EUROPEAN COMMISSION

European Research Area

Evaluation of a national research system: MOROCCO

Roland Waast and Mina Kleiche-Dray

STUDY

CAPACITIES

INTERESTED IN EUROPEAN RESEARCH?

Research*eu is our monthly magazine keeping you in touch with main developments (results, programmes, events, etc.). It is available in English, French, German and Spanish. A free sample copy or free subscription can be obtained from:

European Commission
Directorate-General for Research
Communication Unit
B-1049 Brussels
Fax (32-2) 29-58220
E-mail: research-eu@ec.europa.eu
Internet: http://ec.europa.eu/research/research-eu

EUROPEAN COMMISSION

Directorate-General for Research
Directorate D — International Cooperation
Unit D.3 — Specific International Cooperation Activities

http://ec.europa.eu/research/enquiries

EUROPEAN COMMISSION

Evaluation of a national research system: MOROCCO

Roland Waast and Mina Kleiche-Dray

2009

Directorate-General for Research
International Cooperation

EUROPE DIRECT is a service to help you find answers to your questions about the European Union

Freephone number (*):

00 800 6 7 8 9 10 11

(*) Certain mobile telephone operators do not allow access to 00 800 numbers or these calls may be billed

LEGAL NOTICE

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information.

The views expressed in this publication are the sole responsibility of the author and do not necessarily reflect the views of the European Commission.

A great deal of additional information on the European Union is available on the Internet. It can be accessed through the Europa server (http://europa.eu).

Cataloguing data can be found at the end of this publication.

Luxembourg: Office for Official Publications of the European Communities, 2009

ISBN 978-92-79-12957-5
doi 10.2777/36998

Printed in Belgium

PRINTED ON WHITE CHLORINE-FREE PAPER

TABLE OF CONTENTS

PART 2

PART 3

ABOUT THE AUTHORS

THE EDITORS

Roland WAAST

Roland Waast is an engineer from France's Ecole Polytechnique, sociologist, and Institut de Recherche pour le Développement (Institute of Research for Development (IRD)). He created the 'Sciences, Technologies and Development' research group, and initiated an international network, ALFONSO, on the same topic. He is co-director of the journal, *Science, Technology and Society*. Mr Waast has published 6 books, and has had many papers published over 30 years on subjects such as rural sociology, health economy, and sociology of sciences. He directed the series of books titled *Les sciences hors d'Occident au 20e siècle* (*20th Century Non-Western World Sciences*). Together with Jacques Gaillard and V.V. Krishna, he co-edited the book, *Scientific Communities in the Developing World.*

Mr Waast conceptualised the European Evaluation of the Moroccan Research System project carried out in 2002–2003, and was the project manager.

E-mail: waast@bondy.ird.fr

Mina KLEICHE-DRAY

Mina Kleiche-Dray is a biochemist with a PhD in History of Science and Technology, researcher at IRD, and member of Research Unit 105, Savoirs et Développement. She lived in Morocco from 1995 to 2004, where she carried out several programs on the history of agronomy (i.e. theories and doctrines), and on the role of agronomists (i.e. choice of action, controversies, and social role). She has also studied the current situation of the unemployed graduated group, and the scientific production of French-speaking social sciences. She has written papers and books on these topics.

Ms Kleiche Dray led the European Evaluation of the Moroccan Research System project on-site (2002–2003). Her contribution was deciding (i.e. dealing with the experts, writing history and describing the research system, and observing and analysing the institutions). She is the author of several papers and works on these subjects. She has also contributed to the Initiative Développement Humain du Cinquantenaire (Initiative for the Fiftieth Human Development). Today, she is based in Mexico, working on the history of Mexican chemistry.

E-mail: Mina.Kleiche@ird.fr

THE AUTHORS

Jacques GAILLARD

Jacques Gaillard is an agronomist with a PhD in Science, Technology and Society, and member of IRD's Research Unit 105, Savoirs et Développement. He has been involved (at a senior level) with the International Foundation for Science (IFS, Stockholm) and recently with the International Agency for Atomic Energy (IAEA, Vienne). As a specialist in science policies, specifically related to the research profession and the emergence of national scientific communities in the developing world, Jacques Gaillard has written many papers and books. In the European Evaluation of the Moroccan Research System project, he was one of the experts in the agricultural and forestry domain, and (along with Anne-Marie Gaillard) carried out the questionnaire/survey on Moroccan research laboratories, which provided unprecedented knowledge about them.

Anne-Marie GAILLARD

Anne-Marie Gaillard has a PhD in Social Anthropology, specialising in the study of refugees returning to their country of origin. For several years, she has been working on the mobility of highly qualified professionals, and international scientific migrations. She has written several papers and books. Together with Jacques Gaillard, she carried out the questionnaire/survey on Moroccan research laboratories.

Pier Luigi ROSSI

Pier Luigi Rossi is an engineer at IRD, geologist, and computer scientist specialised in filing systems. Mr Rossi created the methodological approaches on bibliometry, which allowed for a refined analysis of both the strong points and the dynamic of the Moroccan research. He recently developed these approaches, applying them to all the southern Mediterranean countries (European project, ESTIME). He also handles the scanning and categorisation of scientific documentation projects (at an all-embracing scale) at IRD.

Ilham LAAZIZ EL MALTI

Ilham Laaziz el Malti is an engineer at Ecole Mohammadia (Morocco), professor with a PhD in chemistry, and was head of the Technology Development Division at the Ministry of Higher Education in 2003. Today, she is director of the Programme de généralisation des technologies de l'information et de la communication (Program for the generalisation of information and communication technologies (GENIE)) at the Moroccan Ministry of National Education.

Said BELCADI

Said Belcadi has a PhD in physics (Grenoble University), is professor at the Mohamed V University (Rabat, Morocco), and was director of Research and Cooperation at the Ministry of Higher Education. He was also director of Ecole des Mines de Rabat from 1990 to 1994. Today, he is director of Centre National pour la Recherche Scientifique et Technique (National Centre for Scientific and Technology Research (CNRST)).

Ahmed EL HATTAB

Ahmed El Hattab is currently Director of Science at the Ministry of National Education.

PREFACE

By the end of June 1999, as Secrétaire d'Etat in charge of scientific research in Morocco, I contacted the Head of Directorate-General for Research and Technological Development (DG RTD, previously DG XII) of the European Commission in Brussels, Belgium.

Considering our rich economic and cultural exchanges, and the shared historical heritage, we invited the European Commission to carry out an evaluation of Morocco's scientific research system in the exact sciences, life sciences, and engineering sciences.

In response to our request, the European Commission called the Sciences, Technology and Society team, led by Roland Waast of the Institut de Recherche pour le Développement (Institute of Research for Development (IRD)), in order to organise and carry out the whole operation.

Above all, the goal of this operation was to gather comprehensive information but it also aimed to share better knowledge and recognition of the nation's scientific potential. Moreover, the operation allowed us to reinforce the relationship between Europe and Morocco, specifically opening the path for a scientific and technological cooperation agreement between the Kingdom of Morocco and the European Union in July 2003.

We wished for rigorous and unprejudiced judgements in this difficult exercise. The assessment was completed in three phases: bringing to light the state of affairs (a description of the situation), the *in situ* evaluation conducted by 20 European experts, and a presentation of the results to the stakeholders in a National Workshop, 26-27 May 2003, held in Rabat under the High Patronage of His Majesty King Mohamed VI.

This report accounts for the whole process. The operation lasted one-and-a-half years, from 2002 to 2003. *Its methodology stands as a model today.*

Ilham Laaziz, who worked closely on the project, has described the constant interaction between the authorities in charge of research, the institutions, and the assessors. This procedure allowed them to prepare the groundwork, make the evaluation acceptable, and facilitate the experts' work. This strong interaction contributed also to the success of the National Workshop, where debates took place over 2 days, at which 300 researchers participated, and where different interested groups (e.g. officials, managers, and all sorts of users) came to interact with the experts about their reports (available in their entirety).

The framing of the Moroccan research was carried out in different ways.

Mina Kleiche-Dray (IRD coordinator in Morocco) analysed its history (starting her study at the beginning of the 20th century), and characterised the heritage. She also drew an outline of its current organisation.

Pier Luigi Rossi and Roland Waast (the latter of whom was head of the project) accurately mapped the production, per city and per institution, in 100 scientific and engineering domains. They measured the good ranking of Morocco in scientific production (currently in third position for the African continent), highlighted the strong points, and underlined the weaknesses. Furthermore, Jacques Gaillard and Anne-Marie Gaillard sent a questionnaire to all research groups. This supplied fresh information about their composition, collaborations, available means, and difficulties.

The report ends with a synthesis of the evaluation, and a posteriori analysis of this operation by the people in charge of research today (i.e. Ahmed El Hattab and Said Belcadi); they present the lessons retained by the Ministère Délégué à la Recherche Scientifique (Moroccan Ministry for Scientific Research), and the results that followed.

This report appears just at the right time. The question of the role and usefulness of the scientific system is an up-to-date one. Genuine financial and resource efforts have been laid out in Morocco. However, what is at stake is not only a question of mobilising means but also of structuring research — not only institutions but links with society, motivation, human resources and, finally, imagination for choosing relevant and anticipating niches. This a constant concern of the Académie Hassan II des Sciences et des Techniques (Sciences and Technologies Academy of Morocco), which, among other missions, has to contribute to defining the general orientations of scientific and technological development of the country.

Prof. Omar Fassi-Fehri
Secrétaire Perpétuel, Académie Hassan II des Sciences et Techniques (Royaume du Maroc) (2004–), and former minister for Science and Technology, Kingdom of Morocco (1998–2004)

PART 1

METHODOLOGY

1.1 THE APPROACH

Roland Waast

The evaluation of a national research system is a bold and infrequent operation carried out, at best, once every 10 or 15 years. It can give fresh momentum to science policy, lending credibility to research and facilitating agreement in strategic decision-making. But it may also end in failure and generate an unproductive litany of grievances or disinterest.

The decision to launch such an operation arises from a particular set of circumstances and the steadfast *will* of the authorities. In this case, it was the Moroccan Ministry for Scientific Research (hereafter referred to as the 'ministry') — first set up in 1998 — that *wanted* an evaluation of the country's potential ([1]), and requested a completely *external* audit ([2]). The European Commission (Directorate-General for Research and Technological Development) decided to back the operation before the signing of bilateral scientific cooperation agreements, and a qualified — external — organiser was selected ([3]).

As the project manager, I now propose to outline the overall approach.

1.1.1 GOALS

First of all, it is important to bear in mind that the evaluation of a research system *does not* set out to assess individual researchers, laboratories or institutions. That is a job, done on a regular basis, for peer commissions, national committees, and other such ad hoc bodies.

What it does seek to do, on the other hand, is to weigh up a country's scientific potential with a view to its classification by location and by discipline, and to pinpoint the issuest-hat prevent it from fulfilling that potential.

There are all manner of possible handicaps. These can stem from:

- the professional standing, training, and scientific culture of the researchers, as well as their isolation from the pioneering forefront of science or from the demands of society;
- the paucity or poor organisation of means — equipment, access to literature, and management of funding;
- deeper problems concerning the place and perception of research in society.

So, the evaluation can call into question both the research community — epistemological standpoints, management, and conflicting views as to its purpose — and the outside world; communication barriers between opposing 'spheres' or schools of thought.

1 All, except the social and human sciences. Originally, the field was divided into nine areas: mathematics and information technology; physics (solid state, material, and nuclear); geology, geophysics, hydrology and water treatment; energy and the environment; agronomy, agriculture, forestry, veterinary science and medicine; ocean sciences, aquaculture and pisciculture; medical and pharmaceutical research; engineering (mechanical, chemical and civil); and space and telecommunications. That is, almost the entire range of 'exact sciences, life sciences and engineering sciences'. Ultimately, this was the division adopted as the frame of reference, with a few additions and a slight shift in the dividing lines.

2 Along the lines of an earlier audit carried out by Portugal, which served the cause and enhanced the management of research in that country upon its entry into the then European Community in 1986.

3 The Science Technologie et Développement research group, IRD, (Paris, France).

The goal is not to expose shortcomings, but to publicise research, arouse interest among a wealth of different actors, encourage self-analysis and stimulate debate on the benefits of developing scientific activity, and foster mutual agreement on a diagnosis, outlook and possible plan of action.

Ideally, it amounts to a form of 'sociological intervention' in-and-around the research community, aimed at encouraging the actors to emerge from entrenched positions by building greater trust between them, and by reviving relevance and results as priority requirements all-too-often buried beneath conventional wisdom and self-serving statements.

Efforts to achieve this ambitious goal are not always going to hit the mark, of course. But at the end of the day they should at least produce sound, credible documents that can serve as instruments capable of boosting self-awareness, and underpinning wide-ranging discussions between bona fide partners.

1.1.2 APPROACH

There is no standard recipe for success in such an operation. The evaluation of a research system must be 'made-to-measure'.

It sets out to appraise the state of the system, producing a relief map of its non-uniform features and pinpointing the forces that shaped them. It calls for genuine sensitivity toward the interests, values and conflicting rationales that motivate the actors. It seeks to assess the results, and to grasp the conditions in which they have been produced. It must appeal to well-established scientists, and bring them face to face with the researchers in their laboratories.

The golden rules of the approach are that the evaluation must:

- *keep a distance from* … and at the same time *build trust with* all the stakeholders;
- recognise the value of *face-to-face* encounters *in situ* between the evaluators and the evaluated;
- be carried out by professionals capable of gaining respect for their technical expertise.

Let us take a closer look at these points.

1.1.2.1 Keeping a distance

The credibility of an evaluation depends on it remaining visibly *independent* from both its sponsors and those being evaluated.

In this case, the Moroccan Ministry for Scientific Research had opted to request reports only from foreign experts, which was a bold step to take. On the one hand, it meant that the selection of participants was out of its hands; the ministry approved the list, but the actual selection procedure was left to the operator, which appointed its own Moroccan experts to accompany them on field operations. And, on the other hand, the Moroccan scientific community is full of distinguished figures to whom the task could have been entrusted. The decision to choose foreign experts may have come as a surprise, even though it helped bypass any internal rivalries. But the Minister defended the risky decision vigorously at the National Workshop on research held at the end of the operation, arguing that it gave Moroccan research greater international visibility and clarity, together with a seal of approval that could be conferred only by outside authorities.

Clearly, nothing could have been done in Morocco without the will and the support of the country's authorities; the operator had to listen very closely to their views, reasoning and aspirations. That said, the team of evaluators did manage to stand by its modi operandi and field of action. This formed the subject of discussions and, when necessary, negotiations. But what mattered most was that the team was seen by one and all to be acting as part of a *neutral* information-gathering operation, and not as any kind of government taskforce.

Candid discussions took place at each and every stage — in the selection of experts, choice of sites to visit ([4]), scale of the debriefing, and so on — within the framework of an active steering committee, and under the equally watchful eye of a government minister. Operations were monitored every step of the way. But as long as everybody was kept informed and actions were discussed beforehand, the evaluators were free to investigate any site they saw fit in technical terms — including private organisations — and were never discouraged from doing so.

On the contrary, the Ministry for Scientific Research had had the operation endorsed by the Interdepartmental Research Council (IRC), whose standing secretariat it provided. This opened doors to every public body, regardless of which ministry it was answerable to. It engaged actively in publishing official information on every course of action. And it took a courageous and definite stand for the 'independence of the experts' on the rare yet inevitable occasions during which the evaluators caused controversy in the field because their questions and comments were not entirely supportive of the hierarchical and ideological status quo. In short, as long as in-depth discussions were taking place, our team was able to assert its independence and enjoy the greatest possible latitude.

At the same time, a distance had to be kept from those 'under investigation'. In the early stages, this was possible thanks to the decision to carry out part of the evaluation by indirect means: for example, historical survey, laboratory-based questioning, and bibliometrics. However, the core operation involved visits to sites by a panel of 20 or so foreign (European) experts whose eligibility for selection hinged, inter alia, on their lack of any involvement whatsoever in local research action, even under the auspices of cooperation efforts.

The experts obviously met grassroots researchers face-to-face. Some of these researchers took them to task over their motives, while others demanded that they pass on their

[4] A sensitive point at grassroots level: for instance, 'why evaluate me instead of the others?' Reasons had to be given in the shape of 'objective' criteria, and bibliometrics were a great help in that regard. For more on these negotiations, see the chapter on the role of the ministry.

grievances. The teams they encountered urged them to fraternise with them, and/or to shower them with advice. Occasionally, they were boycotted, but more often they were subjected to a calculated charm offensive. In my view, they managed — as a result of having undergone a lengthy selection procedure — to demonstrate composure and sound judgement, as follows: showing, without a hint of arrogance, that they had not been fooled in the slightest; taking a keen interest in the subjects addressed, in organisational matters, and in the prospects outlined, yet refraining from acting as intellectual leaders; voicing reservations or criticism when necessary face-to-face, and not condemning anyone whatsoever in their reports or writing anything that had not been said in public. So, a good deal of distance was maintained on the ground, which helped steer clear of attempts to curry favour, and served to boost the visitors' credibility as a result.

For the record, the operator's independence vis-à-vis the European Commission was just as great. Once the contract, which set out the work plan, had been signed, it submitted a quarterly progress report but came under no pressure whatsoever to adopt one procedure over another, to choose a particular expert or to tone down the results.

1.1.2.2 Building trust

While an evaluator must avoid the trap of becoming too close to the stakeholders — and, hence, the suspicion that it might be pleading its own case — it is equally important to build genuine trust. Such trust must be deserved, in the eyes of every actor.

In the first place, the operator needs to show complete *loyalty* to the sponsors. Every single procedure must be discussed in detail, and be neither bypassed nor revisited once finalised. Also, the operator and the experts must not seek to turn the action to their own advantage, at either a personal or institutional level ([5]). Finally, the results must be kept in the strictest confidence until endorsed and published. The operator's conduct is judged by the contracting authority, and mutual trust is built — and *cooperation* established — one step at a time.

In Morocco, although this is not uncommon elsewhere, the task was complicated by the fact that the research organisations to be visited were answerable to a range of different authorities. Some even belonged to private companies ([6]). Relationships, therefore, needed to be struck up with the various supervising bodies. The ministry was extremely helpful on that score, as was the operator's tact. Once again, openness was of the utmost importance. The experts themselves visited the authorities concerned and provided them, where possible, with a summary of their observations at the end. The benefits of this became apparent at the final debriefing workshop, which featured some highly varied forms of participation, which had a far-reaching impact.

It is not enough merely to gain the trust of the highest authorities, genuine access to the field also calls for close working relations with the establishments visited. It is a matter not only of keeping them fully informed from quite early on, but also of giving them the latitude for initiative and action. In this case, the experts' programmes included mandatory

[5] Hence, the importance of selecting experts with no particular connections in Morocco. Furthermore, as a matter of professional ethics, the operator did not wish to work with any experts from its own institute (IRD), even though it is hardly lacking in qualified staff.

[6] Initially, there were no plans to visit these, but the issue of how the research was being applied and what was being achieved in terms of R&D was too important to ignore. The harmonious relationship established between the ministry, operator, and the unique Association R&D Maroc group of major manufacturers helped open doors.

visits to such establishments as laboratories known for their productivity or for playing a proven role in R&D. However, it was up to their governing bodies to determine the detailed programme, to add laboratories of their own choosing, and to strike a balance between discussions with managers and discussions over the 'work benches'.

The researchers themselves were free to choose whether or not to take part in the *in situ* meetings with the experts. It was always anticipated that the latter would hold an impromptu debriefing session before they left, especially when the establishment managers had chosen not to attend the laboratory visits, so as to leave the researchers completely free to express themselves.

On site, it is up to the experts to show an interest in the activities, the vocation, the values, and projects 'under investigation'. It is easy to see if the interest is genuine or not. They must also show that they are keen to improve the *system*. The turn taken by the enthusiastic and constructive exchanges in many laboratories on this matter — and, furthermore, on the research themes — was an indication of the commitment of the evaluators.

Given the time and consistent approach required to build trust, the *duration* of the evaluation — nine months — was an advantage. The degree of trust built up was evident given the forthright comments of the managers and researchers invited to the national debriefing workshop. This trust owes much to the conduct of the experts; it reflects an appreciation of their abilities — which must be unequivocal — and of their human qualities.

1.1.2.3 The virtues of face-to-face encounters

A system's evaluation will fail if it appears judgemental. Also, its procedures must neither resemble the routine evaluations of researchers or laboratories nor be entrusted to the same authorities. It cannot be carried out on the basis of 'case files' alone. It requires direct contact with real people in real-life situations. It has to probe the underlying meaning of the work and the interests — whether 'pure' or not — of those involved. The conditions in which the work is done determine its limitations and potency, and these therefore must be tested.

So, *on-site visits and face-to-face encounters* are crucial. The experts taking part must be open to surprise, and display quick and accurate powers of observation. Without the knowledge of the field gained as a result — on production conditions, the frame of mind of the actors, and so on — it is impossible to understand the 'system', how it functions, and how it is likely to evolve.

1.1.2.4 Technical expertise

The stakeholders each have their own experience of the research system, its strengths and shortcomings. They see themselves as experts on the matter, and fully capable of carrying out investigations. However, it is important to avoid the pitfall of amateurism.

As a matter of fact, the evaluation of projects, programmes and, what is more, systems is now entrusted — sometimes wholly — to specialists. This is especially the case in Anglo-Saxon countries where a bona fide profession is on the way to becoming 'chartered' (authorised to certify 'quality'). The European Commission is increasingly using a combination of panels of experts and professional firms.

Accurate tools have been developed. Evaluation practitioners form a small community that meets to compare instruments, perfect their technical aspects, and determine their validity and scope of application. The knack, then, is to adapt those tools to the situation on the ground. This still leaves the matter of becoming proficient in the use of these tools.

Experts in the social and human sciences know that questionnaire and interview techniques form the subject of a considerable and continuously revised body of methodological literature. Statisticians know that sampling cannot be improvised, and that it relies on highly codified practices and theories. 'Scientometrics', which incorporates bibliometrics, has become a bona fide discipline, with its own theories, conferences and journals.

It is up to the operator to gain a grasp of such tools; to ensure that the methodological rules governing their correct use are enforced, to show imagination in choosing to use them at the appropriate time, and to tailor them to the situation at hand. The following pages look at the tools adopted, and outline the overall procedure.

1.1.3 THE PROCEDURE

The evaluation was broken down into *three stages*:

- *review* of the existing 'system';
- *evaluation*, carried out *in situ* by some 20 European experts;
- *debriefing* session at a large-scale National Workshop.

The entire process took place over a one–and-a-half year period. It covered every discipline except the *social and human sciences*.

1.1.3.1 Review

The review relied on three tools, as follows.

(1) A *profile* of the existing system, together with an *historical backgrounder* on the various institutions. This document helped the operator choose its tools, and tailor them to the field. It served as a preliminary source of information that was much appreciated by the experts because it avoided them having to take a complete leap into the

unknown ([7]). It must be stressed that the backgrounder is what makes the document so comprehensive. It highlights the current administrative structures, which would otherwise remain unclear, and records the divergent rationales that still prevail among the actors today (i.e. universities versus national centres, doctors versus engineers, etc.).

(2) A *bibliometric analysis* of Moroccan scientific output published over the past 10 years in 6 000 leading international journals. This analysis provided an overview of existing capacity, with details per site and per subfield. It helped trace how this capacity has evolved over time, and to compare it with that of other countries, especially countries in Africa.

(3) A *questionnaire* sent by e-mail to around three-quarters of all Moroccan laboratories. The outstanding response rate made it possible to gain a closer look at the composition, funding, equipment, working relations and output of grassroots units in all their diversity, and see how they perceived the drawbacks and hardships that needed to be addressed.

1.1.3.2 Evaluation

The *actual evaluation* was carried out by some 20 European *scientists* selected on the basis of their proficiency, experience, and the fact that they were in no way involved in any ongoing cooperation with Morocco. Each expert submitted and publicly defended an evaluation report. A consolidated synopsis was also produced for each major field covered by several experts.

1.1.3.3 Debriefing

The *debriefing* was a key phase of the process.

We do not consider this merely a matter of 'good practice'. It is much more of a means of evaluating the evaluation; revealing the degree of interest aroused by the lengthy operation in and around the world of research, and testing the perceptiveness of the diagnoses. The debriefing process is a high point; not an afterthought but a possible prelude to new ideas and fresh momentum.

The benefit of bringing the many actors making up the scientific field face-to-face with the independent experts is that it gives them each a reflection of how they are perceived by the outside world. In Morocco's case, the scope and impact of the exercise hinged on the scale of the event, and on the free and frank nature of the debate that it generated. The organisation, conclusions and — unprecedented — scale of the debriefing are covered in greater depth in another chapter ([8]).

[7] The experts did, of course, plan their mission carefully beforehand, using their networks and a host of information sources in the international scientific community to gain an idea of the situation, and to prepare a 'grid' of questions to explore in their field. In spite of this, they were happy to gain more information on the whole system.

[8] By Ilham Laaziz, on the role of the Ministry for Scientific Research, which devised, organised and took charge of the event.

1.1.4 TAKING STOCK OF THE EXISTING SYSTEM: TOOLS

A more detailed structural analysis of the results is provided later. I would now like to concentrate on the specific contribution of each instrument used, none of which, as I have already said, is sufficient on its own.

1.1.4.1 Profile of institutions and the historical backgrounder

This was the first document produced. It consists of a compilation of facts ranging from an organised directory of research establishments, through to staff employed, status, budgeting and output to the government initiatives and national policies declared in regard to research application fields. The value added in producing this document stems, as we have already said, from the *historical* survey that sheds light on the data; it maps out the route that has led to — and to some extent shaped — the current situation.

The extensive bibliography, inventory of sources, and abundant tables and annexes make this a 'benchmark document'. It is the fruit of labour of some fine research work done over a long period of time by Mina Kleiche-Dray ([9]).

1.1.4.2 Bibliometrics

This tool is useful for a number of reasons. It provides an overview of the scientific field, lends itself well to international comparisons, and centres on the outputs (scientific production) rather than the inputs (e.g. budgets, equipment and staff), which do not say anything about productivity and efficiency.

What does it involve? The basic principle is simple. There are several large international bibliographic databases designed to keep researchers both informed about subjects they consider important and about new releases. These databases process between 6 000 and 8 000 of the 'world's best' journals. For each article published, the database has a record of the authors, their institutional address, the date, place and language of publication, the title and keywords, an abstract, and sometimes its exact scientific subfield and the references cited.

We selected two of the major non-specialised databases, covering all disciplines (except the social and human sciences): the American Science Citation Index (SCI) and the European PASCAL base. We used them from a retrospective rather than a prospective — what is new? — point of view, recording the full range of bibliographical notes on articles published over the past 10 years by authors declaring an affiliation with a Moroccan institute. By developing suitable algorithms ([10]) — a huge undertaking, although the end product will stand the test of time and require only minor adjustments, and the ownership and

[9] The presentation and interpretation of this wealth of material has formed the subject of several publications including Kleiche, M., 2003, 'From Generation to Cultivation by the State: Progress of Moroccan Scientific Research', *Science, Technology and Society*, 8 (2), pp. 283-316, and Kleiche, M., 2002, 'La recherche scientifique au Maroc', *L'état des sciences en Afrique*, Paris: IRD Full text available at: http://www/ird.fr/fr/science/dss/sciences_afrique

[10] With a view to producing *micro-bibliometrics* that would be useful to Morocco (as opposed to the macro-indicators used for comparisons with the world metro poles of science). It meant having to find strategies to identify and code Moroccan cities, institutions and laboratories, and to aggregate the finely-grained topics singled out through scientific classification, so as to build subfields in which the country does indeed make a contribution. Detailed breakdowns were produced in five-year periods, which helped garner meaningful results.

maintenance can be transferred to a Moroccan research institute — it is possible to *construct* an overview of leading national capacities, the country's main sites (by city, institution and laboratory), how production has evolved in each specialist field (100 subfields identified), its main authors, cooperation efforts, publishing strategies, and so on.

The bibliometric data was useful in many respects, especially in that they helped to:

- assess the number of 'effective' researchers, which is in the region of 4 000, a figure well short of the 'theoretical potential' of around 16 000 (counting all 'teacher-researchers'), meaning that Moroccan research has some room for improvement;
- evaluate the number of teams or laboratories authoring articles (around 800) and, more importantly, given that there is no official trace of them, *identify* them;
- decide, in the absence of other laboratory productivity data, *which sites to visit* — as a matter of principle, those producing the most publications on a more regular basis;
- carry out an initial review of the system, the key findings of which are presented later.

The use of bibliometrics made a big impression on stakeholders in Morocco. Its practical scope may well be debatable (cf. below). But in spite of its limitations, it is a source of relevant data and can be of great help to science policy-makers by:

- providing an overall view of the research landscape;
- highlighting the outstanding features (serving as a 'relief map');
- helping to pinpoint strengths and rare skills;
- helping to make historical comparisons;
- helping to make comparisons with other countries;
- helping to construct indicators.

With slight coding adjustments, the tool is updated each year (bibliographic database updates on subscription). It is useful for maintaining a reporting system.

1.1.4.3 Questionnaire

The questionnaire that was e-mailed to laboratories was designed to give the experts a back-up framework for their observations, just in case the sample of laboratories visited happened to be too small. In this event, it made it possible to compare two information sources, and to introduce some interesting details, especially on the resources used.

Carefully drafted by a highly experienced team, it was originally meant to be sent out to one-third of Morocco's laboratories. But an extra effort resulted in the decision to target them all (some 800 units).

The seemingly straightforward procedure of finding their addresses (including e-mails), however, turned out to be rather more complicated than expected. There were no up-to-date directories of research teams; institutional brochures barely gave them a mention, and there were no address links on any of the few existing websites. Significantly, the laboratories did not yet exist as official entities, and had no regular funding; as such, they were not expected to produce a single report or undergo any evaluation, and remained as good as invisible to partners, including Moroccans themselves.

Aware of the problem, the ministry launched repeated appeals to university rectors and heads of the main research institutes to supply this information. Its intervention made it possible to draw up lists. These were cross-tabulated with the bibliometric data, the mini-reports submitted by laboratories to visiting experts, and the additional information requested from local acquaintances (in the absence of reliable addresses, especially e-mails). Finally, after four reminders, 500 usable responses were received, which is an excellent score given that the questionnaire took almost an hour to complete properly. And the information received was fed into a database of addresses that is now available, and well worth improving and keeping up-to-date.

So, perseverance was rewarded. The results obtained have the virtue of being based on a very large sample of research units. They provide reliable orders of magnitude, and are quite unexpected at times ([11]). They cover, inter alia:

- the size of the laboratories (including postgraduate);
- their funding (supplied by institutions or through contracts);
- external cooperation (international and national, including with the private sector);
- equipment maintenance and documentation;
- application of results.

1.1.5 EXPERTISE

The actual *evaluation* was assigned to some 20 European *experts*, and attended by just as many Moroccan experts. Together, the European experts covered the entire range of disciplines. They were each asked to visit a selection of laboratories and to report back on their findings. Some of the findings addressed the state of the laboratories, the organisation, relevance of the subjects addressed, and so on, and the hopes, doubts and plans of the researchers encountered during meetings arranged on-site.

[11] See the chapter in Part 2 on the electronic laboratory survey by A.M. Gaillard and J. Gaillard.

The success of an operation of this kind hinges on the *quality of the experts*. They were subjected to a thorough screening process. High academic qualifications were a must, but we also wanted them to be experienced in the administration and evaluation of science. As a matter of principle, we were not seeking regular visitors to Morocco; not all were coming to a Mediterranean country for the first time, but none had a particular interest or any upcoming projects in this one.

Given that there was to be a limited number of experts covering every field of science, we needed to find evaluators with wide-ranging skills. Yet the more 'learned' the scientists were, the more specialised they tend to be. One really does have to attain the 'very highest level', experts who are both towering figures and capable of covering a vast field. What makes it all the more difficult is the fact that researchers who are *both of great academic standing and knowledgeable about application* are few and far between. Finding people with such a singular profile called for the assistance of the European academies of science (especially that of France) and of Community networks. Then came the matter of having to persuade those very busy individuals to take part in the operation.

Another condition for success: the *choice of sites* to be visited. When working with experts with a limited amount of time to spare, it is better to direct them to the sites where there is more to see. The bibliometrics helped pinpoint the most productive laboratories in each of the 100 targeted scientific subfields. We used this data as the basis upon which to draw up the routes. We then added, when necessary, major applied research institutions — applied research being underrated in the mainstream bibliographic databases — and we arranged meetings at the national and local government levels, and with private-sector technical managers, R&D operators, users and potential clients.

Key point: the evaluation plans were announced, outlined, presented and discussed well in advance with those in charge of the institutions concerned and their various governing bodies. The programme of visits and the experts' CVs were sent in due time to the chosen centres and faculties. Each was free to sign up additional laboratories, if they so wished. And each research unit was at liberty to decide whether they wanted to be visited or not. These meticulous preparations, carried out remarkably well by the ministry, enabled the experts to *gain access to every site* of interest, where they received an attentive welcome on the part of the establishments, and were warmly greeted by the working researchers. The discussions were extremely candid, and the visits animated.

Each European expert was accompanied by a Moroccan counterpart, selected by the ministry from among the country's leading figures in the field ([12]). They were also joined by a member of the IRD team, who went along to explain how the operation was organised, and to observe the institutional aspects of the research.

Furthermore, Association R&D Maroc — set up by the country's major manufacturers to promote research and innovation — kindly made it possible to include visits to leading Moroccan R&D centres, and to arrange an exchange of views between experts and industry managers on such subjects as research needs and uses, the relevance of local work, and communication between industry and academia.

[12] As it was an *external* evaluation, the Moroccan experts obviously neither intervened *in situ* nor took part in the drafting of reports, which were written entirely, and freely, by the European experts alone.

I, myself, had my doubts at first about the expected outcomes of these on-site visits. But the approach proved *perfectly suited to the size* of the Moroccan scientific community. The 20 experts enlisted covered a distance of some 50 000 kilometres, visiting 13 of the 14 universities, most of the research institutes and schools of engineering, and several private and semi-public companies involved in R&D. Out of the 800 identified, 400 teams or laboratories were visited, which gave the experts unique insight into their activities. Some 1 500 researchers attended the meetings organised on-site — that is an estimated one-third to one-half of all Moroccan nationals currently working in research.

