Chapter 5

Comparative Study on National Research Systems: Findings and Lessons

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1. Introduction

Research and analysis in the sociology of science, and science policy studies, have grown exponentially over the past fifty years. In this process our knowledge and understanding of what drives science and scientific growth in the modern economies of the world (mostly in the North) has increased significantly. Country studies, especially comparative analyzes (motivated by the interests of international bodies such as the OECD and UNESCO as well as the agendas of national agencies such as Sida/SAREC and IDRC), have flourished.

However, and perhaps for obvious reasons, these studies did not prioritize the very poor and underdeveloped nations of the world. Whether this reflected a sentiment that these countries were relatively unimportant in the global economy, or a belief that their research systems are not worth studying because of their relative small contribution to world science, or both, is not that important. There have been a few exceptions, namely countries that at one time would have been classified as developing nations (Brazil, China, India, South Africa and others) but more recently now as "emerging countries" and which receive increasing attention. But the bulk of the poor countries of the world generally did not warrant any attention.

This chapter discusses the findings and lessons of a comprehensive review of national research systems in fifty-two developing nations across the globe.[1]

They are presented as follows:

(1) The growing gap in knowledge production between developing nations of the world and the rest,

(2) A discussion of the roots of and reasons for these inequalities.

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

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

(5) Concluding comments on the "de-institutionalization" of science in these countries.

Before discussing the main findings, a brief note on the overall aims of the study as well as key methodologies employed is in order.

2. Methodology and Database

At a workshop held on 6 and 7 April 2006 at UNESCO, Paris, the objectives of a proposed study on national research systems were defined as follows:

> "… to learn more about research systems in developing/poor countries, and to help strengthen research and research capacity. Thus, the project supports research on and for development so that developing/poor countries may articulate and have ownership of these systems which are key assets for their development".

Giving further reflection on this brief, the authors subsequently referred to this study as a meta-review of existing country studies. A meta-review (or systematic review) is a study which has both a descriptive and "evaluative" aim; its descriptive aim is to describe and summarize in sufficient detail the key elements of a particular study (i.e. date, coverage, study objectives, data sources, methodologies used and key findings), and its evaluative aim is to make a judgment on the quality of the study being reviewed. This would entail commenting on the reliability and age of data sources, appropriateness of design and methodology, and the extent of the coverage of the study.

Given the large number of countries to be covered and the potential diversity of studies to be reviewed, a two-phased approach was adopted:

- Phase 1: Utilizing the knowledge and resources of a small number of research co-workers to collect relevant material and complete a first round of study mapping (the collection and mapping phase).
- Phase 2: Comparative and integrative review of the first round study maps (the integrative review phase).

Based on previous studies and collaborations, we were able to call upon a number of knowledgeable and well-placed researchers to assist us in the execution of this commission. Most notably we were able to secure the collaboration of Professors Daniel Villavicencio (Mexico) and Venni Krishna (India) and their collaborators, to assist us with the compilation of the Latin America and Asia country reviews respectively. Their key tasks were twofold:

(1) To work through available and known collections of studies and to systematically summarize all possible sources of information (government resources/ websites/ S&T studies centres), in order to identify studies that meet the criteria for inclusion as outlined above.
(2) To produce a summary "map" of each study in accordance with a framework we developed.

In addition to being able to call upon the cooperation and resources of these two persons, we were also able – especially with regard to the country reviews for Africa and the Arab region – to draw on recent and current studies being undertaken by ourselves and our immediate colleagues (see End Note), and the study produced a wealth of reports[2]

- Four regional compilations (Africa: 22 countries; Arab Region: 11 countries; Latin America: 14 countries; and Asia: 13 countries).
- Four regional reports.
- A consolidated bibliography.
- A Final Synthesis Report and Template.

In a study of this scope, it is inevitable that some countries or some sectors in particular countries will be less well covered than others. Indeed, this is especially the case where no previous integrated study of that country had been done to date, and also applies to statistical data about different research systems. Utilizing the information provided by the UNESCO Institute for Statistics (UIS) in Montreal, as well as from our own sources, we were able to compile statistical tables that were as up-to-date and complete as possible. Again, however, for some of the poorest and smallest countries in our sample, the data sources simply do not exist and such gaps could only be filled through in-country studies.

3. Growing Gap in Knowledge Production

When one looks at the production of science and technology in the majority of developing countries, the first observation is that there is a gap between a handful of "emerging countries", a few intermediary countries (five to ten in each continent) and the bulk of the remaining 100 countries whose productivity remains minute (forty countries), or very small (sixty countries; see Table 1 below).

This is not peculiar to a specific region, even if sub-Saharan Africa has gone through more trials and tribulations, nor is it linked to a decline in publication output. Yet the stagnation of research output means that some countries have lost their relative share compared to the rest of the world. Even in countries that are not very productive there are pockets of good science; the question rather is that of critical mass, and the minimum human and other resources required to maintain scientific quality and build a subsequent generation of scientists.

Table 1. Distribution of Countries According to their Publication Output and Growth over the Twenty-year Period 1987-2006

Emerging	6,000 ⇒ 60,000	**China** 53,000 (x 13) **S. Korea** 22,380 (x 23) India 19,290 (x 1.8) **Taiwan** 13,700 (x 10) Israel 9,900 (x 1.5)	**Brazil** 13,000 (x 5.2)	
Candidates emerging	2,000 ⇒ 6,000	**Singapore** 5,250 (x 11) 3,710 (x 28) Thailand 2,235 (x 6.5)	**Mexico** 5,320 (x 4.1) Argentina 4,337 (x 2) Chile 2,220 (x 2,5)	S. Africa 3,850 (x 1) Egypt 2,740 (x 2)
Intermediary >	600 ⇒ 2,000	**Malaysia** 970 (x 3.5) 930 (x 1.3) Pakistan 750 (x 2.4)	Venezuela 820 (x 1.7) **Colombia** 605 (x 4)	1,080 (x 7.2) 860 (x 6) 730 (x 5)
Intermediary =	200 ⇒ -600	**Viet Nam** 500 (x 8) Indonesia 480 (x 3.4) 480 (x 4) 420 (x 2.4) 410 (x 12) Philippines 390 (x 2.2) 355 (x 1) Bangladesh 350 (x 3)	Cuba 440 (x 4) Uruguay 370 (x 4.7) Peru 240 (x 2)	Nigeria 560 (x 0.6) Kenya 550 (x 1.5) Tanzania 300 (x 3.2) **Cameroon** 280 (x 6.6) **Uganda** 260 (x 7) Ethiopia 240 (x 2) **Ghana** 200 (x 5.6)
Intermediary <	100 ⇒ 200	Sri Lanka 205 (x 1.7) 200 (x 8)	Costa Rica 180 (x 2.4) Panama 145 (x 2.2)	Senegal 140 (x 1.4) Zimbabwe 130 (x 1)

