Science in Africa: an overview

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This paper presents a diagnosis of the changes going on in scientific professional practice in Africa. The analytical assessment is founded on a detailed survey effected in 15 African countries. It draws a sharp contrast between different regions: North Africa, South Africa, and Median Africa (South of the Sahara, excluding South Africa).

In Median Africa, with some variations, the economic crisis has led to the dissolution of the national-based research systems that had flourished and grown in the 1960s and 1970s. With institutions disintegrating and their profession in ruins, researchers have been pushed into a free market for scientific work. The activity of research is thus now practised on the basis of short-term contracts (and no longer on the principle of careers) and within the context of worldwide networks (rather than institutions). The market exerts regulation, not the peers. The "clients" who order the research are manifold and mainly from abroad. However, this new form of knowledge production is encountering certain restrictions. On the initiative of researchers themselves or world sponsors, some reconstruction is under way but the new fledgling institutions are local or regional rather than national.

South Africa seems to be poles apart, with a high performance research complex, old and robust institutions, links with industry, and the firm support of the government. However, this system faces a three-pronged challenge; the process of its Africanisation; a strong shift of emphasis toward strategic research; and its re-incorporation into the general culture, seeing that scepticism towards science is rife.

North Africa (the region from Egypt to the Maghreb countries) has made outstanding progress over the last 20 years, thanks to the dynamic of two public professions (education and a high-level technical civil service); but researchers there have to gain the respect of the people (and sometimes of the State), unify the two scientific fields (academic and technological) and develop regionalisation in order to attain a critical mass.

1. Introduction

Apart from vague and general ideas on the globalisation of science and its possible meaning for Africa, we know very little about the present ways of producing knowledge on the continent. The course of change is very fast. We need data, facts and figures about what is happening, and a specific understanding of how it occurs in different places.

This analytical assessment is based on field studies and on interviews, carried out during 1999-2001 as part of a detailed survey of 15 African countries (including the continent's main producers of research). Case studies of institutions have been extremely useful for demonstrating models and marking out points in the range of possible developments. Accounts given by the people involved are illuminating. They help picture the scene, understand the values in play, and the positioning that motivates behaviour. It is true that this is the realm of real-life experience and of people's representations, but they are part of reality and the

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process under study; they have had their role in opening up and legitimising new practices. Our conviction is that, in the end, the transformation of the institutions and the profession has been the major agent of change, the vector of "globalisation" wherever it has occurred.

The examination of the information gleaned leaves us with a mass of data, which shows great contrasts between regions, countries and even within each country, depending on the discipline, establishments and the types of researcher. Rather than venture into this infinite diversity, we will try, without ignoring this great variety, to tease out the general tendencies at work in three distinctive regions. For reasons linked to the support maintained by the State, and/or to the complexion of scientific communities (which are partly associated with a local industry, to a greater or lesser degree) the same delimiting boundaries have not had the same effects in North Africa, or in the Republic of South Africa and in the rest of Sub-Saharan Africa. Consequently, we'll then propose three diagnoses, one for each of these zones.

2. Diagnosis: Africa South of the Sahara (except South Africa)

Any understanding of the present situation needs some historical background.

2.1 From colonial science to national science

It has to be appreciated that *colonial science* left a considerable legacy:

- **in terms of *knowledge* (disciplines built up: agriculture and tropical medicine; detailed inventories and a recorded body of knowledge etc.);**
- **in terms of *organisational models*: (full-time researchers, employed by specialist agencies, which are responsible to technical ministries that use and diffuse the results);**
- **in terms of strategic choices (agriculture and health are both favoured) [C. Bonneuil, 1999 and 2001].**

This legacy was inherited and enhanced after countries gained independence. Firstly, it was enriched by the development of universities (the great project of the 1960s and 1970s, which led to an autonomous "academic" sphere). Then, it was appropriated in the 1970s, accompanied by the "nationalisation" of research institutes, the Africanisation of research and teaching-research posts, the expansion and multiplication of establishments, and the formulation of rules to regulate the profession and steering bodies charged with prescribing, implementing and monitoring national policies. From 1965 to 1985, states put considerable effort into all this, with generous support from bilateral and multilateral cooperation schemes.

Here are some figures:

> **From 1970 to 1985, the level of Africanisation went from 5 to 55% at the Senegalese Institute for Agricultural Research (ISRA) and from 20 to 70% in most of the universities. The number of research scientists doubled at ISRA; those for students and teaching staff tripled -and so did budgets. In some other countries, such growth was even more spectacular (in Madagascar and Nigeria, for instance, there was a ten-fold increase).**

A new generation of researchers appeared, wholly nurtured through the new trends. This new process of scientific production was called "*national science*" and has the following main characteristics:

- **Science is for the public good.**
- **The State provides most of the finance for it.**
- **The direction of that science is determined by the country's most pressing needs.**
- **Research scientists are civil servants and have the right to pursue careers.**
- **Scientists are imbued with national values as well as scientific ones.**
- **Besides the peer community, the recipients of the product are principally the public authorities. The direct users of the product are hardly involved, and certainly not in any trading relationship, deemed "impure" by researchers.**

This kind of system has had some real successes. In 1985, ensuing scientific publications were noticeable on the international scene; eminent figures emerged; leading-edge establishments acquired fine reputations; and some celebrated innovations were derived from the work (Idachaba, 1995). It must be made clear that *the scientific complex built up at this time is still in place today*, even though many of these institutions remain only in nominal form: they have neither been dissolved nor replaced.

2.2 From national sciences to the free market for scientific work.

After 1985, the signs of a profound change began to bubble through. They were, however, by no means confined to Africa. The free market ethos meant that states worldwide reduced their intervention. The expected source of progress became innovation in private companies and no longer the discoveries of science. The well being of all would come, not from tightly centralised planning, but from the play of market forces. In Africa, this disaffection for science (and indeed for education) occurred against a background of severe and enduring economic crisis.

From 1977, most of the non-oil producing countries descended into economic crisis (countries such as Madagascar, Senegal, Kenya, Tanzania, Zimbabwe). Those that did produce oil were seriously hit from 1985 onwards (countries like Algeria, Cameroon and Nigeria). Countries that currently have a GDP higher than the 1985 figures are rare (Morocco, Tunisia, Egypt and Burkina are the exceptions). Moreover, the public aid for development distributed by the OECD has melted like snow: particularly that from the USA and Canada from 1990 onwards.

The large-scale institutions and projects set up in the preceding period were, nevertheless, still sailing along under their earlier momentum (with massive entries into the universities, in particular). Education, however, was no longer a priority; and higher education, with a reputation for a voracious appetite for budgets, saw its funds and job-creation frozen, or at least severely slowed down. Buildings, facilities and conditions for working and studying deteriorated at an accelerated pace. For universities and research institutes alike, budgets from the State were soon to serve only to pay the devalued salaries of researchers and teacher-researchers.

Between 1985 and 1990, university faculties in Côte d'Ivoire, Nigeria and in Zimbabwe were accepting an additional 15% students each year. The Côte d'Ivoire had figures above this (+21% per year) from 1990 to 1998. However, the student/teaching staff ratio rose from 1 teacher per 10 students in around 1970 to 1/25 in Nigeria and Senegal, 1/35 in Cameroon, and 1/49 in Côte d'Ivoire by the end of the 90s.

In parallel, the intellectual professions and the civil service, often regarded as parasites, had their pay upgraded only if they were in politically strategic positions (in the army or the justice department for instance). This is not usually the case for the functions of teacher or, in particular, researcher. Not only were salary cuts imposed through emergency economic measures (Cameroon, 1990), but runaway inflation rates, the devaluation of the CFA franc (Communauté financière africaine) and other economic measures contributed to a massive drop in researchers' purchasing power. (The annual rate of inflation between 1985 and 1996 was 20% for Madagascar and 34% for Nigeria.)

> **In 1999, a professor was paid 200 $ per month in Nigeria, 150 $ in Tanzania; 300 $ in Burkina and 1000 $ in Senegal. These differentials led to migrations within the African continent, unthinkable just a few years before (for example from Nigeria to St Louis of Senegal). Most of the teaching staff do, however, first try to find solutions locally.**

It is simply no longer possible to live "decently" from the profession of teaching or research in these countries. Parallel jobs are necessary in order to avoid drastic downgrading. Among these, the practice of research can, thus for some, become a good way of earning a living, but only if it is carried out on a consultancy basis.