Such an investigation involves more than mere sampling. The distances to be covered may have made it impossible to visit every 'good' laboratory in Morocco, but the limited number of units visited at each location were investigated in great depth. Nonetheless, the information gathered amounted to a corpus. The experts had the necessary skills to grasp very quickly the practical scope and scientific standing — global or 'provincial'— of the subjects addressed, and to assess the extent to which the amounts of equipment or documentation available imposed restrictions on the work. And, wherever they went, their qualities as human beings prompted disclosures and lively debate on the state of the community and the projects in the offing. The operation was considered a token of respect on the part of the government, and a sign of genuine interest on the part of the ministry.

The experts then produced carefully-drafted reports, presented and defended at the National Workshop on research.

1.1.6 THE NATIONAL WORKSHOP

It was the ministry's wish that a large-scale, debriefing workshop be staged — with some 400 participants, representing all those concerned — which would provide an opportunity to freely discuss every single issue felt to be important.

I do not intend to go into the details here of its meticulous and complex organisation. This will be dealt with later ([13]). Instead, here are a few comments on a pivotal operation that broadened and tested the capacity of those concerned to take 'ownership' of the evaluation.

1.1.6.1 The decision

The initial evaluation contract stipulated the organisation of a final debriefing workshop, without specifying its nature or scale. It was the ministry that opted for a large-scale event, at the suggestion of the operator and in spite of the European Commission's reservations.

Commission officials initially feared that the preparation time — three months — might be too short and the debate too staid or confused to do justice to what was being billed as a model operation. It was supposed to justify the signing of a cooperation agreement

[13] See the chapter on the role of the ministry by Ilham Laaziz.

between Europe and Morocco — a first for a southern Mediterranean country. It would be running a risk to present the handover of results 'live', in the presence of the European Commissioner for Research who would be expected to travel to attend the event.

It would be just as much of a risk for the Moroccan ministry, which had to secure top-level government support and to brace itself to face — also 'live' — the unpredictable mood of the stakeholders; first and foremost the researchers. And the operator, for its part, would be putting the credibility it had slowly accrued on the line.

Deciding to attempt such a prominent event, then, was quite a gamble. Nevertheless, those that had followed the entire evaluation (nearing completion at the time) from the start, could see that it was clearly going to yield sound documents and original data. Also, the fact that the long journey of the experts had been generally well received raised the hope that the scientific community would show its appreciation. So, it seemed a risk worth taking. And if it paid off, it would guarantee the operation a far greater impact than that of a mere report. It would give it the political dimension that, as yet, it still lacked and it could establish the resulting texts as an enduring basis for future debate on research.

1.1.6.2 Implementation

Once the decision had been made, everything depended, crucially, on the *organisation* being flawless, and on the operator working closely with the ministry. The organisation was entrusted to a small, extremely efficient and motivated team at the ministry that made every effort and managed, with great composure, to think of everything: the logistics, which needed to be perfect, diplomatic arrangements, and so on.

The operator played a relatively minor role in this, making sure that reports fit for publication were obtained in time from all of the experts, and designating 10 of them — one leading figure per major research area — to come and defend the report pertaining to their specialist field in person.

In some cases, it took a great deal of to-ing and fro-ing between the operator and individual authors to produce finalised texts in a more or less standard, camera-ready format, and include (in any event) certain mandatory points.

A great deal of thought went into the *participation*. The meeting made it possible to compare the approaches of a large number of researchers, institutional leaders, and potential clients. It gave rise to free and lively *debates* that culminated in a body of *recommendations*. Far from amounting to a litany of demands, these (once sorted into an order of priority) helped the ministry establish a largely consensual 'roadmap'.

1.1.6.3 In the wake of the operation

Responsibility for continuing the exercise was then passed on to the Moroccan authorities involved. At the end of the workshop, the Minister concluded that the *evaluation had facilitated dialogue* with the scientific community. He said that he wanted to:

- make the evaluation public, republish all the reports and recommendations, and the debates with other researchers and economic operators;
- undertake the *follow-up*, 'thematic' working groups, on the initiative of the new Research Department;
- *capitalise on* some of the suggestions and recommendations (e.g. accredited laboratories, equipment platforms, electronic access to scientific information, and unifying themes);
- launch a further evaluation, this time of the *social and human sciences*.

In the final chapter of this book, 'Lessons learned and follow up', those in charge of Moroccan science and technology work take a look, with the benefit of hindsight, at the relevance still attributed to the operation, what has been achieved since, and how it can serve to inspire further action.

1.1.7 CONCLUSION

What can be expected from such an endeavour?

First, it is a means of gaining *self-awareness*.

- The evaluation gives a slightly rough, yet fair *overall view* of the 'system', which cannot be provided by any individual observer.
- The experts' reports make it possible to appreciate, *objectively* and *against the backdrop of international competition*, the *strengths and weaknesses* of the existing potential.
- Taken together, the reports suggest measures likely to improve the system.
- And it is a *relatively inexpensive* means of producing a *quick diagnosis* and delivering *easy to maintain* monitoring tools, including questionnaires, bibliometric algorithms, and other such 'performance indicators'.

Second, it helps *publicise* and *promote appreciation* of domestic research, at both national and international levels.

- The aim is to persuade decision-makers and economic operators, here and elsewhere, that it is not a 'luxury' but a 'lever of development'. In this particular case, the experts endeavoured to put forward a number of *good reasons* for conducting research locally, together with some *ideas* regarding relevant and promising themes likely to bear fruit within a reasonable time frame.
- The experts, by the way, developed an interest in the scientific community to which they were devoting their attention. And they testified, in Morocco and abroad, that the country was capable of benefiting significantly from its sometimes highly impressive scientific capacity ([14]).

Finally, the operation has helped *develop an actual evaluation culture*.

- Its very duration ([15]), tenacity, and the qualities displayed in face-to-face situations — proficiency, attentiveness and neutrality — made an impression in the field ([16]).
- It was often seen in the scientific community as evidence of interest. The spirit of dialogue demonstrated at the final workshop also strengthened the bonds between managers and practitioners.
- The resulting self-(re)cognition, together with the freedom of speech, did indeed *give fresh momentum*.

Clearly, it was then up to the stakeholders themselves to turn it to their advantage.

14 Some teams have achieved some truly remarkable feats with limited means. The subfield reports mention a number of these, in areas ranging from earth sciences to mathematics, and from neurology to information and communication. They pay tribute to the 300 researchers responsible for producing nearly one-third of all recorded Moroccan science, and to the young scientists striving to assert their many up-to-date and original ideas.

15 From start to finish, the operation covered the period between March 2002 and July 2003.

16 At a certain point, 'forgotten' districts were even calling for the evaluation to be extended to them.

1.2 ROLE OF THE MINISTRY

Ilham Laaziz el Malti

In 2000, the Prime Minister entrusted the government authority in charge of scientific research with the task of conducting a comprehensive review of Moroccan capabilities in the field of scientific research ([1]). The authority — the Department of Scientific Research (DSR) — opted for an *external evaluation*, and called on the European Union (Directorate-General for Research and Technological Development of the European Commission) for assistance. *The aim was to produce a survey that would help improve policy-making and national strategy development* for scientific and technological research.

The decision stemmed from earlier discussions with research actors (e.g. universities, research centres, and companies involved in R&D), and the technical departments responsible for research organisations. Subsequently, the 'Assises de la Recherche' conference organised to explore the issue of how to incorporate scientific research into the country's social and economic development.

This set the stage for an evaluation geared to 'improving the efficiency of public research systems'. The operation, carried out at Morocco's request with the assistance of the EU, was prepared and coordinated by a French research team from the Institut de Recherche pour le Développement (IRD)([2]).

The operation would involve European experts making calculated visits to the country's sites of scientific production, and producing a diagnosis of its scientific capabilities. It would *not* cover the *social and human sciences* — to be dealt with later through another ad hoc evaluation — but concentrate on the 'exact sciences, life sciences and engineering sciences', a vast enough field as it is. The Department of Scientific Research had specified nine key areas ([3]):

- medical and pharmaceutical research;
- agronomy, agriculture, forestry, veterinary science and medicine;
- sea sciences, aquaculture and pisciculture;
- geology, geophysics, hydrology and water treatment;
- energy and the environment;
- space and telecommunications;

[1] In 2002, the undersecretary of state appointed in 1998 to take charge of scientific research under the authority of the Minister for Higher Education, Professional and Management Training and Scientific Research drew up an organisational chart that divided his office into a department of technology and a department of science. The following year, the undersecretary's office became the Department of Scientific Research (MDRS). MDRS has since disappeared, but the two departments (technology and science) remain in place within the overarching Ministry of National Education. For our purposes in this chapter, we have opted to refer to that government authority by the general title, Minister or Department of Scientific Research.

[2] The European Commission selected IRD research unit UR 105, Savoirs et Développement, which specialised, inter alia, in surveys of science. While the goal of the evaluation at the national level was to produce a report on the country's scientific and technological capabilities, at the international level it also represented a first step towards the gradual incorporation of Morocco into the European Research Area.

[3] Minor adjustments were made once a clearer idea had been gained of the potential (through bibliometrics, the inventory of laboratories, and so on). For example, every field of chemistry was taken into account, with a special focus on chemistry of natural substances, dealing with water and soil as a self-contained subject, and so on. The national workshop for delivering the final reports was organised on the basis of the finalised list, which covered *every area commonly associated with S&T.*

- civil engineering, chemical engineering, mechanical engineering and metallurgy;
- solid-state physics, material physics, nuclear physics and technology;
- mathematics, applied mathematics and computer engineering.

This was a first for Morocco ([4]). The country had no culture of evaluation as yet — be it internal or, what is more, external — and it lacked the tools for regular assessment of either the people or the institutions ([5]). In this case, it may well have been a survey designed to stimulate debate, rather than a complete and binding 'evaluation'. But it was going to involve large numbers of people; in principle, every teacher in higher education for whom research was a mandatory duty, and many other staff members. Its unusual nature and unpredictable scope were a potential source of concern.

The Department of Scientific Research, to which I belonged, therefore decided to carry out a series of operations to *prepare the Moroccan research community*. The operations were broken down into two phases: a preparatory phase, and an operational phase. In both cases, constant dialogue between the operators — the EU and IRD — and the Department of Scientific Research helped smooth the way to facilitate and make the most of the experts' work.

First of all, in the preparatory phase, the Department of Scientific Research set out to *raise awareness* amongst the scientific community. It initiated discussions on (and went on to ratify) the terms of reference proposed by the EU. It joined the IRD coordinating team in talks to determine the most suitable tools and procedures for choosing the experts' itinerary and completing the review. Finally, it provided support for the implementation, mobilising its various services and, when necessary, notifying the institutions to produce or collect any missing information.

In the second phase, the Department of Scientific Research prepared and organised the experts' visits to the sites to be evaluated. It monitored the progress of the operation on a daily basis. It planned and prepared the National Workshop where the experts' findings were to be presented and debated.

The long-standing interaction between the Department of Scientific Research and the institutions being evaluated was extended to the IRD team coordinating the evaluation (and to the evaluators themselves) in order to, ultimately, foster greater involvement on the part of the research community when the European experts went into the field.

[4] Few other countries have embarked upon such a risky venture. Of those countries, which have, they did so only on a very infrequent basis.

[5] Recent experience in this area has amounted to ad hoc committees in charge of accrediting doctoral training courses (Units for Training and Research (UFR)) or classifying proposals in response to calls for scientific projects (Scientific Research Support Programmes (PARS), and Thematic Scientific Research Support Programmes (PROTARS).

1.2.1 INVOLVING THE SCIENTIFIC COMMUNITY

To begin with, the Department of Scientific Research organised meetings with all of the relevant authorities (6) and the actors involved in scientific research, which helped to pave the way for the scientific community to *accept the evaluation project*. This work of *explaining and encouraging involvement was a necessary precondition* for facilitating the assignment of the experts in the field.

Community awareness-raising and ratification of the terms of reference: two preparatory committees

Given that the responsibility for the Moroccan scientific institutions was dispersed among various government departments (7), the Department of Scientific Research decided to set up two committees to ensure that the awareness-raising campaign covered the entire scientific community:

an 'interdepartmental' committee comprising the technical departments with responsibility for the research bodies involved in the evaluation operation;

a 'committee of experts' comprising, on the one hand, researchers and academics working in higher education or in public and private research, and professional and management training institutions (8), and on the other hand, company R&D managers. All were recognised figures in their field, at national and international levels, and their combined expertise covered every one of the nine areas being evaluated.

The two committees began by studying and ratifying the terms of reference, especially the three-part structure of the evaluation — the operation's groundwork, the field visits by the European experts, and the organisation of the National Workshop to present the results — and the content of each part. They also examined the basic documents prepared by IRD in advance of the operation, which provided an initial description of the research system (9).

Both committees recommended that attention be paid to the impact of the support actions provided to research by the ministry since its inception in 1998. They also stressed the need for a complete overview of the scientific and technological research system in Morocco. They suggested an evaluation covering all science and technology-oriented institutions (universities, 'management and professional training' schools, and research centres). This includes those with no direct affiliations with the Ministry of Higher Education (e.g. Institut National de Recherche Agronomique, Centre de développement des Energies Renouvelables, Laboratoire Public d'Etude et d'Essais, Institut National de Recherches Halieutiques and other public bodies under the authority of the various technical departments). The evaluation would need to be as comprehensive as possible, and capable of enabling the Department of Scientific Research to introduce a national scientific and technological research development strategy attuned to the current and future circumstances of Morocco (10).

6 They are responsible for the public research or management and professional training institutions, subjects of the evaluation.

7 See Mina Kleiche-Dray's report, *Scientific Research in Morocco*, IRD, 2002.

8 Including faculties (of medicine, science, pharmacy, and so on), engineering schools (e.g. Ecole Mohammadia des Ingénieurs (EMI), Ecole Hassania des Travaux Publics (EHTP), and Institut Agronomique et Vétérinaire Hassan II (IAV)), and research centres (e.g. Institut National de Recherche Agronomique (INRA), Institut National de Recherches Halieutiques (INRH), Centre National pour la Recherche Scientifique et Technique (CNRST), Centre de développement des Energies Renouvelables (CDER), and Laboratoire Public d'Etude et d'Essais (LPEE)).

9 These documents included a report on the history of scientific research in Morocco (M. Kleiche-Dray, *Scientific Research in Morocco*, IRD, 2002), and a bibliometric survey of Moroccan scientific production (R. Waast and P. L. Rossi, *Bibliometrics 1991–2001*, IRD, 2002).

10 Only a national agency or committee can do the regular, comprehensive evaluation of every research institution. Setting up such a body is still on the agenda. The external evaluation must not be regarded as a substitute; it was not within the remit of the European experts. That said, every effort was made to ensure that they visited an extensive — and highly diverse — range of sites.

Various other observations were advanced and passed on to the European Commission. The Commission took these into account when drafting the final terms of reference. Particular attention was paid to either the main measures that Morocco had taken for the promotion, support, and funding of the science and technology research system in the field of human resources or in the shape of 'call for research' proposals and the establishment of research networks and skills centres. Special attention should be paid to the arrangements for fostering closer relations between universities and businesses, and to projects scheduled under the 2000–2004 national investment plans.

The terms of reference and the decision to embark upon an overall evaluation of the national research system were then approved by the interdepartmental standing committee for scientific research and technological development at its first meeting on 12 December 2001, chaired by the Prime Minister of Morocco ([11]).

Technical and organisational support: profile of the system and survey of laboratories

Interaction between the Department of Scientific Research and the IRD coordinating team also took place at both technical and organisational levels. A small permanent monitoring team was set up at the Department of Scientific Research to discuss each stage of the evaluation, ratify the procedures, and facilitate implementation. Regular meetings with the IRD coordinators helped prepare and support the operation every step of the way.

The first step was to work together to update and finalise the preliminary report, *Scientific Research in Morocco*, to be submitted to the aforementioned committees: the interdepartmental committee and the committee of experts. The updated version subsequently served to brief the experts before they arrived. Further enhanced and ratified, it would later figure among the basic documents handed out to participants at the final, National Workshop.

It is a substantial text (over 100 pages), designed to provide reference material, with an extensive bibliography and a checklist of sources. It comprises a history of the Moroccan research system, and a description of its current state. It presents both the laws governing the system, and an overview of Morocco's main development goals (together with its economic, social and environmental policies), thus making it possible to assess the relevance of existing scientific and technological research capabilities and policy-making ([12]).

For the sake of accuracy, close working relations were developed between the Department of Scientific Research and the report's author, Mina Kleiche-Dray. When necessary, departmental services and specific research institutions were contacted in order to help answer the author's questions, with a view to checking and comparing data, and presenting data in a manner that was clear, transparent, useful, and as close to the categories employed at the international level as possible. Work on the chapters featuring the directory of institutions, the detailed staff list, and the itemisation of budgets and funding trends was meticulous, and called for a good deal of cooperation.

In addition to this fruitful cooperation, another technical assistance operation proved necessary. The IRD team had offered to conduct a survey of laboratories to supplement the

11 This interdepartmental authority was set up in 2001. It was put in charge, inter alia, of coming up with the strategy and guidelines required for the promotion of scientific and technical research, and the coordination of research activities.

12 See text by Mina Kleiche-Dray, *Scientific Research in Morocco,* National Workshop on the evaluation of the scientific research system in the fields of the exact sciences, life sciences, and engineering sciences, 26-27 May 2003, Rabat.

information on the conditions of scientific production. The aim of the survey was to attain a degree of 'comprehensiveness' — in any event, extensive representation — that might not be possible with the experts' visits. But it would be hard to carry out such a survey without an up-to-date directory of every research team, group, and laboratory operating in Morocco ([13]). Therefore, the Department of Scientific Research called on the scientific community to produce a list of every public research structure in Morocco. A form was sent out to universities, university hospital centres (UHCs), professional and management training establishments, and public research institutions, followed by persistent reminders over a period of several months. In the end, this helped identify 636 research teams and laboratories involved in the 9 fields covered by the evaluation; 444 teams and laboratories at universities, 46 at UHCs, and 146 belonging to public research institutions.

The data on each of these research bodies (e.g. its institutional location, the department to which the team or laboratory belonged, the person in charge, the contact details (phone, fax and e-mail address), and the main thrusts of its research work) were added, together with the list of major equipment, to a database made available to the IRD team. The database comprises over three-quarters of all public research laboratories (not including those working in the social and human sciences). It can be said to reflect their institutional and thematic diversity, as well as their geographical distribution throughout Morocco ([14]).

Combined with the bibliometric information, the database served to help make clear-headed decisions concerning the choice of sites for the experts to visit.

Apart from these two major operations, the Department of Scientific Research also provided *significant support* in organising a *series of meetings* at which the European project leader (IRD research director Roland Waast) and the evaluation coordinator in Morocco (IRD researcher Mina Kleiche-Dray) presented the evaluation project, under the auspices of the Department of Scientific Research, to university presidents, directors of professional and management training establishments and public research institutions, and industrial leaders.

1.2.2 PREPARING AND ORGANISING THE ON-SITE VISITS

The second stage of the operation, which focused on 'improving the efficiency of public research systems', concerned the evaluation of the quality of the scientific research. It involved on-site visits to a representative sample of research laboratories, followed by a presentation and discussion of the experts' findings.

Selecting the experts and preparing the visits

First of all, project leader Roland Waast — in consultation with the European Commission and the Department of Scientific Research — identified and selected the European experts.

13 All the more so because it was an electronic questionnaire, requiring an e-mail address.

14 See the survey report by Jacques and Anne-Marie Gaillard, *Moroccan Research Laboratories: A questionnaire-based survey*, IRD, May 2003.

Each expert was an internationally renowned figure from the worlds of academia (including university professors, emeritus professors, researchers, a member of the French Academy of Science, and scientific foundation managers) or economics and industry (including R&D directors, and consultants). They came from several European countries ([15]).

At the same time, a letter was sent to the heads of institutions to arrange the experts' visits to the laboratories, according to a detailed timetable. For each institution, attention was focused on every aspect of a given discipline — the same field as that of the visiting expert. In some cases, a visit to a specific laboratory was requested on account of its outstanding excellence. Otherwise, the detailed programme of the visit was left to the discretion of the institution, with team leaders and laboratory heads asked to prepare a file presenting their structure.

The visits took place from September to November 2002, then again in February and March 2003. The experts travelled in teams of two or three, accompanied by a member of IRD and a Moroccan counterpart specialising in the field or fields concerned.

The presence of the Moroccan experts — each a member of the aforementioned committee of experts — was intended to make it easier to introduce the European experts to the Moroccan researchers. However, they were instructed not to intervene in the interviews and assessments carried out by the Europeans, so as to respect the ministry's wishes that it be an *external* evaluation.

The visits lasted between 5 and 12 days, depending on the field. The experts travelled a total of 50 000 kilometres, coming into contact with more than 400 research structures belonging to 143 institutions ([16]). This included 13 of the 14 universities, most of the institutes of research and engineering schools, and several semi-public and private companies involved in R&D. Some 1 500 researchers took part in the meetings organised on-site.

Around 200 team profiles — provided by the teams themselves — were collected and recorded in a *database*. This database includes several items of information on the research laboratories, including contact details, membership, equipment, national and international cooperation efforts, publications, and research subjects.

The involvement of the committee of Moroccan experts in the fieldwork was crucial to the evaluation for two reasons. First, its members' knowledge of both the research environment and the research activities in their respective disciplines facilitated the work of the European experts. This was invaluable for monitoring and gathering data during the field visits. Second, the operation gave the Moroccan experts the chance to gain experience in public policy evaluation. As a result, they now form a reservoir of skills that can be used in any ongoing evaluation on scientific research systems, especially within the framework of the research structuring work embarked upon by the universities for the accreditation of research groups (e.g. teams, laboratories and centres).

15 In Part 3 of this book (Evaluation overview), Roland Waast explains the highly rigorous selection criteria that served to identify the experts.

16 Some institutions received several visitors focusing on different fields. The Marrakech Faculty of Science, for instance, was visited for assessments in the fields of mathematics, earth sciences, agriculture, and water and energy.

1.2.3 PREPARING AND ORGANISING A NATIONAL WORKSHOP

Once the experts had delivered their analyses in the shape of reports covering the nine major fields (encompassing exact sciences, life sciences and engineering sciences), the ministry's next concern was to come up with proposals that would help formulate a bona fide research policy, according to a detailed timetable.

The ministry wanted feasible proposals designed in the short term to improve the functioning of every one of the wheels of research, and to introduce a bona fide effective and sustainable research *system* step-by-step.

The National Workshop *on the evaluation of the scientific research system* held in Rabat, May 2003, was designed to help further those aims by presenting the results of the evaluation in the presence of scientists, institutional managers, and the research end users. It was the ministry called for a large-scale event, planned its organisation, and ensured the orderly development of the proceedings.

The workshop brought together some 400 participants — front-line producers of science, institutional managers, and end users — that were selected according to a very precise set of criteria. The *researchers* were chosen for their 'excellence'. Great care was taken to invite not just the leading, authoritative figures in their field but also promising, 'young' Moroccan researchers. They had to come from a broad range of institutions, in terms of purpose and status (e.g. faculties of science, faculties of science and technology, engineering schools and research institutes, together with engineering and industrial R&D companies), in varying proportions (depending on the field). In addition, a determined effort was made to ensure that every region and discipline was represented.

The workshop was also attended by the *institutional managers* directly concerned with the issue of research, including managers of institutions, officials from the ministries in charge, and from those currently (or potentially interested in) using the end results of research (e.g. departments of scientific research, higher education, agriculture, health, and industry). Chief executives of large companies and representatives of the economic sector were invited in their capacity as potential *users*. University presidents, science faculty deans, and the directors of engineering schools and national research institutes also attended the event. Moreover, an outsider's view was ensured through the presence of key foreign figures, including European Commission officials (from the Directorate-General for External Relations, Directorate-General for Development, and Directorate-General for Research and Technological Development), diplomatic representatives, expatriate Moroccan researchers, and a number of international experts.

The project leader of the evaluation summary devoted the first morning's plenary session to the official opening and a presentation ([17]). This was followed by an afternoon of *'thematic' workshops* on the *conditions of scientific production*. The next day, the participants were divided up into *major 'disciplinary' field-specific workshops*.

[17] The event was held under the high patronage of His Majesty King Mohammed VI. The opening session was honoured by the participation of the Prime Minister of the Kingdom of Morocco, Mr Driss Jettou, the European Commissioner for Research, Mr Philippe Busquin, the Advisor to the King, Mr Abdelaziz Meziane Belfkih, several ambassadors, and members of the government (including the Minister of Scientific Research and chairperson of this session, Mr Omar Fassi Fehri).

Each workshop was introduced by a 30-minute reading of a summary note written by the presenter. The floor was then given to a discussant, who had an equal amount of time to reply. The presenter and discussant hailed from different backgrounds (e.g. nationality, and professional status). Next came a 3-hour debate on the workshop theme that was held among the 30 to 50 freely registered participants. Speaking times were limited to allow as many people as possible to have a say. That is exactly what happened, and the statements proved succinct and well thought out.

The seven 'thematic' workshops, held concurrently, focused on *'transversal'* (e.g. interdisciplinary and inter-institutional) issues, concerning:

- coordination and indicators;
- human resources;
- the organisation of research at universities and public research establishments;
- budgets and funding;
- equipment and documentation;
- relations with the production sector;
- international cooperation.

The Department of Scientific Research provided input for the debates in the shape of *workshop-specific discussion papers*. Each paper was summarised by its author as an introduction to the corresponding workshop; the commentator in this case being a researcher (a Moroccan or European expert). All papers were distributed to the participants, who also had copies of the '*basic reports*' produced by the coordinators. These included: *Scientific Research in Morocco*, by Mina Kleiche-Dray (IRD, 2002); *Bibliometrics 1991–2001*, by Roland Waast and Pier Luigi Rossi (IRD, 2002); *Moroccan Research Laboratories: A questionnaire-based survey*, by Jacques Gaillard and Anne-Marie Gaillard (2003); progress reports of the ministry; and documents published by other departments concerned (e.g. the proceedings of a conference on agricultural research).

The next day's workshops on 11 *major disciplinary fields* covered the subjects of:

- agronomy, agriculture and forestry;
- hydrology and water treatment, soil and the environment;
- marine sciences and aquaculture;
- biomedicine and health;

- chemistry of natural substances;
- geosciences (earth sciences);
- information and communication sciences and technologies;
- chemistry;
- physics and energy;
- mechanics and mechanical engineering;
- mathematics.

In each case, one of the European experts in the field was present to explain his/her report. A Moroccan commentator provided a different or complementary point of view. In addition to the aforementioned 'basic documents', participants at these workshops had the diagnosis prepared by the European experts for the field in question, and a copy of the evaluation summary presented at the plenary session.

This was followed by intense, complex and candid discussions, which were reflected in the recommendations presented by each workshop at the closing session ([18]). After a final debate, the Minister of Scientific Research, Mr Omar Fassi Fehri, who had followed the discussions over both days, said how pleased he was at how freely and honestly the participants had expressed themselves. The survey had, in his view, helped foster dialogue with the scientific community. He thanked the participants for their robust proposals, the experts and coordinators for their open cooperation, and the departmental organising team for having devoted so much energy to the project.

Mr Fassi Fehri went back over the history of the evaluation, which he himself had wanted to be *external*, and expressed delight that it provided a key basis for future analysis and proposals. The evaluation, despite being non-exhaustive and in need of further development, he said was nonetheless sound and sustainable. He explained that he was ready to draw on many of the suggestions garnered over the course of the experience.

The press covered some of the statements made during the event, especially by the Prime Minister and the European Commissioner for Research. It welcomed the announcement of a forthcoming doctoral research fellowship system ([19]), and a scientific and technical agreement between Morocco and the European Commission. Furthermore, the media relayed the crux of a statement saying that a country's level of development is measured by its scientific capabilities, communicated the desire to make research one of the levers of development, and reported on the method and results of the operation.

The ministry later published the complete series of workshop documents in the shape of a book, *Atelier national sur l'évaluation du système de la recherche scientifique dans les domaines des sciences exactes, sciences de la vie et sciences de l'ingénieur — 26 et 27*

[18] At the end of each workshop, the reporters drafted their reports and had them validated by the session chairperson so that all the workshop papers could be ready for the closing session, at which two hours were devoted to the debate.

[19] 200 research fellowships were awarded in 2004, 200 in 2005, for a period of three years, and the plan is to increase that figure to 600 a year when the system comes to maturity in 2007.

mai 2003, Hay Riad, Rabat. The publication, which was printed and distributed by the ministry, comprises three volumes:

- Volume 1: speeches and general summary (61 pages);
- Volume 2: evaluation reports (554 pages), including all the IRD preliminary reports, all of the reports by the European experts, and the evaluation summary;
- Volume 3: national scientific research system (163 pages), including all of the discussion papers that the ministry produced when preparing the thematic workshops.

1.2.4 CONCLUSION

In handing over the evaluation results to a large number of stakeholders, the workshop brought to a close a process that had lasted more than one year. The operation had revealed the quality of Morocco's researchers and, in order to stimulate demand, raised awareness of what the country had to offer in terms of research. It had also shown the benefits in investing in research for Morocco, pinpointed the relevant areas of investigation, and prompted the structuring of the scientific community.

Such a course of action serves not just to make people familiar with the research community, but also to raise its profile and earn it greater recognition. Its aim is not only to promote informed decision-making and point out which directions to take, but also to win over and mobilise both the sceptics and those most concerned. Its target audience is both national and international, in this case ranging from the general public to the highest authorities, via a world of potential users.

Given the setup of the national system, there were always going to be problems to bypass, misgivings to overcome, and dissent to be nipped in the bud, both inside and outside the research community. That was what made the operation worth launching in the first place; it provided a pretext for explaining, persuading and instructing.

The undertaking, which was ordered by the ministry, could succeed only if it respected the prerogatives of the everyone: various ministries, heads of institutions, and so on, the free will of the actors (for instance, none of the 'evaluated' were forced to take part in the meetings with experts), and the balance between the various regions, disciplines, ranks and generations (with nobody held in low esteem). It could not be a purely 'technical' operation, and it was far more than a 'publicity drive'. It also had to command attention, and to make its mark by means of its expertise and independence.

As such, strict, close and increasingly trustful working relations between the ministry and the coordinators were necessary. The former was aware of the context, saw the dangers, and knew what was feasible. And the latter had to prove themselves sensitive to that, while at the same time standing by their professionalism and independence. This required constant discussions, followed by determined cooperation.

Granted, the quality of the evaluation stemmed from the work of the European experts, who bore the responsibility for the final diagnosis. But in describing this operation, which was a first in Morocco, we have shown how its success hinged on the constant exchanges taking place from start to finish between the research authority and the coordinating team. In the preliminary stages, those exchanges helped a scientific community with no experience in evaluation culture to prepare to meet international standards in terms of its skills, results and potential. Furthermore, the exchanges gave the evaluators the key to understanding the special nature of Moroccan research. Most of all, however, they made their intervention feasible.

Meanwhile, the IRD members — social science researchers specialising in studies of science — became intermediaries between the evaluators, the evaluated and the authorities. Their participation turned the exchanges into a bona fide interplay that made it possible to move beyond subjectivities and susceptibilities, and enter into a process of objective assessment, notably *in context*. In doing so, the one and only goal was to strive for the construction of a national research system capable of acting as a partner in the country's economic and social development.

PART 2

FRAMEWORK OF MOROCCAN RESEARCH

2.1 A HISTORY OF RESEARCH ORGANISATION

Mina Kleiche-Dray

Scientific activity in any country takes on styles of organisation and overall directions, which depend greatly on the twists, and turns of its history. Our aim here is to trace the history of 'modern science' in Morocco, in order to capture the essence of the background to a science policy that is currently emerging.

2.1.1 GENESIS

The western part of North Africa, the Maghreb, has never been the hub of Arabian science. Nevertheless, more than 1 000 years ago the region was tinted with some glory. Some universities founded long ago were science's finest creations: Kairouan in Tunisia, Tlemcen in Algeria, and the Quaraouiyine of Fez in Morocco (founded in the mid-ninth century and sometimes considered the oldest university in the world). When the Arab empire declined, scholars were no longer protected and left, driven out by persecution. In the 14th and 15th centuries, scientific invention shifted east and west to feed the Indian and European renaissances. The universities fell into ruin or retreated into a role of purveyors of routine teaching. Endogenous knowledge was scattered and not well codified. It either stagnated, unable to revitalise itself, or died out completely. The only traces of that golden era are some popular, rosy images of the typical 'scholar'.

The revival of science in North Africa, in its modern form, came with the advance of the European empires in the 19th century. A country's own governments (as in Egypt and Tunisia) sometimes promoted such regeneration, anxious to harness the powers of medicine and the military sciences of Europeans, who were considered a threat. More often, however, the colonisers, who gained hold of the region in stages (Algeria from 1830, Tunisia in 1896, Egypt in 1879, and Morocco as late as 1912), imported it.

The scientific activity that was established, therefore, was cast in the mould of a specific type of production, attached to human and natural sciences, and directed by the colonising country's institutions. The remit of local science was, above all, data collection. Subjects of indigenous interest hardly featured in such exercises (Gaillard, Krishna & Waast, 1997: 23-29). This colonial style of scientific production was not monolithic, however; it did leave room for considerable variations. Three countries were colonised by France, but the circumstances by which the coloniser gained its grip were different. The result is a set of quite distinct styles of scientific structuring, original combinations of institutions and favoured subject areas. Together, they generated models that continue to leave a strong imprint.

When Algeria (occupied early on and destined to receive a substantial influx of colonisers) was annexed completely as a French *département*, the phase of exploration was a long one. It required all types of research (including fundamental science). Establishments were founded in Algeria to that end. A university even saw the light of day in 1905.