		145 (x 3.5) **Nepal** 140 (x 4)	Ecuador 110 (x 2.9)	**Malawi** 120 (x 4) **B. Faso** 115 (x 4.6) Ivory Coast 105 (x 1.4)
Small science countries > 100	60 ⇒ 100	80 (x 2) 55 (x 1)	Bolivia 90 (x 2.8) Jamaica 85 (x 0.7) Trinidad & Tobago 80 (x 1.7) <u>Guatemala</u> 60 (x 1)	**Botswana** 95 (x 5) Zambia 90 (x 2) **Madagascar** 90 (x 4) Gambia 80 (x 1.5) Sudan 75 (x 0.6) **Mali** 75 (x 5) Gabon 75 (x 2.4) **Benin** 67 (x 4) <u>Namibia</u> 60 (x 3)
"Very" small science countries < 60	1 ⇒ 60	15 countries	18 countries	27 countries
Total No. of countries		40 countries	34 countries	53 countries

Countries are listed in descending order by size of research output (2006).
Legend:

Median score (by continent) is <u>underscored</u>.
Countries with a high growth (more than a factor of 3.5 within the 20-year period) are in **bold.**
Data are for 2006 (Science Citation Index – the non-expanded version), rounded to the next ten.

Discussion:

— Asia is catching up faster than other parts of the world, with approximately eight countries making tremendous efforts and demonstrating continuous progress (with a growth factor of more than 3.5 between 1987 and 2006). Nevertheless, about one third of the countries remains very small in scientific terms, and seems uncommitted to its development (such as Cambodia, Myanmar, Yemen) and whether rich – Brunei, or poor – Laos).

— The average level of scientific output in South America remains good, but there are significant geographical discrepancies. Most of the Andean countries are lagging behind. Central America countries and the Caribbean seem less interested in research, with the two exceptions of Costa Rica and Cuba. In total, half of the countries on the continent could be classified as being "very small" science countries.

— The proportion is the same in Africa. Moreover, and with the exception of South Africa and the North Africa regions, the gap between Africa and other continents is also huge. Small scientific communities are very sensitive to the ups and downs of politics, policies and funding (local or international). Nevertheless they are capable of recovery, and for the past ten years a few countries have shown noticeable growth – such as the Maghreb countries, but also Botswana, Cameroon and Ghana, and some very poor countries such as Burkina Faso, Malawi and Mali. On the other hand, some scientific communities seem to be collapsing (as is the case of Nigeria and Sudan, where very little growth in output is reported).

The decline of a country in "world scientific capacity" is correlated with that part of the national wealth which is invested in research and development, as well as with the number of researchers in proportion to the population (see Table 2 below). But these correlations are not perfect, and there are other factors to explain the development of science than scientific investment and workforce size.

Table 2. Distribution of countries according to GDP per head and GERD (as percentage of GDP)

50 wealthiest	> 25 000			
Emerging	15,000 ⇒ 25,000	**South Korea** 22,000 (**2.6**) **Taiwan** 29,000 (**2.5**) **Singapore** 30,000 (**2.3**) ? (*) Bahrain 22,000 (0.3*) Kuwait 26,500 (0.2) Emirates 25,500 (0.2*)		
Intermediary >	7,000 ⇒ 15,000	11,000 **( )** 8,000 **( )** 16,000 **(** Thailand 7,500 (0.3) Saudi Arabia 15,700 (0.14*)	**Brazil** 8,400 (**1.0**) 12,000 Argentina 14,300 (0.4) Mexico 10,800 (0.4) Costa Rica 10,200 (0.4) Uruguay 10,000 (0.2) Trinidad & Tobago 14,500 (0.1)	**South Africa** 11,100 (**0.8**) Botswana 12,400 (n.a.)
Intermediary =	4,000 ⇒ - 7,000	**China** 6,800 (**1.4**) Jordan 5,500 (0.35) Lebanon 5,600 (0.2) Philippines 5,100 (0.1)	4,300 Panama 7,400 (0.3) Venezuela 6,600 (0.3) Colombia 7,400 (0.1) Peru 6,000 (0.1) Jamaica 4,300 (0.1) Ecuador 4,300 (0.1)	**Tunisia** 8,400 (**1.0**) 7,000 4,600 Egypt 4,300 (0.2)
Intermediary <	2,000 ⇒ 4,000	3,500 **( )** 2,100 Syria 3,800 (0.2) Viet Nam 3,100 (0.2) Pakistan 2,400 (0.2) Sri Lanka 4,600 (0,1) Indonesia 3,800 (0.1)	Bolivia 2,800 (0.3) Guatemala 2,500 (n.a.)	Ghana 2,500 (n.a.) Cameroon 2,300 (n.a.) Zimbabwe 2,000 (n.a.) Sudan 2,000 (n.a.)
Low income	1,000 ⇒ 2,000	1,600		**Uganda** 1,500 (**0.8**) Burkina Faso 1,200 (0.2) Gambia 1,900 (n.a.) Senegal 1,800 (n.a.) Ivory Coast 1,600 (n.a.) Kenya 1,200 (n.a.) Benin 1,100 (n.a.) Nigeria 1,100 (n.a.) Ethiopia 1,100 (n.a.)
Very low income <	1 ⇒ 1,000	15 countries	18 countries	Madagascar 900 (0.1) Mali 1,000 (n.a.)