> **An enquiry recently conducted at the University A. Bello – one of the oldest and most prestigious in Nigeria - shows that, 75% of all teaching staff has a second job from which they derive most of their income. For 40% this involves a farm, for 20% a shop and for 15% it involves putting in extra hours (this is the case for junior staff).**
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> **Of the remaining 25%, half do not claim to have another profession. This group is divided into "academic" figures, faithful to the primary image of their calling – but deprived of the means to keep up to date and pursue their work - and "political" figures, in responsible posts at the university and as State advisors. (Both groups are often financially supported by wives who have better-paid employment). The remaining 12% live off "consultancy" fees, or by doing research on behalf of clients, usually from abroad, who commission it.**
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> **This section of the research scientist population is the most interesting, the only one still active in the profession. In other universities (or in certain research institutes), closer to the capital or to the industrial cities, this section represents a larger portion of the scientific potential: nearly 20% at Lagos or at Ibadan. In other countries, especially in English-speaking Africa, the situation is not very different, and the execution of scientific work is mostly "privatised": Tanzania, Uganda and even Kenya and Zimbabwe. In French-speaking Africa, the institutions are holding their own better. Career progress is linked to the publication of articles whose quality is assessed by an inter-state academic commission (the CAMES), and the status of the teaching staff is not as poor.**

Research has, therefore, not disappeared from the African scene, but in many countries, its mode of production has changed. Now much closer to development than to investigation, knowledge production is less geared towards education and does not much lend itself to publications. Its principles can, thus, be summarised as follows:

- **The profession is practised within a system that depends on orders for research work and on temporary contracts (and not in the context of a career).**
- **The activity is exercised in a worldwide network.**

- **International (and not national) demand determines the programmes and objectives.**
- **The search for benefits and profit (rather than knowledge) becomes the axiom for action.**
- **The system is no longer regulated by peer assessment, but by the market.**

This cultural revolution is being effected by a new generation of research scientists. Consequently, a rift has opened up between the researchers with the "national" ethos, attached to their old established values but fated to be out of work, and researchers open to the "market", paid for their services and connected to the worldwide sectors working on leading speciality subjects. Some of them have research laboratories at their disposal that are almost tailor-made, equipped and built off the university campus with money from abroad. The research topics and areas experience varying fortunes. In Nigeria, for example, electrochemistry and inorganic chemistry no longer have any followers, for lack of demand. However, physical chemistry is thriving, because of its applications to medical biology and to plant chemistry. The hierarchy of the different disciplines and the routes to fame have been turned upside down. The signs of success are no longer expressed in terms of academic achievement (with careers blocked and depressed), but of material prosperity. Young researchers on contracts sometimes earn more than emeritus professors.

Institutions and policies **are destined for failure or are reshaped by the new mode of production.**

- ***Policies*** **are often reduced to a laissez-faire approach.**
- ***The supervising bodies are the first*** **to lose their authority. With no budget, they have no hold over the establishments (which have often changed status and umbrella organisation, to become eligible for loans or donations from international aid organisations). Their best civil servants have left, their meetings have ceased, and no one consults them any more.**
- **Many *establishments have, in turn, floundered*. With a steady income from aid negotiated at government level, many institutes (agricultural ones, in particular) were accustomed to managing their budgets in a bureaucratic administrative way. In the absence of any notion of strategy, they lost their footing when the aid diminished and they have had to propose and negotiate programmes directly with the sponsors. As for the universities, they are in danger of being choked by the number of students (in the French-speaking zone), and of being starved out because research slips away to sites outside their jurisdiction, being neither rewarded nor facilitated (in the English-speaking zone). We will come back to the exceptions later.**
- **Next to give way is *academic regulation and monitoring. The national scientific communities* dissolve. At the same time the profession becomes individualised to the degree that the researchers' set of values change and that the rules for promotion are overturned.**
- **Of the major *scientific figures*, many go abroad (to other African countries or elsewhere in the world) or change their trade (they leave for banks or political positions...).**

2.3 The state of the field

The results of a bibliometric study (Arvanitis et al., 2000) show that Africa has lost 25 % of its "market share" in the arena of world publications over

the last 15 years. Some countries in median Africa have regressed in all subject areas. Nigeria, whose crisis in the research profession is one of the most extensive, has in particular suffered a dramatic reduction of publication output. Whole areas of expertise have been curtailed, or seem to even have disappeared (agricultural sciences in Kenya and Côte d'Ivoire, for example).[1] But, this is, in part, a kind of optical illusion: the capacity has not completely faded away. The research is being done in the private sector, under contract; the projects are more like specialist consultancy work in nature, and do not really lend themselves to publication.

The graph varies from country to country, as it does between the disciplines (the medical sciences are holding firm, but the fundamental sciences are losing ground). The effects of cooperative schemes are effectively expressed (the curves dip when they withdraw, as in the case of Côte d'Ivoire, or Mozambique; they rise again with new investment, as can be seen in Uganda and Ghana, for instance).

Whatever the nature and severity of the crisis (which, thanks to cooperative programmes, has not yet resulted in any complete collapse), it is possible to spot the strengths and weaknesses in each location. These do not automatically correspond to the subject areas proclaimed as national priorities by governments; or to those areas that receive the most researchers' attention or the subject of large contracts. Instead, favourite themes, anchored in the residue of previous policies, are the areas of some noteworthy performances and correspond quite well to what might be expected of a science geared closely to a country's needs: biology applied to agriculture; and in medical sciences, areas like parasitology, immunology and infectious diseases.

However, some completely unexpected strong points emerge, often highly valuable. These tend to be built around a leading scientific figure, or a small circle of specialists. This is the case of mathematics in Cameroon, embryology in Ghana and plant chemistry in Madagascar. These research structures are precarious, because they are based on a small number of practitioners. However, they are also robust, as history has proved, because they benefit from the tenacity of the personalities involved, who are often charismatic and regard their work as a vocation.

2.4 Tensions and initiatives

a) The transition from national sciences to "free market for scientific work" is not always a smooth one. Varying degrees of notable *tension* exist :

- **between the *universities and the research institutes*. Their traditional struggles between professional bodies (those with academic doctorates against engineers) stem from the confrontation of two distinct scientific styles. Universities often pretend to have the monopoly on "quality" research (more upstream), institutes consider that they alone produce research that has real "impact" (positioned more downstream). These divisions are becoming blurred as researchers of both groups are subject to the same kind of levelling process, having to compete in the same "market" for research and in that their training has steadily become more similar. (Many engineers now also have doctorates.)**

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[1] **Nigeria lost 40% of its production between 1989 and 2000. For Kenya, see Eisemon & Davis (1997); for the Côte d'Ivoire, Khelfaoui (2000).**

- **between *generations*. Those who entered careers earlier now occupy the management posts, which prevents those who joined later from attaining such positions. For the most recent entrants, promotion is frozen; besides, these categories are often now only recruited on a short-term basis (half of the teaching staff in Burkina, in Côte d'Ivoire and certainly in a number of other countries, have this status,).**
- **between different *concepts of professional ethos*. Those who have been in the profession longest are attached to the model enshrined in the universities where they studied, to the vision accompanying the disciplines (conveyed in their syllabi) and laboratory practices (without any links to industry) of this same era (the 1960s and early 1970s). The following generation is the one that professionalised research, organised the transition, of what was almost a "sect" of pioneers, to the mainstream "religion" of "Africanised" universities and institutes. It laid down national standards and forged the instruments of a community capable of self-regulation. The latest recruits to research may have been exposed to the most recent developments of disciplines, as well as new strategies adopted by laboratories (connections with industry, financing procured from external sources). By default, they are primarily confronted with the necessity to work under contract in order to make a living from research. This is the generation of the great "technical experts", working in international networks, away from the control of national communities.**
- **between *research scientists and governments*. The researchers no longer expect anything from the State, but still resent the fact that it has abandoned them. Governments mistrust the independence that each profession nurtures and the freedom of movement that funding from outside authorises some to exercise. The degree of tension is also a function of the management style of the scientific institutions.[2]**
- **between *sponsors and recipients*. On the one hand, the states reproach the sponsors for bypassing them, in that they increasingly negotiate directly with laboratories or researchers of their choice. The major issue here is basically one of control over people and of the levying of some sort of tribute on the activities undertaken. However, it is presented in other terms: interference, arrogance and the suspicion of exploitation of natural resources (for example, medicinal plants). On the other hand, the researchers who benefit from cooperation programmes complain about being subject to a narrow agenda and of an unequal division of labour. Many of them estimate that their role has been reduced to that of simple suppliers of data, or of developers of solutions devised out of context, following a standardised model.**

b) Initiatives

These trends are, however, allowed for, and corrected, by numerous initiatives.