For Morocco, the reverse was true. The imperial take-over came late (1912), and the country was not considered' uncharted' territory. The country's 'development', the pragmatic catchphrase of the day, did not seem to call for either erecting grand institutions or conducting basic research in the eyes of the governors that were dispatched from France. A system of colonial research did exist, but became rapidly oriented towards applied research, utility for colonial policy or for the colonists themselves. It was devoted, above all, to two fields: health and agriculture. The system was essentially based on *research centres* (see Table 1), which were placed under the responsibility of the Protectorate's technical services department. These establishments employed full-time, civil-service researchers from France, where they had received their training.

The Pasteur Institutes of Tangier and, later, Casablanca conducted some fundamental research (especially on rabies, Kleiche, 1994), with the tasks of vaccine production and epidemiological surveillance quickly gaining priority over all their other activities. In agriculture, the colonial administration organised its research services around a 'new' discipline: genetics. The first trial gardens, field trial stations, and experimental farms were soon grouped together within the agricultural experimentation centre, which was assigned the task of cereal selection, notably work on wheat (Kleiche, 2000: 15–16).

Twenty years later, there was a change in approach. In France, during the late 1930s, this change was expressed as a prime concern for the planning and coordination of scientific investigations at the scale of the whole empire. The movement was driven by France's newly-formed Centre National de la Recherche Scientifique (National Centre for Scientific Research (CNRS)). The new organisation and the ethos it embodied promised a broadening of the scope of research to make room for fundamental studies and new disciplines.

World War II put the project on the backburner, but it returned to the fore after the end of the conflict (Bonneuil & Petitjean, 1996: 119–145). In Morocco, a Franco-Moroccan Scientific Committee was established at Rabat. With the French Committee for Scientific Research acting as adviser, its job was to watch over the orientation and organisation of research. If original areas of study were considered necessary, it was the joint committee's task to establish partnerships between Morocco and the appropriate French organisations. However, its impetus was curbed by a colonial administration fixed on the short term, and which (in any case) jealously guarded its authority (BIM, 1947: 26–27, and DIP, 1950: 9–10).

The local scientific committee's structure was first determined by the great fields of applied sciences, but gradually changed shape as academic disciplines came on board. It became the sounding board for the claims of researchers. They wanted laboratories with the most modern equipment, the means for taking part in regional and international conferences, the setting-up of an organisation for basic research, and the creation of a special fund devoted to scientific research by the Protectorate. This lobby hardly gained any attention from government and the CNRS was unable to do anything about it. Just one 'information session' was held in 1945 to bring together the researchers and administrators of Morocco. The Franco-Moroccan Scientific Committee subsequently had only about five plenary meetings between 1947 and 1955. The wishes of the committee's sections were never put into practice. In 1955, on the eve of independence and in the face of so much bad grace, some of them stopped holding meetings (BEPM, 1955:10–48).

Table 1. Research institutions in Morocco under the Protectorate

Date founded	Name	Location	Field				
			Agri.	Med.	NS	ES	SHS
1914	Cherifian Scientific Institute	Rabat			+		
1914	Trial gardens	Rabat	+				
1914	Hygiene laboratory	Rabat		+			
1914	Pasteur Institute			+			
1915	Trial gardens	Marrakech	+				
1916	Experimental farm	Fes	+				
1919	Centre for Agricultural Experimentation	Rabat	+				
1920	Institute for Higher Moroccan Studies	Rabat					+
1924	Genetics and seed testing station	Rabat	+				
1928	Centre for Law Studies	Rabat, Casablanca					+
1932	Pasteur Institute	Casablanca		+			
1940–1945	Centre for Advanced Scientific Studies	Rabat					+
1945	Institute of Oceanography	Casablanca			+		
1946	Public Laboratory for Research and Testing (LPEE)	Casablanca				+	
1945	Agronomic Research and Agricultural Experimentation Services	Rabat	+				
1946	Marine Fisheries Institute	Casablanca	+				

Key: Agri. = agricultural sciences, Med. = medical sciences, NS = natural sciences, ES = engineering sciences, and SHS = social and human sciences.

The updating of research envisaged by France after World War II went no further than the foundation of a new Institute of Oceanography in 1945 and, in the applied sector, the creation of a Fisheries Institute and a Public Laboratory for Research and Testing in 1946 to serve industry and civil engineering. Local science remained deprived of means, extremely isolated, and either enslaved to the administration or highly dependent on the science of the colonial power. Both the policy of coordination at empire-scale, and the scheme to build up a network devised by proponents of centralised planning in Paris (under the responsibility of the CNRS) failed.

Nevertheless, in terms of accumulated, stored and usable knowledge, the newly independent Morocco was left with a significant legacy. In terms of institutions, however, it was slim. Research centres were fewer, less diverse, and less well endowed than in other Maghreb countries ([1]). Only in agriculture it was enough strong in order to form a true system, and this took place under the close eye of the corresponding government department. In this case, the system generated models of research and development and even of rural 'scientific development' (Kleiche, 2000: 19). However, in this field as in others (medicine included), practically no Moroccan researcher had been trained to take over; and sometimes not even as assistants.

Colonisation turned out to bring very little for higher education and training (Table 2).

Table 2. Higher education institutions in Morocco at the time of the Protectorate

Date founded	Name	Location	Agri.	NS	SHS
1923	Secular Sciences Institute (Institut des Sciences Profanes)	Fez		+	+
1928	Centre for Law Studies (Centre d'Etudes Juridiques (CEJ))	Rabat, Casablanca			+
1940–1945	Centre for Higher Scientific Studies (Centre d'Etudes Supérieures Scientifiques (CESS))	Rabat			+
1945	School of Agriculture	Meknes	+		
1945	Xavier Bernard School of Agriculture	Rabat	+		
1945	School of Horticulture	Meknes	+		
1945	School of Agriculture	Soueilah (near Marrakech)	+		
1950	Moroccan School of Administration (Ecole Marocaine d'Administration (EMA))	Rabat			+

Key: Agri. = agricultural sciences, NS = natural sciences, and SHS = social and human sciences.

There was a fully operational university in Algeria (albeit largely closed to the local people, referred to at the time as 'the Muslims'), and the creation of one in Tunisia had been under debate (even though the project fell apart in the end).

[1] Algeria was left with the most substantial scientific legacy, such as in the areas of 'discovery' (astronomy, geosciences, and ecology). It was also left with a greater number of 'modern' centres (in nuclear studies, haematology and cancer research, etc.). This sector was sustained by French assistance over more than 10 years, then was picked up and occupied differently by the first, young, trained researchers and academics (see Hocine Khelfaoui, *La Recherche Scientifique en Algérie*, in Roland Waast and Jacques Gaillard (dir.), *La Science en Afrique à l'Aube du 21ème siècle*, Paris, France, December 2000).

The Protectorate of Morocco came to initiate higher studies only in 1928 when it created a Centre for Law Studies (Centre d'Etudes Juridiques (CEJ)) to produce qualified law graduates, with establishments at Rabat and Casablanca. In 1940, a Centre for Higher Scientific Studies was being planned. It was not operational until after liberation. In 1945, a School of Agriculture was founded at Meknes, with the objective of training agricultural technicians ([2]). The beginning of the 1950s saw the establishment of the Moroccan School of Administration (Ecole Marocaine d'Administration (EMA)) in Rabat ([3]), as well as three secondary-level schools of agriculture that produced 'monitors', whose task was to explain and popularise farming information (Table 2).

These establishments were not intended to train for higher degrees or qualifications, although they could provide preparatory grounding for higher studies to be carried out in France. They mainly trained technical assistants needed for the colony. They were, in any case, effectively close to Moroccans, at least at the beginning. When local people gained wider access to these centres (from 1950 onwards) they aimed largely at humanities, law and non-scientific disciplines because of the associated job prospects. Such dispositions were to have an influence on how higher education turned out after independence (1956).

Morocco had not been devoid of higher education before French power gained hold. It was a Muslim system and colonisation did not suppress it. However, it did remain enclosed in its own methods of recruitment, and was detached from any form of training for employment and from any teaching of 'modern' sciences. Demands by students and initiatives by progressive intellectuals from the higher echelons of Moroccan society brought attempts to bring in courses in mathematics, cosmography, applied astronomy, history and geography (Quaraouiyine: Institut des Sciences Profanes (Institute of Secular Sciences), 1923–1933). However, they were short-lived, for lack of suitable teachers and equipment (Paye, 1957: 395). Scientific education seemed, therefore, to offer no career prospects for young Moroccans, who found it better to become interpreters or lawyers in the framework of the Protectorate.

Under the Protectorate, no medical or paramedical teaching institution saw the light of day; it was the same story for engineering and technical training (except in agriculture). The higher education establishments were merely at an embryonic stage and had no great culture of research. Moreover, the training of students in the specialist *écoles* or universities of the colonial country (or in other countries abroad), which provided a positive educational contribution in other countries of the Maghreb, was for Morocco no more than a trickle. At independence, Morocco could barely count on 100 engineers or technical professionals (half of whom were in agriculture), about 20 doctors and 6 pharmacists (Laberge, 1987: 194) ([4]).

[2] This was mainly reserved for descendants of colonial settlers. Its annual intake was about 30 students, who were trained over a 3-year course.

[3] After independence this School became the National School of Public Administration (Ecole Nationale d'Administration Publique (ENAP)).

[4] According to Paule Laberge, at independence there were just 19 Moroccan nationals who were doctors (out of 587 practitioners) and 6 pharmacists (out of 348) available.

2.1.2 A SHIFT OF BALANCE: THE RISE OF HIGHER EDUCATION AFTER INDEPENDENCE (1956–1986)

When independence came, most colonial technicians left the country. The Moroccan government, therefore, found itself in charge of a range of infrastructures whose functioning was jeopardised by the absence of qualified or managerial-level personnel. All administrative, scientific and technical services were faced with the same problem. It was important, therefore, to organise an effective system of accelerated training that was of a high standard.

The task was first assigned to a rapidly-founded university system. The national government built this up (first at Rabat) from the embryonic higher education structure they inherited, and extended it prodigiously. In a second phase, a specific national system termed 'Formation des cadres' (professional and management training) undertook to serve the different professional spheres (business schools and engineering colleges). At the same time, the university system grew even further, with establishments setting up in many Moroccan towns. During this period, the services of the pre-existing research centres and institutes were either maintained (to a large extent by French development aid) or transferred to the university sector, the latter of which was the case for the natural sciences, law and social sciences. Those establishments gradually lost their monopoly in scientific production, as higher education gained strength and became more professional.

2.1.3 THE UNIVERSITY SYSTEM

In the period just after independence, the milestones in the organisation of education in Morocco were the Royal Commission on Reform of June 1957, and the Maâmora Symposium in April 1964 ([5]). The policy decided upon was embodied in a Charter for Education (April 1966). The question of higher education was approached from the need for 'Moroccanisation' at managerial and professional levels, and not from a concern for research. At the time, the Moroccan government, like most states on the African continent, showed little interest in scientific creativity. It did not set up any new infrastructure, but maintained the research establishments in place with the aid of France, which delegated qualified aid workers to run them.

In 1957, the Institut des Hautes Etudes Marocaines (research in humanities and social sciences), the Centre d'Etudes Supérieures Scientifiques (Centre for Higher Scientific Studies) and Centre d'Etudes Juridiques (Centre for Law Studies) were amalgamated into a single Faculty of Letters. As for the Institut Scientifique Chérifien, the establishment concerned with natural sciences research, it was incorporated into the Faculty of Sciences. The two

[5] The conclusion was that all the various systems had to be *united* under the same structure, and that the programme content should be *converted to Arabic*. The managerial levels were to be *Moroccanised* and education *made universal* (at independence, only 12 % of children aged 7–14 years received schooling). In summary, 'The objective was to provide education, in Arabic, to as many children as possible, administered by Moroccan teachers, with common nationwide curricula and schooling hours'. These principles especially concerned primary education (see Moatassime, 1978: 22–34).

faculties made up the Mohamed V University ([6]), of which was cast in the mould of French counterparts ([7]). It employed a substantial number of aid workers from France until Moroccan teachers could take over.

2.1.4 THE *GRANDES ÉCOLES*

Adding to the problem of a lack of administrators, there was also a shortage of scientific and technical personnel at managerial level. In 1957, the government, composed largely of people trained in humanities or law, set the organisation of elementary education (along with teacher and administrator training) as its priority. A handful of qualified French engineers, who were called in to take over important technical posts, pressed for the creation of high-level specialist schools (*écoles supérieures*), along the lines they had come to know in France. At first, little notice was taken. However, some of them ([8]) banded together with the aim of alleviating the shortage of people qualified with the scientific *baccalauréat*.

They launched preparatory courses for entry into the engineering and technical *grandes écoles*, which recruited their students from the penultimate secondary school class. Two years later, this preparatory organisation itself became (with Unesco's financial backing) the first of Morocco's high-level engineering schools — the Ecole Mohammedia d'Ingénieurs (EMI) — for mining, industry and public works (Vermeren, 2000: 303).

In 1966, the Institut Agronomique et Vétérinaire Hassan II (Hassan II National Institute School for Agriculture and Veterinary Studies) was created. Although they did not have a high profile at the time, these *écoles* were to become extremely prestigious. They soon stood out as a model showing the way for higher education policy (see Appendix 1: Development of higher education in Morocco, 1956–2003).

The situation changed during the 1970s. In the humanities and legal fields, the Moroccanisation of managerial echelons was a reality. A true critical mass of nationals in such positions had been reached. In contrast, scientific disciplines suffered the effects of the shortage of qualified technical people, aggravated by Moroccan students' lack of enthusiasm for this kind of training (Table 3). The government had to respond at once to a strong demand for education, which was concentrated in the arts and humanities, and to the needs of the public services and an expanding industrial base, which were calling for different knowledge and skills.

These conditions posed a dilemma. Moreover, the economic and political situation had seriously deteriorated. Morocco was reeling from a fall in the price of phosphates (its main export), and suffered the full shock of the oil crisis. The country soon had to submit to the constraints of Structural Adjustment Plans, imposed by the International Monetary Fund, which limited state expenditure.

6 A Faculty of Medicine was added in 1962.

7 Its degrees and the quality of its courses and teaching are guaranteed by the University of Bordeaux.

8 Among the most prominent include Driss Amor (chemical engineer, and Minister for Industry), Mohamed Berrada (telecommunications engineer, and Minister for Posts and Telecommunications), Mohamed Douiri (graduate from the Ecole Polytechnique, engineer, and Minister for Public Works) and Abraham Serfaty (engineer graduate from the Ecole des Mines, and Director of Mines and Geology). Source: Vermeren, and an account by Abraham Serfaty recorded on 15 March 2002 at Mohammedia, Morocco.

Table 3. Breakdown of Moroccan students per educational field — 1960s

	Sciences	Medicine	Engineering	Agriculture	Humanities & Law
1964–1965	12 %	10 %	4 %	1 %	63 %
1969–1970	4 %	11.9 %	2.6 %	2 %	79.5 %

Source: Laberge (1987).

At the same time, the universities had turned into an immense hotbed of unrest. In 1957, the founding of a students' union linked with the opposition made it a favoured forum of expression for those kept away from power (Vermeren, 1996). Education became a very sensitive and highly political issue. At the Oaks Symposium devoted to the topic in 1964, a tendency emerged in favour of a process of Arabisation and Islamisation, which opposed the government's bilingual policy (El Masslout, 1999).

During the Ifrane Symposium on higher education (1970), a kind of 'national front' seized the opportunity to form a coalition, calling on students to boycott national elections. From 1965 to 1972, minister after minister proved powerless to contain the dissent. Repression increased. Between 1973 and 1974, arrests became more and more frequent, and the students' unions were disbanded (Squali & Merrouni, 1981: 143–146).

Faced with this situation, the government opted for a large increase in the number of faculties in the provinces, but allocated meagre resources to them ([9]). It devoted most of its efforts to creating new professional and managerial schools (*écoles de cadres*) outside the university sphere. The idea was to get around the drawbacks inherent in universities. Admission to the *grandes écoles* was selective, and students were under much closer supervision (less politicised). They remained centres of education that were expressly bilingual, in the name of scientific communication.

Besides, this system had the approval of the now powerful chiefs in the government's technical departments, many of whom had been educated in that mould and who dreaded the functional inexperience of the universities. They wanted to have their collegial say over the content of the teaching. They also saw the potential for quickly and assuredly getting hold of qualified personnel for middle management functions in their departments, by practising a policy of grants and pre-recruitment within the *écoles*.

From the 1970s onwards, the more specialised sectors (business, various types of engineering, rural, and environmental specialities) began to find their place under the different ministries (except education). Assistance from bilateral or international aid funds was channelled preferentially towards this new means of education and training. The five-year plan for 1973–1977 encouraged private investment and sought to modernise those sectors that could earn foreign currency. It banked on the *grandes écoles* system to produce the managers and professionals necessary for bringing new development, and agricultural and tourism projects to fruition.

[9] The government order of 16 October 1975 upgraded all the advanced establishments in any given town to the status of universities.

It was for political reasons, therefore, either to separate these establishments from the universities (which had become the centres of unrest) or because of the need to build captive breeding grounds for rare talents, that the government chose the *grande école* blueprint, which had been so little appreciated before. This new sector soon strengthened with the addition of many institutes to tertiary-level schools, avoiding the dual risk of succumbing to mass intake and Arabisation (see Appendix 1).

This is the salient feature of Moroccan higher education: in order to disconnect the sector termed 'professional and management training' from the universities, the leaders of that sector had the idea to link up their establishment to supervisory bodies other than the ministry of Education. The dual nature thus built into the higher education system was to come into play between the 'academic' and 'technological' sectors, as soon as the *grandes écoles* started to develop their own style of science.

2.1.5 ACADEMIC AND TECHNOLOGICAL RESEARCH: SEPARATE DEVELOPMENT

With the research centres, universities and *grandes écoles*, we have presented the main players on the Moroccan research scene, which was to experience a strong upsurge. This was achieved, however, without much support from the state (even though in the 1970s the state began to be persuaded by the idea that scientific progress was the source of development) ([10]). Growth, however, was more the result of dynamics within professional circles. A distinction must be made between two professions: university teachers and 'technologists'.

2.1.5.1 University expansion and mass intake (1980–1990): dynamics of the academic world

The main mission of the new universities was teaching. The government gave no stimulus at all to research within them. However, the strong growth in student numbers led also to an increase in teaching staff. The situation was not easy for the new recruits. As soon as they arrived, they had to take on a lot of teaching for an ever-increasing number of students. The burden of teaching left little time for accomplishing 'personal' work — and the universities considered research to be just that, as they had not yet developed a research culture. The mass increase was no illusion. Student numbers climbed from 25 000 in 1975 to 50 000 in 1980, 100 000 in 1985 and 200 000 in 1990. The university network in Morocco expanded (Appendix 1) and the universities recruited substantially (Table 4).

10 A subject area commonly promoted at the time by Unesco.

Table 4. Growth in student numbers and teaching staff in university establishments in Morocco (1955–2000)

Academic years	Number of students	Number of student-researchers
1955–1956	1 687	0
1960–1961	5 117	172
1970–1971	14 808	488
1980–1981	86 844	2 490
1990–1991	206 725	6 437
1998–1999	249 253	9 867
2003–2004	277 428	10 413

Source: Ministry of Higher Education (website: http://www.dfc.gov.ma/).

In 1975, the first laws were established that were entirely devoted to university organisation ([11]). They conferred a status on teacher-researchers, and a specific salary scale was introduced that led to a salary increase. The university system matured. It started offering higher degree courses. Some of these teachers began to regard research as part of their vocation. In spite of adverse circumstances (and almost non-existent financing from the institutions), they worked diligently at developing original research. They considered that it was the real job of university academics, which set them apart from their colleagues working at a different level, and that it was the duty of a teacher worthy of the title 'superior'. They were also undoubtedly spurred by the academic rule, which (in principle, at least) makes career advances dependent on research output.

With full Moroccanisation (during the 1980s) and the arrival on the scene of many young teachers, fresh with research experience from recent doctoral or post-doctoral studies, output became highly visible. Development aid from abroad had an essential role in the observed 'upsurge in research'. However, because hitherto the government had not expressed any priorities with regard to research, the subjects stemmed largely from the researchers' personal choices (or rather the opportunities for external funding they succeeded in grasping). Those who did the research wanted their work to have relevance, but the absence of coordination of 'upstream' research activities, insufficient 'downstream' assessment, and deficiency in government financing encouraged an individualistic approach; at least, that was the case in some disciplines (particularly in the humanities and social sciences).

Researchers could group together only in response to criteria of the moment, and not as a response to building up lasting research entities or laboratories ([12]), which (in any case) would not have been recognised as formal structures. Furthermore, they did not gather with the intention of pursuing national programmes, which were subject to state policy devised only for immediate or short-term considerations. The research groups which formed generally owed their existence to the personal action of a researcher or professor, sometimes associated with a small team. Their project could not easily be dovetailed with others. They had limited means, and often they survived only thanks to international

[11] At the time, the universities were under the wing of the Ministry of Higher Education and Research, created in 1976, whereas the specialised schools of engineering (*écoles d'ingénieurs*) continued to depend on the technical ministries. The establishments were given autonomy over budget and elected advisory councils were envisaged. These instructions were hardly acted upon at all.

[12] There are, of course, exceptions that are more numerous than people report. Interviews conducted with researchers (particularly those who have been productive for a long time) highlight the tenacity of teams who kept up a lengthy project at the university. In contrast, several institutions (Hassan II, Mohammedia, etc.) have built up their reputation on the strategic planning of their research.

aid. This aid was based on friendships that the director may have made with colleagues in a host university in Europe while preparing his/her thesis or with partners in bilateral scientific aid schemes while working on joint projects.

2.1.5.2 Growth of the 'technological' sector

Two types of establishments, which were created outside the university system, contributed to the country's research potential. They were the specialised research centres (active mainly in agriculture and health) and the newly created high-level *grandes écoles*. By the beginning of the 1970s, the research centre world had stagnated. The Pasteur Institute, which had experienced some organisational problems, seemed to be in complete decline in the 1980s (Laberge, 1987). From 1970 onwards, the Institute of Marine Fisheries became more involved in commercial affairs than in scientific activities. The Institut National de Recherche Agronomique (National Agronomic Institute (INRA)), one of the paramount institutes of the colonial era that had fallen into decay and dissolved, was reborn in 1982, but no longer had the mission of planning and coordinating agricultural research. In its revised form, it was a modest executive agency, which performed applied and development research work at the command of its own Division of Agricultural Education, Research and Development.

The research revival came from elsewhere. The Institut Agronomique et Vétérinaire Hassan II (Hassan II National Institute School for Agriculture and Veterinary Studies) demonstrated initiative and built bridges between basic research and action research. Its teachers were recruited from among its own students (the best), and sent for PhD training in the US. There, they benefited from research experience (of the 'research-by-doing' type). The institute also insisted that they continue to devote themselves to research upon their return. It was decentralised, and had branches in nine regions of the country. Original research was conducted, which was soon to make the institute the principal producer of scientific results in agriculture.

In order to achieve this, it adopted an aggressive canvassing strategy to obtain finance. It relied on its ability to propose relevant subjects, and insisted that students were represented in the research project (students, in turn, were obligated to participate in work experience and deliver reports). In the experimental areas, the institute maintained permanent contact with the field, farmers and professionals in agricultural development. These major advantages rendered it worthy of interest to all the international development aid bodies, and those in charge locally. It attracted a substantial influx of money locally. The research it conducted was a mark of the prestige and high standard of the establishment, and (at the same time) a source of funding.

This original model inspired some imitators. Its arrival on the scene heralded the emergence of a new 'technological' field. It was not what would be considered 'academic' (even though the institute that promoted it in Morocco devoted itself to teaching), in the sense that the research performed had no crucial significance for career promotions. It was done on a larger scale than the applied research of the old specialist institutes because it included work carried out 'upstream', and involved (at the same time) a direct link with the development services, which were beginning to be developed in government departments and industry (industrial companies).

Around the 1980s, a major novelty was the introduction of research and development centres within most ministries and some large public companies. Fifteen public or quasi-public research establishments arose mainly in the fields of mining, phosphates, energy and nuclear technology (see Appendix 2). They employed full-time researchers, often on a contract basis (not as civil servants). These centres were often better equipped than the universities, and had better financial resources. However, more was expected of them in terms of immediate, solid application results than from exploratory or education-oriented research.

2.1.6 CONCLUSION

On the one hand, it can be seen that the few elements of inherited colonial infrastructure, once modified, re-appropriated and enhanced, were essentially the bricks with which to build a national, tertiary academic education apparatus. This system, intended for training administrative middle management, left room — thanks to the determination of teachers at the time — for a strong research dynamic to develop at its margins.

On the other hand, the state had backed technological research in public institutes set up for that purpose. Clearly, research as an activity was defined differently in the two cases. The research centre sector mainly conducted work for development, and mostly employed engineers with advanced qualifications and high-level technicians. The university sector did research in an exploratory vein or for educational purposes. Its researchers were largely academically qualified with masters' degrees and now, above all, doctorates.

As a result, Moroccan research at present is conducted in two distinct styles of science, flourishing in separate institutions (Appendix 2).

Could a new situation bring a convergence of the two styles? What topics of common interest could crop up for researchers? What initiative on the part of the authorities could make it happen (when for a long time neither 'camp' was able or willing to make the effort)? This is not a rhetorical question, but one that we are bound to consider, given recent developments. It is a new paradox of research, which has developed spontaneously, and abruptly becomes an object of interest and regulation. Before examining this original episode, we will take stock of the situation.

Appendix 1. Development of higher education in Morocco, 1956–2003

1a. Universities

Date founded	Name	Location	No of students	No of researchers	Field				**No pub. 1997–2001
					Med.	NS	ES	HSS	
1956	Mohamed V University	Rabat	43 721	2 271	+ (1962)	+	+ (1959)	+	446
1974	Hassan II University	Casa-blanca, and Mohammedia	46 349	1 916	+	+	+ (after 1990)	+	317
1975	Sidi Md Ben Abdellah University	Fez	34 788	1 078	+ (1998)		+ (1995)	+	261
1978	Cadi Ayad University	Marrakech, Safi, Beni-Mellal, and Errachidia	32 684	1 269	+ (1998)	+	+ (after 1990)	+	620
1978	Mohamed I University	Oujda	19 535	587		+	+ (1990)	+	152
1978	Ibn Tofail University	Kenitra	8 707	405		+	+ (1990)	+	217
1978	Chouaib Doukkali University	El Jadida	8 374	438		+	+ (after 1990)	+	226
1978	Moulay Ismaïl University	Meknes	24 879	663		+	+	+	233
1980	Abdelmalek Saadi University	Tétouan, and Tangier	13 133	548+27		+	+ (after 1990)	+	114
1980	Ibn Zohr University	Agadir	12 590	455+21			+ (after 1990)	+	216
1980	Other Universities	Settat, Errachidia, etc.	4 491	189			+ (after 1990)	+	164
Total Number (1999)	**11**		**249 253**	**9 867**					**2 966**

Key: Med. = medical sciences, NS = natural sciences, ES = engineering sciences, and HSS = human and social sciences.
*** Number of articles: total number for the period from 1997 to 2001, except for human and medical sciences.*
Source: Rossi & Waast (2002).

1b. Ecoles de formation des cadres *(advanced specialist schools created outside the university system; they belong to the 'sector' termed 'management and professional training')*

Date founded	Name	Location	No of students in 1998	No of researchers in 1998	Field				No pub. 1997–2001
					Agriculture, forestry, etc.	Civil engineering, chemistry, electrical, minerals industry, etc.	Management and professional training (economics, law, architecture)	Specialist in education	
1970	Ecole Nationale Forestière des Ingénieurs (ENFI)	Salé	111	23	+				
1963–1966	Institut Agronomique et Vétérinaire Hassan II (IAV)	Rabat	1 560	328	+				137
1945	Ecole Nationale d'Agriculture de Meknès (ENAM)	Meknes	397	74	+				57
1971	Institut Supérieur de Commerce et d'Administration (ISCAE)	Casablanca	889	56			+		
1971	Institut National des Postes et Télécommunications (INPT)	Rabat	131	46			+		32
1971	Ecole Hassania des Travaux Publics (EHTP)	Casablanca	294	71		+			26
1972	Ecole Nationale de l'Industrie Minérale (ENIM)	Rabat	258	83		+			14
1986	Ecole Supérieure d'Electricité et de Mécanique (ENSEM)	Casablanca	347	69		+			12
1996	Ecole Supérieur Industries Textiles et d'Habillement (ESITH)	Rabat	115	26		+			
1967	Institut National de Statistiques et d'économie Appliquée (INSEA)	Rabat	159	50			+		12
1978	Institut Supérieur d'Etudes Maritimes (ISEM)	Rabat	128	20		+			
1980	Ecole Nationale d'Architecture (ENA)	Rabat	395	13		+			

Date founded	Name	Location	No of students in 1998	No of researchers in 1998	Field				No pub. 1997–2001
					Agriculture, forestry, etc.	Civil engineering, chemistry, electrical, minerals industry, etc.	Management and professional training (economics, law, architecture)	Specialist in education	
1978	Ecoles Normales Supérieures (8)	Casablanca, Rabat, Fez, Marrakech, Meknes, and Tétouan	1 106	943				+	103
1974	Ecole Supérieure des Sciences de l'Information (ESI)	Rabat	348	20			+		
1950	Ecole Nationale d'Administration (ENA, ex ENAP)	Rabat	48	41			+		
	Others		1 337	542			+		135
Total	**40 specialist schools belonging to the *Formation des Cadres***		**7 623**	**2 405**					**528**

** Figures for 1998.*
*** Figures for 1997–2001.*

Appendix 2. Research institutes in Morocco

Date founded	Name	Location	No of researchers	Field			No pub. 1997–2001
				Agriculture, forestry, etc.	Civil engineering, chemistry, electrical, minerals industry, etc.	Medical research	
1914	Institut National d'Hygiène (INH)	Rabat				+	12
1914, 1932	Institut Pasteur (IP)	Casablanca, Tangier	136			+	25
1982	Institut National de Recherche Agronomique (INRA-Maroc)	Rabat	135	+			56
1945	Institut National de Recherche Halieutique (INRH)	Casablanca		+			16
1946	Laboratoire Public d'Essais (LPEE)	Casablanca	435		+		32

Date founded	Name	Location	No of researchers	Field			No pub. 1997–2001
				Agriculture, forestry, etc.	Civil engineering, chemistry, electrical, minerals industry, etc.	Medical research	
1985	Centre National d'Etude Spatiale, de Télédétection et d'Energie Nucléaire (CNESTEN)	Rabat			+		8
	Centre de Recherche et d'Etude Démographiques (CERED)	Rabat	90				
1990s	Centre de Développement et d'Energie Renouvelables (CDER)	Rabat	90		+		5
1990s	Centre National de Recherche Forestière (CNRF)	Rabat	21	+			3
1990s	Dir. des mines et de la géologie Bureau de Recherche et de Prospection Minière (BRPM)	Rabat	17		+		9
	Centre National des Etudes Routières (CNER)	Rabat	17		+		6
1975	Groupe OCP (CERPHOS)	Casablanca, Marrakech	817		+		9
1976, 1981, 2000	Centre National pour la Recherche Scientifique et Technique (CNRST)	Rabat			+		12
1990s	Office National des Eaux Potables (ONEP)		220		+		6
1990s	Office National de Recherche et d'Exploitation Pétrolière (ONAREP)				+		15
TOTAL			**2 500***				**227****

** Figures for 1998.*
*** Figures for the period from 1997 to 2001.*

2.2 THE MOROCCAN RESEARCH SYSTEM: ORGANISATION AND NEW INITIATIVES

Mina Kleiche-Dray

Here, we examine the organisation and present dynamics of Moroccan research.

2.2.1 THE RESEARCH SYSTEM

2.2.1.1 Organisation of the overall system and coordination

Most Moroccan scientific research currently falls within the public sector domain. The most productive establishments operate at present under the same major ministry, which groups together (under separate divisions) the universities, professional and management training schools (called *écoles*), and research institutes (15 specialised government institutes). Other establishments exist that depend on it only for recruitment and personnel management, while their budget and programmes are under the authority of another ministry (which is the case in important fields, such as agriculture and health). Finally, various services and laboratories are in the quasi-public sphere, created by offices and companies devoted to development and industrialisation, whose research needs they serve (see Appendix 1).

The Centre National de Coordination et de Planification de la Recherche Scientifique et Technique (National Centre for Coordination and Planning of Scientific and Technical Research (CNCPRST)) ([1]) was set up in the late 1970s to stimulate and coordinate research throughout the Moroccan system. It has, however, never really been able to exercise its role. It seemed the diverse supervisory organisations were anxious to keep their grip on the programmes, and working terms and conditions of personnel in the establishments within their competence. Fragmentation was considerably lessened in 1976 with the establishment of a wide-reaching Ministry of Higher Education, Management Training and Research. This new ministry was also active, as a secondary supervisory body, in establishments governed for budget purposes by other ministries. The very recent advance

[1] This subsequently became the Centre National de la Recherche (CNR), and now the Centre National de la Recherche Scientifique et Technique (CNRST).

towards a national policy for science has brought back to the agenda the question of a coordinating body, one that could generate consensus and be accepted as the authority. The right formula remains to be found and proven.

2.2.1.2 Main sites of production

The absence of a more central system has not held back the dynamism of Morocco's research (active in many different centres), which has been progressing for 20 years or so. However, bibliographic databases indicate certain significant achievements. And a CNCPRST's larger-scale survey gave a census of active research groups and their members was published in 1995 ([2]).

Outside the humanities and social sciences, output indexed by an international database (PASCAL, 1997–2000) amounts to 900 annual references on average, which confirms continuous strides for over 15 years now. This output can be ascribed to 700 different laboratories. Even if some of these laboratories are especially active, scores for individual laboratories range from 1 reference to 35 references over 4 years. The universities make up by far the greatest contribution: 83 % of articles itemised (although such bases tend to reveal the more academic research without ignoring the 'technological' kind). Another feature is that the contributions of different institutions are highly unequal. The first-generation universities are those where the research culture is deeply embedded (Rabat and Casablanca amount to 60 % of contributions) ([3]). In the 'young' universities, output figures are fed by particular fields, built around prominent scientists who have gone there to get established. Some engineering schools show high productivity (in particular those *écoles* that train agricultural specialists: Institut Agronomique et Vétérinaire Hassan II (IAV), Rabat, Ecole Nationale d'Agriculture de Meknès (ENA), Meknes).