				Zambia 1,000 (n.a.) Tanzania 750 (n.a.) Malawi 700 (n.a.) + 21 countries
Total number of countries		45 countries	33 countries	53 countries
Some comparisons	**Sweden** 33,000 (**3.7**) **USA** 42,000 (**2.7**) **France** 30,500 (**2.2**)	**Israel** 25,900 (**5.1**)		

Source: Human Development Reports (UNDP, 2007). Figures for 2005 completed from UIS or Nour (2005) for some Arab countries.

Legend:
Countries are listed in descending order by GERD.
Countries with a high GERD (≥ 1% percentage of GDP) are in **bold** letters.
Countries with a reasonable GERD (0.6% ⇒ 1%) are in (Nour, 2005).

Some comments are in order:

— Table 2 should be read in comparison with Table 1. Though there is some congruence with the GDP (per capita), the interest in research is not linked to it in a simplistic, linear fashion. Some rich countries do NOT invest in the development of science (see Trinidad and Tobago, and until recently, most Gulf countries). Much depends on the will and interest of the government, ambient values, and international support.

— Nevertheless, emerging countries (or "candidates emerging", see rows at the top of the table) are increasingly investing in the development of original research (bold letters). The table also shows the real dynamism of "intermediary countries" such as Cuba or the Maghreb countries. Observers consider, and results seem to confirm, that these countries are creating a reservoir of new wealth.

— Other intermediary countries (and even poor ones) choose to invest in research with the help of international aid. This is the case for Ghana, Malawi and Uganda, while Burkina Faso, Costa Rica or Kenya have more skilfully created a friendly environment for housing international research centres. The choice to invest relies on the availability of a local scientific profession of good quality, working under conditions of adequate infrastructure and funding.

The case of "intermediary countries" (about forty in our sample: not yet "emerging" but considering science, or at least in full possession of the means and capabilities to do so) is especially interesting. It clearly points to those factors that constrain and even impede the rise of research, and the difficulties of successful strategies (even in choosing efficient topics) in a world where scientific achievement on a level playing field has become a rarity: advances are unequally distributed, and jealously guarded, on account of their contribution to local prosperity.

4. Roots of Inequality

Our investigation of the fifty-two countries has provided some answers as to why such significant inequalities in world science have developed, and still exist.

plays its role. Latin America is clearly ahead of the other continents, its own inequalities notwithstanding. Colonial times are now very much ancient history, and there is a relative abundance of universities, staff, and reputable establishments (universities or Institutes, private and public). Though the state has more often than not been "abusive" in its treatment of scientists, there has been ample time to develop a "space for science", and to build socio-cognitive blocs in support of these endeavours (Schwartman, 1991). Other examples can be found around the world. In Africa, the two main producers (South Africa and Egypt) are countries which have also been engaged in the development of a national science base for more than a century, and were only "semi-colonies"; Thailand is another instance. It must be stressed that sometimes the historical role lays less in "whole countries" than in specific establishments, which are "sanctuaries" for research where and when there is no continuing interest in it. Examples of these could include the Saint Joseph or American Universities in Beirut. In most places there is a specific role for a few establishments, and often the oldest are the most attached to high standards. Renowned scientists may also have a lasting influence, as Nobel Prize winners (such as Abdus Salam [Nobel Prize in Physics, 1979]) or other talents who were the pride of their country and went on to set up deeply-rooted Institutes (such as the Institute of Physiology of Bernardo Houssay in Argentina, or the Oswaldo Cruz Institute in Brazil). Naturally, older institutions and persons may also be conservative and possibly unproductive.

, past and present, have powerful and enduring effects; Singapore is a good example. For half a century the country has been driven by an export economy and interventionist Government. Beginning with worker discipline and modest technical ambitions, the Government of Singapore moved on to the training of professionals and the production of more technological goods, and now to the growth of a powerful scientific community, featuring high-end training and devoted to strategic or applied research in computer science and biotechnologies. Publications grew in the last twenty years from a low of 500 to over 5,200 in 2006, an "emerging country" score; this shows that the size of a country is not the decisive factor in scientific production.

On the contrary, countries relying on income from natural resources (for instance the oil economies), or striving mainly for the development of services (as in most of the Caribbean countries) do not really need science and research. They may maintain universities, invite top-flight 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 (as could be seen in the Democratic Republic of Congo and Nigeria, and a number of other places).

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 Brazil, Egypt for some time, the Maghreb countries and a number of others). 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.

: There must clearly be some pact (at least an implicit one) between science and society. For a long time, since the Second World War, the opinion has been that the development of science benefited the people and generated new, salutary technologies. It was the 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 into the building of higher education and research centres, with the support of international cooperation and funding and with greater or lesser ambitions (enlightening minds, or harvesting rapid, useful results). Scientists organized professionally, but the promises seemed a long time in coming. The 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 "national" mode of knowledge production fell into disgrace, and more linkages were established with the market economy. This shift, more often than not, led to a withdrawal of state support, and sometimes to the disparaging of local scientists as parasites (as in, Bangladesh, Nigeria and Tanzania).

Of course, even during times of misfortune, science may have a pact with parts of society. This was the case in Asia, in Egypt, in Latin America on several occasions (Argentina, Brazil and Venezuela) during the beginnings of or under dictatorships), and in South Africa during Apartheid. Nevertheless, it seems better that there be some general consensus (or debate) about the uses of science; its best grounding nowadays seems to be in the pursuit of innovation, which implies energetic support from the state for "strategic" and applied research, organized in "clusters" in collaboration with dynamic firms. Malaysia is resolutely on this path, as well as Argentina, Chile and Mexico. Thailand is considering it. 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. Indeed, this is the choice of emerging countries as well as "candidate" emerging ones. All "intermediary" countries where science is growing fast do the same; some others hesitate, and may lose ground (Morocco). Small scientific countries are not destitute: they may try to find niches of excellence, with the help of international cooperation if necessary (as in Burkina Faso).