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[2] Some administrators perceive their task as being one of surveillance. They ostensibly create a distance between themselves and the working researchers and often reserve privileges for themselves drawn from the meagre resources available for running costs (Côte d'Ivoire, Nigeria, etc.). Others play the role of scientific manager or of a buffer, without either privileges or ostentation (Burkina, Cameroon for instance). See Khelfaoui (2000).

- **At grass-roots level, the researchers have learnt to obtain maximum value from their knowledge and know-how, either on an individual basis, or in the framework of multidisciplinary consultancies. This approach is certainly a competitive one. Most researchers jealously guard the secret of their sponsors and the exclusive nature of their relationship with them, to the extent of creating a pool of dependent workers for themselves who, each in turn, can meet the demand. Many consultancies are no more than associations of convenience, which allow administrative and management costs to be shared and enable researchers to capture the market for varying demands. However, by changing subjects and practising a multidisciplinary approach, the researchers ensure they have a field of action and a degree of liberty that the discipline-led regime of scientific endeavour does not permit, and which may lead to their success (Shinn & Waast, 1998).**
- **In a more original approach, some have simultaneously set up an NGO for research and an NGO dedicated to action (Madagascar: the coastal environment; Senegal: reproductive health; women and development and so on). A few have managed to get a private laboratory established whose objectives and programme they themselves manage (physical chemistry: Ibadan, Nigeria). Others have formed a regional or continent-wide network of cooperation, a working laboratory of concepts and experimentation that has commanded the interest of sponsors, and which then enjoys greater research freedom than any national institution might be prepared to accord it. (For example, the Economic and Social Research Foundation; Eastern and Southern Africa University Research programme, that specifically undertakes work in comparative politics in Southern Africa; and on a larger scale, CODESRIA). Certain projects become autonomous entities even within the institutions to which the researchers belong, which they regenerate in a way by introducing new standards of production, new topics and recent advances of international research. In Madagascar, a project incorporated into the Institute of Statistics has developed public-opinion surveys and studies widely covered in the media, on education, poverty and the political vote (F. Roubaud, 2000). Other examples of this growing autonomy regarding production within public institutions are the veterinary service in Senegal and various NGOs linked to university teaching hospital services.**
- **Whole establishments have also been able to adapt and make their mark of quality a symbol to attract orders (from national or international sources). They nurture their researchers' loyalty, by ensuring that they have a constant supply of work and a share of the profits (for example, the Engineering Faculty of Dar es Salaam). It should also be noted here that as a result of all these initiatives researchers are able to improve their income, which is a necessary condition if such schemes are to develop.**
- **Finally, at national level, a number of "strategists", with the benevolent neutrality of the government that appointed them, are once again taking the initiative. This is especially so in French-speaking Africa. Here, national-level calls to tender, mobilising/stimulatory programmes, and regionally-oriented specialist centres (such as that for mathematics in Cameroon) are emerging, at the initiative of secretaries of state for research or of departments within ministries of education, albeit with slender means.**

- **The sponsors, for their part, are seeking to restructure the whole area. Some (like the World Bank and a diversity of foundations) are working to foster the emergence of private companies (in solar energy for example); export systems for agricultural and food produce, supported by research (US-AID); or non-governmental research institutes that would be suitable as new institutional partners (FAO in agriculture). There are other cooperative schemes aimed at re-establishing the dialogue with states in relation to aid for science (mainly European and French programmes, and also some set up by the Netherlands and the Scandinavian countries).**

2.5 What kind of framework for policies in science and cooperation?

What form of national policy?

Generally speaking, the withdrawal of the State has rendered any discourse on *science policy* futile. Such policy has been reduced to a laissez-faire approach, either explicitly stated (as in Nigeria: "so much the better if certain research enterprises turn out to be profitable", see Lebeau (2000)), or implied (as in Tanzania, where the government issues scientistic incantations and calls to rally researchers to work for the public good – without the concomitant improvement in their situation).

Only recently, under the pressure of international sponsors, has there been a return to some degree of involvement by some governments. The rehabilitation of the universities has been put on the agenda by the World Bank, which has proposed well-financed plans for recuperation in this vein to several countries: first Nigeria, then Senegal and now Kenya, Tanzania and Zimbabwe. These schemes have not overlooked the objective of restoring research. On the contrary, they envisage the setting up of a large Research Fund, fed by the faculties and the State (which would, in this way, have to commit themselves to regular support of the activity), with the aid of sizeable loans at favourable rates of interest. These proposals have simultaneously raised the hopes of many of the teaching staff – and triggered hitherto unresolved controversies.

The question arises as to who will regulate the use of these Funds: possibly the State (but, anxious to preserve their rather slight autonomies, the academics are mistrustful, to the extent that the reform has failed in Nigeria and has broken down in Senegal). These Funds could also possibly be controlled by the departments responsible for research at the ministry of education, or by the university authorities. However, it is clear that many see such parties as part of a biased or partisan establishment. Should individual researchers be responsible for handling these Funds? (They would obviously benefit from grants abroad that would enable them to spend their sabbatical years, to which they are entitled, as long as they worked in the direction of the programme.) However, the funding organisations would prefer to use this opportunity to structure the research world into teams or laboratories rather, and to steer the research topics towards the areas of their choice. The difficulty of achieving consensus is evidence of the current fragmentation of research effort, of the long absence of strategic considerations in the area, and of the decay affecting the scientific communities. (This kind of conflict does not usually defuse through to the incontestable and independent learned bodies that are capable of arbitrating between projects objectively and competently).

What sort of policies for cooperation?

It is worthwhile knowing the tenets and policies of cooperation as subscribed to by the main donors of scientific cooperation. These parties find themselves at a crossroad, uncertain whether to withdraw (or restrict

themselves to "technological" cooperation schemes, largely led by the industrial companies) or to reinvest (from the fear that scientific communities might otherwise just disappear, being unable to regenerate themselves). A great debate has reopened over the necessity of maintaining a scientific capacity in the country (and not merely a body of engineers or technologists, for example) and the alternative, where countries shop around in the world science supermarket – for "science of excellence" to apply to their problems. Another point of discussion is the choice of agencies or partners. Should institutions, or even academic bodies that may have been founded arbitrarily, be reconstructed – and charged with the management of funding (for instance, as the Netherlands think, to a certain extent).

For information on these doctrines and practices, it is essential to refer to recent books (for example J. Gaillard (2000) or R. Waast (2001). These works examine the practices of cooperation programmes initiated by North America (USA and Canada), Japan and the approach of several European countries.

3. Diagnosis: The Republic of South Africa

South Africa seems to be poles apart from the former situation.

3.1 The origins of the research complex

An old established scientific system was forged over two centuries. Research rapidly split into two streams: science for learning (initiated by amateurs, as early as the 18th century and later established in the universities, which go back to 1870); and science for doing (first geology and veterinary microbiology, from the mid-19th century). But the two fields were unified during The Second World War, largely due to the work of the new Council for Scientific and Industrial Research (and later, other Councils in other fields). It created laboratories in subject areas considered strategic for modern industry and created alliances with companies; it managed an incentive fund, which brought university research into the picture; and it helped draw up a national policy. The following regimes (including the post-apartheid one) took great care not to weaken this apparatus, whose abilities range from aeronautics to nuclear engineering, from chemistry to metallurgy, from agriculture and food to specialities at the forefront of medicine. What the new government is endeavouring to do, however, is to better align research to serve basic needs and industrial competitiveness; and to give Black South Africans an opportunity to become part of the system.

3.2 From criticism of the system to its reorganisation

As soon as the African National Congress came into power, (and even a few years before) the Ministry of the Arts and Sciences commissioned an assessment of the capacities and the institutions. Councils, universities, and the whole the system were closely examined. Documents were drawn up for a new policy in collaboration with stakeholders. For some time, a debate raged between two possible objectives. Should priority be given to meeting the needs of the deprived sections of society (implying favourable treatment for action-oriented research, without fundamental discoveries or advanced technology as an end) or should the "competitiveness of industry" (associated with the converse scientific characteristics) be paramount? The debate remains significant today. The policy guidelines (White Paper, 1996) recognise the two potential goals, but pay special

attention to the second. And the instruments for reform reflect more the latter orientation.