Our own survey (Gérard & Kleiche, 2002) brings in additional data concerning the humanities and social sciences. The formation of these sciences appears less structured around laboratories than the exact and natural sciences. Output here is often the work of individual researchers (some of whom are brilliant, although not really seeking to create a research following or group). The 'focal points' are bound to a small number of subject areas, tackled in an exclusive way by a specific discipline (e.g. studies on the state, the political system, work, and development). Nevertheless, substantial research is conducted, unobtrusively and rather in isolation, around a whole range of topics studied from a variety of disciplinary angles (therefore less as 'specialities', for example, women, science, and so on). Our assessment is that output of the humanities and social sciences is similar to that of the natural sciences (about 20 % of the country's total output).

These results are quite consistent with those of the CNCPRST survey, which was devised around a different methodology. The census lists 910 research 'units and/or teams', most of which had no official status at the time (1995). Most (79 %) of these de facto groups were teams of people at universities (CNR, 1997). Humanities and social sciences work accounted for 20 % ([4]) (here, we come across the 700 or so units attached to the other sciences); if they still exist, their composition will surely have changed since then.

[2] This directory, updated as far as possible, remains an important reference.

[3] Distinctions must still be made. At Casablanca, for example, the research culture is strong in medicine but mediocre in S&T. It is the opposite at Rabat.

[4] Forty percent of teachers employed are in these disciplines. It is evident, therefore, that they devote themselves less to research than their colleagues working in other fields (the CNCPRST census has identified groups, even ephemeral ones, consisting of a professor and his doctoral students). It is true that in the humanities and social sciences there is a particularly heavy load of teaching duties, with a staff: student ratio twice as high as in the other disciplines (72 % of the students for 40 % of the teaching staff).

2.2.1.3 Numbers

Research capacity can be measured by the number of people who, by their professional status, could be assumed to devote themselves to this activity (theoretical potential) or, in terms of 'full-time equivalent', the amount of work time they dedicate to research. Many precautions must be taken so as to make such estimates representative of the real situation ([5]). These figures are valuable mainly for making international comparisons.

From the point of view of sheer numbers, universities possess the greatest human resource potential. The number of teacher-researchers has increased by 4 times over two decades (and by 20 times in three decades!). They amount to about 10 000 individuals (over 65 % of the total potential) ([6]). There are also thought to be about 2 000 teacher-researchers employed in professional and management training, and 3 000 researchers not involved in teaching (e.g. government institutes, industrial firms, and agencies).

If the full-time equivalent is the yardstick, the proportions are different. The switch to the use of full-time equivalents is evidently made on the basis of certain hypotheses. It is clear that a teacher does not do research full-time. In developed countries, the norm is to consider that a teacher spends one-third of their work time on research. This approximation has to be revised case by case.

In Morocco, many university teachers do no conduct research at all, and this is particularly true of the professional and management training sector. In 1996–1997, the department in charge of this sector estimated the number of teacher-researchers who performed both teaching duties and research at 595 out of more than 2 000 individuals. For the sake of simplification, we have taken the full-time equivalent to be one-sixth in the universities, one-sixth in management training, and two-thirds in the 'dedicated' sector (other than the teaching sphere) ([7]). A revised distribution can be calculated, provided some corrections are made to account for certain establishments whose exceptionally intense research activity is documented, such as IAV.

Table 1. Number of persons theoretically involved in research

	Humanities & Soc. Sci.	Exact & Natural Sci.	Medical Sci.	Engineering	Agric. Sci.	Total	% of potential
University	3 700	4 100	1 200	700	300	10 000	66
Professional & Mgmnt Training	200	700	-	750	450	2 100	14
Outside Teaching	-	-	200	2 300	400	2 900	20
TOTAL	**3 900**	**4 800**	**1 400**	**3 750**	**1 150**	**15 000**	**100%**

Source: Kleiche (2000).

[5] Nothing is mentioned about the productivity of each one or of the style of science that it represents. This is another subject, which the paper takes up further on (section 2.2.1.5: Output).

[6] In June 2000, the CNCPRST counted 14 522 researchers, which comes down to 0.5/1 000 inhabitants (compare: 3.7 in the US, 3.8 in Israel, and 2 in the European Union).

[7] This ratio is debatable because many of the people listed as being involved in 'research' within the production boards, the mining companies, or the Public Works Research and Testing Laboratory no doubt perform more tasks to do with service (routine analyses) than with development.

Table 2. Number of researchers expressed as full-time equivalent

	Humanities & Soc. Sci.	Exact & Natural Sci.	Medical Sci.	Engineering	Agric. Sci.	Total (rounded)	% of active researchers
University	950	1 050	350	175	100	2 600	52
Professional & Mgmnt Training	50	150	-	125	80	400	8
Non-Teaching	-	-	100	1 600	270	2 000	40
TOTAL	**1 000**	**1 200**	**450**	**2 000**	**450**	**5 000**	**100**

The research strength can, therefore, be estimated at a little over 5 000 full-time equivalents, half of whom are university academics, about 400 are in management training, and 2 000 are scientific workers outside the teaching realm. Work in human sciences (possibly applied) involves 20 % of them. A further 25 % are devoted to natural or experimental sciences, 8 % work in medical sciences, and about the same in agriculture. Engineering takes the lion's share: 40 % of the work time available.

Universities conduct research mainly in exact sciences and social sciences and humanities; very little work is devoted to engineering sciences ([8]). The teachers practising in professional and management training establishments do a type of research that lies somewhere in-between, partly (let us say, half) in basic research and the other half in engineering. The greatest number of them (943 or 45 %) belongs to the eight *écoles normales supérieures*. They excel specifically in physics, chemistry, and the corresponding branches of engineering.

A large number of researchers belong to schools of agriculture (22.13 % of the total, highly active in applied research). Finally, the bulk of non-teaching personnel are mainly made up of engineers and technicians, who perform development research on request by their employer (e.g. semi-public industrial companies in mining, phosphates, telecommunications, and so on). In 1997, MESFCRS statistics show that 2 900 people had such research occupations, which is equivalent to our estimation of 2 000 full-time researchers ([9]).

The figure for researchers who are more-or-less active fall between the two estimates. In universities, the number is exacerbated by doctoral students (and in medicine, by residents) who, although they do not have the status of researchers, are no less productive (when they belong to structures that have a strong research culture). Besides, even if they devote a limited amount of time, many teachers (not all, but more than the full-time equivalent score might suggest) do show their interest and produce work at their own pace. In any case, this number, which the bibliographic databases confirm, is still smaller than the theoretical potential. An encouraging sign, perhaps, is that there is still a reserve of researchers that could be mobilised. It could also, nevertheless, be an alarm signal, and prompt the question of what holds people back from committing themselves to research. This might be answered in part by the financial means available.

8 They are also the great producers of results in health-related fields (bio-medical or clinical research).

9 In Morocco, 8.6 engineers out of 10 000 habitants have been counted (64 in France, 540 in Japan, 8.9 in Tunisia), 40% of whom work in administration.

2.2.1.4. Financing of research

In 2000, public expenditure (salaries not included) devoted to scientific research (investments and running costs) represented officially 0.14 % of the gross domestic product (MAD 381.7 million). The supplementary funding contributed by the private sector is difficult to quantify. It is likely to be confined to internal expenses and engineering purchases from abroad, much more than it is to feeding national public research contracts.

The budget allocation for higher education establishments (MAD 398 million) covers expenditure that has no direct link with research activity. It has to provide a salary supplement paid to all teachers (to compensate for pay freezes), which has nothing to do with any research conducted (although this allowance is called a 'research bonus'). It also covers the payment to grant-holders studying for higher degrees (who certainly contribute as an additional workforce, but do not bring in any material means to their host laboratory).

Seven percent of the visible funding assigned, therefore, is put towards the actual programmes; in other words, for purchasing consumable materials, equipment maintenance, travel for conferences, and obtaining documents (in short, everything needed to conduct research work instead of staying effectively laid off). In reality, higher education establishments have less means at their disposal for research. In 1995, the CNCPRST's survey estimated that most universities earmarked 12 to 15 % of their operating budget for 'research', a sum of MAD 23.05 million. However, once bonuses and grants are deducted, this leaves MAD 2 million (USD 200 000) for programme support. There is no doubt that the state, more interested in 'technological' research, makes a relatively greater effort in endowments to the research centres (and the specialist engineering and technical *écoles*).

Given such financial constraints, scientific output (especially in the universities) seems quite remarkable — even more so given that it has been continually growing for two decades now. This strong rise can in no way be attributed to just the increase in numbers, which has practically stopped.

2.2.1.5 Output

Between 1991 and 1997, the PASCAL database recorded 2 798 'publications' with Moroccans as authors ([10]). These come down to 2 559 papers (including books, monographs and communications to symposia), and represent an average of 360 papers or 400 'publications' per year. During this same period, output rose by more than 66 %, growing over 100 % in medical sciences and more than 50 % in exact and engineering sciences, and remaining constant (as an absolute value) in agricultural sciences. This strong, regular expansion runs counter to the major trend observed elsewhere in Africa, where the usual research 'giants' fell back; Egypt receded a little, South Africa quite noticeably, and Nigeria dramatically. Other countries on the continent, with very few exceptions, hung on with various degrees of difficulty ([11]). The Maghreb countries were an exception, and Morocco achieved the strongest advance.

[10] 2 788 papers were recorded at the same time by the American SCI (Source: Narvaez 1999).

[11] Tunisia is making progress, but more modestly than Morocco: + 15 % in 7 years.

Table 3. Moroccan scientific output (1991–1997)

As % of papers published	Morocco 1991–1997	Morocco 1997	Morocco 1997–2001	Total number of articles (1997–2001)	North Africa	Africa 1997
Agric. sci.	12 %	8% ⇩	8 %	355	9 %	12 %
Biomedical	14 %	16 % ⇧	11 %	484	14.5 %	21 %
Clin. medicine	24 %	25 % =	21 %	899	14.5 %	18 %
Other biological sci.	9 %	6 % ⇩	5 %	228	8 %	13 %
Earth and Planet. sci.	9 %	6 % ⇩	7 %	318	6.5 %	10 %
Physics	14 %	18 % ⇧	20 %	866	13.5 %	7.5 %
Chemistry	5 %	6 % ⇧	5 %	209	11.5 %	5 %
Maths-Computer sci.	3 %	3 % =	5 %	227	2.5 %	1.5 %
Engineering sci.	10 %	10 % =	18 %	769	20 %	12 %
Mean annual no of references	**400**	**600**	**870**	**4 355**		**8 000**

Source: Waast (2000 b), and Rossi & Waast (2002), after PASCAL database.

A more recent check highlighted a further leap forward for the years 1997–2000 ([12]), with the proportions of each discipline maintained more or less. The medical sciences, in particular, are very strong (41 %), with regard to the theoretical 'potential' in this area. Although not exceptional for North Africa (i.e. Morocco, Algeria, Tunisia and Egypt), the 50 % score reached by publications in fundamental or engineering sciences is indeed the case when compared with the normal performance of the rest of French-speaking Africa. The basic sciences (mathematics — an extremely strong point in Morocco — physics and chemistry) are particularly active and are progressing markedly.

The progress can be attributed to 1 000 research teams or laboratories and 7 000 authors ('active' researchers). However, half of them are involved in only 1 publication every 4 years, and 10 % of them produce 25 % of contributions. About 100 teams produce more than 2 articles per year in influential international journals (those covered by the large bibliographic databases). This figure can reach as high as 10 (this is the case for urology at Rabat, and mathematics at Marrakech).

2.2.1.6 Aid partnerships

There is no doubt that scientific aid partly explains the steady progress achieved for Morocco's scientific output. About 75 % of references recorded by the American bibliographic

[12] A change in methods used for PASCAL (the recording of all the authors in a reference instead of only the first author) in 1998, raised the expectation of an automatic rise in annual output of 30 %. The real figure is 50%.

database, SCI, are co-authored by Moroccans alongside authors from a variety of countries. According to the PASCAL database, which covers Moroccan journals, this statistic falls to 50 % ([13]).

Publication in international periodicals, which shows partnership aid involvement, represents a sizeable volume, and is increasing. Schemes run with French teams predominate (a constant figure of 80 % of co-authored articles) ([14]). In contrast, American aid has declined in the past 10 years, whereas new European projects are diversifying the scene. Morocco has achieved remarkable successes, through work with various laboratories, in the context of Europe's INCO (international cooperation) programmes. These are designed to support joint research projects between European countries and countries of the south, mainly in agriculture, health and the environment and, more recently, in town planning, biotechnology and advanced technology.

Partnership aid has helped update the theoretical bases. It has combined the modern methods and training of younger generations with state-of-the-art knowledge. Schemes have concentrated on trying to generate an academic style for the basic sciences. This is certainly the case of French scientific aid, highly active since 1970. Such programmes first focused on training of teacher-researchers (the same as American aid efforts, active at the time in agriculture and engineering). In the 1980s, new French programmes consisted of joint research projects, with strong training and method transfer elements. These were 'PICS', Programme International Communautaire Scientifique (International Community Scientific Programme), managed and financed from 1982 by France's Centre National de la Recherche Scientifique (National Centre for Research (CNRS)). From 1983, they would become 'PAI', Programme d'Action Intégrée (Integrated Action Programme), financed by the ministries of the both countries. The calls for tenders target the laboratories, which must join together in 'twinning' arrangements to respond. An evenly balanced Franco-Moroccan scientific committee determines selection and assessment (during the project and at the end). The areas covered are the basic sciences (PICS and (PAI)), and sometimes applied sciences (PRAD, Programme d'Aide à la Recherche et au Développement (Aid for Research and Development Programme) which derived from PAI for agriculture, and health).

Other aid programmes have recently begun along the same lines, this time with Spain and Portugal (Ministerial Office for Scientific Research, 2000). Morocco is trying to diversify both kinds of regimes: liaison and partner countries, twinning with 'European scientific regions', such as the Languedoc; and schemes based more on 'technological' research, organised around 'Moroccan spheres of competence' rather than around laboratories.

The French aid effort is contributing to this change in tactic. However, the adjustment is being approached cautiously, and in no way cancels older established programmes ([15]). They receive less finance (in 1996–2001, French funding decreased by 17 %) but still provide the bulk of scientific output (measured by co-authorship of articles; in 1995–2000, French scientific partnership grew in Morocco more rapidly than anywhere in Africa).

The leap forward seen in Moroccan scientific output, therefore, results largely from international aid partnerships. These schemes, initially built around a few individuals or

[13] Where local journals exist, Moroccans usually publish on their own. If they want to publish in international journals, they team up with foreign scientists in partnership schemes. There is no doubt that these foreign teams occasionally publish on their own in journals in their own country.

[14] A survey conducted by CNCPRST in 1996 found that out of 1 071 joint projects with foreign research teams declared by Moroccan groups, over 80 % were being carried out with French partners (50 % of them in agriculture), Secretary of State's Office for Scientific Research (Secrétariat d'Etat Chargé de la Recherche Scientifique), 1998.

[15] The total grants France has made available for PAI since 1983 has been estimated at FRF 115 million. In spite of a decrease, this item (with MAD 16 million annually) currently represents 24 % of the funds assigned by French overseas aid to Morocco.

laboratories, are on sound footing. The new element is that now the government is endeavouring to increase their size and scope. It intends to make them an integral part of its new science and technology policy.

2.2.1.7 Research and development: the weak link in the Moroccan system?

Even if basic science is by far the main focus of research, there are some applied research laboratories (often outside the university sphere) that produce results. A market-economy framework began to take hold in the 1990s, which had to be more competitive to link up with the European economic zone. The need for innovation came to the forefront, essential for delivering high-quality products and improved processes.

Research was expected to shift its efforts towards these concerns, and research establishments had to show an entrepreneurial spirit. Technological research had increased during the 1980s and 1990s; centres of research and development had sprung up and grown in the bigger industries, and applied research centres in the public sector. Some *grandes écoles* (and some university centres) followed in their footsteps. Some of them succeeded in raising substantial funds of their own, selling their expertise as revenue.

This was the case in the agriculture and food, hydrocarbons, chemistry, energy and mining resources sectors. Large institutions formed, embracing the specialist *écoles* (Institutes of Applied Research and Centres of Research and Development), with potential for evolving into hubs of technology-based activity. They developed a new research culture, differentiated from academic science by the ethos of producing applications. Their work was not an integral part of an overall plan but oriented in an autonomous way, according to the needs expressed by the companies, the branch or the sector it concerned.

This was a significant trend but it was far from the case generally. Small and medium-sized enterprises dominated the industrial fabric. They used somewhat 'mature' technologies and relied on a cheap and scarcely qualified workforce. The sector has little concern for renewing techniques and know-how.

A survey conducted in 1997 by the Ministry for Industry showed that out of 500 large companies, 100 had carried out R&D or used subcontracting locally. Three types of activity made up the bulk of this R&D: experimental development (55 %), applied research (42 %), and basic research (3 %). The overall total expenditure was MAD 56 million (MESFCRS, 1999: 16).

It is experimental development that is under-represented here, in comparison with international norms (a ratio of 100:10:1 for development, applied research and basic research. Above all, for the moment, industrial companies rely to a very large extent on external organisations to meet their engineering needs. Investors call most often on ready-to-use technologies, manufacturing under licence or foreign experts to fill in gaps.

These practices preclude any recourse to local services judged to be slow or not reliable, whether concerned with national research or engineering.

The local engineering sector was insignificant and, quite logically, there was proportionally little call for its services. In 1997, 468 patents were filed at the Moroccan Patent Office, 25 % of which came from nationals, 10 of these (1 in 50) from academics (often filed on a personal basis). Water treatment was the subject of 115 of them (MESFCRS, 1999: 19). Inter-university partnerships with countries in the north rarely focused on development, with particular exceptions (such as the Franco-Moroccan PRAD in agriculture and the European MEDA programmes) ([16]). Their results were seldom applied and hardly any patents were filed. Much remained to be done to initiate, stimulate and organise effective joint action between researchers, laboratories and the world of production.

Reliance on technology transfer was justified by the need to set up an operational industrial base in the shortest time possible. Promotion of national technology was only of secondary importance. However, the situation changed. The debt burden, the energy crisis, and the constraints imposed by structural adjustment brought out the huge cost of engineering-related imports (swelled further by the need to remain competitive). Such expenditure amounted to MAD 4 billion, half the bill for oil. Moroccan engineering covered only 15 % of total needs. This rate did, however, vary with the sector. It was nearly 100 % in the building industry, about 90 % in large-scale water engineering, and hardly anything in industrial engineering. In total, 1.6 % of GNP was spent externally in foreign currency, part of which could be saved.

The need for research specifically directed and geared to modernising the national production complex, which was antiquated in some quarters ([17]), was now recognised in several government circles. Innovative industrial circles had similar concerns. A new demand for technological research rose up, primarily for the 'non-academic' sector.

2.2.1.8 University research: locked in its ivory tower?

Some would like to associate technical research with the universities because they offer greater potential in terms of researchers. Universities, under fire in this respect and in others, were first expected to produce administrative managers and renew the teacher supply. This was accomplished, but the state has practically stopped all recruitment.

The ever increasing number of unemployed graduates shows that the profiles developed by education and training no longer fit the jobs on offer. Is there a need to remodel the curricula? Do teachers have the knowledge and skills to handle this? Since 1990, other means for gaining professionally-oriented qualifications have developed: bachelor degrees in applied subjects, science and technology faculties, specialised *écoles supérieures* in the field of technology, and high-level national *écoles* included within faculties (commerce and management, applied sciences, industrial arts and trades). All of these forms of training only accommodate 4 % of students. Much is, however, expected of the experiment in terms of a closer association with the production sector.

16 A 1996 survey by the Scientific Research Department of the MESFCRS showed that 96 Integrated Action Programmes (PAI) had been carried out in partnership with French academic establishments but very few had led to patents. Only four were filed in this context, mostly in chemistry (cf. Belcadi, 1996: 148).

17 Moroccan industry specialised either in commonplace products (e.g. textiles, leather, food and agricultural produce for export), construction materials and consumer goods of low added value or mining and associated products (phosphate).

This overhaul of the universities' tasks raises the question of whether the research done can and should, in its turn, be given a new direction. Are they developing (and how?) within the new forms of training? What advantage can be drawn from academic work, actively pursued in the more classical set-ups? All this is the subject of lively debate.

Some arguments claim that the research world is cloistered, distant from society, and produces no useful applications. Reformists and neo-free market proponents agree on this theme. Moroccan academic research is, thereby, considered completely oriented towards the industrialised countries and not very interested in topics related to immediate, local or national preoccupations (except in medicine). University teachers are perceived as cut off from their economic and social environment. Their status exempts them from any accountability to the administration concerning their research work, which has little to do with the life of the establishments. Their research activity has a poor structural framework, meaning that if the head of the operation left the institution, for whatever reason, the work could not continue.

Researchers, on their part, express their goodwill. However, they complain about the indifference of industrial leaders and the government. The quite recent halt to teaching staff recruitment is now compounded by the departure of some of them to northern countries. Those who stay, say they have lost their motivation, realising that when they have devoted four or five years to training a talented student, they often see them go abroad or (in the worst cases) participate in sit-ins organised by unemployed graduates protesting in front of the Parliament or the Ministry of Higher Education.

The fact is that meagre finances and inadequate infrastructures push the universities towards research without equipment. In mathematics, physics and biology, theoretical research is preferred over experimental research, due to the lack of heavy and specialised equipment. Moreover, Moroccan researchers find access to recent information difficult since low budgets place regular subscriptions to major journals out of reach. They often have to ask acquaintances from abroad to select and send papers to them. Adding to this problem, local sources that hold results of national research are scattered. The direct benefit of this type of activity is perhaps to keep teachers up-to-date in their discipline and speciality. It is, therefore, the quality of their teaching that will mainly be improved. They also maintain their participation in international Networks of Excellence, representing a substantial potential that remains to be tapped into.

The dispersion of the scientific community, and the absence of both any overriding plan and research assessment activities shows a weakness in national policy. These factors have marginalised academic research, keeping it outside the development processes taking place in the country. This situation is changing and will now be examined.

2.2.2 INITIATIVES AND NEW CHALLENGES

The idea of linking up academic research with development began to emerge in the early 1990s but it needed a political storm before it could gain substance. A new government, arriving with a whirl of changing mentalities and balance of power, started laying the foundations in 1998 of a nationwide scientific research policy.

2.2.2.1 Government initiative revived

For the first time ever, a ministerial office for research was created at Secretary of State level. It was placed under a large ministry, which had the brief of unifying the scattered fields of higher education, research and professional and management training.

The Minister of the time, Mr Zerouali stated, '[at the end of the past decade] there was research in Morocco but it was research based essentially on individual initiative. Because of this it was completely fragmented and dispersed, and furthermore its results were not transformed in the field. The result: it was not applied and was not applicable' ([18]). This summed up how a new authority, which was concerned for the first time about the state of research and wanting to govern it, saw the situation. The task is complicated, owing to the extreme divisions between institutions with different histories and under different parent organisations, and because of the two divergent research traditions: academic and development-oriented.

Several measures have been taken to set up an institutional framework.

A law came into effect to reorganise higher education ([19]). It includes several measures to encourage teaching staff and establishments to conduct research (such as career incentives, sharing results, and grants to universities partly linked to doctoral programmes). A Higher Council for Scientific Research was set up, responsible for both proposing national policy and showing concern for research markets.

A National Research Foundation was established to finance priority projects and programmes and responsible for managing the National Research Fund, another new body that will be enlarged on further. A new culture began to take shape with the formation of assessment committees per discipline, linked to priority national programmes being set in place. They had good opportunities to 'break in' their systems, and try and impose their legitimacy: first by choosing the areas of university training most fit to offer PhD programmes ([20]), then by meeting to evaluate the proposals received in response to ministerial calls for tender (Scientific Research Support Programme (PARS) and Thematic Scientific Research Support Programme (PROTARS)).

These new overseeing bodies were first set up within the auspices of the Ministry of Higher Education, Professional and Management Training and Research. They dealt with

[18] Interview given to a journalist of the Moroccan newspaper, *Libération*, 7 December 1999.

[19] Law No 01-00, enacted by Dahir No 1-00-199 of 15 Safar 1421 (19 May 2000).

[20] Special Training and Research Units (Unités de Formation et de Recherche (UFR)), which exist only in small numbers since the specialist diploma and doctoral level programmes reform of 1997.

the establishments primarily or secondarily under its wing but their mission was much broader. In order to 'integrate' scientific research ([21]), the government recently created an Interministerial Committee on Scientific Research and Technological Development in order to initiate and to plan it.

Nevertheless, it stayed on to clarify the functions of structures set up previously with similar remits, which had not been abolished. The establishments concerned were the Hassan II Academy of Sciences and Technology, created by *Dahir* in 1993, and the CNRST ([22]) (whose roles might overlap). Their orientation functions were in disuse and their operational bodies were dormant. In any case, updating would eventually be necessary.

Another major step to be taken was the forging of a link with those involved in research under the aegis of different ministries (e.g. agriculture, health, and mining).

The powerful Ministry of Agriculture (followed by others) re-evaluated its entire system. Wide-ranging conferences on agricultural research were held in 2001. The Department of Education, Research and Agricultural Development consulted with its establishments: the National Institute for Agronomic Research, a specialist agency employing full-time researchers; Hassan II Institute, which has university status; and other engineering schools and scientific communication services. What was at stake was to draw up a conclusive reorganisation plan, integrating training, research and spreading, in line with the new government policy and coordinated with the Ministry of Higher Education's system.

2.2.2.2 The strategy

The Secretary of State's Office for Research had the task of implementing the overall policy. It set to work actively, following a three-pronged strategy: creating incentives, building a structure, and then directing research activities.

- **Creating incentives**

The government's first job was to make research more attractive among teacher-researchers after the reform of the doctoral-level programmes (1997) ([23]). Today their promotion assessments (including for changing grade) is based on their publications (even if this existed partially in the texts of 1975). For the first time, a two-speed system of career advancement began to be possible.

From now on, the law on higher education allows universities to use some of their own revenues from research work and services sold. They are channelled into supplementary allowances for those who have contributed to generating those revenues as an encouragement or to stimulate competition. The government intended to reward researchers' activity through this reform and hoped to give it a strong boost ([24]).

Establishments were also encouraged to embark on research. The endowment of each university is now supplemented by a 'scientific research promotion' budget allocation ([25]). This

21 Contribution by the Prime Minister, Abderrahman Youssoufi, in *Actes de la Rencontre Nationale, Recherche Scientifique et Développement*, Rabat, 13-14 April 2001, p. 11.

22 Both of them have the mission of coordinating and planning research, with the Academy having perhaps a more consultative role, and the CNRST a more active, operational function.

23 See Decree No 2-96-796 of 11 Chaoual 1417 (19 February 1997), establishing the regulations for studies and examinations for the doctorate, Diplôme d'Etudes Supérieures Approfondies (DESA) and the Diplôme d'Etudes Supérieures Spécialisées (DESS) as well as the terms and conditions for certification of university establishments authorised to prepare students, and to confer these qualifications.

24 See interview given by Driss Khalil, Minister for Higher Education and Management and Professional 'Training: The universities: a reform under consideration for efficiency', *l'Economiste*, No 195.

25 For the academic year 1998–1999, this financial contribution was about MAD 3.5 million and for 1999–2000, it was around MAD 13.5 million.

is granted to approved doctoral programmes (UFRs) depending on the number of postgraduate, doctorate-level students and teacher-researchers who work there. It provides operating costs in proportion to the number of people working on the programmes and supports scientific publication.

The research centres are now also able to recruit, under contract, young researchers who can aspire to greater freedom in their own initiatives and better career prospects than at the universities, where recruitment is rare and the higher grades or greater means are appropriated by their seniors (and will be for a long time to come).

The financing of research (particularly academic) has been clarified and made more stable. Officially, scientific research features as a budgetary item within the endowment for each university and cannot be converted into any other type of expenditure ([26]). This provision avoids the loss of direct programme support in a sea of subsidies, grants, teaching expenses and building maintenance.

The endowment rose from MAD 20 million in 1995 (about USD 2 million) to MAD 45 million in 1998. In addition, other items have been entered into the national budget and contribute to direct support for research activities: MAD 10 million as a 'subsidy to scientific organisations'; MAD 20 million for Morocco's contribution to partnership actions (financed moreover by the partner countries); and MAD 10 million in postgraduate-level grants (the recipients of which were at the laboratories' disposal).

This new mechanism should be topped up by other resources whose institutional basis has been delayed but whose should shortly be set in motion. State subsidies, public or private sector companies, and international partnership aid should support a National Research Fund planned since 1998. The government contribution has been written into the 2002 finance act. If the competitive funds are taken into account, the university teams will have access to a programme support budget, which has unquestionably doubled in three years. These funds, however, are not specifically earmarked for them even though the research teams are allotted considerable assistance from them. However, such financial support has the virtue of being explicitly assigned to the teams that won the tenders.

Building a research structure

Formation of units for training and research

The doctoral-level reform of the higher education system ([27]) instigated a single doctorate qualification, and Unités de Formation et de Recherche (Units for Training and Research (UFR)) appointed to prepare for it. Their authorisation is for a two-year period, renewable after assessment. They have the task of devising and conducting research work, with which candidates for the doctorate or for the Diplôme d'Etudes Supérieures Approfondies (DESA) becomes involved in to develop their theses.

[26] See the operational budget for academic establishments and research centres for 1995.

[27] See Decree No 2-96-796 of 11 Chaoual 1417 (19 February 1997) establishing the regulations for studies and examinations for DESA and DESS as well as the terms and conditions for certification of university establishments authorised to prepare students for and confer these qualifications.

Organising centres of subject-area expertise

Centres of specialist expertise have been built up as subject-focused networks. These initiatives have the objective of providing a sound framework that facilitates collaboration between researchers working on the same subjects in solidly set-up research units. Five subject-area networks (i.e. particle physics, marine science and technology, space science and technology, biotechnology, and product and process quality improvement) are today identified as centres of expertise.

Research support bodies

The Moroccan Academic and Research Wide Area *Network* (MARWAN) should enable those involved in economic issues and researchers to communicate with one another. It provides access to scientific and technological information sorted according to their needs.

The Moroccan Institute for Scientific and Technical Information will have the task of collecting from national stakeholders (researchers and institutions) the fruits of their labour (e.g. books, articles, theses, conference proceedings and seminars). It will also have the responsibility of making available to the scientific community the works and publications necessary for them to carry out their work (by buying them or through exchanges).

Direct research

The Ministry of Research and Higher Education now organises calls for tender. Its first operation in support of research (known as PARS) was launched in 1998 to aid basic research. A budget of MAD 37 million (USD 3.7 million) was allocated to it for 3 years. It financed 227 projects out of 713 proposals submitted ([28]). PARS was a means of learning which subjects were spontaneously declared to be of interest by the scientific community, identifying young teams and planning for future theme-based programmes, in the certainty that research capacity was strong enough to tackle them.

Six more tightly focused PROTARS were set up based on this information. Their budget allocation was MAD 55 million (USD 5.5 million), which financed 516 new projects. PROTARS financed proposals as much from researchers belonging to university establishments as from other public research institutes or laboratories. The first true call for proposals addressing the scientific community at large (1999–2000) gave priority to industrial product quality, water science and technology, space studies, and biotechnology and particle physics. In 2001, six new, theme-based programmes were launched, concerning standard of living, natural resources, economic and social development, information science and technology, agriculture in harsh conditions, and innovation and competitiveness of industrial companies.

By way of these programmes, the Secretary of State's Office sought to diversify and multiply joint ventures between establishments — and between different scientific styles and worlds (enterprise and research), ventures that can generate a new momentum. One of the special

[28] Expert committees (organised around the main broad disciplines) assessed these projects according to the criteria of scientific quality and feasibility but also on aspects that might contribute to structure building: for example, multidisciplinary nature, planning over a timescale of several years, group effort in UFRs or in networks, linkages within international partnership schemes, partnership with industry and sectors of production, and joint financing.

features is that the support systems are not exclusively earmarked for one or other of the sectors (academic or 'technological' specialised *écoles* and research centres), making either eligible under the variety of programmes. Some institutions (such as the Hassan II Agronomic and Veterinary Institute, and Ecole Mohammadia) have already built bridges between basic research and applied research, the productive sector, and various research sectors. Points of resistance, nevertheless, strongly persist and sectional interests still assert themselves.

2.2.2.3 Linking research with local industry

Forces with different rhythms and centres of activity that vary widely in character are elaborating the new research policy on. The approach was pragmatic and care was taken to avoid immediately imposing new national-level bodies to direct the course of research. Such organisations are in an embryonic stage, and gradual development can only give them opportunities for becoming more effective. However, when directions of research and subjects for study are considered, the options of the different umbrella organisations can diverge.

The Five Year Plan for 2000–2004 was concerned with indicating priority lines of research. Providing for a significant investment of MAD 567.8 million over 5 years for scientific research, the declared objectives for this period are to make scientific and technological research meet the concerns of those active in the social and economic spheres. Companies are encouraged to set up research-based subsidiaries or to take shares in other companies of that type. They have the option of putting 20 % of their tax-exempt profits into research and development, and for some this has even been made compulsory. For example, in certain cases, 1 % of turnover must be devoted to research (e.g. in telecommunications).

Sectors declared as priority areas include agriculture, health, fisheries, forestry, drinking water, geology, mining, energy, the environment, information and telecommunications technologies, and transport. This approach highlights the need for effective institutional coordination, which enables different parties to work together around common priority socio-economic objectives. Such joint research undertakings usually require the involvement of several disciplines and institutes. For example, the concern for a healthy diet (with aspects involving agriculture, industry, disciplines of nutrition and health) translates into research subjects that need to call on expertise scattered over many universities, and institutes (the National Institute for Research in Agronomy (INRA), National Institute for Fisheries Research (INRH), Pasteur Institute (IP), and the National Institute of Hygiene (INH)). All these fall under different ministerial departments.