The 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, India, Thailand and Viet Nam. 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 values, values related to aristocratic ancestry or to the family, may also predominate and override all other considerations. These tendencies may well interfere with a commitment to science and its standards. Among others, Jordan is a well-documented case of self-censorship for partially religious or political reasons, and of family duties superseding professional obligations. In a number of places, this may reach the point where practising 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 aim to work in research centres, where (they believe) they will escape a heavy burden of teaching and too many additional professional demands. At the least, 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.

is part of the scientists' trade, as there is a constant need for scientists to develop role models and promote the understanding of science. And there should be appreciation within epistemic communities for different kinds and levels of science: pure and theoretical of course, but also applied, and even development and action research. There are interesting examples of the peaceful coexistence of several circles and arenas for example in biology in Egypt, where a few teams have impressive international credentials, while many others just develop very simple devices (which they even go and sell to peasants in the neighbourhood) to protect local plants from characteristic insects. In India also the participation of engineers and scientists in movements and research centres that develop and diffuse incremental improvements for poor peasants is a well-known and regarded activity. The same is true in many places, especially where research is not well established: see for instance the action research at the University of the West Indies (UWI) in the Caribbean, or in Mozambique (about agriculture). Of course, such achievements are not properly reflected in the international bibliographic databases. But they are very useful to the entire society. The lesson here is that in the developing world, popularization is part of the science system, and it requires support and effort from the scientists themselves – perhaps more than elsewhere.

5. Human Capacity, Scientific Capital

At the other end of the production of science, there are of course individuals, the (more or less) talented persons in charge of generating knowledge.

production is roughly indexed on the volume of staff (in countries and establishments), and the larger that is the larger the diversity of topics and approaches. The number of researchers per million people is an index of the interest of the government (and of the people) in the development of the human capital base of science (Table 3).

Table 3. Distribution of countries according to GDP per capita and number of researchers per million inhabitants

50 wealthiest	> 25,000			
Emerging	15,000 ⇒ 25,000	**Taiwan** 29,000 (**2,500**) **Singapore** 30,000 (**5,000**) **S. Korea** 22,000 (**3,200**) Kuwait 26,500 (210) Emirates 25,500 (n.a) Bahrain 22,000 (n.a.) Qatar? (600*)		
Intermediary >	7,000 ⇒ 15,000	**Iran** 8,000 (**1 300**) 11,000 **Thailand** 7,500 Oman 16,000 (10*) Saudi Arabia (100*)	14,300 ( ) 12,000 ( ) 10,000 **( )** 8,400 ( ) Trinidad & Tobago 14,500 (n.a.) Mexico 10,800 (270) Costa Rica 10,200 (n.a.)	Botswana 12,400 (n.a.) 11,100 ( )

Intermediary =	4,000 ⇒ -7,000	6,800 ( ) Lebanon 5,600 (200*.) Jordan 5,500 (280*.) Philippines 5,100 (50)	Colombia 7,400 (110) Panama 7,400 (100) Venezuela 6,600 (n.a.) Peru 6,000 (230) Cuba 4,300 (n.a) Jamaica 4,300 (n.a.) Ecuador 4,300 (50)	**Tunisia** 8,400 (**1 000**) 4,300 ( ) Algeria 7,000 (n.a.) Morocco 4,600 (250*)
Intermediary <	2,000 ⇒ 4,000	S. Lanka 4,600 (130) Indonesia 3,800 (210) India 3,500 (120) Syria 3,800 (30) Viet Nam 3,100 (120) Pakistan 2,400 (75) Bangladesh 2,100 (50)	Bolivia 2,800 (120) Guatemala 2,500 (n.a.)	Ghana 2,500 (n.a.) Cameroon 2,300 (n.a.) Zimbabwe 2,000 (n.a.) Sudan 2,000 (100*.)
Low income	1,000 ⇒ 2,000	1,600 (60)		Gambia 1,900 (n.a.) Senegal 1,800 (n.a.) Ivory Coast 1,600 (n.a.) Uganda 1,500 (n.a.) B. Faso 1,200 (20) Kenya 1,200 (n.a.) Benin 1,100 (n.a.) Nigeria 1,100 (n.a.) Ethiopia 1,100 (n.a.)
Very low income <	1 ⇒ 1,000	15 countries	18 countries	Mali 1,000 (n.a.) Zambia 1,000 (50) Madagascar 900 (15) Tanzania 750 (n.a.) Malawi 700 (n.a.) + 21 countries
Total number of countries		45 countries	33 countries	53 countries
Some comparisons	**Sweden** 33,000 (**5,400)** **USA** 42,000 (**4,600**) **Franc** 30,500 (**3,200**)	Israel 25,900 (n.a.)		

Legend: Countries with a high number of researchers (≥ 1,000 / Million of population) are in **bold.**

Countries with a reasonable number of research (300 ⇒ 1,000 / M pop) are in

Discussion:

- This table gives an indication of the commitment of different countries to the development of research. It is clearly indexed (though with some discrepancies) on the level of income, i.e. of success in "development".
- Oil-producing countries have invested less than they could (and should) have done; but clearly the Gulf countries are beginning to prepare themselves for the "post-petroleum" era.
- Several countries in the Southern zone of Latin America are among the most committed to knowledge and innovation. Andean countries and the Caribbean lag well behind, in spite of having some very old and reputable establishments. Costa Rica and Cuba are the two noteworthy exceptions.
- In Africa, Tunisia is by far the most dynamic (and persevering) place for research. The rest of North Africa (and South Africa) are now on the path of mass higher education, hence a larger reservoir of teachers doing research. The rest of the continent lags behind on account of its young (and often elitist) universities.

Other considerations may be more important. One of them is the question of 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. A more refined analysis (per establishment and per field and topic) may be a good management tool however: 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; and within each of these 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. A full range of management questions applies: How to develop relevant international cooperation? How to build appropriate networks? How to consolidate efficient niches?

Qualifications are hugely unequal across countries. In Latin America, there are numerous universities and their staff complements are relatively large, even though the lecturers are globally less qualified than elsewhere. This does not mean that they are unable to conduct good research, but some commentators have indicated that further training and professional development is required. The same is true for researchers working in mission-oriented research centres (for instance in agriculture) all over the developing world.