A dual result has been achieved in very little time. The relative decline in research funding has been halted[3]. In parallel, the financing system has changed radically, towards a competition-based system. A Council for Innovation has been set up. Several incentive funds have been established[4].

Apparently, there have been tangible effects. Three thousand academics questioned in 1999 [Mouton, 2000] themselves classified the work they were doing as one-quarter basic or fundamental research and three-quarters as "strategic" and/or "applied" research[5]. Forty per cent of their work is financed by incentive funds and 12% by their university's core funding, complemented by money from industry (12%), from government contracts (10%) and foreign cooperation schemes (25%, mainly applied research). About seventy per cent of all basic research is supported by the National Research Foundation, twelve per cent by core funding, and the balance from other sources.

The South African situation is thus incomparable with that of "median" Africa. The public effort is growing in favour of research. Fundamental research is far from being starved. The public institutions still benefit from a high level of core funding (50% to 70% of their expenditure). Besides the fact that salaries have remained attractive, the facilities and maintenance are generally excellent. Development research is also rising in industrial companies (certainly in the largest ones and, notably, the semi-public companies). State intervention is much more assertive than in the previous period. The incentive measures are very similar to the steps taken by industrial countries of the North, aimed at bringing the "two worlds", research and industry, closer together. Here is a government that is pursuing a sustained interest in research, convinced that its socio-economic future depends on it.

3.3 The state of the field

South Africa currently has 21 universities and 15 Teknikons (Schools of Engineering). It has at its disposal 7 Councils, which are specialist agencies employing full-time researchers[6] in industrial (CSIR), medical (MRC), agricultural (ARC), human sciences (HSRC), mining (MINTEK), geosciences and instrumentation. The two systems are similar in size, in terms of human potential (3000 full-time equivalent researchers are attached to the Councils and 5000 to higher education) and committed expenditure (1.2 billion Rand each in 1999). However, their cultures are quite different and little work is done jointly.

The Councils are expected to demonstrate a spirit of accomplishment, for realising projects ("science for doing"). Having been established to

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[3] It fell from 1.04% of GNP in 1987 to 0.75% in 1993 and 0.68% in 1995. Present real spending is double that of 1995 (in Rand at current value; in other words 0.9% of the GNP).

[4] THRIP: "Technology and Human Resources for Industry Programmes"; SPII: "Support Programme for Industrial Innovation"; NIF: "National Innovation Fund". The NRF (National Research Foundation) is becoming more and more interested in strategic science. For details, see Mouton (2000, 2001).

[5] Only 8% stated that they did R&D.

[6] The Councils also play a role as a financing agency in their particular area. Although this is not really the case for the CSIR, it is for ARC. And the MRC plays an enormous role in funding. Its subsidised teams mainly work in universities.

respond to national socio-economic goals, they are more closely tied to the Government and are directly accountable to it.

Universities (highly active in research today) are devoted rather to the advancement of knowledge; academic researchers' career progress (i.e. towards posts in ever-better endowed and more prestigious universities) is made in proportion to their publications. They also have greater autonomy (once their allocation has been determined, the universities are autonomous). They used to have the reputation of not knowing how to work in "real time" and of taking a long time to incorporate advances in various disciplines and in opening up new fields, but this charge is no longer valid. The university academics, nevertheless, certainly continue to value the slow and methodical work of the scholar, more so than the "rapid and dirty" work of the engineer.

A single method of evaluation can therefore hardly account for all the activities and positions of such a widely different research force. This is even more so when one tries to account for the 5000 researchers (full-time equivalent) employed in development research by the private sector. The "Councils" have, for example, been subject to an assessment, which was not based solely on the number of publications produced or patents filed. Panels of international experts and local end-users, able to appreciate the knowledge and skills generated and transferred, and also the relevance of the targets and subjects chosen, carried out the assessment.

The results were inconsistent. The CSIR received credit for nearly all aspects (including its educational abilities in interventions in companies, its efforts towards the conversion from military to civil work, the brisk development of a department of light technology for the underprivileged, and its anticipation of future technologies). At the other end of the spectrum, ARC was criticised, for its lack of "vision", for dragging its feet in getting black people and women fully involved but praised for its unstinting dedication to the large agriculture and food industry. It was not the researchers' ability that was in question (their excellence was noted, especially in wine-growing and veterinary studies), but the institution's ability to mobilise the skills required to turn to a new clientele and find the means to achieve a successful transfer. Fortunately, US-AID stepped into the breach, having just launched a cooperative programme that aims to organise the small-scale black farmers into production networks for export produce (starting with fruit and vegetables out-of-season in the importing countries, with the collaboration of the American association of importers of these products).

It is also helpful to examine bibliographic databases, as there is a correlation between capacity in applied or basic sciences (of which they take better account) and the potential of development research. Some notable results are discussed in the following paragraphs (see Waast, 2000 for details).

> **Production saw a sharp rise in the 1970s and 80s, followed by a regression from 1987 to 1991 (the boycott period, exacerbated by many liberal-minded researchers leaving the country to escape apartheid). Since then the number of publications has increased, again reaching the 1987 level.**

Nevertheless, South Africa has lost some of the world scientific market share and has regressed when compared with other emerging countries used as a yardstick (Chile, Malaysia, and Singapore).[7]

A study has compared the performances of South Africa (number of articles, and the attention they receive) with those of other industrialised countries. Seven particularly active disciplines stand out (Pouris, 1996) (astrophysics, agriculture, zoology and veterinary medicine, botany, ecology, geology and clinical medicine[8]; the first three improved their figures over 15 years (from 1980 to 1995), agriculture being the one which captured the most attention. In contrast, publications in physics, chemistry, mathematics, pharmacology, molecular biology and computing, among others, appeared not to have developed much and to have only a small audience.

It might be worthwhile, as we have done with other countries, to compare South Africa with the rest of the continent. In this framework, the country's relatively firm position becomes clearer. South Africa, alone, produces 20% to 30% of all African publications in chemistry or engineering, 30% to 40% of those in physics, 40% to 50% of those in mathematics, half of those in clinical medicine and non-medical biology (agricultural sciences and natural sciences), between 50% and 60% of biomedical research and a similar percentage of the earth and planetary sciences (Waast 2000).

Another table shows that compared with the rest of the continent, South Africa concentrates on work in internal medicine and general biology, botany and the environment, astrophysics, materials and metallurgy. More interesting strengths and weaknesses can be identified where the proportion of a discipline within the African production is at least 33% higher (or lower) than that of the general field to which it is attached (for example: relative performance of cardiology in relation to that of clinical medicine). This index highlights South Africa's exceptional capacities in anaesthesia, surgery, cardiology and nephrology in the medical sciences; marine biology and zoology in the natural sciences; aeronautics in engineering science and nuclear physics for the exact sciences. Weaker points (relatively so, as the scores are nonetheless honourable) appear, however, in tropical medicine, immunology and parasitology, nutrition, sexually transmitted diseases and public health. South Africa clearly is a scientific giant in its environment. Some complementary ground could be found within this data: South Africa's "weak points" are exactly those where median Africa's efforts and successes are concentrated. Nevertheless, only North Africa stands as an equivalent partner (and often in the same areas).

All this production results from the activity of a host of establishments and yet capacity is at the same time highly concentrated. Between 1993 and 1999, 1500 different institutions produced at least one publication referenced by the SCI. But more than half the indexed articles are the product of just five universities, the celebrated "top 5" are the universities of Cape Town, Witwatersrand, Pretoria, Natal and Stellenbosch. One of the "Councils", that for medical sciences, is also at the same high level. Other universities feature next, then the CSIR (which publishes only one-tenth of

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[7] Production went from 2200 publications indexed by SCI in 1980, to 3400 in 1987, and today the figure is around 3300. That signifies a world market share of 0.4% in 1980, 0.7% in 1987 and 0.4% now.

[8] Surprisingly, the first sciences to be established, back in the 18th and 19th centuries, can again be recognised here.

the output of one single "top 5" university). The ARC follows with its Agricultural Institutes (but above all veterinary centres), then the South African Institute of Medical Research (a private foundation), the Observatories, the Museums, various "Councils" and the first "black" universities. (Durban Westville and Western Cape each have 40 to 50 references per year as against the 400 to 600 of the top five universitites.) Finally, with an annual average of 3 to 5 articles, are some of the large industrial companies.