The Secretary of State's Office is the hub of the activity. The broad subjects chosen for its PROTARS are as close as can be to the priorities laid out in the plan. Many ministries are prepared to adopt a common programme policy but the real challenge comes from the high fragmentation of the research scene. This instils a heavy inertia between supervising bodies (still nowhere near the convergence envisaged), between institutions, and even between disciplines. One example comes from within the aegis of a single authority (the Ministry of Health). A scheme has been afoot since 1995 to bring the institutes and laboratories within its scope together into the single Institute of Health Sciences Research and Expertise. This has still not materialised.

Nevertheless, some universities, like the *grandes écoles*, are taking the initiative. The Marrakech Faculty of Sciences is an example. It has set up a structure to develop applications and market the potential of academic research work and an incubator. This is a service to help young enterprises, built on new technical ideas whose profitability (and even translation into marketable products) is not yet assured, to fully develop their business plan. The company formed can remain linked to the laboratory that invented the idea by way of R&D contracts.

The industrial and academic spheres are separate worlds, and such initiatives come up against this divide. Projects have also to face the weakness of private industry, which is unenthusiastic for innovation by taking on board the fruits of local research. The linkage between public research and the economic sphere cannot do without interface's institutions. These are starting to appear in one or other of the two worlds. Research and industry clubs are an expression of this approach, an example being the original Association R&D Maroc. Founded in 1997 on the initiative of large Moroccan industrial groups (e.g. Office Chérifien des Phosphates (OCP) and Omnium Nord Africain (ONA)), it aims to 'initiate, promote and activate innovation by way of R&D', support the dissemination of research results, strengthen ties with Moroccan experts living abroad, promote research and development, and set up innovating companies. It has just issued its own calls for tender ([29]).

The semi-public sector, whose top managers have a Saint-Simonian frame of mind, is the leader in this kind of project. In any case, nothing could be achieved without the initiative of the establishments, especially not without voluntary (and even determined) interaction between researchers and entrepreneurs, guided by the feeling of belonging to the same socio-cognitive group (that of 'technologists', facing up to a patrimonial society). This period has perhaps already begun.

2.2.2.4 Researchers' reactions: recognition at last, but...

Researchers' opinions are divided on the new policy and on the sudden enthusiasm for a particular scientific ambition ([30]). Generally, they feel they have gained some recognition at last. Calls for tender offer the opportunity to show the media (and government) the wealth of research the country has to offer. They also reveal the diversity of subjects tackled, highly promising themes, the dynamism of research teams and their productivity, and their international reputation. However, gaps have been exposed in some areas.

Certain researchers (especially academics) are worried about an excessively strong government hand in scientific orientation (even though basic research is sustained). They are also reluctant to accept the systematic assessment procedures. Some complain that these

[29] The association has chosen several research and development proposals submitted by companies or individuals. It will support six schemes for 'incubators'. These are units devoted to developing the results of academic research for industrialisation and marketing. The idea is to bring to fruition a commercial project whose feasibility has yet to be demonstrated, and then to set up a company based on it.

[30] We have interviewed about 30 researchers on these matters. Sampling was done methodically, setting quotas so as to place discipline and level of 'performance'. The survey was conducted mainly at Casablanca, Rabat and Marrakech, and we visited specialist *écoles* as well as universities. Most interviews were held with researchers in the exact sciences.

are not completely equitable or transparent. Does this reflect the inexperience of a new institution or is it a pretext for the lofty rejection of the whole practice?

Besides, universities have had to withstand formidable difficulties for 15 years. They are torn between defending their general educational role (without a direct link to production) and the requirement to train qualified people for the job market (insisted on by the new Charter for Education). Considerable strain is caused by having new educational duties, on the one hand, and the concern for contributing to the country's development through research, on the other. The community seems split across several 'generations' of groups, as follows.

The 'builders' (a minority of whom remain at university, if they do not hold a post in the present government). They provide unshakable support for research, often of the academic kind. This generation arrived at the universities in the 1970s.

The 'educationalists' formed the intake of the 1980s. As a generation, they had to face the expansion of universities to mass entry, coming just as Structural Adjustment Plans began to bite. They seem quite attached to research and seek to leave the universities to make the most of their status by selling their expertise or entering private enterprise.

The 'inheritors' entered university in just a trickle during the 1990s. They wanted to show their worth. They decided to play the game with the government, by grasping any opportunity offered to demonstrate their institution's dynamism.

2.2.3 CONCLUSION

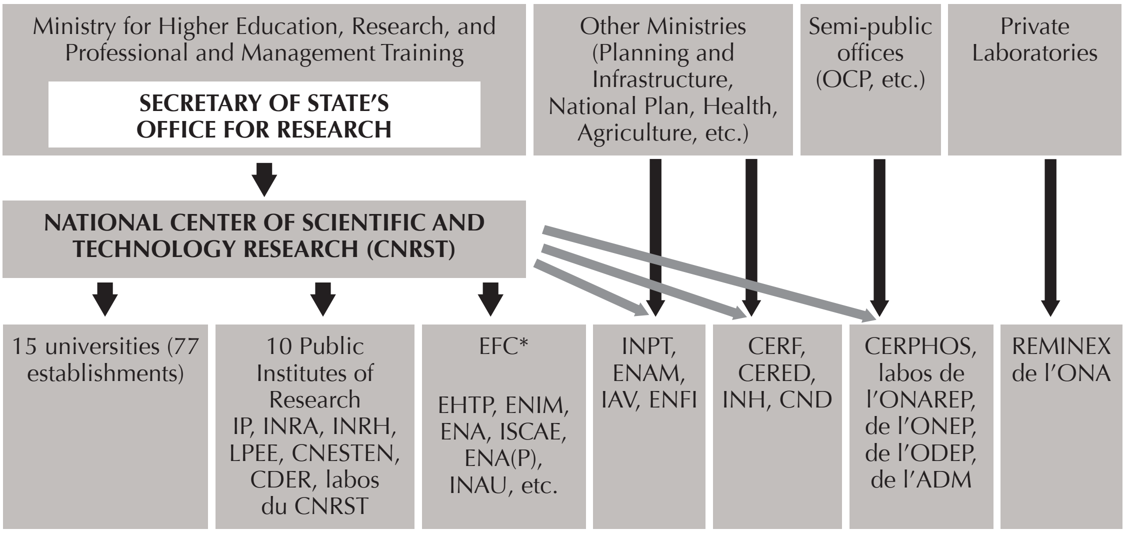
In Morocco, development of scientific research and the harnessing of technology are recurring themes of political discourse. They are currently taking on added force with the forthcoming strengthening of links with the European market, and the noticeably increased exposure of national industry to world markets.

The government's line is not just a declaration of intent. It has invested strongly in the creation of a country-wide higher education system. It has preserved (and what is more recently added to) a network of technologically-oriented research centres, employing full-time researchers, some with an entrepreneurial spirit.

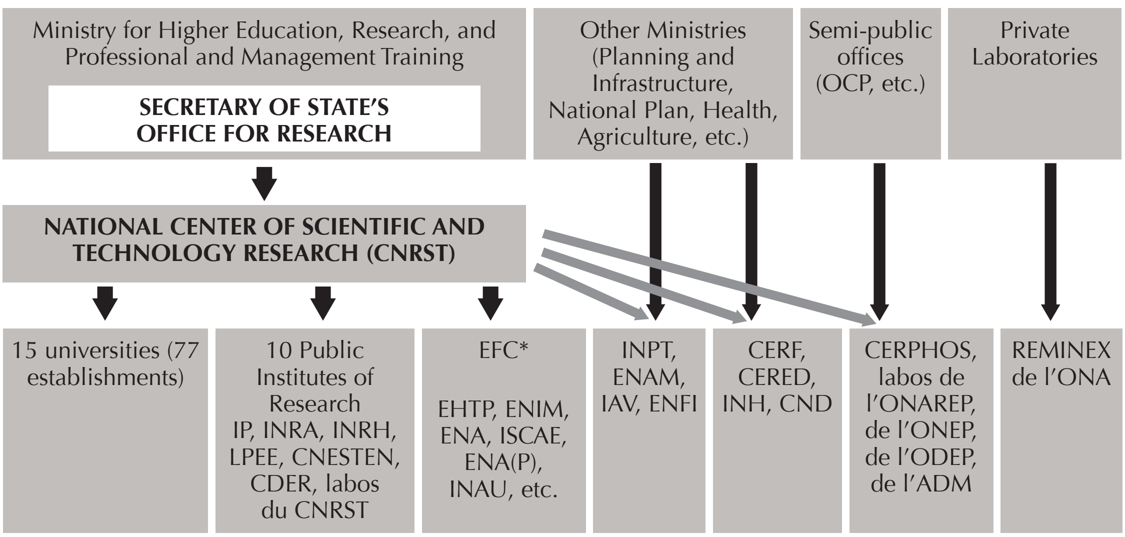
Admittedly, these efforts have not always had any noticeable effects in terms of social or material improvement nor have they enhanced the technological capability of an industry that is fairly obsolete today. Also true is the fact that several sectors have developed separately, with quite different scientific styles (e.g. academic in universities, and technological in the specialist technical and engineering *écoles* and research centres).

Moroccan research is, nevertheless, rising spectacularly in strength. Its growth rate (in terms of publications in the best international journals) is the highest in Africa. And Morocco is now the third science producer on that continent. The government has recently given itself the means to encourage and place this vigorous, fully determined potential on a sound framework. For the first time, a flexible yet sustained policy for research is taking shape, modelled on a succession of initiatives. It could effectively give added impetus to the dynamism already in motion, and give it direction.

Appendix 1. Organisation of scientific and technological research in Morocco



Appendix 2. Organisation of scientific and technological research in Morocco



2.3 DETAILED BIBLIOMETRIC ANALYSIS: METHODS AND OUTCOMES

Pier Luigi Rossi and Roland Waast

2.3.1 METHODOLOGY

In the first chapter, we mentioned the worth of 'bibliometric' guidelines as a means of approaching Moroccan science, referencing scientific papers signed by local authors that are published in the best world journals of their speciality. These papers are recorded on bibliographic databases, from which one can extract all that comes from a country, institution, town or author. We, then, can compare this output with that of other countries, cities, and so forth, during the same period or course of time.

There are good reasons to be interested in these publications. In theory (Merton, 1977), first of all, it is essential for researchers to seek recognition from the scientific community ('peers'). They have to publish their results, and do it quickly (fame will be attached to originality and discovery). Even if reality is more complex than this, all perspectives recognise the importance of these publications. The competition between researchers leads to the famous 'publish or perish' ethos. Admittedly, science is penetrated by 'profane' interests and a search for resources, however, in that very quest, scientists and their allies need quality 'certificates', and publications in the very strictly revered journals are the more prestigious.

In practice, there is a constant and considerable increase of papers and scientific journals, which no longer makes it possible for the specialists (or the distinguished "invisible college" among them) to read them all. This was the reason behind the creation of bibliographic databases. They allow researchers to keep a bird's-eye view on the activities in progress, get an idea of the tendencies, and distinguish the influence (quotations of others) of the recently produced works. These databases are evidently selective, reviewing a batch of chosen journals.

This is how bibliometry was born. Founded by De Solla Price, this discipline ([1]) is based on 'laws' confirmed continuously by observations. The most important (Lotka law) states that the production is very concentrated; only a small part of the actors are responsible for most of the production. This applies not only to authors but also to the laboratories at

[1] Bibliometry, or better scientometry, which doesn't use the sole bibliography databases, from now on nurtures its own journals (*Scientometrics* is the most important) its community, associations and congresses.

which they work. Surely, these actors aim at (and are sought after by) prestigious journals. As a consequence, it is legitimate to claim that science can be represented (in any case, influential science) by the content of a limited number of well-chosen journals. This is how the big bibliography databases proceed.

These databases are not immune to criticism. They have language biases, and review only very little of the 'local' journals. They reflect better the activities of basic science than those of applied sciences ([2]). They have difficulty in accounting for interdisciplinary work and are suspected to report poorly on science in the developing world (Arvanitis & Gaillard, 1992) ([3]).

Yet, regarding this last point, we can mention two original studies.

In South Africa, the first study compares a list of 'excellent' authors set by the national scientific commissions to a second list created through a 'referendum' (led by a large sample of researchers who were asked to point out their best colleagues). Both lists are compared with the PASCAL database.

One result is that the referendum ignores three-quarters of the 'excellent' researchers classified by their peers, while PASCAL knows and classifies them in good positions; this is because each researcher asked does not know other colleagues in other disciplines.

Another result is that the referendum mentions 7 times more authors than the list of 'excellent' ones selected by the peers; and PASCAL knows of 12 times more authors (that is to say three-quarters of the scientific active community, according to specialised centre, CREST). The database is thus a good guiding instrument.

The second study compares the total production reported by the agronomists from a prestigious institute in Morocco (The Agricultural and veterinary Faculty: IAV) with what several international bibliographic databases store; for instance, CAB and AGRIS, specialised in agriculture, and PASCAL, in general (Doghraji A., 1993).

From 1968 to 1990, the reported production includes 40 % papers, 30 % speeches at congresses, and 25 % research reports. Half of the papers are published in local journals. Essentially, the databases review the papers (mostly the international ones): PASCAL indexes 1 out of 5 of these, CAB 1 out of 4, and AGRIS 1 out of 3. Counting all ([4]), the databases miss 50–70 % of the reported production.

We have to ask ourselves if the hidden part corresponds to the preliminary outcomes (without a large analytic and practical impact) or if it is an original science (with a local view) carried out with its own methods on relevant topics that do not appear on the global agenda. This question cannot be answered. Only the experts of this domain can solve it. This is why the heart of our research system evaluation consisted of the visits made by the European peers to the laboratories.

We must know, however, that the production movement from period to period is truly accounted for by these databases (their thermometer is constant: same journals, same

[2] These have other expression and competition forums than just the journals.

[3] Some countries create their own databases (e.g. South Africa, Japan, China, and experiments in Latin America).

[4] The lists contain redundancies; reports and communications are handled again in order to reach the standard paper forms (40 % could have this origin). The papers are sometimes published several times (in different languages or at international level, with similar layouts).

method). Moreover, the experts agree (in all disciplines; it was the case in Morocco) that databases miss neither the excellent authors nor the main institutions.

But a number of less visible actors can be identified by experts as 'well-positioned' (both scientifically or socio-economically). Conversely, abundant results recorded in databases could be linked to tracks without a large perspective on a great discovery or application. Hence, when dealing with research strategies, bibliometry deserves to be completed by experts who are up-to-date with recent movements in science and technology around the world. However, bibliometry is a good tool for drawing a quick sketch, fair and sound (though not complete) of the national science: e.g. main authors, cities, institutions bearing strong points, and their evolution. It is in this spirit we built our study.

- ***Our objective: a detailed bibliometric analysis (MICRO BIBLIOMETRICS)***

Thanks to the bibliographical databases, it is easy to follow the global performance of a country, and compare it (according to broad scientific fields) with the main producers of the planet.

But such data is neither all that matters for the science stakeholders of a developing country; nor may be the most important. Their interest is more about similar or neighbouring countries (we took African countries as a comparison). It will focus on identifying strong and weak points, opportunity niches, and sites and competent actors on which one can stand (e.g authors and institutions).

To get these details, we have to implement subtle methods that few specialists of bibliometric analysis have developed until now. We must inter alia:

- obviously choose an appropriate reference database;
- categorise each paper according to its subject code, in an ad hoc classification list ([5]);
- extract from the address given by the author — not only the country but also the town, institution, and even the laboratory to which he/she is affiliated.

2.3.2 PROCESSING TECHNIQUES

2.3.2.1 The choice of a reference base

Our aim was to analyse the wide variety of the basic and engineering sciences. We had to choose a general base covering all these fields. Specialised bases (e.g. medicine or chemistry) are richer but it is impossible to relate them as their methodology differs greatly.

[5] Categories should be detailed enough to make scientific sense, and rough enough to gather a sufficient number of articles in a short period (3 to 5 years).

As a consequence, the choice was limited to the Science Citation Index (SCI), produced by the ISI from Philadelphia), or to PASCAL (a database produced by the National Institute for Scientific and Technical Information, CNRS, France).

The SCI is a rigorously built database, with a constant quality, generally used by the specialists of bibliometric analysis. Its biases are known; above all, it is in favour of English language and medicine, and not in favour of the journals of 'small scientific countries'. By reviewing all the citations mentioned in each indexed paper, its exclusive advantage is that it allows the measure of the citations received. As a consequence, it also allows the measure of the influence of articles, authors, journals, institutions, and so forth; that is, the 'impact'.

The production quality of PASCAL was less regular (Arvanitis et al, 2000) ([6]). The citations are not reviewed. But the database has the best coverage for most of the French-speaking countries, and it reviews some more local journals. Above all, PASCAL attributes to each reviewed paper one or several detailed codes describing their subject ([7]).

The detailed definition of strong points for Morocco is one of our main objectives, which is why we remained with the PASCAL database.

To check the results, now and then we also used SCI, and compared its macro indicators with the PASCAL ones (e.g. production volume, authors, and evolution over 15 years).

2.3.2.2 Building appropriate subfields

The codes describing the topic, which PASCAL attributes to each paper, are very detailed (too much for our needs). The 'classification plan', which we would eventually achieve, was a compromise between a concern for precision (detailed categories) and the constraint of statistical procedure (each 'box' dealt with had to contain a minimum of 5 to 10 items).

In order to satisfy this double constraint, we decided to carry out the study per subfields on the number of publications gathered through five-year periods. In that way, we could show the contributions of an institution to some rare subfields, even though they would remain invisible (statistically not significant) if they were dealt with year by year ([8]).

This choice allowed us to differentiate 100 subfields of research. About 30 cities and several institutions contribute to them regularly. We kept the same division made by PASCAL in regard to branches and sub-branches of disciplines. We were more detailed with some of the domains of applied sciences that were considered important by the government (i.e. agriculture and health). In some cases, we fixed boundaries so that the combination of 2 or 3 of our categories covered a multidisciplinary field of practical concern (water, for example).

The reshaping plan was a topic of debate for the ministry and the specialists. Our aim was to obtain a partition that discriminated the present capacities (e.g. avoided categories with too many or too little participants) and that accounted for the future (e.g.

[6] The database has been evolving since 1985. For example, all authors have been reviewed since 1996 (and not only the first ones at the beginning of the reviews), and the writing notices have been standardised in a better way. The use of them in bibliometry needs, nevertheless, more fastidious work for preparing files. Inappropriate unsubscribing modified the database content around 1993–1995. The time comparison requests precaution; as a consequence, we took the 1996 year as a milestone (upper or lower bound for the periods we considered).

[7] SCI does not do it. The papers are classified according to journal, where they are published in roughly eight great scientific domains. The shift to 100 subdomains is made by a complex and arguable procedure of attribution of subdomain 'parts' to each journal.

[8] This layout also allowed the reduction of the impact of exceptional events (e.g. world congresses, and publication of an important collective book) for some years, which may have inflated the discipline or institution score.

ministry priorities, and foreseeable evolutions of the science world). It was obvious that the PASCAL subtle codes made it possible to review the division at any given moment.

We set the correlations table between our plan and the PASCAL codes. We then transcoded into our categories, the codes attributed by the database to each paper.

2.3.2.3 Sites of production

A major phase remained: to locate the sites of production (e.g. country, city, institution, and laboratory too, if necessary). For each paper, this data appears in a unique and dense field; 'the address' given by the author. We had to divide it into items, and codify each.

- The country of work usually appears at the end of the address as a three-letter code. As a consequence, we initially extracted from the whole PASCAL database the papers in which the address ends with 'MAR' (code for Morocco). This was our reference file (MAROC 1).

  For better use, we transferred it to documentation software (TEXTO). We then limited the file to the items published between 1990 and 2001 (included). This was the MAROC 2 file.

  Extraction of the 'cities' where the activity takes place. The next phase consisted of identifying the penultimate segment of the authors' address. As a rule, it was the city where they worked. This segment was re-positioned by us at the beginning of the address, and this new file was classified by alphabetic order of the 'cities'.

  The normalisation of city names was 'handmade' from a printed listing. The authors report a large number of working 'cities'. One could observe that several of them were suburbs or districts in big cities. With a good geographical perspective of the country, we created a correlation table that linked them to their metropolis. The table carried a simple number for each metropolis, which also assisted with the problem of incorrect spelling, and was easy to deal with in the following phases.

  Only a limited number of cities were codified in that way (for Morocco, there were around 20). We took into account the reported publication volume. Around 30 other cities are codified in the category 'Miscellaneous'. The other cases (e.g. towns with scores of less than 2 publications over 10 years, and addresses without city names) are not codified and are included in a category 'Others'.

  When the transcription was done, we checked that the operation was satisfying (the addresses begin by a N° (number) of city). Any important 'city' had its code; what we left out were personal or rare addresses. This was the MAROC 3 file.

- Extraction of the 'institutions'. This operation was the most meticulous of all the operations performed. The institution where the author had stated he/she works had to be identified in the 'remaining' part of the address. Nevertheless, there were several written forms for the same institution. For our bibliometric purposes, we had to choose a unique symbol to describe each of them.

The operation was done by hand, city by city on the MAROC 3 listing. This allowed us to avoid ambiguities. For example, the Centres Hospitaliers Universitaires (university hospitals), which are important actors, are often named by the authors in all cities with the simple symbol 'CHU'. To conduct a bibliometric analysis per institution, each hospital had to be assigned a particular acronym.

The identity of establishments was better detected city by city. The examination of the listing guides towards the coding strategies was most often done in an upside-down funnel manner, starting from the most specific (unquestionable 'brand' of an institution, for example the postal code) to the least specific (e.g. College of Engineers and universities, without other precision). In each city, we had to search for discriminating words (or phrases) in the lowest number possible, which would account for the whole of the observed corporate names (with their numerous written forms).

A correlation table established the one-to-one link to an institution, itself represented by an acronym. After application, the MAROC 4 file was obtained, where the references were classified by addresses beginning with a N° (number) of city, and then by a symbol of institution.

The operation was tedious. The advantage being that it was revised quickly on periodical upgrading. The experience showed, for example, that in the span of five years, there were only a small number of new productive institutions (or original written forms for corporate names). If the first coding was done well, we believed it would be strong.

- Extraction of 'laboratories'. By proceeding as in the previous phase, it was possible to identify (in MAROC 4) the laboratories inside the institutions, and to attribute an acronym to them. It was only relevant for very productive and long standing laboratories, and there were not many.

The proceedings of the data begin now.

2.3.3 OUTCOMES

The aim was not to compare with Japan or the US, and that was why we didn't calculate the 'world shares' held by each discipline. To better focus on Morocco's interior phenomena, we presented instead the number of indexed publications, which was more useful at the micro level of cities and institutions). When necessary, we used Africa as a comparison horizon (it offered enough heavyweights to compete with).

For the authors, cities and institutions, we presented 'integer counts' of their 'participations' in scientific creation, which meant that we gave one point for each paper with an address of at least one Moroccan author. Thus, in our counting, a paper co-signed by two Moroccan authors from the same institution would get one point for that institution and one point for each author. Another paper signed by two Moroccan authors belonging this time to two different institutions would get one point for each institution and one for each author.

Another way of counting the contributions (fractional counting) was to give a fraction of a point to each author of a paper in relation to the total number of authors. In the preceding cases, if two foreign authors were added to Moroccan authors, each institution and each Moroccan author would be credited with one-quarter of a point (i.e. two times one-quarter of a point for an institution accommodating two authors). The latter way of counting was 'fairer' but not convenient for us. The aim here was not to evaluate people or institutions but to identify the sites and the capacities. 'Participations' in the writing of papers were their best indicator in each precise field ([9]).

In some cases, we compared the PASCAL outcomes with the SCI ones. This was to check the results (evolution in time of the recorded production) or as a matter of precaution (varying the ways of catching the evolution of the most productive authors). We will see that both databases agreed to a great extent on the main tendencies.

2.3.3.1 Global view

This study was done after another one was carried out under the more general frame of research on 'sciences in Africa' (Waast & Gaillard, 2001). It highlighted the rapid expansion of Moroccan science between 1987 and 1996, against the general trend present on the rest of the continent. The resumption of this study with more details (e.g. precise bibliometry on the scale of the institutions and of the 100 science subfields) confirmed the tendency and specified it (1997–2001). In both cases, we took into account the Moroccan publications recorded on the PASCAL bibliographic database. Sometimes, we confronted this data with SCI data, and both sources converged on the main points.

2.3.3.1.1 The rapid expansion of Moroccan science (1987–1996)

Our first study showed (Figure 1 below) that for the period 1990–1996 there was a powerful expansion of Moroccan scientific publications (the indexed production from 1990 to 1996 doubled from 242 to 510 publications per year in PASCAL, Waast & Rossi, 2001). This rapid expansion was in sharp contrast to the general recorded movement of the African continent. While the two giants (South Africa and Egypt) struggled to maintain their scores and lost positions in the world competition arena, Morocco propelled itself to the first rank of the outsiders, more or less *ex aequo* with Tunisia.

9 The number of indexed papers is not equal to the number of 'Participations'. It is inferior since the same paper could be attributed not to one but to two or more institutions (e.g. authors and cities). In the comparative tables of our cities (or institutions), we presented the number of participations, and gave (as a matter of interest) the total number of the corresponding papers in a summary column.-

At the same time, Nigeria, formerly ranked in third place (in terms of African scientific power) lost half of its contributing capacity to world science, and Kenya progressed but with a lower rhythm than other Maghreb countries. As for other African countries, where research had gone through a deep institutional and professional crisis, despite efforts by some great personalities that managed to preserve some strong points, their global scores were very modest (Arvanitis et al., 2000).

Moroccan progress from 1987 to 1996 is all the more amazing considering there was no articulated national policy to support it. In her monograph on Moroccan science, in 2001 Mina Kleiche highlights the role of strong figures who began the construction of scientific fields and institutions that developed research culture (i.e. IAV, and Rabat and Marrakech universities). She shows the constitution of intellectual circles and the deep-rooting of science in the professions (mostly medical, and sometimes engineering). She takes into account the constant and faithful cooperation maintained by Moroccan researchers with world science, with which the first links were established initially through education (PhD), and then kept going thanks to bilateral cooperation programs (with France mostly and through ups-and-downs with the US).

One also has to consider a decisive factor consisting of the regulation of the academic profession. This was in relation to the requirement to present a substantial piece of research for each change of grade ([10]).

For the following years, 1997–2001, our new study extends the analysis made with the PASCAL database. These were the years when the active and voluntary national research policy was built up. Thus, we were able to compare the outcomes of both periods, and to comment on the differential progress made.

2.3.3.1.2 The increase is confirmed (1997–2001)

The 1997–2001 data confirms an increase in relation to previous years. Following PASCAL, Morocco again doubled its production in this short period (moving from 510 to 1 010 references indexed annually).

Table 1. Evolution of Moroccan scientific production (1996–2001).

Years	1996	1997	1998	1999	2000	2001
No of papers	510	598	948	1 058	958	1 010

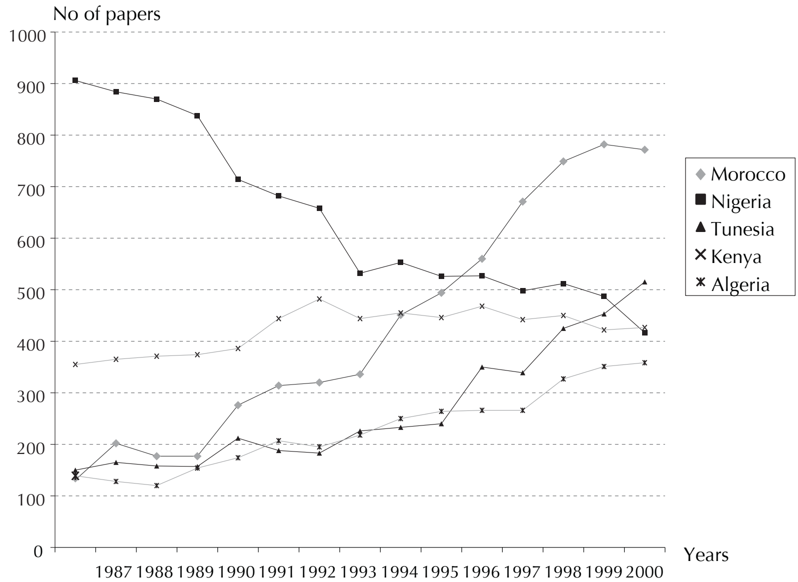
Number of papers per year, recorded in PASCAL database.

In the scientific world, such success is exceptional. Again, this evolution runs against all that could be observed in Africa in this period. The fall in rank for Nigeria as well as Kenya's difficulties, linked to a general science crisis in 'middle Africa', have not subsided (Waast, 2003). Egypt progresses slowly. Tunisia obtained a clear rebound after 1997. However, it is Morocco that shows the strongest progression in Africa during this last decade.

[10] There are several 'theses' to consider (not only the PhD).

From now on, Morocco ranks third as a producer of science on the African continent ([11]). The Science Citation Index, although uncertain in 1996, now confirms this rank beyond a doubt. The trend over a long period is depicted in the following figure. We limited it to the 'pursuing pack' of the two main producers in Africa (South Africa and Egypt, which are not shown here but are unattainable right now.

Figure 1. Evolution of scientific production (1987–2001) in five African countries: Morocco, Tunisia, Nigeria, Kenya, and Algeria



Data: SCI. Processing: PL Rossi.

2.3.3.1.3 A plateau seems to appear (2000–2001)

During these last two years, 2000 and 2001, both PASCAL and SCI databases are in agreement when it comes to recording an inflection of Moroccan growth. This 'pause' is represented in Figure 2. The new trend conveys conflicting tendencies for both a continuing of this momentum and deep reorganisation. We shall analyse it next. We interpret this break not as a sign of exhaustion but as a consequence of several other tendencies; for example, diversification of sites, interest in new specialities, arrival of new generations, restructuring, and the need for a new professionalisation.

First, we will examine the strong points and the most successful domains of Moroccan science.

[11] Behind South Africa and Egypt, which are beyond reach right now. However, the three associated Maghreb countries come close to the Egyptian capacity (from now on).

Figure 2. Break of the Moroccan growth (1997-2001): comparative data of ISI (Institute for Scientific Information) and PASCAL

Data: SCI & PASCAL. Processing: P.L. Rossi.

2.3.3.2 Domains of Moroccan science: from foundations to diversification

We arrive here to a detailed bibliometry, developed especially for the evaluation of the Moroccan research system. We will investigate the specialities and the strong points of the country by examining its achievements in about 100 subfields.

This is what the PASCAL database makes possible by attributing to each reviewed paper a very detailed code (sometimes several) describing its topic.

2.3.3.2.1 From the origins: solid foundations in basic sciences (1987–1996)

In PASCAL (Waast & Rossi, 2001), we surveyed the domains where research efforts were concentrated during the studied period; those where Morocco gained a remarkable share of the African production, and those which can qualify as its strong and weak points (a ratio of the position gained in Africa to the efforts invested).

In terms of research efforts, the distribution comes close to that prevalent in the rest of the world. The basic and engineering sciences account for 50 % of the production, the medical sciences 40 %, and the agricultural sciences around 10 %. The profile differs from that of the rest of Africa (except South Africa) where agricultural and medical sciences are better represented).

Table 2. Main domains of Moroccan production (1987–1996)

% of indexed papers	Agriculture	Medical Sc.	Basic Sciences	Engineering Sc.
Morocco (1987–1996)	**12 %**	**38 %**	**40 %**	**10 %**
North Africa	9 %	29 %	42 %	20 %
Rep. of South Africa	8 %	36 %	39 %	17 %
Other Anglophone Af.	21 %	48 %	21 %	10 %
Other Francophone Af.	15 %	63 %	19 %	3 %
Africa	**12 %**	**39 %**	**37 %**	**12 %**

NB: The social sciences are excluded from the analysis.
Data: PASCAL (1987–1996). Processing: R. Arvanitis.

The basic sciences include a significant part of mathematics ([12]). The rest is shared in more or less equal parts between physics, chemistry, geosciences and fundamental biology. The medical sciences include relatively few basic biology papers.

For the record, in this period the other countries of north Africa offer similar profiles but with nuances. Egypt shows a considerable concentration of research in chemistry as well as in engineering sciences, where it excels and holds first place ranking on the continent. Algeria's strong point is physics (and it enjoys a rather good position in several engineering sciences and to a lesser extent in chemistry). Tunisia ranks among the main African countries for mathematics, and to a lesser extent for basic sciences and clinical research.

Some interesting features appear when we analyse the subfields where Morocco distinguishes itself. Table 3 summarises the domains where efforts are concentrated, and where these efforts count for a significant part of African production ([13]).

The major characteristic is that the effort is concentrated on the basic sciences, and more precisely on its basic subfields (e.g. botany, basic geology, general physics and chemistry, and mathematics). Outstanding successes and strong points are related to these 'fundamental' subfields (even when they are not the object of an exceptional concentration of papers, e.g. zoology, oceanography, marine biology, and all branches of mathematics).

In other domains that are less institutionalised, the situation depends more on the whims of fortune. In the medical sciences, great successes (e.g. neurology and radiology) are organised around key personalities. In the agricultural sciences, animal pathology became

[12] Four percent of all Moroccan references equates to more than we can observe in most of the world, and twice as much as in the rest of Africa (south of the Sahara).

[13] 'Strong points' are in fact specialisation indicators; Morocco's share in African production (in a specific subfield) as compared to its share in the corresponding domain (e.g. agriculture, and medical sciences).

a notable speciality early on ([14]). In the engineering sciences, the good outcomes in materials science and metallurgy render strength in physical chemistry and crystallography. The favourable position of civil and nuclear engineering results from the dynamism of a specific institution in charge of them.

Table 3. Focus and strong points of Moroccan science (1987–1996)

Main fields	Focus	Strong points	Weak points
Agriculture & Biology (non-medical)	Animal Science Agronomy Plant science	**Animal Pathology** Marine Biology & Zoology	
Clinical Medicine	Internal medicine **Neuropathology** **Radiology**	Cardiology **Neuropathology** Radiology Nuclear medicine	Public Health Infectious Diseases
Medical biology	Microbiology Physiology		
Geo-sciences	Geology Geophysics Oceanography	Geology	
Physics	General Physics **Nuclear Physics** Solid State **Acoustics**	**General Physics**	
Chemistry	General Chemistry Physical Chemistry	**General Chemistry** **Physical Chemistry** Medical chemistry Pharmacy	
Mathematics	All subfields	**All subfields**	
Engineering	Metallurgy Materials science Electronics	**Metallurgy** Materials Science Nuclear Engineering Civil Engineering	Mechanical Eng. Computer Science

Data: PASCAL. Processing: Waast & Rossi (2001).

