked well, among other reasons because the EC research activities were parallel to the construction of European institutions in other areas (economy, agricultural funding and so on). In the case of inter-Arab cooperation there is little international cooperation and research remains isolated. Additionally, a recent evaluation of the EU 7^{th} framework cooperation shows that EU funding to non-EU partners is quite low. Partner Med countries in these projects received approximately 10% of the total funding.

It is unclear to what degree inter-regional cooperation will be promoted by Gulf, Turkish or Iranian funding efforts. Bilateral programmes might be more efficient, and we should remember that European countries have not abandoned their bilateral funding of research and higher education in the neighbouring regions. France, Italy, Spain, Germany and -- to a lesser extent – the UK have been active in funding research through bilateral programmes in the Middle-East region or the Maghreb. As useful as Gulf funding, or any other source, would be, partnerships should be accompanied by policies with clear, stated objectives.

Inter-Arab cooperation is thus quite low; nonetheless, more funding is available and we believe that only time will tell us if the increasing money from institutions such as Qatar Foundation will fill the gap. It may be true that the old objective of “national self-reliance” – or even regional self-reliance – is no longer achievable, or even desirable.

Rather, we believe that the driving force will not be funding per se but professionalization of the funding mechanisms. The areas of research funded by Qatar Foundation have been successful in large part because of the strength of the evaluation and funding mechanism. Funding research is a profession, and there is a clear need for transparency and professional rules in using the money given through competitive funds. It is also clear that no research will ever grow satisfactorily if the internal mechanisms for spending external funds are not modified in most research institutions. Today, the challenge is less a lack of money than the management capacity to efficiently and effectively spend the money. We would recommend the promotion of systems of management for research and innovation, and make it a topic of high priority for training in the near future. Again, the experience of the EU Framework programmes shows the strong capacity for more research and better oriented programmes as a result of networking. Projects that are by themselves small networks tend always to expand in order to interest larger networks. The professional networking is thus particularly efficient and grounded on the actual practice of research. There is no reason why this kind of networking wouldn't work in specific professional areas.

This kind of linking strategy would make sense if it permits relatively strong research teams to participate. Participation in international collaborative networks without a parallel consolidation strategy would be like entering a river; it will end dissolving in the sea. Strong network poles that gather many researchers working in one topic would be profit from the knowledge contained in each network.

The World Bank has a quite clear view of what it calls the 'knowledge economy'. It has designed a Knowledge Economy Index (KEI) which has a rather clear view of the future based on market liberalization (including more S&T and innovation, increased entrepreneurship, privatization, more flexible markets, and less control and state activity). Why do we not consider a more diversified model to take into account the different types of sciences, as well as the different roles of the state according to the issues addressed?

Making research a political topic

During the Arab Summit of March 2010, the Heads of State adopted a resolution mandating the General Secretariat of the League of Arab States to develop an S&T strategy for the entire Arab region, in co-ordination with specialized Arab and international bodies. This strategy was due to be submitted to the Arab summit in 2011 for adoption. It was expected to address the important issue of facilitating the mobility of scientists within the region and to enhance collaborative research with the sizeable community of expatriate Arab scientists. Both the strategy and the subsequent Arab Science and Technology Plan of Action (ASTPA) will be drawn up by a panel of experts from the region with the institutional support of the Arab League Educational, Cultural and Scientific Organization (ALECSO), the Union of Arab Scientific Research Councils and UNESCO, among others. ASTPA will envisage both national and pan-Arab initiatives in about 14 priority areas, including water, food, agriculture and energy. It is also expected to recommend the launch of an online Arab S&T observatory to monitor the S&T scene in Arab states and highlight any shortcomings in implementation. One of the keys to implementing measures at the country level will lie in identifying some of the national challenges that Arab countries face. Political support for research and innovation (or "science and technology" as it is usually termed) at the highest level is required, coupled with affirmative government action, an upgrade of existing STI infrastructure and an increase in GERD. (UNESCO, 2010: 256 – 257)

At the same time, lessons learnt from many countries in Latin America suggest the importance of connectivity in the level of institutions and individual researchers. Thus top down and bottom-up approaches are required.

Refereed academic journals

The Arab world needs more journals to publish scientific results. The objective should be to create a dynamic of exchange between members of the scientific community locally and to mobilize allies from peers, the public and decision makers. It should be noted that the main dynamic behind the publication of journals is the existence of a lively scientific community. Large publishing companies (Elsevier, Kluwer) have taken strong commercial positions, making the scientific community an instrument of commercial objectives. With the advent of Open Science, strong protests have emerged from working scientists that have used the force of 'social digital networks' to mobilize the community giving way to a renewal of peer partnerships. The Arab World could profit from this tendency; it should also encourage publishing in Arabic when – and only when this condition is given—there is a group of scientists that is demanding it. The main difficulty here is that academic institutions for reasons that are purely institutional have a tendency to promote departmental journals. In very large universities that might make sense; it is a waste of time in smaller ones. Journals are better defended when they belong to a specific disciplinary group, focused on some very precise topics or on broader disciplinary areas if the persons that want to defend the journal feel such a need. Moreover, universities and science councils should defend the popularization of science. A massive effort should be given to create a wider audience for science, technology and innovation by creating lively journals, websites, films, documentaries and other dissemination tools for scientific and technological activities. Citizens shouldn't be kept in the ignorance of what happens in their own countries in the laboratories, schools and universities.

Diaspora options

There are many lesson learnt from the experiences in the last 15 years of TOKTEN program and Networking. It is extremely important that UNDP or any international organizations foster the temporary stay of scientific expatriates in their country of origin. All countries in the Arab world need the equivalent of PALESTA, Palestinian network of diaspora scientists involved with the development of Palestine remotely. This network costs little money but can harness development in the Arab World.

Better living conditions

Scientists and engineers would probably accept comparatively lower salaries than their colleagues in the USA or Europe if they have better conditions in the academic institutions in their own country.

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