3.4 Causes for concern and challenges

This structure consisting of active disciplines and productive establishments constitutes a great wealth of capacity. Yet the complex is a rather awkward one from the perspective of making science an integral part of the "new South Africa". The main challenges concerning science were mentioned earlier: democratisation, in particular, access for black people; and the re-incorporation of science into the overall society and culture.

Democratisation

In 1952, there were only about 1000 non-whites students out of a total of 20 000 . In 1959, there were 1700 out of 30 000. The apartheid government decided to move them to separate universities. (These were Durban Westville University in Natal for the Indians; the University of the Western Cape in a Cape Town suburb for the mixed-race students; and several "campuses" for "Africans" of each ethnic group. The latter were built in country areas far from urban centres, where instruction was mainly in the arts and humanities and where students, boarding on site, were under the supervision of an often poorly qualified teaching staff). Thirty-five years later, the proportions had changed. The "Africans" made up 40% of the student population. However, they (and this applies to women of all races as well) were largely excluded from scientific and technical employment. (See Table below.)

In 1994 (end of apartheid)	*Whites*	*Non-whites*	% of whom are Indians	% of whom are of mixed-race	% of which are Africans	*Men*	*Women*
% of population	13%	87%	3%	9%	75%	50 %	50 %
% of students	46%	54 %	7%	4%	43%	70%	30%
% of S&T jobs*	82%	18 %	6%	4%	8%		
% of S&T graduates						80 to 92%	8 to 20%**

Source: SA S&T indicators.

***not counting nurses (profession where non-whites and women are over-represented).**

****8% of engineers and 21% of agronomists are women. Many women with a bachelor degree forego further studies, or give them up, or confine themselves to short courses; they mainly become nurses.**

The post-apartheid government has set itself the task of correcting these disparities.

Vigorous programmes offering grants and support have been set in motion to foster the success of women and "black people" in higher education, particularly *in the sciences*. Universities that were historically "for blacks" have had to be renovated (in terms of facilities, qualifications of teaching staff). This also applies to secondary and primary schools, in aspects of staffing, management and teaching (especially in sciences and in the poorer areas). The populations concerned responded enthusiastically to this immense initiative. In 5 years, the number of "non-white" students has doubled. 18% of the 20-24 year age group is enrolled in higher education[9]. This is a very good figure for Africa.

However, the adjustment according to population groupings has not been achieved: among the Whites, 57% of the 20-24 year old group are enrolled in higher education, 35% among the Indians, and 11% among the others. Sustaining the growth rate to meet people's expectations would require an *enormous increase in numbers*. A doubling of the proportion of the "black people" of that age group attending university would entail the creation of 300 000 new places: the equivalent of all the universities that exist in Nigeria! The economic situation is difficult, and we know the crisis in the teaching profession elsewhere in Africa has generated massive growth in the number of students. Other, unforeseen difficulties might add to that. The rehabilitation plan for the "historically black" universities is seriously behind schedule. Deserted by their "clients" and severely in debt,[10] some of these universities are sinking into a spiral of disintegration that, some observers believe, is irreversible. In a kind of symmetry, the campuses that are "historically white" are full to the brim. Tensions are developing there, even among the body of professors and lecturers. The lecture workload has increased. And the question has to be asked: Will this adversely affect *research activity?*

This is a crucial question both for the academics (for whom research is a defining function of their profession) and for the institutions (which are financed to a large degree by the government depending on the product of the research). How can excellence be maintained (and all the institutions have an eye on awards of all kinds which can classify them)? Some advocate the raising of criteria for admissions (but these are already high). Others think in terms of an increase in registration fees (also already high). Some envisage a two-speed university: some of their constituent faculties or Institutes, in a favourable relation with a sector of the job market, could set the bar higher for cost and admission criteria; the others would manage to somehow accommodate all who want to study (and who have less money).

Still other tensions divide teaching body. In 1994, its composition reflected that of scientific employment. Out of 22 000 "academics" more than 16 000 were "white" (75%) –and only 3000 "African" (14%). These proportions are even more lopsided at university (85% whites, 6% Africans) and in full-time research (the same percentages as for

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[9] There are 200 times the number of "black" students today than there were in 1960 (although that started from next to nothing); and four times more than 10 years ago.

[10] The registration fees represent one-third of the universities' resources. Here the students refuse to pay them. The Government's "funding formula" favours the institutions that carry out research: the HBUs do not have a research culture. Furthermore, many of their students now prefer to enrol at universities whose degrees are held in greater esteem, even if it means interrupting their studies intermittently in order to work and earn enough to pay the high fees, and they are granted facilities to help with this. Only the historical nature of some HBUs prevented them from being completely dissolved in 1999 because of bankruptcy.

universities). Since then, the universities and the Councils have undertaken to correct these inequalities. Searches have been made abroad for young (often brilliant) academics, who have started to pursue a career there, having benefited from grants obtained through the ANC and blacks students who finish their doctoral training are swiftly integrated (to junior posts, of necessity). However, it is the wealthiest universities that can make the best offers to the most brilliant black people: this reinforces their (the universities) advantage. This is sometimes complicated by a lack of understanding between older academics (in influential posts) and newcomers (who differ in their social origin, early life experiences, political stance and vision of the world).

Integration into the culture, inclusion into society.

Other tensions, present at the changeover of the regime, have waned. One of these is the tension between the "activists", keen to shift the direction of research to serve the immediate needs of the deprived populations, and the "academics", anxious to preserve an exploratory research capacity and more tuned to reflection. The conflict has abated, with the protagonists spread between consultancies, "Councils" and universities. Another preoccupation focused on certain "weak" points in South African science: epidemiology, infectious diseases, agriculture and small-scale farmers. Efforts, such as intensification of training in these fields, the expansion of available posts and cooperation schemes is still far from filling the deficit. The conversion of research for "security" ends (arms, nuclear defence) to serve civilian industry is taking longer to achieve than envisaged at first: the areas of specialisation are different, and the collaborative networks have not yet been established. There are other worrying aspects: the volatile nature of small research teams, notably in the social sciences, which disappear when their leading members withdraw (as often happens) on account of advisory duties required by the political authorities; the competition with private-sector salaries in certain activities (like computing) where it is difficult to retain professors, researchers and good students. Finally, there is the constant underlying risk of seeing talents go abroad, if security or the quality of children's education deteriorates severely.[11]

However, the residues of old tensions should not be underestimated. Collaboration between disciplines, or between categories of establishments that apartheid kept separate, is still uncommon: "Councils" versus higher education, Historically "white" or "black" universities, English-speaking or Afrikaans universities.

However, *the true challenge* set before science could here be expressed in terms of its *inclusion into the general culture*. Although the majority of people do not reject science, science "illiteracy" is widespread (as surveys have indeed measured).[12] The Ministry places a lot of emphasis on this and is devoted to popularisation campaigns to raise the awareness of science. But real scepticism might well develop in their midst, based on a number of doubts. These include: Is modern science "white" science? Isn't it just an ethno-science? What is the point of following the method of thinking and the proceedings demanded by its methods? Can other forms of knowledge be held up to confront them? Is the establishment, which

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[11] The brain drain has not affected research. Other professionals have sometimes gone abroad: especially doctors, computer specialists and – the largest group - accountants. (see J. B. Meyer 1999).

[12] See: SA science indicators, 1996, and our first survey report on South Africa.

regulates science, preventing it from being rapidly appropriated and harnessed to serve the people?

While these questions may seem out of place to some, they have recently been circulating, even at the initiative of the political powers. On the heels of calls for an "African Renaissance"[13], a keen interest is mounting in "indigenous knowledge". Can these be incorporated into the existing science system? More recently, a heated controversy, played out in full view of the world, set those who refuted the theories about Aids, in confrontation with the almost entire national and international scientific community[14].

The urgency to see mass needs satisfied, the negligence of the technological sciences of these needs, and the temptation to mix the activity with political issues contribute to the calling into question the rigours of the system of science. This problem is related to the need for science to be absorbed into the social environment. It is reflected in the institutions through the tension between "old academics" and young scientists newly integrated into the system (already refered to), but who have had a very different life experience and sometimes follow a different professional model.