Note: focus is linked to concentration = subfields in Morocco that concentrate more than 15 % of the production in the main field to which they belong. Items have been highlighted in the table when these are a particularity in Africa.

Strong points: Moroccan share of the African production in this subfield is at least two times superior to the usual share of Morocco in all the subfields. This indicator is built up taking into account the concentration of the efforts (both Moroccan and African).

At this point in time, Moroccan science is at the same time strong and 'incomplete'. This is neither surprising nor worrying. With limited strengths and means, it is natural that some choices have to be made. The important thing is that in the beginning a strong basic capacity is built, which will be capable of developing later into a variety of precise

[14] Agronomy has a recognised value but is not higher than that of other very specialised African countries (i.e. Nigeria, Ghana and Egypt) or very powerful African countries (South Africa).

specialisations. Our 1997–2001 study makes an attempt to prove such an outcome, thanks to a very detailed coding of the subfields.

2.3.3.2.2 Growth and diversification: 1997–2001

Earlier in the report, we pointed out that scientific growth in Morocco progressed during this period. It is noteworthy to analyse the components of this growth.

- ***Growth is based on previously set strong basic competencies***

Between 1991 and 1996 and beyond, Morocco achieved a solid third ranking in Africa for mathematics, physics and basic chemistry. In general chemistry, it ranked above South Africa, and above Egypt in physics of particles; in these subfields (and in general mathematics) it ranked second in Africa.

We have shown other areas in which the difference with the two 'big' African countries is not considerable. For example, this is the case for earth sciences (geology) and for some engineering sciences (e.g. materials and metallurgy).

The 1997–2001 outcomes show that this foundation is strong. Mathematics is increasing its results and general physics and basic chemistry are progressing. The earth sciences remain stable, and general geology shows consistently good outcomes. In biology, progress is small; this concerns basic biology as well as its applications. Nevertheless, they are supported by strong points in the past (e.g. zoology and animal physiology, which have jumped again), with some new developments (e.g. now in the plant domain) ([15]). The number of authors recorded is increasing strongly, more so in applied fields than in basic research.

Table 4. Number of papers' signatures per main discipline — basic and applied sciences — Morocco (1991–1996 and 1997–2001)

	Fundamental		Applied	
Disciplines	**1991–1996**	**1997–2001**	**1991–1996**	**1997–2001**
Mathematics	88	149	21	107
Physics	350	638	104	441
Chemistry	88	159	14	85
Engineering Sc.			359	778
Biology non-med.	180	192	299	658
(of which Agric.)			259	493
Geo-Sc.	256	238	243	292
(of which Geology)	103	123	180	191
TOTAL	**962**	**1 376**	**1 040**	**2 361**

Data: PASCAL. Processing: PL Rossi.

[15] The capacity in regard to molecular biology and biochemistry needs confirmation.

- ***The capacities become differentiated***

From the core knowledge base, a second strong force developed during the years 1997–2001. The choice of research topics evolved. Acoustics is now applied to marine studies, algebra to epidemiology, fluid mechanics to pollution problems, and metallurgy is interested in linking with agriculture (corrosion). New specialities are developing. The communication and information technologies are progressing (in Rabat, Fez and Casablanca). In physics, subdisciplines are taking off (e.g. semi-conductors and supra-conductivity). The biotechnology capacities (mostly related to agriculture) have some important quarters (Marrakech is the main one). The domains of water, pollution and energy engineering (with a variety of disciplines involved) show a particularly notable expansion (see table below — 'progress' in the different subfields and main laboratories involved).

Albeit with fewer details, SCI confirms these tendencies. In a study just published (OST, 2006), through this database the French Science and Technology Observer examines the evolution of Moroccan performances in 36 subdomains. It notes a jump in the world's share of publications (globally multiplied by 2) during the period from 1996 to 2001, especially in basic physics and mathematics (multiplied by 2.5) and to a lesser degree in chemistry (+70 %).

Above all, this growth is evident in the applied research domains:

- optics-electronics-signal (x 3);
- ecology-environment (x 2.5);
- computer science (x 2.5);
- applied physics, chemical engineering, and materials-metallurgy (x 2).

According to SCI data, Moroccan papers that have the strongest 'impact' in the world belong to the engineering sciences (e.g. materials sciences, plant science and agronomy, and applied physics). Next, come mathematics, geology and ecology-environment, physics and medical chemistry.

These outcomes confirm the recent differentiation of Moroccan science. Fundamental research is not abandoned. Instead, it nourishes higher education, whose quality remains undisputed. On this foundation, applied subfields are being built up with great success ([16]).

2.3.3.3 Redeployment of the production sites

The deployment of new topics is based on the restructuring of institutions and sites where the papers are produced. This is what precise bibliometry reveals.

[16] The European experts who visited the laboratories underline this point.

2.3.3.3.1 Production sites become more diverse

A new element appears with the powerful growth of universities in provincial cities. Meknes and Agadir are an example, and even more so Fez, El Jadida and Kenitra. They are the cities where research production has grown most (multiplied by three or more). Next (multiplied by two or three), are Oujda and new sciences and technology faculty sites (i.e. Errachidia, Mohammadia and Settat). The cities with great scientific tradition progress in a limited way (i.e. Casablanca and Marrakech) or almost imperceptibly (Rabat).

Table 5. Number of articles (integer count) per city (1991–1996 and 1997–2001)

No of signatures	Agadir	Casa	Fez	Jadida	Kenitra	Makch	Meknes	Oujda	Rabat	Tet., Tang	Misc.	No of Articles	No of Particip.
1991–1996	76	204	95	59	61	394	90	64	836	60	61	1 530	2 002
1997–2001	225	406	347	225	232	642	278	155	954	115	158	2 972	3 737
Multipliying Factor	3	2	3.7	3.8	3.8	1.6	3	2.4	1.1	1.9	2.6	1.9	1.9

Data: PASCAL. Processing: PL Rossi.

Table 6. Main provincial new sites and laboratories in Morocco (some subfields: 1997–2001)

Total Morocco	Subfields/Cities	Agadir	Fez	Jadida	Kenitra	Meknès	Oujda	Tet. Tang.	Misc.
121	General Math.		8	5	8	6	10***	3	12
75	Physics (instruments & theory)	6	4	5	2	1	10***	3	1
40	Optics, acoustics magnetism	17 LIM*	3	8		1	2		2
199	Crystallography	1	16***	20 PCM**	18 lpmc***	15***	4	7	7
102	Solid state (mecan & thermic properties)	13	4	2	12	20*	1	1	2
58	Semiconductors	2	23 LPS*	3		5	11**		3
19	Supraconductors	10*	1	4		3			1
202	Solid state (electro. & magnet. properties)	15 LPS**	32 lcp*	10 lmc	5	28*		1	6
80	Spectroscopy	14*	9	3	4	4	1	1	2
111	Materials Sc.	13 LTM**	9	4	13	6	5		1
74	Chemistry (theory, phases & catalysis)	9	2	12 cpc & cca**	1	8	1	2	1
43	Electrochem., Induction	10 lcp**		1	6	3		2	2

Total Morocco	Subfields/Cities	Agadir	Fez	Jadida	Kenitra	Meknès	Oujda	Tet. Tang.	Misc.
70	Physical Chem. (surface & colloids)	1	14 EST**	7	5	5	3	7	8
30	Mineral Chem.	1	9 LCM**	2		2	1		4
28	Software	1	7**			1	4	1	2
78	Automation		11 lessi**	5	1	2	5	1	1
60	Electronics		6	9	2	4	3	4	8 Erchd**
34	Telecom.		12 lessi**	1	1	5	3	1	
119	Chem. Engin.	5	11**	1	15*	10**	9	10	5
93	Metallurgy	9 LTM*	2	8	9	5	9	2	1
183	Pollution, Decontamination	6	20**	10	15**	8	1	3	8
101	Hydrology		3	3	10**	2	4	3	1
82	Soil Sc.	1	5	11**	6	6	3	2	2
86	Food Industry	2	1	5	7***	6	5		3
67	Ecology	2	14**	3	3	1	6	3	
37	Botany, Plant Physiology	4	1	1	2	2		4	1
72	Zoology, Animal Physio	1	10**	7	4	4	1	1	3
68	Geochemistry		2	5	10**	4	2	1	3
351	Geology	18***	18***	11	11	27***	24***	15	4

Data: PASCAL. Processing: PL Rossi.
*Key: * site ranking first at national level, ** ranking second, and *** ranking third.*
Figures in the boxes are for the number of papers in the period. Abbreviations in the boxes are acronyms of the main laboratories.

Growth in the provinces is evidenced in defined specialities, as shown in Table 6. This table has been extracted from the full table identifying the main sites and laboratories of the country. Casablanca, Marrakech and Rabat (ancient academic centres) were excluded from Table 6. Up to now, they have claimed first ranking in many subfields. Nevertheless, in a certain number of specialities, other cities are (from now on) equal to them or even better; they became sites ranked in first or second position at national level.

At the level of Rabat and Casablanca, Meknes stands out in solid state physics. Fez has specialised with success in semiconductors. Surprisingly, Fez is also leads the way in computer science, automation and telecommunications ([17]). Without feigning to be at first place, Oujda appears in a good position in a variety of branches in physics and mathematics. Jadida became the second main national site for crystallography, an important subfield in which Morocco excels ([18]), and one of the main sites for all kinds of sea sciences. Kenitra developed a major multidisciplinary 'water' centre of excellence, with contributions in all sorts of geosciences, agricultural sciences, and physics and mathematics.

[17] Thanks to LESSI laboratory through the unexpected institution, Ecole de Sciences et Techniques (EST); in theory devoted to basic technological training.

[18] The first site is in Rabat and Marrakech (*ex aequo*).

2.3.3.3.2 Hearths of institutional dynamic are moving

The unequal progression of the cities is explained (in part) by the fluctuating dynamism of institutions that the cities contain.

- ***The withdrawal of well-established institutions***

At this level, the main surprise comes from the apparent withdrawal of some prestigious institutions (Table 7). This is the case for some 'colleges' (*écoles*) of established reputation ([19]).

At the Ecole Normale Supérieure de Takkadoum (Teachers training College, Rabat) the decrease affects mainly physics and the engineering sciences, while chemistry and mathematics keep constant. The Institut Agronomique et Vétérinaire Hassan II (Hassan II Agronomic and Veterinary Institute: IAV)) remains the first or second national site for research related to the food industry, farming methods, plant protection, soil science and veterinary medicine. New research is developing around environment protection and medicinal plants. Nevertheless, a decline (in the number of publications and the national ranking) is becoming evident in several domains (i.e. basic biology, agronomy, and even biotechnology, of which the IAV was a pioneer).

An interpretation of these special cases remains to be dealt with. Are the mission and vocation shifts of the *écoles normales* the reasons for their change ([20])? Is IAV drifting towards consultancy and development research, which makes results less fit for publishing? Experts could answer these questions. For us, what we are doing here is to measure the evolution, with a database whose method and sources do not vary.

- ***The unequal progress of the universities***

At the same time, it is worth noting that those universities that have a great science tradition progress more slowly than the newer ones. Rabat remains stable in chemistry and mathematics, and declines in biology and earth sciences. Marrakech and Casablanca are decreasing in the engineering sciences.

In a number of subfields, these institutions definitely remain active centres of production and even major ones ([21]). Besides, they have already high publication scores, which cannot progress at the same quick pace as they did in the beginning.

However, we must pay attention to these changes seen for the first time. They occurred in the recent 'break' of Moroccan growth (furthermore, they concern important producers).

[19] In Morocco (as in France and in India (see IITs), and even the US (see Caltech, M.I.T.)) some elitist institutions, often outside the university, are in charge of training selected students to become engineers or highly skilled civil servants, managers or professors. They are called *écoles* (schools or colleges), a concept difficult to translate.

[20] For a long time, this *école* had the mission to train the best professors for the country's high schools (a number of them became professors at universities or directors of establishments). This mission is now fading (given that there is a sufficient number of trained people), and several key figures of this *école* have left to join universities.

[21] Marrakech, for example, did a big leap in agricultural sciences and biotechnology. This university remains one of the national major centres dealing with water and environment issues (with Kénitra), and one of the main centres of the country's agricultural sciences and natural substances chemistry. It is also the 'capital' of mathematics. Rabat maintains a high rank in this discipline. This university also shows visible progress in physics, engineering sciences, and (above all) in biology for agriculture applications. Let's not forget Casablanca, which has a good position, most notably in physics and chemistry.

Table 7. Main progress during the decade, per sites and fields: comparison of the articles produced from 1991 to 1996 and from 1997 to 2001

	Math.	Phys.	Chem.	Engin.	Agric.	Water, Vet-erin.	Biol-ogy	Geo. Sc.	Clinical Med.	Med. Bio. & Chem.
école misc.	9 1	27 5	19 3	48 12	20 9	23 20	5 4	11 10		
école EMI	8 1	19 14	7 4	33 6	6 0	39 31	2 0	3 0		
école ENS	17 14	**45 72**	10 10	**27 49**	2 1	12 10	1 3	**5 20**		
école IAV	0 1	0	0	25 26	**42 58**	18 18	**11 47**	15 3		
Gov. Cent. INRA	0	0	0	0	41 31	4 1	3 0	0		
Gov. Cent. misc.	4 0	1 0	1 0	10 2	14 9	11 4	17 7	31 12	50 22	34 08
Gov. Cent. LPEE	0	0	0	3 1	1	8 4	2	18 10		
Offices & Hosp.	0	0	0	11 3	9 2	31 16	7 2	34 19	63 04	64 44
Recap Outside Univ.	38 17	93 91	37 17	157 99	135 110	146 104	49 63	117 74		
Recap Univ.	218									
Univ. Rabat	33 30	177104	20 13	81 45	42 11	18 17	**22 27**	**45 55**	771 317	244196
Univ. Casa	23 17	144 79	20 9	46 58	13 1	18 10	24 15	24 10	590 408	**237305**
Univ. Marrakech	69 38	133 70	29 23	97107	73 25	45 35	61 48	81 96		14 0
Univ. Agadir	1 4	98 27	24 8	24 10	20 8	10 3	10 9	26 7		5 0
Univ. Fez	20 2	83 27	26 5	59 7	9 6	12 15	27 8	22 25		
Univ. Jadida	7 4	75 12	22 8	34 11	24 10	14 8	17 4	18 12		
Univ. Kenitra	13 1	63 9	13 5	38 13	19 17	26 8	10 5	25 14		
Univ. Meknes	9 2	93 19	19 15	35 3	21 8	12 6	11 9	32 20		
Univ. Oujda	14 2	40 3	8 3	34 7	4 2	5 4	11 21	31 24		
Univ. Tetou-Tangr	8 9	27 7	11 7	29 7	4 2	6 0	10 9	19 6		
Univ. misc.	21 2	45 7	20 3	31 7	13 2	10 0	11 1	6		

Data: PASCAL. Processing: PL Rossi.
Key: ■ *= very quick progress,* ■ *= quick progress,* ■ *= appreciable progress, and* **bold** *= retreat.*

In each box: figure on the left = score for the period from 1997 to 2001, and figure on the right = score for the period from 1991 to 1996.

■ *The new dynamics of several* écoles *and government institutes*

In contrast, several *écoles* show significant dynamics. First among them is the Ecole Mohammedia des Ingénieurs (EMI Engineering School), which shows significant progress in mathematics, computer science and telecommunication, and some other engineering sciences. Others include the College for Computer Science in Rabat (ENSIAS), the College for Agricultural Engineering (Ecole Nationale d'Agriculture de Meknès), and the Ecole des Mines de Rabat (School for Mining Engineering: ENIM, where a research team managed to mobilise an international consortium and to carry through several sheets of the geological map of the country). Finally, one of the most famous research *écoles* is by now the Mail and Telecommunication Institute (Institut National des Postes et Télécommunications (INPT)), which recently took the lead in its domain ([22]).

We must not forget various government institutes, centres and services that have sometimes earned a good reputation in specific subfields; especially in agriculture, earth sciences and particular types of engineering. These include CNESTEN for nuclear engineering, LPEE for water and soil, and INRA, which is in charge of plant improvement (with exceptional expertise in dry areas). They are often modest producers of 'certified' science (i.e. published in renowned journals) but have developed strong competencies, which are recognised by applied science users and have been published in professional media outlets.

The strong growth of young universities

Nevertheless, it is obvious that the youngest universities show the strongest growth. Fez is a good example, having made a great leap forward in mathematics and in the new technologies (e.g. information, communication, and signal processing), in physical chemistry and even biotechnology. Agadir has developed important skills in the agriculture field but also strong specialities in acoustics, supra-conductivity, electrochemistry and metallurgy. Jadida and Meknès have multiplied their skills in different areas of physics. Jadida is also the new academic centre of activity for the marine sciences. Kénitra shows a genuine research strategy (multidisciplinary in regard to water issues). Oujda stands out in mathematics and semi-conductors area.

It is important to point out that the Faculties of Science and Technology (Facultés de Sciences et Techniques) in Casablanca, Tanger, Fez, Settat, Errachidia, Beni Slimane and Mohammadia, which are designed for shorter and applied training, are part of this challenge. In fact, at these faculties academics often display greater initiative and a strong will to have their work published. The same is also true for some technology institutes (*écoles supérieures de technologie*), such as the one located in Fez, which ranks among the national leaders in several subfields — notably in signal processing.

This quick listing falls short of providing fair recognition to the explosion of research and innovation that can be seen in the young universities. These universities often owe their dynamism to good governance. Their vibrant interest in research is also based on professional norms. In several places, one can meet young researchers who left the metropolis hoping for more freedom. They do not have any other ambition but to succeed in research and conform to its standards ([23]). Even though they do not make up the bulk of the academics, they are numerous enough in each faculty to organise into 'communities' and promote their activities, provided the head of the institution offers them support.

To conclude, *the scientific geography of the country is much more dispersed* than it was in the past. This is true for each discipline and every field. This has encouraged imagination to foster new research topics. But, conversely, new problems are evident: critical mass in the subfields, coordination between several sites, and sharing large equipment through effective organisation.

[22] According to the experts, ENSIAS remains mainly a good place for training. This *école* has some excellent researchers but does not really support them. Institut National des Postes et Télécommunications (INPT) also has a very good training program, but research there is much in favour. It contributes strongly to the international reputation of this *école*, where more than one-third of the graduates are recruited by foreign companies before they finish.

[23] Maybe they have less opportunity (or desire) than in the capital and the big metropolis for consultancy or in accessing advisory and top jobs in the important public organisations. They take more pride practicing their job with professionalism.

2.3.3.4 From the pioneer stage to the professionalisation age

When the professionalisation of science is in its beginnings, special attention should be paid to people. Scientific activity remains an individual choice, a vocation, even though later institutions begin to be established ([24]). As a consequence, we moved the bibliometric survey forward to a detailed analysis of the authors. The outcomes suggest that the turbulences that Moroccan research is experiencing stem in part from the reorganisation of the scientific community.

2.3.3.4.1 A generation of authors passes the torch

We know that scientific production (in Morocco, as is the case everywhere) is very concentrated. More than half of the authors located through the databases signed only one paper in four or five years, and many of them will not produce more (they will turn to another trade).

In contrast, 5 % of the authors are accountable for 15 % to 20 % of the participation in papers, whereas 15 % of the authors are accountable for 35 % to 60 %. These 'highly publishing authors' are not only the main carriers of scientific knowledge, they are also the great 'disseminators'. They pass on their knowledge to their students and disciples, who can adapt it to 'clients' or update it through international cooperation projects and competition.

These key authors play an important role. They are often charismatic personalities, and the transition to a more organised practice (performed by more people) can be delicate. These pioneers founded specialist circles. They have served as guides for young researchers. They have printed a 'brand' onto the discipline (e.g. selection of the 'interesting' issues, methods for treating them, and curiosity or otherwise for their applications). The professional norms (i.e. ethos, standards, and the competition area) often follow this 'brand'.

In Morocco today, it seems that the first generation of these keen scientists is ready to pass on their place to newer ones. We can see this by comparing a variety of lists. The first list is the one with the most productive authors between the years 1991 and 1996, identified through PASCAL. We will see whether they remain major contributors in forthcoming years (in PASCAL: 1997–2001). Another comparison was made in selecting the authors marked out as highly productive during a longer period through the SCI database, and by determining how they behave today.

It is not easy to synthesise this very personalised data. Let's first look at what could be called 'retreats' from research.

[24] In Morocco recently, the new Secretariat d'Etat à la Recherche (and Ministère Délégué) carried out intense legislative work to organise and promote research activity in the country.

2.3.3.4.2 Retreats from research

We identified the 'great publishing authors' designated by the SCI (at least 15 publications indexed by the database during 15 years). Then, we examined the evolution of their publications in five-year intervals in PASCAL (which knows too these authors). We can distinguish four profiles: constancy, production increase, 'progressive retreat', and 'radical retreat'.

The progressive retreat concerns 10 authors with impressive scores (from 40 to 95 papers indexed by SCI). Their activity has been decreasing by around half every five years since 1990. We can presume that, as their time and energy was taken up by other tasks, they have withdrawn progressively and irreversibly. This withdrawal signals a normal pattern; with increase in age and career advancement, the researchers gradually move further away from direct production. Even though they remain good advisors and useful mediators, there must be replacement forces in their team (i.e. field and establishment).

Seven of these researchers belong to the Mohamed V University (Rabat), all of them in solid state physics. In this discipline, we can say that the 'Rabat School' is beginning a delicate transition. Two other researchers are from Marrakech, and the other is from Casablanca.

The radical retreat concerns 35 authors identified by SCI who, for the last five years, no longer appear as active in research (PASCAL data). Twenty of them are also from Rabat. This reveals both the antiquity of the research tradition in this university, and also the important withdrawal of significant personalities, which the university will have to face.

Although not signaled by the SCI database, we added seven other authors identified by the PASCAL database. They were very active between 1991 and 1996, and then disappeared between 1997 and 2001. They belong mainly to IAV and ENS Rabat: two *écoles*, as we have shown, with decreasing production numbers in many domains. Maybe this was caused by professional changes (e.g. more consultancy, new positions as managers or a change in their trade). Such a phenomenon would not be disturbing (on the contrary, it allows for a transfer of expertise) wouldn't it systematically hit these institutions, where the replacement of researchers is not certain. It highlights all the more how important it is to find incentives in order to keep working amongst the best.

All of these retreats correspond to a deficit of capable advisors, broken down as in the following table.

Table 8. Deficit of advisors linked to the withdrawal of 'great publishing authors', per city (1997–2001)

	Agadir	Casa	Fez	Jadida	Kenitra	Makch	Meknes	Oujda	Rabat	Tet.Tang.	Misc.	Total
Radical withdrawal		1	3	1		8	1	2	26			42
Progressive withdrawal		1				2			7			10
Deficit advisors		2	3	1		10	1	2	33			52

Data: PASCAL. Processing: R Waast.

2.3.3.4.3 What about the replacement?

Fortunately, all the great publishing authors have not moved away yet. As proof of their research vocation, a good many persist in their activity. Thirty authors identified by SCI are in this category. They maintain their production at a high level.

Besides, it is possible to identify 'new great starting authors'. Observed in SCI over a 15-year period, their scores are more modest than those of their predecessors. But they are in the early period of their careers. They stand out because they show regular increase in their production (observed in PASCAL in the last 5 to 10 years). We count 43 authors in this category.

These authors are almost all located in the provincial universities, and the advancement of their institutions correlate with their specialities. The outcomes are summarised in the following table.

Table 9. Geographic redistribution of capable advisors (great authors), from 1997 to 2001

	Agadir	Casa	Fez	Jadida	Kenitr	Mkch	Mkns	Oujda	Rabat	Tet.Tang.	Misc.	Total
Persisting great authors	1	5	1		2	6	1	2	12			30
New starting great authors	4	3	7	3	3	11	5	2	3	1	1	43
(among which are highly growing numbers of producers)	3	1	2	2	1	5	5	2	0			21
Total great advisors	5	8	8	3	5	17	6	4	15	1	1	73

Data: PASCAL. Processing: R. Waast.

Finally, we tried to outline the whole of this replacement phenomenon. We looked for authors whose average production was 1 publication per year during the last 5 years (PASCAL database); although they appear neither in PASCAL for the previous years (1991–1996) nor in SCI in the last 15 years. In this category, belong 175 new authors. This is the expected replacement, broken down per city, as in the following table.

Table 10. Starting authors, per city (1997–2001)

	Agadir	Casa	Fez	Jadida	Kenitra	Mkch	Meknes	Oujda	Rabat	Tet.Tang.	Misc.	Total
Starting authors	23	20	15	12	8	29	9	5	46	3	5	175

Data: PASCAL. Processing: R. Waast.

To recapitulate, we can draw on the ensuing table.

Table 11. Evolution of human resources, per city (1997–2001)

	Agadir	Casa	Fez	Jadida	Kenitr	Mkch	Mkns	Oujda	Rabat	Tet.Tang.	Misc.	Total
Withdrawals		2	3	1		10	1	2	33			52
Great advisors	5	8	8	3	5	17	6	4	15	1	1	73
Starting authors	23	20	15	12	8	29	9	5	46	3	5	175

Data: PASCAL. Processing: R. Waast.

One can infer that the generation transition will certainly be delicate in Rabat, where 'historical' advisors are withdrawing but few new great authors are showing. In contrast, the young provincial universities benefit in the way of the most promising offer of human resources (and thus have a noticeable growth potential).

Marrakech University has to be added to them because it gives rise to a great number of starting authors. This is a result of its continued support to research. It is in this way that the university can hope to solve the difficulties in passing on the torch.

In fact, some universities are more attractive than others (or favour research more). Another point to be stressed is that the small universities are fragile when the torch has to be passed on in specific fields. For the production there is based on a small number of key figures ([25]).

2.3.3.4.4 Autonomisation of the scientific community

The increase in numbers of regular authors shows a process of professionalisation. This implies the spread of norms and standards, by listening to great advisors, sometimes training abroad, and taking part in international programmes.

The Moroccan scientific circles far from depend on their relations with foreign colleagues. Upon reviewing of the papers' co-signatures, there appears the existence of extended intra-Moroccan networks. The publication strategies are instructive. According to the bibliographic database ISI, the authors co-publish considerably with foreigners. However, this database has a kind of myopia vis-à-vis the local media. The PASCAL database finds different results. In French-speaking journals, and especially in the Moroccan or regional journals (when they exist), the national researchers publish on their own. They publish in Arabic too (to a lesser degree but specialised media are rare). To introduce themselves to other linguistic regions, they activate their international networks: evidence of their good connections.

The morphology of these diverse networks (national and international) has to be turned into an inventory. Bibliometrics could be helpful.

[25] Oujda and Tetouan are in this case.

However, it must be admitted that (if there is a desire for it) there is a long way to go for the forging of national communities based on discipline. Certainly, local relations become dense, the associations in each domain are numerous, and with small subsidies they manage to organise congresses regularly on current topics, publish the proceedings, and sometimes maintain a journal. But the research work of each individual often depends on foreign financing and facilities (e.g. documentation, equipment, and information on international programmes). Personal relationships in foreign countries often take precedence over the relationships inside and between local teams. The experts who visited the laboratories insisted on the idea of staying just a subcontractor. Obviously, the researchers have to elaborate autonomous and heuristic research strategies, and the community has to show enough cohesion to promote them. But this question of relevance is beyond the limits of a bibliometric analysis.

2.3.3.5 The special case of the medical sciences

The situation in medicine differs from the one prevailing in other disciplines.

- ***The volume of publications is argued about***

SCI credits the medical sciences with 20 % of the total science production in Morocco. This database accounts for only about 20 authors with significant scores over 15 years (against 120 names for the total of all the other sciences). In contrast, over the last 5 years PASCAL records only around 140 'great publishing authors' and a considerable production (40 % of the indexed references).

This difference reflects a specificity in this domain. The Moroccan researchers in the medical sciences have several expression forums and diverse publication strategies. These can be international but they willingly focus on their own neighbourhood (i.e. Europe, the region, the country). They find possibilities to express themselves in a variety of French-speaking journals, dealing mainly with conveying clinical knowledge to the practitioners. PASCAL reviews them and SCI does not ([26]).

We've used both databases. Despite the difference in methods, both agree on the main points.

- ***Strong points and weak points***

The strong points, highlighted from both databases, are the same. Previously, we accounted for them using PASCAL. In the table below are the outcomes suggested by SCI (1991–1996).

The great successes focus on particular specialities, often sophisticated, and organise themselves around key figures. Some of them have very thoughtful strategies on the choice of subject. This is the feature of pioneering science that owes a lot to its founders.

[26] The medical circles have a marked preoccupation for recording each little item of research, and each reflection about practice. One can find everywhere (including Morocco) many scholarly societies set up per discipline. These societies organise congresses and workshops whose proceedings are published. Two journals of continuous training are published in Maghreb, which include many Moroccan papers. Other such papers are published in equivalent French journals). SCI does not review them (mainly because they are not English-speaking). PASCAL reviews a lot of them. These remarks are true, above all, for clinical research; here, researchers are also professors and heads of hospital service, and they have a special respected status. Medical biologists are less highlighted. Their papers have to be submitted in the international competition arena because they don't have media for publishing their works locally.

Table 12. Strong points in medical sciences (1991–1996)

	Clinical Med.	Neuro.	Radio.	Cardio.	Nephro.	Bio-med.	Bio Phy.	Cyto-Histo.	Pharmaco.
Morocco's share in African production (%)	2	15.9	13.5	6.6	4.5	3	10.0	6.0	4.4
Rank in Africa	10th	2th	3rd	4th	4th	8th	3rd	3rd	5th

Data: SCI. Processing: Narvaez.

It is possible to do the reverse, and wonder about the fields of 'under specialisation'. The next table shows the main outcomes.

Table 13. Fields of Moroccan under specialisation (medical sciences, 1991–1996)

	Clinical Med.	Infectious Diseases	Haemato.	Surgery	Internal Med.	Immuno.	Public Health	Bio-med.	Parasito.
Morocco's share in African production (%)	2	0.2	0.3	0.3	0.5	1.6	0.6	3	2.6
Rank in Africa	10th	14th	14th	12th	13th	15th	15th	8th	9th

Data: SCI. Processing: Narvaez.

In comparing with the rest of Africa, we can understand that relatively less research deals with non-prevailing diseases (e.g. tropical medicine and parasitology). However, we can be surprised by the 'deficit' in publications on the topic of public health.

Haematology (more developed in the rest of North Africa) shows poorly. We notice that commonplace areas of specialisation do not necessarily produce most of the papers: surgery and internal medicine pay little attention to research.

The evolutions

Using the PASCAL database, we analysed the evolution of the production between the start (1991–1996) and the end (1997–2001) of the decade. The main results are detailed below.

- The growth in volume is significant; PASCAL records a 60 % increase of papers during the period.
- Production is still concentrated in Rabat and Casablanca (90 %). Regarding research, the young faculties at Fez and Marrakech have not yet grown significantly.

- Universities (including faculties and university hospitals) produce the bulk of research (75 % of the total). Its score increases by 40 % in Casablanca and 80 % in Rabat.

- The specialised institutes either stay fair (e.g. Pasteur in Casablanca) or progress (e.g. Institut National d'Hygiène (National Institute of Hygiene in Rabat)) in strategic domains but keeping modest scores (i.e. 10 % for medical biology, 5 % for public health, 2 % for clinical research). The military hospitals are active, mainly in some specialities (e.g. infectious diseases, trauma units, neurology, ophthalmology and pharmacology).

- Finally, we can see an increase in the research performed by health centres (as well as associations and foundations) that develop creative niches (e.g. sexually transmitted diseases, nutrition, occupational medicine, and public health).

- Quality fields have been confirmed. Cardiology and neuropathology show a strong dynamism (score multiplied by two). Pharmacochemistry appears as a new speciality (it multiplied its publications by four). According to SCI, the impact of biomedicine work doubled between 1996 and 2001 ([27]).

- Passing of the torch to a new generation is not yet on the agenda.

We applied our methodology to the medical sciences, comparing author lists from period to period. The result is as follows.

Table 14. Balance of human resources per medical speciality (1997–2001)

Morocco	Surg.	Gyneco.	Pediat.	Cardio.	Neuro.	OphtORL	HGE	Uro.	Endo+	Lab.	Misc.	Total
Great withdrawals	4	1	3	4	1	1	4	1	4	1	15	39
Great persisting	12	2	1	4	2	6	4	4		6	1	42
Great starting	17	15	8	3	3	12	16	9	7	6	1	+97
Balance Great advisors	+13	+14	+5	-1	+2	+11	+12	+8	+3	+5	-14	+58
New starting authors	19	25	13	11	13	15	9	7	7	18	13	150

Data: SCI & PASCAL. Processing: R. Waast.

Key: Surg. = surgery and anaesthesia; HGE = hepato-gastro-enterology; Endo+ = endocrinology, metabolic diseases, haematology, and oncology; Lab. = laboratory, medical biology, pharmacology-toxicology, and medical imaging; and Misc. = other clinical specialties.

On the whole, the arrival of new authors (that include a significant number of highly publishing ones) makes withdrawals from research easier to deal with. The strong domains ensure a replacement, and some new specialities are steadily following this pattern (e.g. gastrology, uro-nephrology, ophthalmology, surgery, gynaecology, and to a lesser degree

[27] When compared with mathematics or physics, the world impact stays modest. However, it is strong for some subdisciplines (neurosciences).

paediatrics). The situation is a little tricky in some cases, such as when the production is weak and jeopardised by the withdrawal of important authors without brilliant successors (e.g. psychiatry, rheumatology, pneumology).

A review per city shows that each one preserves its own strong points. Nevertheless, Rabat shows a great dynamism in all disciplines. Casablanca shows a positive balance in gynaecology, ophthalmology, medical biology and surgery. In contrast, the transition seems more difficult in cardiology and hepato-gastroenterology (both strong points) as well as in haematology and endocrinology.