Yet qualifications are not everything. "Episteme" is another dimension, and by this we refer to the scope of problems which the researcher considers worth facing, and solving, through "scientific" investigation. This is often a matter of thinking styles (deductive, inductive, retroductive, etc.), education and type of establishment where the scientist was trained (for instance universities versus engineering schools), the science curriculum (with more or less experimental practice), job conditions and expectations, and the research culture (or lack thereof) of the institution itself. It might mean that the scientist is more open to theoretical or applied approaches, or considers problems at specific levels (full complexity at local level, or simplified approach at global level). Such postures differentiate populations of scientists, who have of their own fields of interest and success.

: working and living conditions are included in this, and the motivation and orientation of research are dependent on them. Though action parameters are limited (except for national policies), a few comments are in order. For a while (during the 1950s to 1980s), the profession of researcher in research centres was seen as rewarding, and that of teachers in higher education even more so. Students were relatively few, university professors were respected and well-remunerated, and there were fringe benefits. In ex-colonies, many researchers had been trained in the best laboratories of the former metropolis and had excellent networks and links with the international scientific community. They were able to pursue high standards in their own research, and academic freedom was the rule. The 1990s introduced big changes, as university degrees were increasingly seen as the way to advance in society and the workplace. The subsequent demand led to an exponential increase in university enrolments, which forced governments to invest more in building new universities – often with campuses scattered through the whole country in order to avoid dangerous concentrations. But this was also the time when "liberalism" enjoined them to restrain their spending, especially in social and non-productive sectors. Few new teachers were taken on, salaries were cut or frozen, initial expectations about the benefits of sci-

Box 1
Human Resources and Profession: the Case of Jordan
(Extract from P. Larzillière, ESTIME Report on Jordan, here based on a contribution from Abdel Hakim al Huzban, Yarmouk University)

According to the regulations of higher education in Jordan, a faculty member in a university is defined first as an instructor whose main job is to teach and whose work hours are teaching hours. In spite of that, job promotions in universities are entirely dependent upon research activity and record.

Number of credit hours that each staff member should teach per week:

Lecturer	15 credit hours
Full Lecturer	12 credit hours
Assistant Professor	12 credit hours
Associate Professor	12 credit hours
Full Professor	9 credit hours

The academic ladder for the Ph.D. academic staff in Jordan consists of three ranks. Academic promotion leads to a considerable rise of salary. There is then no real incentive for researchers who have the professorship, so many of them switch to less momentum after this rank; the professorship becomes the ultimate purpose, not the research.

The income of people involved in research work (most of the research in the country is carried out mainly at the universities) is relatively good, compared with those with other careers in both the public and private sectors. All public universities have a (more or less) similar scale for salaries which mainly depends of the professional rank of the research staff (assistant professor/researcher, associate/professor). Research staff who work on large-scale projects and get involved in some administrative work usually get paid for such extra efforts.

Table showing the rate of salaries in the public universities in Jordan

Lecturer	J.D. 600-700
Full Lecturer	J.D. 800-900
Assistant Professor	J.D. 900-1000
Associate Professor	J.D. 1,100-1,300
Full Professor	J.D. 1,400-1,600

The average salary of some professions and public careers

Career	Salary
General Doctor working in the Ministry of Health	400 J.D
School Teacher in a public school	240 J.D
Army officer	400 J.D

Source: A. H. al Huzban and P. Larzillière, in ESTIME Project, op cit.

Nevertheless the profession has changed. As recruitment was frozen, a large part of the profession is now made up of a proletariat of "casual or contract labourers", with poor career prospects and significant turnover. The core funding of establishments is limited. Running costs for research are linked to contracts (individual or not). And setting up a project often requires a sum of minute supports, and significant labour in accounting for their use.

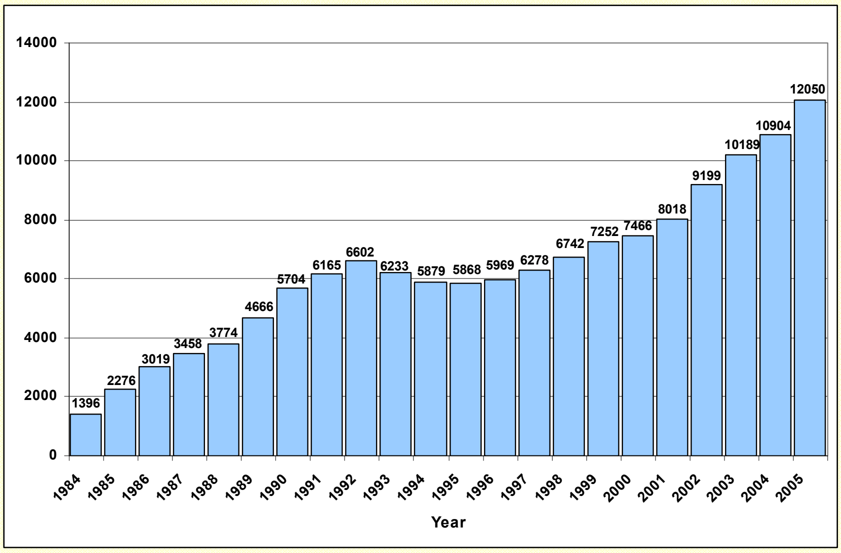
When the state takes interest in the activity, it sets strict evaluation rules for the professionals. For instance, in Latin America a system of "national researchers" spread through the continent, significantly promoting a small number of deserving researchers (Box 2).

Box 2
A Way to Regulate the Profession:
The "National System of Researchers" (SNI) in Mexico
by D. Villavicencio; UNESCO Global Report to the UNESCO Forum, January 2008

The National System of Researchers (SNI) was created in July 1984, with the aim of acknowledging and rewarding the work performed by researchers in the country, whether at public universities, public research centers, or some private universities having an agreement with the CONACYT. The quality of work and the prestige of contributions made are recognized on the basis of an evaluation (currently performed every 3 or 4 years). SNI members are given monthly financial incentives ranging from $800 USD (Junior Research) to $1,300 USD (for Seniors).