3.5 Recent initiatives

In spite of these uncertainties, scientific activity is one of the fields that has generated the greatest initiatives. We have already mentioned some very important ones led by the government (popularisation, reorganisation, university funding to foster research, incentive funds promoting a link with industry, and so on).

These interventions have given rise to the idea among researchers of so-called "strategic" research. The concept is gaining ground, either for coming to terms with the immediate necessities or as a sign of a new way of defining suitable research topics and producing results (Mouton, 2000). Here we can see the start of a new contract between researchers and the State, less crudely political, more open to initiatives from grassroots, to medium-term activity and the plurality of users, but nevertheless lending itself to the orientation and coordination of research work.

The new trend has prompted varied reactions within the establishments. They can be classified into 3 types (Mouton, 2000):

- **an *entrepreneurial* reaction: aggressive promotion (marketing) of programmes, opening up of new fields, building of previously unseen alliances and partnerships, the whole serving a strategic shift of position. It is the approach of large, old establishments, with an active, innovatory, amenable management that is sensitive to the context (Examples are: most of the "Councils", notably CSIR and MRC; some universities, especially the "top 5").**
- **a reaction involving *refocusing of activities*. This signifies a reorganisation in order to get rid of weak points or efforts too remote from central themes, and a consolidation of strengths, without excessive**

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[13] The idea of the African Renaissance expresses the retrieval of initiative founded on modern knowledge. It authenticates the latter by placing it in the continuity of ancestral technological inventions, demonstrating a spirit of reflection.

[14] In several African countries, where the Aids epidemic is raging and modern treatments are inaccessible (Ghana, Nigeria and others), interpretations of the disease have emerged based on traditional knowledge systems and inventors of remedies who have short-circuited scientific methods.

risk-taking. This is the case of some of the "Councils" (HSRC, ARC) and of most universities.

- **a *survival* reaction. Management of crises and dysfunction in internal democracy and financial management, little innovation, a growing dependence on the government. Some "historically underprivileged" universities are in this position.**

To a well-informed observer, this activity as a whole makes up a system "brimming with health and even vibrant in several sectors, thanks to its scientific tradition, a solid institutional capacity, a critical mass, and centres of excellence aplenty". No doubt, it should be added to complete this picture, it requires the emphatic support of the government and the backing of socio-cognitive groups who are powerful (linked to the industrial circles –trade unions included) although not representative all of society.

3.6 Cooperation partnership schemes

South Africa is a favourable arena for observation for many different sciences (astronomy, oceanography, ecology, flora and fauna; and generally, natural sciences and earth and planetary sciences). Commercial interests also find their place, as is standard practice today via engagement in technological alliances. The South African learned and professional communities are quite strongly represented in those fields. It is, therefore, not surprising that scientific and technical partnerships have been developed and are multiplying.

The situation does not, however, just boil down to these aspects. South Africa is still an underdeveloped country in certain respects, with scientific weaknesses that do not exactly allow for any rapid advance towards solving urgent problems. What is more, although the disciplines are solidly built up, they cannot survive properly in seclusion, far from the rest of the world and with no network contact to keep them up-to-date. The updating of knowledge and skills, today continuously renewed by the "Triad of scientific metropolises",[15] can only be achieved through entering into joint ventures with this same bloc. This is why the country is eager to engage in collaborative schemes.

One should not forget that South Africa was deprived of such cooperation for nearly 10 years, by the very effective boycott of the apartheid regime. The years 1988-93 were characterised by a decrease, not only of work under jointly-signed agreements, but of the indexed scientific production originating from the country. This loss of scientific weight (and indeed of level: measurements on "impact" confirm this) has barely been made up, even today. During that period, the networks forged by interacting relationships and acquaintance dwindled and the reference points were lost. Regeneration of the ability to spot the pioneer fronts and pioneering places, the fabric of relations with them is taking a long time. A general lesson can be drawn from this: *perseverance is needed* for any scientific cooperation to succeed.

Currently, though, the collaboration has resumed. Co-authorship, which represented only 10% of publications indexed in 1987, is now 30% and will surely increase. The USA is the primary partner (a third of the co-signatures) including in fields deemed of "social priority" (such as the organisation of small-scale black farmers to producing export produce). The United Kingdom is second and, when grouped as a whole, the European countries account for more than the American continent (42% of

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[15] USA, Japan and Western Europe.

the co-authors, shared, other than the United Kingdom between Germany: 10%, Italy, France, Belgium, the Netherlands: 3 to 6% of co-authors[16]).

Cooperation programmes are rapidly developing in earth and planetary sciences and in fundamental biology (two fields linked to the interest of international science for South Africa as a site for research). However, there is also considerable activity in mathematics, physics and chemistry. A vast field remains open for new joint projects in areas associated with applications (engineering sciences, biotechnologies, agriculture, medicine and public health) and the social sciences. There is high demand for collaboration in these subjects and the partners are of a high calibre. It just remains to effectively target projects of mutual interest.

4. Diagnosis: North Africa

North Africa shows yet another situation: the case of science was solidly propped up by the State and enclosed in two public, but opposing, professions. These are education and a high-level technical civil service. The way their professions are organised stimulates activity; but their duality hampers the unification of the scientific field; and innovation. There are sensitive issues too, which are linked to the cultural inscription of science, and the nationalistic frames of mind (which prevent the building of critical masses, on the regional scale of Maghreb.

4.1 The two incubators: education and technological structures

Colonial science, sometimes brilliant, developed behind the closed doors of institutions that excluded Moslems. The institutions' successes were used as an ideological weapon when the opportunity arose, discrediting and dispersing the corpus of popular knowledge.[17] The colonial heritage is quite considerable but not culturally integrated. After independence, the research institutes were maintained by the former colonial power for a long time, and later inherited by young national researchers who took them up in a different fashion, with the associated consolidating elements (respected journals, linked to a world network). However, the new science did not get under way in this manner.

A nationally-based science was to re-emerge in a particular force field situated between universities and the technological structure. The case of Algeria is typical. Two tendencies coexisted in the FLN[18], offering opposing visions for the future nation. The "patrimonialists" considered that the most urgent task was to rebuild national identity. Education was their reserved domain. It would be for the masses and delivered in Arabic, starting with elementary instruction, and would favour traditional disciplines (arts subjects rather than sciences). The "industrialists", in contrast, wanted to create a "new man". Their faith was in technology to mould the new citizens and to develop the country. A bitter struggle developed between the two factions, until, making the most of a favourable balance of power, the "industrialists" gained hold on the patrimonialists' territory.

In the early 1970s, the "industrialists" took hold of the Ministry of Higher Education and launched university reform. They set up a whole series of

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[16] Switzerland, Austria and Spain are also active. Most of these countries (except the UK and France) have a preferential partnership with the countries of the South that are "large-scale producers".

[17] On the use of medical successes to counter "traditional" epistemologies, see Y. Turin, Ideological struggles in colonial Algeria.

Schools of Engineering and Institutes of Technology, dependent on the Technical Ministries and whose teaching (administered in part by professionals) included a number of practical courses.

In the meantime, an impressive industrial base sprang up (such as petrochemicals, steel, mechanical industry) calling for a large number of technical managers. Following the same logic, and for the first time, research became an official preoccupation. A National Office was created. In less than ten years this ONRS, with substantial resources, stimulated people's vocations, built up a structure (creation of laboratories and research centres), stimulated production, and set standards (assessment of projects by scientific committees, editorial panels, centres directed by councils of peers, and so on).

In 1983, when the regime changed and "patrimonialism" came back into force, ONRS was dissolved. Research was played down, dismembered and apportioned among the Ministry of Higher Education, departments answering to the technical ministries and the Secretary of State's office responsible for specialised institutes. Scientific and technical enterprise as a whole was reviled for being "inauthentic" and "cosmopolitan". With no other form of inclusion in society, science had allied itself with the "technicist" faction. Its fate was radically linked to it. The industrial trusts were pulled apart, and the teaching staff was obliged to speak Arabic. Many "industrialists" were imprisoned and some researchers were threatened and killed. A new period began (see the following section), where science survived only enclosed within the separate bodies of the universities on the one hand and of the technical complex on the other.

In Morocco, history has evidently witnessed less drastic upheaval. Nevertheless, one may observe that research was finally demarcated into two separate camps: the Universities system, and the technological field (Schools for Engineers, Centres of applied research, R&D departments within some large firms, the supervision of which is not assigned to the Ministry of Education) (Kleiche, 2001).