On the whole, the renewal of researchers is widely ensured, and the capacity for highly producing authors is expanding. Among authors with more modest scores, the potential remains amazingly constant. The following table accounts for this.

Table 15. Active scientific community in medical research (evolution from 1991 to 2001)

No of publications	5 to 7 articles	3 or 4 articles	2 articles	Recap. more than 1 article	1 article
MOROCCO 1997–2001	170	302	476	948	NA
MOROCCO 1991–1996	165	279	431	875	NA

Data: SCI. and PASCAL. Processing: R. Waast.

2.3.4 CONCLUSION

Fifteen years of rapid and spontaneous growth in Morocco has created a base for important scientific potential. Five years of government support has ensured it recognition and given it a starting point for better organisation. Today, Moroccan science is both vibrant and at a crossroad.

Abilities are now differentiated and have been reallocated through more institutions and cities. This means the existence of issues related to critical mass, the sharing of equipment, and coordination. A pioneering generation is preparing to pass on the torch. This has created concern about the possible incentives, motivation and type of professional model available for researchers to come.

Quality fields must definitely be cultivated. Morocco already excels in some specialities. Others remain fragile, depending on rare talents and founding figures. These talents must be detected, and support made available to the 'living treasures'.

The foundations, however, are set. Capacity in basic science is solid. From this skills and knowledge core, it is possible to develop (and identify with the help of experts, if necessary) niches that present a useful link between research and the development of the country.

2.4 THE ROLE OF THE E-SURVEY IN EVALUATING NATIONAL RESEARCH SYSTEMS: A STUDY OF MOROCCAN RESEARCH LABORATORIES

Anne-Marie Gaillard and Jacques Gaillard

This questionnaire/survey on Moroccan research laboratories was carried out between January and March 2003. It was part of an evaluation of the Moroccan scientific and technological research system ([1]), undertaken by the Ministère Délégué à la Recherche Scientifique in 2002 and 2003 with support from the European Commission. It focused mainly on funding, cooperation, the state and maintenance of research equipment, scientific and technical output as well as the laboratories' administrative and technical problems. It also sought to bring out information on research staff (such as numbers, age, training, and main types of activities) and how their research findings were capitalised.

This paper gives a summary of the survey results but the main focus is on the investigation method itself. This is because, although flexible and appealing, an electronic survey operates in a volatile context due to its reliance (in the main) on electronic addresses. The results, therefore, may not be representative, especially when the targeted population is little or not well known. This article, thus, draws attention to the steps that must be completed in order to obtain reliable results.

[1] This article, and several others in the book, summarise all the results that were referred to. They were published by the Moroccan Ministry of Scientific Research as *Atelier national sur l'évaluation du système de la recherche scientifique dans les domaines des sciences exactes, sciences de la vie et sciences de l'ingénieur,* Rabat, 26-27 May 2003, evaluation report, 3 volumes. Volume 2 ('Rapports d'évaluation', 554 pages) is the most informative. We refer to it in several places as '*Atelier 2*'.

2.4.1 HOW TO REACH THE POPULATION TARGETED BY THE SURVEY

The first of the two main challenges inherent in this type of a survey is to reach the target population. The survey team either has to have a database of live electronic data available (remember that e-mail addresses can be very short-lived) or create one. That brings up the question of legitimacy; what is the basis for selecting addresses, and how are these addresses obtained? What about confidentiality? The respondents need to have confidence in the interviewer, and be sure that the information they provide is not misused.

The second challenge (assuming that the first one has been overcome) is to evaluate the sample of addresses available; how representative is it of the total population to be studied? What percentage of individuals in this population can be reached by e-mail and how representative are they? Lack of tools for evaluating the samples may seriously jeopardise the reliability of the survey results.

As concerns the Moroccan laboratories, since there was no recent, reliable database covering the whole target population or a representative sample available before the survey, it was essential to carry out a countrywide investigation to draw up an inventory. This inventory had to be as complete as possible, representing all the laboratories, including the names of the laboratory directors and their e-mail addresses. The Ministère Délégué à la Recherche Scientifique (Ministry of Scientific Research) ([2]) commissioned the evaluation and launched the survey. Most of the survey respondents felt that the request was justified ([3]). During the pre-study, a questionnaire was sent out by post to all the main scientific departments (except the human sciences) at the universities, the research institutes and the schools of higher education (*écoles supérieures*). The questionnaire contained a short list of questions: name of research laboratory, supervisory institute, facility (or university faculty), city, name of person in charge, e-mail address, scientific discipline/s involved, lab telephone and fax numbers. The ministry compiled the 610 responses into a database that we used as a starting point in the survey.

As more information was collected, the information compiled by the ministry was completed and expanded, as part of the first phase of the qualitative evaluation ([4]). It was done so using the work of scientific experts in the field and through individual questionnaires sent direct to leading scientists in the main Moroccan research institutes ([5]). That led to the identification of 778 laboratories, and served to create a database called 'identified laboratories' with the entire data list above. This new database not only made it possible to send a questionnaire to all the laboratories that had an e-mail address (659) ([6]) but was of great use when the data was studied to determine the representativeness of the responses (by putting the results obtained in the proper perspective) ([7]).

[2] The Secrétariat d'État à la Recherche du Maroc was its predecessor. Ministère Délégué à la Recherche Scientifique, created after the November 2002 elections, is the name used in this study.

[3] Some laboratories and institutions that were accountable to a ministry other than the one that commissioned the study hesitated or even refused to answer, and felt that the questionnaire intruded on the prerogatives of their home ministry.

[4] Visits to laboratories by European experts. See earlier chapter, and *Atelier 2,* op.cit.

[5] Requests were mainly sent to the deans of faculties (e.g. faculty of science, faculty of science and techniques, and faculty of medicine), and heads of schools of higher education, and research institutes.

[6] We may have been able to find some or even all of the 119 laboratory directors for whom we did not have e-mail addresses but they probably did not want to give their personal addresses (unlike many others).

[7] This is the basis of all our references to the concept of 'identified laboratories' in the text, tables and graphs.

2.4.2 METHODOLOGICAL APPROACH

2.4.2.1 Creating the questionnaire

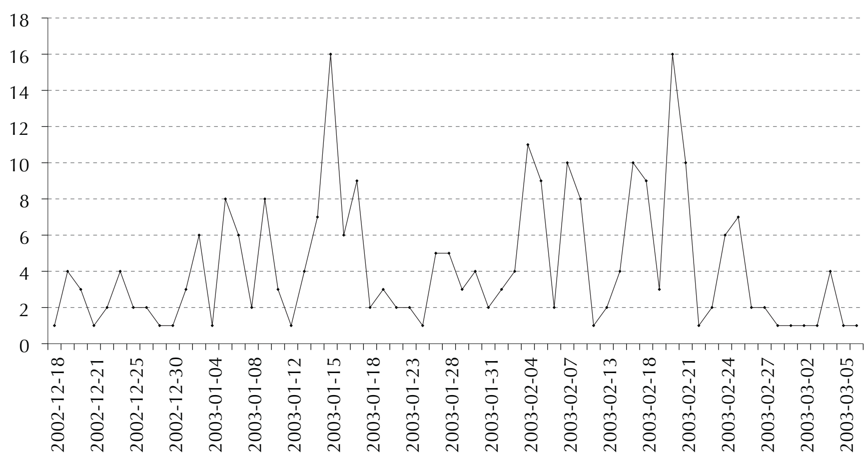
Preparing and carrying out the questionnaire/survey was greatly facilitated by two earlier studies on scientific research in Morocco ([8]). The first was on the history, development and institutionalisation of scientific research in Morocco ([9]), and the second was a bibliometric study on Moroccan scientific output showing institutional dynamics in relation to the main fields of scientific output ([10]).

Reports by European experts, who had begun their studies in September and December 2002 ([11]), made it easier to interpret and contextualise the results obtained. Finally, the discussions with Moroccan scientists in the laboratories (i.e. Rabat, Marrakech and Agadir in September 2002) contributed substantially to finalising the questionnaire. Several of the scientists also volunteered to test the questionnaire. This last validation step enabled us to finalise the questionnaire, and check that the time needed to fill it in was not excessively long ([12]).

The e-questionnaire and how to manage it

The survey, together with a letter explaining the background of the request (i.e. evaluation of the scientific and technological system in Morocco, a project launched by the Moroccan authorities with support from the European Union) and an explanation of the goal (i.e. preparation of a quantitative report to be presented at a report-backed meeting in Spring 2003 in Morocco) was then sent as an 'attached document' to all the laboratory directors who had an e-mail address. The letter guaranteed anonymous data processing and set a deadline for returning the questionnaire.

Figure 1. Questionnaire reception dates



8 These two studies are an integral part of the evaluation of the Moroccan scientific and technical research system.

9 Kleiche Dray, M., earlier chapters, and *Atelier 2* op.cit.

10 Waast, R. & Rossi, P.L., earlier chapters, and *Atelier 2* op.cit.

11 Eight final or partial experts' reports were available when we processed the research findings. They focused on mathematics, information and communication science and technology, physics, science of the sea, agriculture and forestry, chemistry, chemistry of natural substances, and medicine.

12 According to the first tests, filling in the questionnaire took 30–40 minutes. This was probably low. Several laboratory directors told us later that it took over an hour to answer the questions carefully.

The questionnaire was designed for on-screen response by checking boxes and choosing from various proposals on scroll-down menus.

It was first sent on 17 December 2002. Four reminders were sent out at 10 to 15 day intervals between 15 January and 21 February 2003. The last questionnaire was received on 6 March 2003. Figure 1 shows the importance of sending out the reminders to obtain a good return rate; before the first reminder, only 37 % of the questionnaires had been completed and returned. The 48 % response rate to the last two reminders was almost as high as the 51 % received following the first three batches ([13]).

Processing the questionnaire was more difficult than expected and required day-to-day monitoring, mainly for the reasons highlighted below.

After the questionnaires were first sent out, a considerable number (over 100) were returned and marked 'address unknown'. All possible resources (mainly previously identified Moroccan scientists in each of the institutions) were used to find errors in the addresses, changes of addresses, and ways to inform certain addressees that their mailbox (these were personal addresses) were full. Despite all these efforts, we were unable to contact 74 laboratories at their listed e-mail address. Close to one-third of the laboratory directors used their personal e-mail addresses, (i.e. yahoo, hotmail and caramail), and many of them used foreign addresses (e.g. @yahoo.fr) rather than their institution's address. Finally, many laboratory directors change personal e-mail addresses more or less often (as we all do), depending on what the market has to offer, thus making the databases, which are not updated regularly, unusable for e-mail contacts ([14]).

A non-negligible number of questionnaires that had been filled in and returned bore no sender (person or laboratory) name. In other words, the questionnaire was sent back from an address, (take a fictitious example such as cdpc@hotmail.com) with the 'name of your laboratory' field reading 'Laboratory of Applied Physics' and the 'name of your institution' field reading 'Faculty of Science'. It was difficult to know how to process these questionnaires. We had to work out each case-by-case and distinguish between one-answer laboratories and duplicates. In some cases, laboratories sent responses although they had not been identified in the preliminary study. In other cases, the laboratory director (whose identity was known) sent the questionnaire back from his/her personal address.

In other cases, there were duplicates (two people who both considered themselves to be 'head of laboratory' and answered the questionnaire.) There was also the case of the laboratory director who, 'just to be sure', sent the same questionnaire from his home address and from his professional address. In each and every case, we wrote back (using the 'reply to sender' function) and, at times, had to persuade the sender (by promising that their identity would be kept fully confidential) that we needed to know the name of the laboratory for methodological reasons.

Since we were dealing with scientists, these arguments were understood and, ultimately, we were able to list the identity of all the participating laboratories. This problem could have been avoided if each questionnaire had been assigned a locked number that

[13] This does not match the usual profiles for responses to postal surveys; the number of responses usually decreases gradually as more reminders are sent.

[14] This proved true once again when we circulated the survey report to the participating laboratories. We saw that over 100 addresses to which we sent out the questionnaire did not exist any longer.

corresponded to the basic list of 'identified laboratories' (although this would have been more complicated since each questionnaire would have had to have been sent out individually, rather than being grouped).

The survey benefited from a (very marginal) 'snowball' effect. In other words, responses were received from certain laboratories that had not received the questionnaire when it was first sent out.

There were also certain technical problems related to filling in the questionnaire and transmitting the data. The *formulaire* format on Microsoft text processing software, with its numerous scroll-down menus and predetermined choices, was incompatible with certain text processing software. This led to considerable e-mail exchanges with the Moroccan laboratory directors. Alternative methods were often found but we had to retype the questionnaire close to a dozen times. The decision to use an 'on-line questionnaire' would have been an efficient choice except that the need to stay on-line while filling out the questionnaire penalised one-third of the respondents (i.e. the laboratory managers who responded on their personal address) since it took from 60 to 90 minutes to complete the questionnaire.

Despite these difficulties, our survey method seemed to have many advantages (e.g. propagation and speed of contacts that facilitated adjustment and fine-tuning of responses). It was also useful in verifying information on certain questions that were sometimes not well understood, e.g. answers to questions on the laboratories' budgets were to be expressed in thousands of dirham (kDh). This question proved to be poorly formulated because very few Moroccan laboratories have budgets (other than the wages and bonuses budgets) expressed in kDh. The result was that many laboratory directors responded in Dirham (Dh); adding 'k' for thousands would have given budgetary figures that, at least in some cases, would have been sky high.

Using an electronic mailing system made it possible to check information quickly. Managing the method may seem simple, but it requires daily follow through and, for this survey, more than 1 000 e-mail messages (excluding the bulk batches and reminders) were sent out.

2.4.2.2 Construction of the database stemming from the responses to the questionnaire

To import the information from the questionnaire to a database, the software interface had to be programmed to allow for direct transposition of responses from the questionnaire to an Excel spreadsheet, so that they could be imported into an Access database at a later stage.

This software (programmed in Language C) is based on the recognition of character chains from a Word document (format of questionnaire), which allowed for part of the original text (i.e. the answers in the response zone) to be entered on an Excel spreadsheet. When a chain has been recognised (i.e. the chain that corresponds to a question on the questionnaire), the software enables Excel to enter the answer into the assigned zone of the spreadsheet (i.e. a given column. The software only works if the Word document (the questionnaire) has been converted into 'text with line return' so that the software can run through the answers and put the 'responses' in the right columns of the spreadsheet.

After the questionnaires have been scanned by the software, the resulting Excel file has to be cleaned up before being imported into Access. The main problem was readjusting answers from questionnaires that had come unlocked and thus had to be slightly modified ([15]).

2.4.3 HOW REPRESENTATIVE WAS THE SURVEY?

First, it was not possible to contact all the laboratories on the list; there were only 659 e-mail addresses available for the 778 laboratories in the inventory, and only 585 were actually contacted (74 messages never reached their destination). In other words, our questionnaire only reached 585 laboratory directors. Second, a distinction has to be made between the number of questionnaires received, and the number of laboratories that participated in the survey. In 150 cases, the laboratory director responded for one single laboratory but in 113 cases, the answer covered several laboratories, in other words the 263 responses received covered 496 laboratories (see Table 1). The questionnaire response rates (64 % of the laboratories identified, and 85 % of the laboratories solicited), were thus more than satisfactory.

However, there is no justification for claiming that the responses, in one way or another, were representative of the community as a whole. Due to the choice of method (impossible to obtain a representative sample) and the context (the survey was a part of the assessment of the national research system), there was a risk of a non-controllable bias in interpreting the results.

In certain fields, the response rate may have been affected by an earlier evaluation conducted by European experts in autumn 2002. But this could have had an impact one way or the other; for example, encourage addressees to answer (because the laboratories were involved) or limit participation (fatigue phenomenon). It is likely that the representativeness of the institutions depended on the commitment of their directors ([16]). This was the context in which the first database, produced to identify laboratories (called 'identified laboratories') proved its great value. It included 778 laboratories, a 'reference population' that could be used to identify, at least in part, the representativeness of the laboratories that responded to the questionnaire.

15 This incident could have been avoided if we had added an access code when locking the questions. This was a very costly omission!

16 Some directors of major university establishments, for instance, neither responded to our request for laboratory identification nor provided the e-mail addresses of the laboratory directors.

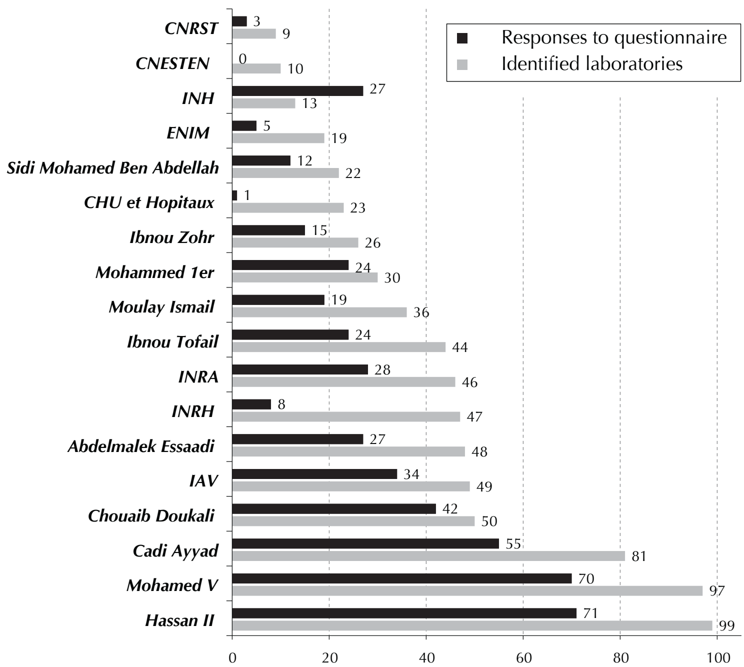
Table 1. Number of questionnaires received and number of laboratories that participated in the survey

	Number of questionnaires	Number of laboratories that participated in the survey
1 laboratory per questionnaire	150	150
More than 1 laboratory per questionnaire	113	346
TOTAL	**263**	**496**

2.4.3.1 Institutional representation of responses

There were a few exceptions ([17]) but the major science-producing Moroccan institutions were well represented in the survey. The very small number of hospital laboratories that responded must be seen in relative terms because their responses were channelled through their faculties of medicine in most cases, and not through the hospitals themselves. They, therefore, are listed among responses from university institutions (but are not identified in this figure). This is confirmed in Figure 3, where (as concerns laboratory response figures) we see that the pharmaceutical, medical and biological research sectors are the best represented in the survey (and second in number of responses).

Figure 2. Laboratories identified and responses to questionnaire, by institution



[17] Exceptions were the Faculté des Sciences et des Techniques of the Université Hassan 1er (Faculty of Science and Technology of the Hassan Ist University) in Settat and the Faculté des Sciences of the Université Sidi Mohammed Ben Abdellah (Faculty of Science and Technology of the Sidi Mohammed Ben Abdellah University) in Fez.

The institutions can be grouped into three main categories: university institutions, public research institutes, and other facilities (mainly *écoles supérieures*, non-university institutions of higher education, whether accountable to a university or not). It is interesting to see the very great similarity between the sample of laboratories in the survey and the reference population ('identified laboratories', Table 2).

Table 2. Institutional representativeness of laboratories in survey

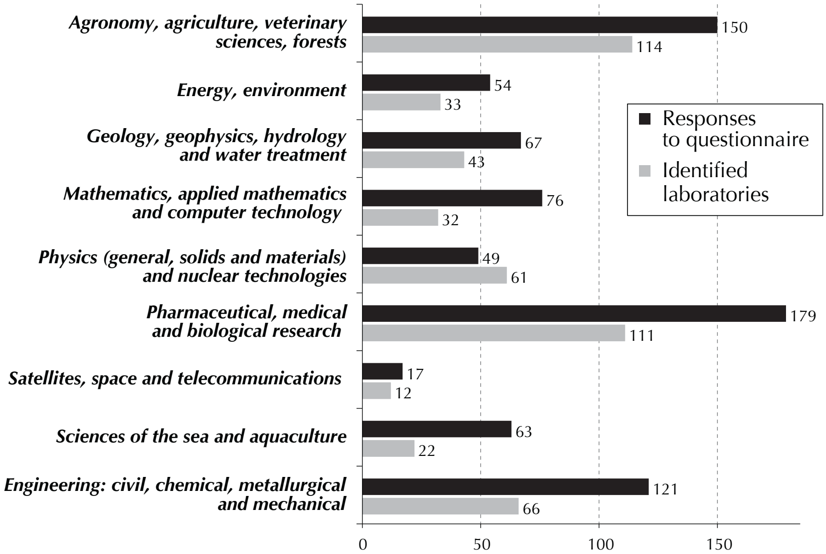
	University	Public institutes	Other establishments	Total
Identified laboratories	71 %	20 %	9 %	100 %
Laboratory in survey	73 %	18 %	9 %	100 %

2.4.3.2 Representation by scientific field

Classifying the laboratories by predetermined scientific domain is sometimes tricky. So much so, that the laboratory directors we talked to generally avoided the problem by giving several answers to the question. Since the borderline between various disciplines is becoming increasingly unclear, laboratories may by classified in much more general domains as a result of scientific applications; for example, classification in agronomy might mean research in biology and, likewise, classification in engineering might mean research in physics, chemistry or mathematics.

The classification of scientific domains in this study abides by the classifications selected jointly by the Moroccan authorities and the European Commission. University laboratories have been classified by faculty and department; laboratories accountable to public research institutes have been classified according to their home institute's established mandate. This is an arbitrary classification system that was adopted when the first database was created (i.e. database on 'identified laboratories') and puts the sample in perspective in relation to the scientific domains (Figure 3).

Figure 3. Laboratories identified and answers to questionnaires, per scientific domain



In 7 of the 9 domains, the representativeness of participating laboratories surpasses 50 % but there are major differences between the domains; from 35 % for 'Science of the sea and aquaculture' to 76 % for 'agronomy, agriculture and veterinary sciences'. The difference can already be seen in Figure 2, which shows that certain institutions responded quite extensively to the questionnaire (e.g. IAV 69 % and INRA 60 %), while others did not (e.g. INRH 17 %). The participation level of university laboratories partly makes up for the disparities in levels of participation of these research institutes.

The results obtained in 'physics and nuclear technology' can be explained by the fact that the laboratories, the teams, and the research groups that answered the questionnaire, regardless of domain, had not all been identified before the questionnaire was sent out. The first 'identified laboratories' database, for instance, was rounded out during the survey period but this was the only domain that brought in more responses than the number of laboratories solicited at the beginning of the survey. We were able to contact a large majority of these laboratories (81 %); many of them prepared joint answers (an average of 2.2 laboratories per response).

The remarks on the figure above are confirmed in Table 3, which shows the perspective of the various domains within the reference groups and the survey sample. The figures for 7 of the 9 domains appear to be relatively close in the 2 groups (reference group and survey), except for the sciences of the sea (50 % lower in the sample), and physics (50 % higher in the sample). Despite these differences (observed in domains which, as a percentage of the whole, are relatively minor), the overall picture given in this table indicates a rather close correlation between the two compared categories.

After assessing its representativeness, it was clear that the sample was good — in some cases excellent — and that the biases observed made it possible to see certain results in more relative terms.

Table 3. Representativeness of laboratories participating in the survey, per scientific domain

Scientific domains	Laboratories identified	Laboratories interviewed
Engineering (civil, chemical, metallurgical and mechanical)	15.6 %	13.3 %
Sciences of the sea and aquaculture	8.0 %	4.4 %
Satellites, space and telecommunications	2.3 %	2.4 %
Pharmaceutical, medical and biological research	23.0 %	22.3 %
Physics (solids, materials and general) and nuclear technologies	6.5 %	12.3 %
Mathematics, applied mathematics and computer technology	9.7 %	6.4 %
Geology, geophysics, hydrology and water treatment	8.6 %	8.6 %
Energy and environment	7.1 %	7.0 %
Agronomy, agriculture, veterinary sciences and forests	19.2 %	23.3 %
TOTAL	**100 %**	**100 %**

2.4.4 THE LABORATORIES, A POLYMORPHIC REALITY

Another challenge in conducting this survey was to start with an entity called 'Moroccan laboratory', although the very nature of this entity was unknown. This question crops up every time investigations or studies focus on laboratories. Laboratories, as places of scientific production, supervision and publication, have very different structures and fields of activity.

This issue first came up during the study when we looked at the database of laboratories created by the Moroccan Ministère Délégué à la Recherche Scientifique. The database was composed of a relatively large number of laboratories that were all under one director and, in some cases, had a very small scientific staff (i.e. a few teachers-researchers, engineers, technicians or, sometimes, only students). For example, a university professor could be responsible for four or five laboratories, sometimes with a staff of only two people (including themselves). Could this merely be a research team within a single laboratory or even specific research themes as part of a given programme (the combination of a teacher and a PhD candidate working on a thesis topic could even be dubbed 'a laboratory')?

This being the case, before reporting results of the survey, we felt we should try to show the relative value of these results in relation to what laboratories can be in other countries, for example certain European countries ([18]). We saw that there was no 'typical' or 'ideal' average profile of a laboratory in Europe based on size or funding. Several recent evaluations of French research institutions ([19]) suggest that, although laboratories benefit from more abundant resources, it is difficult for them (in time) to maintain cohesion among themes that do not always develop along the same lines; internal growth and grouping of units has made certain units too big and may hinder the coherence, and thus the effectiveness of research. Conversely, targeted research within a small ad hoc unit is not necessarily restrictive nor incompatible with innovation.

Methods of funding vary greatly. In France, the core budgets of institutions are the most common source of long-term public funding, followed by other national sources (e.g. competitive calls for tender and foundations). In Spain and Germany, funding (to differing degrees) comes from national calls for tender but less from the core budgets of the institutions (and in Spain, regional funds are relatively important). In the United Kingdom, the main source is foundations, followed by the core budget of the institutions. In Italy and Sweden (like Spain and Germany), funds come mainly from competitive calls for tender but foundations also provide considerable funding; in Italy, even more than the institution ([20]).

2.4.5 MAIN RESULTS OF SURVEY ON MOROCCAN LABORATORIES

This section briefly describes the results of the survey.

2.4.5.1 Size of laboratories

The survey provides an indication of the size of Moroccan research laboratories. The information supports the perception of European experts, who recognise that the terms used to describe Moroccan research groups are vague (e.g. laboratories, groups, teams, and research units), and that these groups or laboratories are usually small units with little inter-unit coordination or structure, and no real official existence.

The way in which responses were prepared to the questionnaire (individual or grouped) further supports the impression of semantic imprecision referred to above. When combined, the 496 laboratories have 2 487 employees (of which 2 079 are scientists) and 1 262 PhD doctoral students. This gives an average, per laboratory, of just under four teacher-scientists or full-time scientists, and a little more than one additional staff member (engineer/technician or administrative staff), and two-and-a-half PhD students. This is a total of just over seven people per laboratory. The average laboratory, thus, is a small research unit, but this average hides many disparities. Table 4 shows size differences in relation to scientific domain.

[18] Gaillard et Gaillard, op. cit.

[19] CNER, *De nouveaux espaces pour l'évaluation de la recherche*, 1997, Paris: La Documentation Française. The quotations have been taken from this publication (p. 281).

[20] Larédo, et al., 'A report of the PSR project of the EU TSER programme', 1999, Paris: CSI.

Table 4. Average number of scientific staff per laboratory in relation to scientific domain

Scientific domains	Scientific staff per laboratory	PhD students per laboratory	Total scientific staff
Agronomy, agriculture, veterinary sciences and forests	3.1	1.8	4.9
Energy and environment	4.3	3.5	7.8
Geology, geophysics, hydrology and water treatment	4.3	2.8	7.8
Mathematics, applied mathematics and computer technology	7.1	4.9	12.0
Physics (solids, materials, general) and nuclear technologies	12.9	3	15.9
Pharmaceutical, medical and biological research	3.6	1.7	5.3
Satellites, space and telecommunications	7.9	4.4	12.3
Sciences of the sea and aquaculture	3.4	2.1	5.5
Engineering (civil, chemical, metallurgical and mechanical)	5.0	2.6	7.6

2.4.5.2 Laboratory staff

The vast majority of Moroccan laboratories are located in universities, which means that most laboratory staff are professors in institutions of higher education performing research activities. Overall, 8 % of the staff are full-time scientists, and 6 % are research engineers (*ingénieur de recherche*); the numbers are higher in the research institutes. Overall, only 13 % of the staff are technicians and lab assistants but only 5 % in the university laboratories. Furthermore, in the sample, administrative staff only accounted for 3 % of the total staff. Most of the scientific staff are rather young (85 % between 30 and 50 years of age), with 72 % male and 51 % highly qualified (Doctorat d'État). The vast majority graduated in Morocco or France.

Table 5. Highest level qualifications for scientific staff, per type of institution

Institutions	Licence, BSc	Masters, Engineer, MSc	DESS DESA/DEA	Doctorat 3e cycle, Docteur Ingénieur	PhD, Thèse de doctorat	Doctorat d'État
Research institutes	3 %	35 %	17 %	17 %	17 %	11 %
Universities	–	1 %	4 %	18 %	18 %	58 %
Institutions for higher education	–	3 %	18 %	13 %	24 %	42 %
TOTAL	**–**	**6 %**	**7 %**	**17 %**	**19 %**	**51 %**

The relatively high number of students at PhD level (32 % of the research staff in the sample of university laboratories) is remarkable (Table 6). Since the number of scholarships has decreased considerably (in some educational establishments there are no more offered), it is surprising to see such a high level of PhD student commitment. There are very few jobs available in the academic world in Morocco (as in many other countries); only slightly over 10 % are employed by the institution at where they complete their studies, and unemployment among graduates is a widespread problem. Morocco has, indeed, a large pool of well-trained scientists, and both scientists being trained to work in research or in the scientific departments of various productive fields.

Table 6. PhD students in training or having graduated during the last 10 years

Number of students	1993–1998	1998–2002	In training
In training	936	1 955	1 290
Graduated	848	1 339	

2.4.5.3 Recruiting scientific staff

During the last five years, recruitment of scientific staff has been at very low, with the average recruitment per laboratory being a mere 0.7 persons. Of course, the figure varies greatly: 94 laboratories hired 242 scientists (i.e. 2.6 persons per laboratory) and 169 laboratories hired none (i.e. 64 %). Yet the heads of laboratories or research groups were satisfied since, when asked ‘do you feel that the number of persons working in your laboratory is big enough to carry out your scientific agenda’, 70 % of them responded somewhere between ‘no shortage’ and ‘tolerable shortage’ (Table 7).

Table 7. How laboratory directors see the shortage of scientific staff

Type of institution	No answer	None	Insignificant	Tolerable	Serious
Institutions of higher education	2	2	4	17	9
Universities	7	7	16	113	49
Research institutes	0	2	10	14	11
TOTAL	**9**	**11**	**30**	**144**	**69**

This reveals an ambivalent feeling among the laboratory directors who, on the one hand, say they can live with the current situation and, on the other hand, 60 % of them think that their laboratories do not have the necessary critical mass (Table 8). A large majority of the laboratory directors (59.7 %) would prefer joining with other laboratories to create a critical mass. This strongly supports a strategy that favours synergy among the existing scientific forces.

Table 8. Should laboratories join together to form a critical mass?

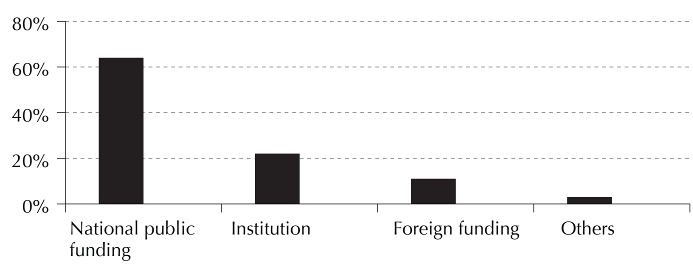
Type of institution	Yes	No	Yes and No	No response
Institutions of higher education	21	12	0	1
Universities	118	59	3	11
Research institutes	18	19	1	0
TOTAL	**157**	**90**	**4**	**12**
%	**59.7**	**34.2**	**1.5**	**4.6**

2.4.5.4 Funding

Laboratory research budgets are considered to be far too low. Half of the laboratories (50.5 %) have an average annual operating budget of MAD 10 000 (about EUR 1 000) per staff scientist. The survey showed that there were great differences between laboratories. A very small minority (about 20) have over EUR 80 000 per year. The best endowed laboratories receive nearly all of their budget from national sources, and are very much involved in services, such as healthcare, agriculture and mining. A global analysis of the origin of the funding brings out the decisive role of national public funding (64 %), followed by funding from the institution (22 %), and foreign funding (11 %).

National public funding comes essentially from PARS, and its follow up programme, PROTARS. Over half of the foreign funding comes from international institutions (60 %). Half of this amount comes from the European Union. France is the leader in bilateral cooperation but not far ahead of Germany and the United States. The average per laboratory and per scientist budgets are (with a few exceptions) too small to support normal laboratory operations, although the Moroccan authorities have been making greater efforts during the last few years (Figure 4).

Figure 4. Origin of funding (%)



2.4.5.5 Scientific collaboration

Arguments in support of scientific collaboration are convincing for countries like Morocco because collaboration enables laboratories to reach a critical mass in a specific domain (especially when a multidisciplinary approach is needed), and share costs by combining both national and international skills.

The vast majority of the laboratory directors stated that they are involved in national (82.5 %) or international (88.2 %) collaborative programmes. Three-quarters (400 out of 547) of such collaborative efforts were with partners in the public sector, although collaboration with the private sector was far from insignificant. Laboratory collaborations through activity-specific partnerships were mainly conducted with the research community, both public sector (37 %) and private sector (12 %), followed by partnerships in agriculture (public: 15 % and private: 5 %), industry (8 % and 4 %), healthcare (7 % and 3%) and, lastly, services (5 % and 2 %).