The SNI classifies national researchers in accordance with their accomplishments in science and technology (the first requirement is that they must hold a doctorate) (CONACYT-SNI, 2006). This classification includes five categories: "Candidate" (Junior), Levels 1, 2, 3, and Emeritus. The table below shows the evolution of the SNI and highlights the significant growth in the number of members it has over the last few years.

Figure 1. Members of the SNI, 1984-2005, Mexico



Source: CONACYT, 2004 and 2005a.

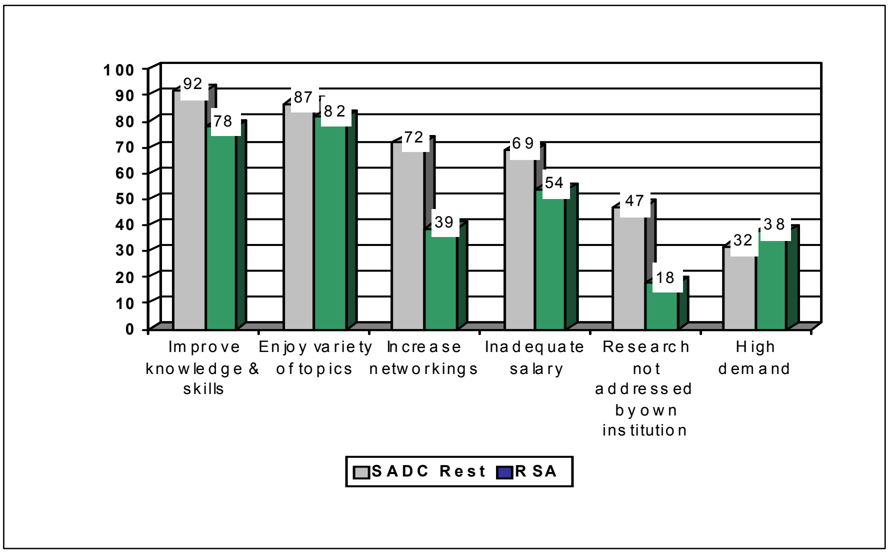
It has now been completed by a scheme for budgeting groups (and not only individuals), selected after strict screening. The government may also launch calls for tenders, strive to boost research in remote places (Chile, Mexico) and organize the players in teams, within "clusters" where they are supposed to have business dealings with firms (Malaysia, Tunisia…). In these (favourable) cases, the academy and related institutions have much less control over the quality, choice of topics and orientation of research. In other cases (countries which do not trust science, or seek other results than those valued) it is up to the researcher (or team) to find his/her own budget by persuading sponsors and making international connections. Many academics prefer to refrain from such activities.

Many constraints and poor working conditions persist in low-income countries, increasingly forcing academics to revert to consultancy work; oftentimes this is for international agencies and governments, rather than for local agencies. In a recent study of public science in the SADC Region[3] we collected data (one of the first studies of its kind) on the extent and nature of consultancy activities in these countries. The results show that more than two thirds of all academics in the region regularly engage in consultancy. What are the main reasons respondents provided for engaging in consultancy? Figure 2 below presents a comparison of the South African and other SADC responses. There are some noticeable (and statistically significant) differences. In two areas we notice very little difference: first, the fact that consultancy is undertaken because the respondent enjoys the variety of topics that this brings (87 vs. 82 per cent); second, that consultancy is done because of the demand in the market (32 vs. 38 per cent).

But the other reasons provided demonstrate larger differences between the South African and other respondents:

— Inadequate salary is cited as a reason by significantly more SADC respondents: SA (54 per cent)/SADC Rest (69 per cent).
— Consultancy advances my networks and my career: RSA (39 per cent)/SADC (72 per cent).
— My research interests are not addressed by my own institution: RSA (18 per cent)/SADC (47 per cent).
— Consultancy improves my knowledge and skills: RSA (78 per cent)/SADC (92 per cent).

Figure 2. Reasons for Consultancy



A further breakdown by scientific field revealed significant field differences, but mostly in the expected direction. Respondents in very applied fields (where there are close links with industry and also government) such as applied sciences and technologies, earth sciences, engineering, material sciences and also social sciences (with policy work) reported high percentages of consultancy engagement. In other fields, such as mathematical sciences, little consultancy opportunities exist.

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 not replaced, 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 of quality. It is important that newcomers inherit authoritative mentors, but also that they import new methods and cutting-edge science, that won't soon be outmoded and will be useful to engineers, doctors and scientific and technological managers on a long-term basis. The same is true for professionals, who should also be enrolled in topical research and sometimes renew their knowledge. A number of our monographs acknowledge that (especially in provincial areas, in Andean and Caribbean countries, and in some countries in Asia) there is a lack of scientific life, and a need for upgrading the 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 (advice to government, gathering of funds, and liaison with industry…).

In a recent survey of brain drain in the fourteen countries of the SADC region, 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. When the results were disaggregated and South African respondents compared to the other thirteen SADC countries (Angola, Botswana, DRC, Lesotho Madagascar, Malawi, Mauritius, Mozambique, Namibia, Swaziland, Tanzania, Zambia and Zimbabwe), nearly one in four of respondents from the other SADC countries responded in the affirmative to the question.

Table 4. Do you plan on moving to another country in the near future?

South Africa	Valid	Yes	33	14.0
		No	202	86.0
		Total	235	100.0
Other SADC	Valid	Yes	93	24.8
		No	282	75.2
		Total	375	100.0

Linked to that concern is the organized locally, especially in Latin America and sub-Saharan Africa. Of course, it remains of interest that many good students complete their degree course abroad (doctoral thesis or post doc). But it has been argued (without much proof) that this mechanism encourages brain drain and diverts young researchers from relevant topics at home. "Sandwich programmes" are not an obvious solution, and at best only a short-term one. The necessity of a sensible reproduction of local scientific capacity is the strongest argument for developing graduate training ; this is a challenge for the scientific community, local and international, and appropriate aid programmes are required. One main principle is probably that the latter should aim not only at capacity-building, but simultaneously at institution-building: namely, that they help to develop (through specific means in each situation) a sustainable scientific life locally. Good examples of such projects include the networks supported by the Swedish ISP, or the French programme supporting mathematics in Africa, the Southern Research and Innovation Management Association ( ), which helps to establish laboratories (supervising doctoral candidates) and insert graduates immediately in regional networks.