In Egypt, where engineers and doctors have an old and prestigious story of separate training and professional dignity, the same division prevails. In Tunisia, the development of an academic field can be attributed to the creation of an official statute for teachers in the Universities (1973), and its apportionment of positions of internal power. Research had its place here, at least as "a moment in an academic career": for promotion was linked to publication (Siino, 1999). At the edge of this academic field, the schools devoted to professional training (including engineers), technical services and research establishments associated with strategic national needs, operated.[18] From 1978, the latter sector suddenly received considerable special attention. Around the Director of research at the ministry, a handful of university academics, whose style and career experience were unusual, delivered a critical assessment of academic research (mandarin style, taking international norms for reference, choice of subjects having nothing to do with the country's future). They launched national programmes, with great aims for technology, mainly upheld by the increased number of research centres. There followed an undeclared but fierce war with Higher Education, who defended the universities'

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[18] Schools: ENS (*Ecole Nationale Supérieure*), ENSET for training teachers, schools of engineering and technical studies, notably agricultural; research centres and departments: Centre for Research on Arid Zones, promoted by UNESCO in 1961, Atomic Energy Authority (CEA), amalgamated in 1969 with the Institute of Scientific and Technological research (IRST). This employed academics who were discharged from teaching duties.

monopoly on research. Finally the territory was divided between the Secretariat of State for Research, answering to the Prime Minister and the Ministry of Higher Education, who were constantly wrangling.

4.2 The division of the scientific field

In the mid-1980s, the landscape was fixed. At first ensconced in two distinct professions (education and higher technical civil service), the practice of science became part of their professional profiles. However, structurally, the activity was divided, between two fields: the academic and the technological. Thus it was maintained by two irreconcilable socio-cognitive groups, each advocating completely opposing scientific styles. The scientific field was neither unified nor autonomous.

The university system made research subordinate to the tasks of instruction and training. Such activity was marked with aims more educational than exploratory. It was not equipped for the transfer to productive sectors. Teaching staff had to publish, but only to further their career (because publications are an important factor for promotion, which distinguished the authors from lower calibre teachers).

In the technological camp, science was practised *for doing*. But scientists here were highly dependent on the State and its demands, and for orders from industrial companies. Research hesitated between the bold ventures of applied research (such as the desalination of sea water), for which there were few industrial operators to follow up, and straightforward projects of technological adaptation, intended to win over the existing professionals. Even in a subordinate role, research was nevertheless full of dynamism. It had its sanctuaries and its enthusiasts but was essentially carried by two professions (which received much less rough a treatment here than elsewhere in Africa). Situations vary markedly, however, from one country to another.

In North Africa, the countries that have shown the least respect for their professional people are Egypt and Algeria. In Egypt, research workers and teaching staff are now so poorly paid that, like most in public service, they have to have a second job. But for the support of foreign cooperation (from the US in particular), many would have abandoned research, unable to make a living from it. Government policy is akin to the *laissez-faire* characteristic of many countries south of the Sahara. One difference is that "surplus" brainpower is deliberately exported. Talented people are "lent" to universities and companies in the Gulf States, in return for payment of a tax, with the guarantee of resuming their post on their return. The exodus of the most capable brains to industrial countries of the North follows an already ancient trend. More so than elsewhere, links with the diaspora irrigate local science. Many of those who publish from their home country work part time in the USA.[19]

In Algeria, the research system is highly fragmented. The economic crisis, which has been holding sway since 1985, has affected higher education teaching staff.[20] They have lost nearly half of their purchasing power. Since 1991, opposing factions in an insidious civil war have hounded all professional people – who constitute the embryo of a civilian society that the protagonists do not want. Threats and murders have caused a mass

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[19] They hold permanent jobs there at the same time as looking after a laboratory locally. Their plans for the future are determined by a strong attachment to their home country with their eventual return there envisaged.

[20] However, researchers were less severely hit, no doubt because some research centres were in the sphere of military services (renewable energy, nuclear studies).

exodus of highly experienced professors, doctors and engineers. Career paths were thus abruptly opened for the youngest professionals.

Paradoxically, the war's torments have also triggered a revived interest for research among those who stayed, as a distraction from deteriorating living standards and working situations. A proportion of the teaching personnel have committed themselves to research work supported by cooperative programmes (and sometimes by industry). Here we find a young generation that is well educated and trained but without many links with external networks. This is re-forming a science with a nationalistic ethos, oriented towards applied research, and with a strong local reference base.

It is in Morocco and Tunisia, though, that the profession has suffered least from the recession, and where State support, although a long time in coming, is now the most energetic. In Tunisia, [21] science has been enjoying pride of place for a decade now. It is deemed to symbolise the qualities of the State: rationality, competence, reaching towards the heights of modernity. "Strategic" (in the face of the technological weaponry of the North) and ideological purposes (a bulwark against obscurantism) are assigned to it. The President regularly demonstrates his interest, in events highly publicised in the media. His attentions are translated into action with great political determination: the creation of an office at Secretary of State level with real political power; a law that ensures good funding over the medium term; the creation of institutions and launching of programmes to activate scientists. The Office of the Secretary of State, which has sole responsibility for the research centres (except agriculture), is now undertaking to build the whole sector (including universities) into a structure based on laboratories. It has the backing of a new generation of "technicians" (some of whom have trained in the USA), who want to promote new tools and areas of research: such as transplant medicine, computing; telecommunications or biotechnology. Nevertheless, the university world has not dropped its guard and sees in these measures a new attempt to marginalise it and, by way of the laboratories, to take control of its considerable potential.

In Morocco, the 1980s recession hit the profession. Promotions were blocked for several years and any making good of low salaries was only by bonuses. However, the damage was nothing like that suffered in Africa south of the Sahara (or even in neighbouring Algeria). The profession (of higher education teacher, or research scientist) remained attractive and highly regarded. Some (especially senior staff) do consulting or trade in their skills (by opening private university institutes); in this way they earn exceptionally comfortable incomes. There is no lack of "market", but it is not indispensable for survival.

Only quite recently, did the government discover how dynamic its scientist population is, and is now striving to derive maximum benefit from it. The Moroccan government has strengthened budgets and created an office at Secretary of State level that is responsible for research. This office is endeavouring to organise the sector into a structure, around nuclei of specialist competencies associated with strategic programmes. It has initiated and maintains a tendering procedure, which identifies young talent. It strives to expand and diversify the sources and formulae for cooperation (for example, by way of teaming up with European regions).

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[21] The analysis that follows is largely borrowed from F. Siino (1999).

Efforts are being made to stimulate industrial demand.[22] These initiatives are aimed simultaneously towards both the academic and the technological sectors. Some institutions have already succeeded in adopting a position where the different styles of science can meet (applied and fundamental research).[23] The scientific field could become united here.

4.3. The state of the field.

The academic and technological sectors do not have an equal calibre of facilities. The "technological" sphere involves much fewer people than the universities (7 to 10% in terms of staff and only 4% in Egypt). However, it is in favour with the government and receives the best budgets. In terms of equivalent full-time numbers, the relationship is more balanced. Here the university again dominates its rivals by a factor of 2 or 3 (even as much as 6, in Egypt). The intensity and the quality of work depends on the institution: on their equipment and their research culture. The "historical" institutions often consist of circles of solid structure and hierarchy. This can become stifling with their ultra-establishment administration. A young generation is beginning to shun them, seeking other centres with more freedom. This phenomenon is clearly evident in the bibliographic data, which identifies the poles of activity: these have been diversifying for several years now

The bibliographic databases are also a good tool for identifying favourite areas and the strengths and weaknesses of this research apparatus. Undoubtedly, they give a measure of the publications, the favoured means of academic expression. Nevertheless, the scope of technological preoccupation has not been overlooked. All the countries of this region have strong sectors in the engineering sciences, chemistry (Egypt, Morocco), physics (Morocco, Algeria), mathematics (Maghreb), and, sometimes, medical research (Tunisia)[24]. The growth of scientific production has been the greatest in Africa over the last 15 years (Maghreb). As for the human and social sciences, although satisfactory bibliographic data for these are lacking, they are a weak point in all the countries concerned. The direct survey showed that in Egypt they operate on the basis of a now-obsolete functionalism. In Tunisia, expression of critical views is not welcome. In Algeria, it has become increasingly difficult to gain access to the field. Production of these disciplines in Morocco is the preserve of a few "stars", aimed largely at the international community rather than at influencing thought at home. There are some exceptions, but they do not alter the overall state of the field.