Brain drain is of course the reverse concern, and there is a need for figures and studies about this much-discussed question. One first recommendation is that longitudinal surveys be conducted in order to investigate this more systematically. Nevertheless, there are enough scattered data to demonstrate, at least in specific countries or regions, the extent of this phenomenon and its fluctuations.

Table 5. Brain Drain from the Near East

Number of scientists and engineers established in USA (born in the Near East), 2000

	Egypt	Lebanon	Jordan	Syria	Palestine	Kuwait	Maghreb
Established in USA	12,500	11,500	4,000	5,000	2,600	2,400	ε
Employed in R&D	4,400	4,900	2,000	1,800	700	1,200	ε
Researchers in the country headcount*	75,000	6,000	6,500		Nd	2,400	40,000
Researchers in the country FTE*	15,000 **	600	750	400 *	Nd	500	8,000

Source: Johnson, J. (NSF), in Barré, R. and Meyer, J.-B. 2003. . Paris: IRD.
* = ESTIME.

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; and 90 per 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).

In 2003, Jean Johnson from the NSF published very detailed figures (op. cit.) on the number of foreign residents holding a degree in Sciences and Engineering and living in the USA. By the turn of this century, Latin America provided about 200,000 degree holders to the USA, nearly half from South America and half from Central America and the Caribbean. Among them, 30 per cent worked in the R&D sector.

For these Latin American degree-holders working in R&D, there are three main patterns:

— Those working in the USA outnumber by far those working in their home (Caribbean) country.
— Those working in the USA are equivalent to those working in their home (Andean) country.
— Those working in the USA are less than those working in their home (Cone) country. But the expatriation is significant among Argentinean (and to a lesser extent Chilean) degree holders: 1/5 to 1/4 of the scientific community has left for the USA. There are a few exceptions, such as Costa Rica and Uruguay.

There is a range of opinions about brain drain. In many countries, the official point of view is that emigrants are despicable traitors, who prefer their own material well-being to their homeland's interests. Added to that 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. There are elements of truth in these arguments (especially the second one); but intellectuals are not the only ones fleeing some countries, and there is no reason for them to remain the hostages of governments that do not care (or know how) to use their talents. Some recent studies have convincingly proven that most intellectuals' attitudes depend on the national science policies, and on the movements of international industry. The North African case has been well-documented: as far as the profession is decently treated (status, income, and no tremendous claims) and scientific life can go on, brain drain is much lower (as in Algeria or Morocco) and most students come back home after completing a doctoral degree abroad. They may be giving up lucrative careers in the metropolis, but prefer (managerial) positions in their home environment (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 opinion 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. This approach has inspired recent, radical measures in some Gulf countries (Qatar and United Arab Emirates [UAE]) that have built grand "Science Cities" and offered facilities to prestigious foreign universities and firms. On a smaller scale, Brazil did the same decades ago when it established in São Paulo a brilliant School of aeronautical engineers (and subsequently an aviation industry). There is some value in this approach. National scientists may come back home (and they often prefer their country, for cultural and personal reasons, so long as a scientific life is possible and career prospects are acceptable). With sufficient incentives, China and Singapore have re-imported from the USA those they needed. And highly-qualified Indian scientists went a similar way to build the computer industry in their home country.

This means that there is room for science management and policies. The "diaspora option" (attempting to liaise between the local scientific community and associations of highly-qualified expatriate nationals) is one tool that was tested (with varying success); targeted enticement in specific developing niches is another one (aiming at firms as well as staff); and the establishment of new postgraduate courses, the layout of science-friendly environments, and support to scientific life are also useful measures in order to curb brain drain. Of course such policies have to be linked with a fair valuation of the profession and with job creation. At any rate, they deserve genuine international attention and support.

6. Specific Role of Universities

There are different sorts of research performers. Each type has its own mission, its style of science and its fields of success. Pr

To sum it up, the of university research exceeds much of its traditional justification, namely to enhance the quality of training and ensure the reproduction of the academy. These goals are important, but the need for academic research goes beyond them. The university is best positioned to link up with the world scientific community, and with the advancement of knowledge; it is most capable of doing whatever basic research is necessary, but also of mobilizing its results and translating them into ideas for "strategic" implementation.

The function of research for Universities:

- We already mentioned that research was indeed an asset for the not only the training of academics and researchers to be, but the training of all sorts of highly-qualified technicians, whose knowledge will remain relevant on a long-term basis. A complementary task for Universities is the continuing education of staff in productive sectors.
- Research is also part of the of academics: it is their way to keep themselves up to date, to remain informed of the advancement of world science and to gain a sense of the technological stakes. Equipped in this way, they may aim at competition with other colleagues and laboratories, local and foreign; they may build scientific comparative advantages, choose original topics, select opportune cooperation and carry out autonomous work. They can also enter into contractual collaborations with local users who will take them seriously.

Research also gives institutional .

- Many Universities deliver good teaching, but research is a label which makes a notable difference (see the Shanghai Jiao Tong Rankings [Institute of Higher Education, University of Shanghai Jiao Tong] of the world's universities); it guarantees (supposedly) that the best talents are there; and it attracts students and helps to raise funds and contracts.
- Research is also a way to enhance the social mission of the university in its region, through "clusters" of collaboration with local users.
- Research may lead to a long-lasting, national reputation of quality, including in branches which become known for a speciality (see "water" for Kenitra University, etc).