The data just given reveal nothing about the real capacity for innovation. The problem is to find a link to a demand. Locally, industry has neither the means nor the necessity to do research (because it is the sort which makes use of technologies already developed, relying on the advantages of a protected market or of a cheap workforce). Certainly, there are some large companies (especially in the semi-public sectors: oil and steel in Algeria; and phosphates and mining in Tunisia) that are ready to present problems for investigation. (However, they tend to restrict themselves to primarily

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[22] The Association for R&D, set up by a group of large-scale industrial concerns, belonging either to the public or para-public sectors, was the first association to be working in this direction. The proclaimed argument for new government intervention stresses the need to improve the quality of Moroccan products, so that they can withstand the competition that comes with any link to the European market.

[23] For example the Hassan II Agricultural and Veterinary Institute, or the Mohammadia School for Engineers.

[24] See more details in Waast (2001).

addressing straightforward engineering problems, and even then with caution as they are more accustomed to utilising international research and development that contributes in "real time").

The State could get involved in bolder programmes and make national research both a project owner and a contractor/project manager (concerning water supply; fishing resources; improved quality standards for industrial products; application of new technology to social needs: agricultural biotechnology, translations into Arabic and so on). Stimulation from Europe (through its market, and the competition it implies) would also foster action. (This has already happened in Tunisia and Morocco.)

4.4. Tensions, challenges, initiatives.

a. Tensions

- The main tension clearly occurs between *the "academic" and "technological" sectors*. In Tunisia, the conflict lurks beneath the surface and the scars of old battles have not disappeared. In Egypt, rivalry is harsh in the race to win resources that accrue from foreign cooperative partnerships. In Algeria, the confrontation is diminishing insofar as civil war has erased inter-professional quarrels.[25] In Morocco, some institutions have succeeded in adopting a position where the different styles of science can meet, and the Government is attempting to work towards bringing the sectors closer together without alienating any of them. However, the division is present in every institution, latent and intractable, through many intertwining factors.

- Another, more recent conflict has entered the scene which does change the situation. It is tension that surfaces *between generations*. The generation of the founders, often committed nationalists, close to problems at ground level, attached to proven methods, and who battled to create institutions or keep essential departments running, is steadily being replaced. The generation that followed is the one that imposed professional standards and set up regulatory bodies. They also now occupy the highest posts in the hierarchy. A third generation is entering the arena. It has fewer promotion prospects, although it is well trained, knowledgeable about advanced tools and contemporary scientific problems, often the result of theses done in France or the USA as part of cooperative projects. This generation is also in tune with the present operation of laboratories in the industrially developed North, that are linked by contracts, especially industrial ones. This is the generation of "technicians". Impatient within universities, they are often drawn to the research centres, which recruit by contract and put their money on young talent (as is the case in Morocco and Tunisia). Their relations with the preceding generation are not always straightforward (especially in the context of institutions that exude a highly mandarin style, as many in the region do). This new generation, with a different professional outlook, is attracted by research, with applications as objectives. It does not fit in with the scenario of the two opposing styles of science. Certain institutions have, in fact, also built bridges between the two (see IAV in Morocco, already mentioned), as have some professions like medicine (which adopts the professor-researcher-head of department as role-model, most often the client for his own work, devoted to improving his practices).

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[25] Universities have long sought out interaction with large-scale industries (at least in certain domains: chemistry, social sciences and so on). However, researchers and university academics have different statutes and supervising organisations and they are still generally unacquainted with each other.

In the interactions between *the State and researchers*, should we talk of tension and conflict? In any case, in this region science is seen wholly as a function of the State (alongside it, thanks to its will and its support, with no other mandate from society, or initial legitimacy required). Subsequently, governments showed interest only in fits and starts and it was left to the public-sector professions to take up the task. State intervention, nevertheless, remains crucial for ensuring a certain financial independence (especially in the face of a low level of social demand), a plan and the reaffirmation of legitimacy. When government funding was re-introduced (in Morocco and Tunisia), it was received with both relief and mistrust. Professional scientists, who have been successful in preserving their activity, do not wish to see their project or their organisation undervalued. Everyone is waiting for the tensions that permeate the field (between academics and technologists, between generations and so on) to be resolved, but each to their own advantage. "Reforms" can only be pursued with caution. Where the State has withdrawn, researchers harbour a persistent grudge towards it.

Can commercial demand take the place of State action? Undoubtedly not, if one compares highly advanced scientific forces with the concerns of technological adaptation of poorly innovative local companies. Nor can State action be replaced if it means being subject to commercial demand from abroad, judging by the nationalist perspectives that these forces subscribe to.

b. Challenges.

- Other challenges could prove to be decisive. One of them is the *cultural integration* of science. The resurgence of Islam has given the cultural question a highly political significance. Is science opposed to religion? Can religion be set against science? The insults suffered by Algerian industrialists and the rebound felt by scientists, considered as being in league with them, have already been mentioned. Modern science, the resulting technology and the way of life it results in are perceived to be "immoral" and "foreign" by significant sections of society throughout the Moslem world. This science must explain itself concerning its values and practices. This is all the more urgent now that science is being used as an instrument of conflict by all camps. Some use it as a bulwark against obscurantism; others use it as a tool to serve the faith. (Note that it can be used, but it is improper to get involved in its creative activity).

This question ties in with that of *integration of science into society*. It is true that access to science has been made more democratic, thanks to mass education. However, the language and teaching methods have recently brought this gain into question. An update also appears to be necessary. What kind of science does the nation need? Must it satisfy basic needs? Should it serve industry? What perspectives does science offer the country for independence and for removing alienation? At a time when science has become globalised, can it continue to be simply national and nationalist?

- The major challenge is perhaps to find a tolerable level of cosmopolitan interaction, in other words developing *regionalisation*. You will have noticed that, in spite of certain common characteristics, we have often presented the case of different countries separately. Although they might well converge, this is only after taking quite distinct paths, which each country considers unique, the history of others acting as a foil. All indications might lead to a belief that the existing potential would constitute a "critical mass" if it were to be given expression in a *regional*

context. The converse is true, however, as the bibliographic databases show clearly how cooperative programmes of this scale are lacking.

Table: % of publications of one country with co-authors from different countries

From/with	World	% of which co-authored with:					
		Morocco	Algeria	Tunisia	Maghreb	Egypt	N. Africa
Morocco	79%		1%	0.5%	1.5%	0	1.5%
Algeria	68%	1%		1%	2%	1%	3%
Tunisia	55%	0.5%0	1%		15%	0	1.5%
Egypt	32%	0		0			

There certainly are learned societies in the Maghreb in almost all disciplines. However, they are usually imbued with competition rather than a spirit of emulation. The construction of a scientific sphere for the Maghreb (a fortiori one of Maghreb-Machrek) is far from being on the agenda. This clearly constitutes a handicap.

c. Initiatives

The main initiatives have already been highlighted. There are those of states taking renewed responsibility for science (Morocco and Tunisia), those launched by institutions which position themselves at the interface of scientific styles (IAV Morocco for instance) and of learned societies trying to give substance to a scientific region. Individuals are active, too. Many and scattered, they endeavour to maintain their activity by seeking out contracts and working in multinational or bilateral networks.

4.5. Cooperative schemes

In this region agreements about cooperation play an essential role in sustaining the momentum of activity and updating capabilities. Elsewhere (in South-East Asia and in South America) it has been observed that, once a certain point has been reached, the necessary partnerships with the industrialised countries are partly substituted by regional cooperative programmes. That is not the case here, however, where (as we have seen) the area is not gelling as a region. Each country, though, up to now, has managed to keep abreast of new theories, methods and technology, thanks to perseverance in their bilateral links. European involvement in scientific cooperation (overwhelmingly French assistance in Maghreb) clearly predominates. This is being reinforced, moreover (as it is in South Africa) to the detriment of the regions of median Africa (which are scientifically less up-to-date). The tendency is a slow but lasting one.

US participation in such partnerships is predominantly in Egypt, and much less in the Maghreb countries. Nevertheless, the US has played a considerable role (as in the 1980s, for instance, in the form of massive PhD training programmes, aimed at researchers or teachers already working in a selection of institutions (like IAV Morocco or IRST Tunis). Their notion of the scientific profession has been changed through this, as well as their vision of what research should be (i.e. more geared to "doing").

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