7. Conclusion: On the De-Institutionalization of Science in Developing Nations

Science systems in developed and highly industrialized countries have a certain number of clear and evident features, including being dense (well-populated) with highly articulated scientific institutions. "Scientific institution" is understood here to refer to any formal organization or entity which is dedicated to the pursuit of scientific knowledge production, dissemination and utilization. This definition includes bodies that perform R&D such as university centres, laboratories and institutes, as well as R&D performing entities outside the higher education sector. But it also includes scientific publishing houses, journals, conferences, workshops and seminars, which are "organizations" for the dissemination of scientific knowledge. And it also includes bodies such as technology incubators, technology transfer offices, patenting offices and so on, that promote the utilization and commercialization of scientific knowledge.

In a modern science system there are typically a multitude of these scientific institutions that perform clearly articulated functions and roles, and together constitute what could be termed the "national mode of scientific production". The "national mode" means that science is conducted for the public good and that the direction of science is shaped and steered by a nation's most pressing socio-economic needs. It also implies that the state assumes a major responsibility for financing research and development activities.

Unfortunately, few of the features of the modern scientific system apply to many countries in the developing world and especially to the very poor (low-income) countries in our study. Many of the scientific institutions in these countries are fragile, susceptible to the vagaries of political and military events, and severely under-resourced. They also suffer from a lack of clarity and articulation regarding science governance issues, demonstrated by constant shifts in ministerial responsibility for science. In fact, one could even refer to some of these science systems and their associated institutions as operating in a "subsistence" mode, where they struggle to even reproduce themselves. A "subsistence mode" refers to a system that basically produces knowledge for its own use only and does not export knowledge. In fact it does not make a significant contribution to global knowledge production.

It is even debatable whether one can talk of a science "system" in many of these countries, as they do not exhibit typical systemic characteristics. Institutions are not typically aligned through input, process and output flows, and there is no typically 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 some of these countries, particularly in many countries of sub-Saharan Africa (with the exceptions of South Africa and possibly Kenya, Malawi and Tanzania). However one should also be cautious of over-generalization and over-simplification, as there are some small but robust institutions (universities and research centres) that have survived political changes and economic fluctuations, and where pockets of significant science are still found. In these isolated cases (for example in Botswana, Burkina Faso and more recently Rwanda), science is publicly supported by the government, there is reasonable political stability, and there is good governance of the science system. In many of these cases, there are also well-established links and collaborative networks, including with strong research establishments elsewhere in the world.

Much of current scientific inquiry at many institutions in developing countries is under-funded. It is often driven by the individual scientist's priorities and interests, and is ultimately aimed at advancing the career of the individual academic. We have also shown how investment in R&D in the majority of poor countries is low: despite commitments by ministers of science and technology to strive towards investing at least 1 per cent of GDP on R&D annually, the reality is that most countries spend less than 0.4 per cent. As a result very few governments support public research through a national system of research grants and scholarships, which also explains the high reliance of many scientists on foreign funding.

The solution is straightforward: the symbolic commitment to increased investment in R&D by governments needs to be put into practice. It seems that, despite the rhetoric, governments still view research and knowledge production as a luxury given the huge pressures to address socio-economic challenges such as poverty, infectious diseases, food security and so on.

Since public funding for research is not channelled through a properly articulated and monitored system (e.g. through a national funding agency), the individual scientist and academic at a university receives his or her funding directly from foreign fundraisers (or through the mediation of a local representative). Those who are privileged to receive such funding use it to pursue their own research interests (provided they have first satisfied their sponsor), and also to advance their own careers. This allows them to travel overseas, attend international conferences, and in general have the required resources to build their own individual research capital, and this focus on building one's own curriculum vitae must be understood within the context of poor academic salaries and working conditions, and a general lack of sufficient research and library resources.

However, this kind of scientific endeavour rarely converts into institutional research capacity; it is not linked, for example, to training doctoral or even post-doctoral students. In fact, there are so few doctoral programmes at many of these universities that "reproducing" existing scientific work through doctoral students is not even possible. The current focus on the individual's own research interests and the advancement of his or her own career also means that such scientific endeavours are not cumulative over time, and do not culminate in the building of a programme or Centre of Excellence that could act as a platform for future research and postgraduate training.

Ultimately, the restoration and improvement of research institutions (and specifically, many universities in Africa) requires a strategy that focuses on institution-building interventions rather than on building the capacity of individual scientists. This does not mean that training of and support to individual scientists, whether they are emerging or established, is unimportant. On the contrary, our proposition is that such individual capacity-building should be embedded in a framework of building the institutions of science. The restoration of research institutions and their development into centres of scientific excellence will only take place if future interventions focus on re-establishing them as such: institutions that are dedicated to the pursuit of science for the common good, and to the attainment of national goals and priorities.

Notes

1 The complete draft reports of individual countries, four regional reports and a synthesis report, were submitted in January 2008 to UNESCO, which commissioned the study. Due to space constraints, this chapter limits itself to the most important, high-level findings of the study.

2 The reports of this study are available on the UNESCO website at the following URL: http://portal.unesco.org/shs/en/ev.php-URL_ID=11896&URL_DO=DO_TOPIC&URL_SEC-TION=201.html.

3 Study conducted by the Centre for Research on Science and Technology at Stellenbosch University under commission from the Southern African Regional Universities Association (SARUA)); final report projected for release by the end of 2008.

References

Gérard, E. et al. 2008. . Paris: Publisud.

Khelfaoui, H. 2004. "Scientific Research in Algeria: Institutionalisation versus Professionalisation". (9) 2, 75-101.

Kleiche, M. and Waast, R. 2008 . Paris: Publisud.

Nour, S.S. 2005. "Science and Technology Indicators in the Arab Region". (10) 2, 240-275.

Rossi, P. L. 2009. Bibliometric study of Mediterranean Countries (for the ESTIME Project, http://www.estime.ird.fr).

Rossi, P. L. and Waast, R. 2008. ESTIME, HSS Bibliometrics Report.

Schwartman, S. 1991. . University of Pennsylvania Press.

Waast, R. and Rossi, P. L. (2009) Bibliometric Study of Mediterranean Countries, http://www.estime.ird.fr

Wight, D. 2008. "Most of Our Social Scientists are not Institution-Based, They Are for Hire: Research Consultancies and Social Science Capacity for Health Research in East Africa". 66, 110-116.

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