In most cases, the laboratory director said the collaboration was 'regular' ([21]), whether national or international, and that it was 'medium term' (between 1 and 3 years for 39 % of the national collaborations, and 45 % for the international collaborations.) International collaboration focused especially on research projects that were carried out together with a partner laboratory (44 %), and that encouraged the scientists to travel between Morocco and the partner countries; of these, 16 % involved scientific personnel exchanges, and 16 % allowed the scientists to carry out scientific work at the partner's laboratory.

Table 9. Importance of national collaboration and domain of national partners

Partners	Public sector		Private sector	
	Number of collaborations	%	Number of collaborations	%
Research	200	37	68	12
Agriculture	92	17	26	5
Industry	45	8	22	4
Healthcare	36	7	17	3
Services	27	5	14	2
Total	**400**	**74 %**	**147**	**26 %**

Out of Morocco's 622 international collaborations recorded during the last 5 years, two-thirds (66.4 % or 413) were with French entities, making France the leading scientific partner, by far. Then came Spain (10.0 %), Belgium (4.7 %), and Germany, Canada, and Italy (approximately 4 % each). The United States was in seventh place (3.5 %, measured in number of collaborations).

[21] The questionnaire offered a choice between 'regular' and 'occasional'.

Table 10. Morocco's main scientific partner countries

Country	Number of collaborations	% of collaborations	Publications with foreign co-authors
France	413	66.4	65
Spain	62	10.0	4
Belgium	29	4.7	3
Germany	27	4.3	2
Canada	26	4.2	2
Italy	25	4.0	5
US	22	3.5	9
United Kingdom	8	1.3	2
Switzerland	7	1.1	1
Sweden	3	0.5	1
Other	53	8.5	6
Total	**622**	**100 %**	**100 %**

Source for right-hand column: ISI (1991–1999).

International collaborations lead to the publication of articles with a foreign co-author in international journals. Table 10 shows a relative correlation between the number of international collaborations with a given country (third column) and the number of co-publication with authors of that same country (fourth column). With few exceptions, the country classification remains much the same; France is far ahead with about the same number of French co-authors (65 %) as international collaborations with French scientists (66.4 %). This classification, however, does not hold for two countries: the United States, which accounts for 9 % of the co-publications with Morocco but only 3.5 % of the collaborations, and Spain, which accounts for only 4 % of the co-publications but 10 % of the collaborations.

2.4.5.6 Scientific documentation

Access to scientific and technical documentation is a serious problem for most of the laboratories in the survey. To obtain documentation, scientists either have to buy it with their own money (34 % of them) or rely heavily on their foreign partners (35 % of them).

Table 11. Mode of access to documentation

In the laboratory, documentation is	%
Personal (bought by the scientists using their own money)	34
Available in the laboratory (bought with laboratory funds)	7
Available within the institution	9
Available thanks to our Moroccan partners (e.g. inter-institutional loan)	5
Available thanks to our foreign partners	35
Other	10

There were 257 responses in total.

The non-existence of a documentation access system seems to be the main reason given by the laboratory directors to the question of access to documentation, i.e. lack of funding (at the level of the institution or the laboratory), and lack of an inter-institutional loan system. These responses are backed up by the reasons that the heads of laboratories and groups of laboratories give under 'Other' in the questionnaire: for example, instability of funding from one year to the next, prohibitive cost of subscriptions and publications, lack of specific budget, and access to summaries but not full publications because of the high price. Operational reasons are also added, including administrative problems in ordering publications abroad and paying for them, poorly functioning documentation centres, isolation of institutions, administrative red tape, and little or no spirit of collaboration or feeling for scientific and technological exchanges between scientists and institutions.

These seem to be institutional reasons. A prerequisite to the first step in solving certain problems encountered by the scientists in the sample would be for research institutions to recognise the paramount importance of scientific and technical documentation as a tool that conditions scientific output and its inclusion in world science, and act accordingly.

An overwhelming majority of the research scientists (87.3 %) have Internet connections. But in over half the laboratories, several (usually two or three) scientists have to share a terminal. The directors of 5 small laboratories said that their teams only had 1 terminal for over 20 scientists (one said that 50 scientists were sharing one terminal). Furthermore, about one-third of the laboratory directors in the survey use their personal e-mail address (often a foreign-based one, with a server usually in France) rather than the institution's addresses. The connection to the Morocco Academic and Research Wide Area Network (MARWAN), the national information network dedicated to education, training and research, seems far less important. Only 51 laboratory directors (i.e. under 20 %) said they were connected. Others said that their institutions may be connected without their knowing it.

2.4.5.7 Research equipment

The European experts all considered research equipment and maintenance an important problem. They observed a shortage of equipment (e.g. even small pieces were difficult to procure because of the cost, intermediaries involved, time lag caused by administrative red tape, and heavy customs duties) and, frequently, inadequate maintenance (mainly because of the shortage of specialised technicians).

It is not surprising that the vast majority (87 %) of the 259 laboratory directors answered 'no' to the question, 'Is your laboratory reasonably well equipped?'. Among the main obstacles to procuring equipment, 88 % of the laboratory directors responded that the lack of funding was the first reason; a problem that 67 % said was 'very constraining', and 21 % said was 'very important'. The next problem was the administrative angle of the acquisition process, which started with the obligation to launch a call for a public works contract. This was problematic for 64 % of the laboratory directors ('major' for 18 % of them, and 'very constraining' for 46 %), and 59 % of the respondents felt that the government payment period was a problem ('major' for 22 % of them, and 'very constraining' for 37 %).

Table 12. Main difficulties in research equipment procurement

Reason cited	Level of dissatisfaction			
	Not very important	Moderately important	Important	Very constraining
Lack of funding	2 %	5 %	21 %	67 %
Lack of information	32 %	13 %	5 %	5 %
Importation problems	14 %	11 %	21 %	24 %
Public works contract obligation	5 %	9 %	18 %	46 %
Government payment period	6 %	11 %	22 %	37 %
Lack of technical know-how to use and maintain equipment	10 %	17 %	16 %	27 %

The laboratory directors did not feel that maintenance of research equipment was the main problem. Problems of maintenance are recorded as 'important' by less than half of the laboratories (43 % of the responses; 16 % considered it 'important' and 27%, 'very constraining'). Yet, if we weigh this against responses to questions on the maintenance of the equipment itself, we see that close to three-quarters (73 %) of the laboratory directors feel that the equipment in their laboratories are generally 'not repaired', which means that the equipment has been replaced by new equipment (only 10 % of the cases) or has not been replaced at all (in the large majority of cases). This confirms reports by European experts and responses through interviews that consider this a rather serious problem.

2.4.5.8 Scientific production

In terms of publication numbers, scientific production has grown remarkably during the last five years, although the output, per scientist, is still relatively low. As an annual average, each scientist has written 0.4 papers that were published in seminar proceedings, a little under 0.4 articles for international journals, and 0.09 articles for national reviews. The relatively low importance of national publications needs further study. The annual contribution to scientific publications per 1 000 scientists is a mere 7 book chapters and 6 books as authors, and 5 books as scientific editor.

Table 1. Scientific output per scientist per year

Nature of the publication	Total number 5 years	Average per year	Average per year, per scientist
Articles published in seminar proceedings	4 027	805.4	0.410
Articles in international journals	3 413	682.6	0.348
Articles in national journals	879	175.8	0.090
Chapters in co-authored books	66	13.2	0.007
Scientific book as author	60	12	0.006
Scientific book as scientific editor	47	9.4	0.005
Total	**8 492**	**1 698.4**	**0.866**

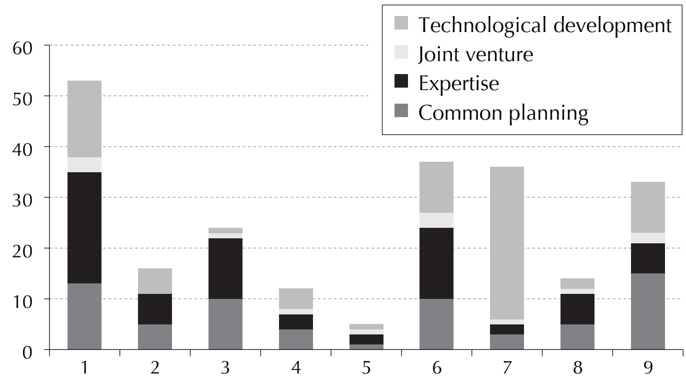
These general averages, per scientist, hide very varied situations. A large number of laboratories publish very little, while a small number of them publish a lot and in very different types of publications. Half (49 %) of the laboratory directors said that they capitalised their research findings by teaching in ongoing training schemes. Close to half (45 %) said that they had obtained research results that were taken up in 278 practical applications.

Further, 48 patents were filed by 24 laboratories or groups of laboratories during the last 10 years. Most of the patents were filed in domains corresponding to the 278 practical applications. The 48 patents, thus, were filed by a small number of laboratories; 12 reported filing for only one patent each, and the other 12 filed for 36 patents (1 laboratory obtained 8 patents, another laboratory obtained 5 patents, 3 laboratories obtained 3 patents, and 7 laboratories obtained 2 patents). Out of the 547 collaborations identified in the survey (see Table 13), 205 were sustained through partnerships in the economic and production sectors.

Table 14. Collaboration sustention with economic partners

Types of collaboration sustention	Frequency
Expert consultation	73
Joint planning of research	66
Participation in partner's technological development activities	53
Joint-venture at the production level	13

Figure 5. Breakdown, per domain, of activities that were sustained through economic partnerships



(1) Agronomy, agriculture, veterinary sciences and forests

(2) Energy and environment

(3) Geology, geophysics, hydrology and water treatment

(4) Mathematics, applied mathematics and computer technology

(5) Physics (solids, materials, general) and nuclear technologies

(6) Pharmaceutical, medical and biological research

(7) Satellites, space and telecommunications

(8) Marine Sciences and aquaculture

(9) Engineering (civil, chemical, metallurgical and mechanical)

2.4.6 ANALYSIS OF RESULTS AND CONCLUSION

2.4.6.1 Brief summary

The results presented above give a contrasted picture of Moroccan research laboratories. Most of them are small units (slightly over 7 people on average), mainly located in universities (82 %). The staff is highly educated (51 % have a Doctorat d'Etat), which combines teaching and research, and is predominantly male (72 %). Many of these laboratories do not have the necessary critical mass, and would benefit from combining efforts by forming a larger research group that could synergise sources of scientific expertise, and create greater scientific and thematic coherence.

Although situations vary greatly, most research budgets are too low. An analysis of the budgets indicated the overriding importance of national public funding (64 %). Access to scientific and technical documentation is a serious problem. At the time of the survey, the large majority of laboratories (87.3 %) had Internet connections but scientists often used their personal connections with professional contacts, since the terminals in the laboratories in over half the cases had to be shared or were difficult to access. The scientific equipment was considered insufficient by 87 % of the laboratory directors (firstly for budgetary, and then administrative reasons), and equipment maintenance was very irregular.

Despite the above, Moroccan scientific output (measured in number of publications) has grown remarkably during the last five years. The productivity per scientist is, in general, low to average, with very pronounced differences. Almost half (49 %) of the laboratory directors reported that they capitalised on their research findings by teaching in ongoing training schemes. Close to half (45 %) stated that their research findings had led to practical applications but during the last 10 years only 48 patents had been filed by 24 laboratories.

The Moroccan scientific community has strong potential, with highly qualified members that are seriously underutilised, especially in higher education institutions where some 10 000 teachers (out of 14 522 in the CNCPRST census conducted in 2000) carry out next to no research. Finally, the survey showed that within the research laboratories, despite a weak job market, there are a large number of PhD students that make up a very substantial reservoir of prospective future expertise.

2.4.6.2 Methodology

The results presented above suggest that our survey method allowed for highly efficient information collection and processing in a relatively short period of time (between January and March 2003). These results, however, would have been useless if they had not been obtained from a controlled sample, and with clear identification of any biases in relation to the total population being studied. The authors of the survey were able to control the sample, thanks to a pre-study carried out by the Moroccan authorities and (with their agreement), which the authors were then able to pursue further. The survey also produced a relatively reliable map of the Moroccan research laboratories and their institutional context.

The greatest problem in using this method was the volatility of e-mail addresses, especially personal addresses (used for one-third of the responses), which often changed, depending on the latest market offer. Furthermore, these addresses had only been communicated to a select circle of contacts. Professional addresses were easier to find, thanks to the institution websites (but not all institutions in Morocco have websites). Hence, to contact a target population requires access to a very up-to-date electronic address book.

This difficulty can be avoided by having the questionnaire filled out on line. In our survey, however, we faced two major problems. Firstly, the penalisation (or even exclusion) of people responding from their own terminal (the cost of the local communication was more or less expensive, depending on the time it took to fill in the questionnaire). Secondly, the difficulty of controlling a sample (measuring representativeness) when there is no overall, reliable information on the total population being studied (in this case, the number of laboratories, locations, and research domains).

Once these difficulties have been solved, this method (if meticulously managed) has many advantages; for example, it is flexible and allows for a large number of fast exchanges. It is a highly 'personalised' tool, thanks to its built-in interactivity. The method does not only allow for numerous reminders (which are limited when questionnaires are sent by post) but, whenever necessary, can adjust and fine-tune responses. That said, an e-survey is not a time-saving tool. Although it allows for more 'technological' management of certain facets of a survey, it entails larger numbers of contacts (probably to obtain higher quality results), and requires the interviewer to carefully keep track of each and every step of the survey.

It is also an important tool for evaluating national research systems. Its approach is complementary to that of other tools (e.g. inventories, bibliometrics, and evaluation of scientific domains by experts), thus generating both quantitative and qualitative indicators of laboratory characteristics (e.g. personnel, practices, output, and funding). The results can be validated at the national level if the survey is based on an existing inventory or directory that can be used to produce a representative sample prior to the survey, and (as was the case in this survey) allows for a posteriori sample control. If not, the results can be used for an initial approximation of the national research potential, and can indicate more or less strong trends that can be helpful in formulating ad hoc science, technology and innovation policies.

PART 3

SYNTHESIS AND CONTINUATION

3.1 EVALUATION OVERVIEW

Roland Waast

The evaluation of the national research system was carried out at the request of the Moroccan Ministry for Scientific Research, with the support of the European Commission. This chapter covers its methods and main results.

Organised by a specialist research team ([1]), it was, in accordance with the ministry's wishes, a resolutely external evaluation, limited to the exact sciences, life sciences, and engineering sciences (i.e. all but the social and human sciences) ([2]).

The *in situ* visits to many Moroccan laboratories by some 20 European experts were a core part of the process. Preparations for these involved painstaking efforts to take stock of current capabilities. The operation lasted a year-and-a-half (in 2002 and 2003) and culminated in a large-scale workshop to hand over the results ([3]).

I shall now outline briefly the tools and results of the preliminary survey, before moving on to the experts' verdict.

3.1.1 METHOD

The method adopted divided the action into three phases: the preliminary survey, the actual evaluation (i.e. laboratory visits by the experts), and the handover of results in a public workshop.

Phase one (the preliminary survey) set out to produce a body of original, reliable and detailed information that would provide a robust picture of the state of Moroccan research. It hinged on three tools:

- historical backgrounder on Moroccan scientific institutions;
- bibliometric analysis of Moroccan scientific output published over the previous 10 years in the world's 6 000 leading journals;
- questionnaire e-mailed to some three-quarters of all Moroccan laboratories, focusing on the resources of grassroots units, and on their views of the difficulties and drawbacks that need to be removed.

1 The Science, Technologie et Société team belonging to Savoirs et Développement research unit of the Institut de Recherche pour le Développement (Institute of Research for Development (IRD)) , France.

2 These will be evaluated later, in light of the results of the operation presented herein.

3 The operation took nearly a year to prepare. The experts' visits were spread over a period of 6 months. Three months were needed to organise the workshop, and prepare its basic documents. This *length of time* served to ensure not only the quality of the work but also the participation and involvement of various stakeholders.

The actual evaluation was done by around 20 European experts selected for their proficiency (academic and applied), experience in management, leadership and evaluation, and the fact that they were in no way involved in any ongoing cooperation with Morocco. They each submitted a report on their respective areas of expertise, and defended its content at the final public meeting.

It was understood that the results would be presented and debated at a national workshop on the Moroccan research system. The ministry that organised the event wanted it to be a large-scale gathering with wide-ranging discussions. All of the various stakeholders (e.g. responsible ministries, producers and users) were involved. The experts' reports, made available in full and defended by their authors, provided a basis for two days of substantial, lively debate. Those documents, later compiled by the ministry into an extensive three-volume work ([4]), form a robust frame of reference that continues to inspire analysis and action today.

3.1.2 STATE OF EXISTING CAPABILITIES

At the risk of repeating some of the points made in previous chapters, I shall now recap on the nature and main results of the tools used to take stock of existing capabilities.

- ***The institutional, historical backgrounder***

The institutional backgrounder included a *catalogue raisonné* of the establishments with research facilities, providing details on staff, assignments and activities. It showed how those parameters had changed over the years. At the national level, it examined research budgets, legislation and the governing bodies, and stated priorities.

The historical perspective embossed the overview. The main points that it brought to light are detailed below.

It was in setting up a junior minister's office for research in 1998 that Morocco demonstrated its desire to provide itself with policy in this area. Previously, though, research had continued to develop 'unprompted' in specific places and for specific reasons, as follows.

- First, development began at the universities, where teachers seeking promotion needed to present a succession of theses ([5]). This means of regulating the profession had a major impact from the 1980s onwards with the extension of access to university to an ever-wider public, and large numbers of people embarking on a career in teaching.

- Development took place within 'management and professional training' schools, operating outside the university system, which made their mark for their applied research capacities. They were set up and governed by various ministries to tackle the shortcomings of the university syllabus in some engineering and technical areas. They

[4] Department of Research, *Atelier National sur l'évaluation du Système de la Recherche Scientifique dans les Domaines des Sciences Exactes, Sciences de la Vie et Sciences de l'Ingénieur, Rabat, 26-27 Mai 2003, Rapport d'évaluation*, 3 volumes, MESFCRS: Rabat.

[5] 'Diploma-based' promotion and recruitment was part of the status of teachers, which had been reformed in 1975 with the increase in staff numbers. It was no more than a matter of career management. No particular thesis themes were prioritised, and no funding was provided. Individuals had to do their work or strive to forge relationships with well-equipped foreign laboratories off their own bat. Scientific cooperation, formal or otherwise, would be the only form of research policy for quite some time to come.

were selective and highly supervised. After a tentative start in the late 1960s, they came to be established as a model and proliferated in the second half of the 1970s ([6]).

- It also occurred in offices and agencies with a partial commitment to conducting surveys and research. They had long operated, in fits and starts, as 'research institutes' or 'research centres'. They employed full-time staff, and operated under the supervision of the technical ministries, in what the state regarded as its areas of responsibility. These included public works, agriculture, marine affairs, fishing, and public health, and from 1980, nuclear, oil, demography, forestry, and so forth.

- Finally, developed took place within a number of industries (e.g. phosphates and ONA: Omnium Nord Africain), which had developed their own R&D centres or departments; lately, a number of research consultancy have begun to be set up.

So, Moroccan research had been constructed in a composite, and at times unexpected manner. The research system comprised establishments that had emerged at different periods, with differing status and supervising bodies, in response to differing concerns, where research was often regarded as a task of secondary importance.

This historical background accounts for the complexity of the organisational charts. It helps understand the system's internal tensions: between regulatory authorities, sometimes between branches and among staff (due to their unequal status), and between epistemological stances and conceptions of what constitutes worthwhile science ([7]). It also reveals the great scope of recent government initiatives (e.g. coordination mechanisms, national bids for tender, and incentives to encourage researchers to network).

The backgrounder was much appreciated by the experts when they were preparing their assignments. It also served to organise visits to the widest possible variety of establishments. The historical perspective, the extensive bibliography, and the large number of tables and annexes, made it a key source of reference material.

- ***'Bibliometric' backgrounder***

To recall the basic principles, the aim here was to use measurable output as a means of producing a fine-tuned description of Moroccan research. Publishing work, which is normally the goal of every researcher ([8]), represents one such means. Large bibliographic databases record all articles published in a wide range of journals. We selected 2 general-interest databases, covering the best 6 000 journals that included all of our target disciplines, and extracted every article published over a period of 10 years by authors with a declared attachment to an institution in Morocco. We then divided those articles into 100 scientific subfields, and examined their origins by city, institution, year of publication, and author.

This provided an overview of the overall scientific field, capable of serving as a basis for comparisons between different periods and with other countries. The results can be presented from two points of view.

[6] The university's main underlying purpose was to train teachers and administrative managers. Not finding this to their advantage, the technical ministries gradually created their own schools to train engineers and marketing people. Staff did not have the same status, remits and supervising authorities as in the national education system. Initially peripheral, this 'sector' later came to be presented as a model and was expanded in the 1970s.

[7] Broadly speaking, there are two styles of science: one that is more 'academic' (based mainly at the universities and linked more to academic status), and another that is more 'engineering'-minded (more present at schools and centres, more downstream-oriented, and whose staff, for the time being, lack their own specific status).

[8] For more on this point, see the chapter on 'Bibliometrics'.

The first point of view highlights the rapid expansion of Moroccan research (output quadrupled between 1990 and 2001). Such progress — an outstanding achievement by global standards — has enabled the country to establish itself firmly as the third-ranking science producer in Africa ([9]). It has clearly outstripped Nigeria, which once held an apparently unassailable position but has slipped into decline, as well as Kenya and Tunisia ([10]).

Among others, strengths have emerged in the fields of mathematics, nuclear physics, general chemistry, oceanography, marine zoology and marine biology, livestock rearing and veterinary medicine, geology (more than geophysics), some of the engineering sciences (including civil engineering), and metallurgy. Outstanding areas in the field of health include neuropathology, cardiology, medical imaging, and genetics (more than microbiology). More often than not, this data was confirmed by the views of the experts, which was an encouraging sign vis-a-vis the reliability of the bibliometrics (see Part 2. 3 — Detailed bibliometric analysis: methods and outcomes).

The second point of view is the one in which the results described the current situation. They showed that the growth had continued but the pace of expansion had eased ([11]). A transition was on the cards; skills were differentiating and becoming spatially redistributed (see Bibliometric analysis), giving rise to problems of critical mass, shared equipment, and coordination. A pioneering generation was preparing to pass on the torch, raising the issue of the new researchers' model of professionalism and motivation.

The bibliometric data was useful in many ways. It helped assess the number of approximately 4 000 'active' researchers — this was far fewer than the 'theoretical potential' of 16 000 (including all academics), meaning that Moroccan research still had room for improvement — and the number of teams and laboratories producing published work (around 800). They also made it possible, in the absence of any other data on productivity, to choose which sites the experts should visit.

Notwithstanding its obvious limitations — underestimation of output in the applied sciences, delays in recording the work, poor coverage of the few local journals, and so forth — it is a robust, efficient and reliable tool (as confirmed in the experts' reports). It can be updated every year, with minor coding adjustments. It is a good instrument for maintaining a panel of indicators.

■ *Laboratory questionnaire*

A questionnaire was sent to the laboratories by e-mail. It focused on aspects that would otherwise be hard to grasp routinely during the experts' visits; for example, the laboratory's structure, budget, collaborations (national and international), equipment and maintenance, documentation, output, and marketing of results. First and foremost, it would cover the full range (or a representative sample of) laboratories; unlike the visits, which would inevitably end up being selective.

Carefully prepared in terms of its substance and form, the questionnaire was tested thoroughly in advance, and was prepared as a methodological test. What seemed

[9] Unsurprisingly, Morocco remains some way behind South Africa (four times more powerful, and the leader in virtually every field), and Egypt (two to three times more active, especially in engineering sciences).

[10] Followed by Algeria, and then a cluster of around 10 or so smaller scientific countries.

[11] Reasons for this can be found in the experts' reports.

the easiest part of the exercise turned out to be the hardest — finding the e-mail addresses to which to send the file. It became clear that there was no directory of the 'laboratories', due to the lack of any official records of their existence (i.e. no status, no budget and, hence, no activity reports). It was, therefore, necessary to build a directory with the assistance of the ministry. E-mail subsequently proved to have many benefits, making it easier to despatch reminders and, when necessary, requests for further clarification. However, it also required daily follow-up. Although recipients showed a great deal of goodwill in replying, unreliable addresses prevented us from reaching everyone on the list.

With a highly satisfactory reply rate — 500 out of the 800 laboratories identified — the final results were based on a very large sample of research units. They established reliable orders of magnitude, and occasionally the results came as quite a surprise. The main findings are as follows.

- The average size of laboratory staff was around seven or so people. This is not very different from an average-sized 'team' in Europe. What was surprising here, though, was the number of PhD students: two for every four academics, and one engineer.

- Although individual situations varied greatly, laboratory budgets averaged some MAD 16 000 per researcher (PhD students included) annually ([12]). The key point was that the laboratories had clearly begun enjoying an influx of state funding (PARS and PROTARS research support programmes occupying a major place in this area).

- While the private sector and public authorities contributed little in the way of funding ([13]), collaborations with them were far more numerous than expected. Eighty percent of the laboratories were involved in national collaborations, a quarter of them with the private sector, and an equally large number of international collaborations ([14]).

- Almost every laboratory manager regarded their units as being underequipped. Maintenance was a source of concern, together with slow management procedures, and heavy red tape. One major worry revolved around access to 'hot' documentation.

- Articles were published mainly in international journals — and in a mere handful of national ones — with a more or less equal number of papers delivered at conferences.

- The figures here confirmed the bibliometric data. Average 'productivity'— one article every two years — left some room for improvement. Yet output here, as elsewhere, was highly concentrated at times, with one-fifth of the laboratories presenting vastly superior scores.

- There were many different forms of results spreading. Patents were few. Endeavours to meet the socio-economic demand were more informal and direct. The spreading of results hinged on continuing education (provided by half of the laboratories), R&D (with half the laboratories reporting at least one application in the previous five years

12 Half of the units had an average of MAD 3 000 per researcher annually (MAD 10 was the equivalent of more or less EUR 1 at the time). At the other extreme, a quarter of the laboratories had between 10 and 30 times as much. The extra funds derived from successful tender bids in Morocco or abroad.

13 In the form of payment for services, studies or R&D instead of research funding provided by supervising authorities.

14 France was the main partner at the time — in two-thirds of the cases — but the picture has become more diversified, with Spain leading the field, followed by Belgium, Germany, Italy and Canada.

— a claim needing to be checked), and sustained relationships with a number of economic operators (e.g. provision of expertise and collaboration in R&D).

3.1.3 VIEWS OF THE EXPERTS

The actual evaluation was assigned to around 20 European experts, assisted by an equal number of Moroccan experts. This represented the core of the operation. Together, the European experts covered the entire range of disciplines. They were each asked to visit a selection of laboratories, and to report back on their observations in relation to the state and structure of the laboratories, and relevance of the subjects addressed, and the ambitions, questions and plans of the researchers encountered during the on-site meetings.

3.1.3.1 A reminder of the method

I have already talked about the conditions laid down for recruiting the experts (cf. Chapter 1). They needed to be of a high academic level, conversant with application, leaders of experienced teams, and well-established evaluators. And they had to have no current interest in Morocco. I have also recounted how the sites to be visited were selected: on the objective basis of the bibliometric data, upgraded through the addition of major private or applied research institutions ([15]). Heads of institutions had the chance to add particular laboratories to the list of those being visited on their premises; and researchers were under no obligation to take part in the *in situ* meetings.

In practice, the operation was seen as a sign of respect on the part of the government, and of genuine interest on the part of the ministry. This had much to do with the meticulous groundwork and the human qualities of the experts, as well as the duration of the operation; while the visits initially met with a degree of scepticism at times, they were frequent and incisive enough to be taken seriously in the long run. Let us remember that the experts covered some 50 000 kilometres, visiting 13 of the 14 universities, most of the research institutes and engineering schools, and several private and semi-public companies carrying out R&D. Four hundred ‘laboratories’ were visited, and 1 500 researchers — i.e. an estimated third to a half of the national research capacity — attended the meetings organised on-site.

The method proved perfectly suited to the size of the Moroccan scientific community. The on-site visits by experienced, foreign scientists generated a good deal of interest, and high hopes of the revival and recognition of research, which was one of the community’s main expectations.

[15] Establishments that had slipped through the net of the publication-based approach (see chapter on Bibliometrics).

3.1.3.2 The verdict in a nutshell

The European experts then carefully drafted their reports, which were presented at the final workshop. They were neither simplistic nor uncritical. I do not intend to go into the wealth of their content here: they deserve to be read in full ([16]). Instead, I shall confine myself to those comments where opinions tended to converge, albeit with shades of difference in some areas, forming a single overall view rather than a collection of scattered ratings.

The experts regarded *Moroccan research as being at a crossroads*.

On the one hand, the previous 20 years had seen the powerful and continuous expansion of capacity and output. Morocco, as mentioned above, had just established itself as the third-ranking producer of science in Africa. In most disciplines, it now boasts a large number of high-quality researchers who have personally made a name for themselves on the international stage, and many of whom are anxious to serve their country. Furthermore, a highly active, dedicated ministry has, in recent years, taken a good many initiatives; for example, introducing incentive budgets, providing support for networking, launching evaluations, and implementing national tools for assisting research units (such as equipment, computer link-ups, and documentation).

But a research system remains to be structured and linked to innovation.

The investment has been achieved, and it is now a matter of ensuring that it bears fruit by means of wise deployment. This can be done, relatively inexpensively. The following paragraphs highlight some of the details of this assessment.

3.1.3.3 The researchers: a strong point and an Achilles heel

The main strength of Moroccan research lies in the quality of its researchers. Evidence of this can be seen in the long-term growth of scientific output. It is a fact that the experts themselves confirmed and elaborated on, as shown in the details and discipline-specific variations set out in their reports.

The driving force behind that growth was the requirement to produce theses in order to move up the academic ladder. But that driving force has run out of steam. Most applicants are now accredited; research has all but ceased being a precondition for their promotion, and the recruitment of new teachers is no longer a priority (at least not as much as before). Finding new incentives likely to attract PhD students and young researchers, for instance, has become a must.

Unless a new driving force is found, the capital so painstakingly amassed will soon erode. The warning signs are clear to see. Many researchers, after completing their theses, are

[16] Ministère Délégué à la Recherche, *Atelier National sur l'évaluation du système de la recherche scientifique dans les domaines des sciences exactes, sciences de la vie et sciences de l'ingénieur, Rabat, 26-27 mai 2003, rapport d'évaluation*, 3 volumes, Rabat: MESFCRS.

channelling their energies into other — personally more profitable — activities. In some places, no more than one-quarter to one-third of them are estimated to still be working in research. And active teams are in danger of having no choice other than to apply their trade within the framework of a global division of labour, where they occupy the position of subcontractors (e.g. when preparing theses abroad).

Furthermore, capabilities are dispersed among institutions of differing status, whose declared duties, in some cases, do not include research. They are fragmented (due to individual academic research), and sustained by vertical international relations. They neither have the time nor the means to build a national scientific community capable of acting as a regulatory body, organising meetings, providing impetus, and making proposals.

All of this makes it hard for the researchers to choose the best research subjects. Independent access to scientific documentation is not easy. Except when taking part in major international programmes — especially in the fields of science and industry — can researchers perceive the stakes and opportunities (commercial included) linked to the advancement of science. The desire to work on national themes does not always take into account the sound tools necessary for evaluating their relevance, effectiveness and feasibility.

A subject cannot be considered relevant, for instance, just because it has something to do with Morocco. It must tally with a scientifically and economically innovative niche, to give due weight to the advancement of science at both the local and global level, and downstream opportunities.

There have, of course, been some noteworthy successes on that score in Morocco. The experts highlighted and examined these with a view to showing how to build an appropriate strategy for choosing subjects ([17]). But one cannot rely only on the researchers to prepare such strategies on their own. They need the regulatory oversight of a scientific community, they must establish a rapport with the socio-economic environment, and, most importantly, they have to have the guidance and support of the national authorities.

3.1.3.4 Creation of a dedicated ministry and the work it has initiated: a strong point in need of perseverance

Recently, significant progress has been made as far as this latter point is concerned. The creation of a dedicated ministry was a decisive step forward.

The setting up of a specialised Interdepartmental Committee — one of whose first moves was to endorse the external evaluation — has provided a forum for coherent planning, and for distributing tasks. Various kinds of research assignments exist in such fields as water, maritime affairs, agriculture, and health. In regard to the latter, for instance, health issues should be dealt with by the Ministry of Health, while related matters to do with sci-

[17] Ministère Délégué à la Recherche, op.cit., especially the chapters on medicine, physics, chemistry of natural substances, information-communication, and marine sciences.

entific excellence have to be assigned to the Department of Research. Now it is possible to devise cross-disciplinary, national programmes, and a coordinated division of labour.

Significant support has been provided for grassroots units, mainly in the shape of incentive funding schemes such as Scientific Research Support Programme (PARS) and Thematic Scientific Research Support Programme (PROTARS). Researchers have regarded this not just as an injection of support but also as a welcome sign of attention, and they have become enthusiastic players in bidding for tenders.

What is more, it has helped introduce and initiate a culture of evaluation. Previously, the certification of doctoral training programmes had paved the way for this, and given rise to the first efforts to encourage individual academics to work together. Current backing given to 'Centres of Excellence' is furthering such endeavours through support for team networking.

Everybody was talking about the newly established "MARWAN" interuniversity computer network, and the budgeting of research central support units, including the Institut Marocain de l'Information Scientifique et Technique (Institute for Scientific and Technical Information (IMIST)) . The experts noted that active researchers had applauded and fully adhered to these initiatives.

A considerable amount of legislative work had been done. Although less instantly recognisable, it was just as significant at grassroots level. Decrees had been issued on sabbaticals and on duty-free imports of scientific equipment. Efforts were under way to introduce PhD fellowships. And institutional independence was expected to open up a huge field of action.

So, the right work was being done on a good many fronts to overcome the existing handicaps, and to make the most of the national research system.

3.1.3.5 The research system: weak yet changing

Morocco's scientific capital is a godsend. However, the country must take a major step forward in order to reposition itself economically, and to address the inequalities. It needs to develop national expertise, technological imagination, and the capacity to understand and anticipate change. The practice of carrying out 'focused' research (including in basic science) will be extremely helpful.

But scientific capacity alone is not enough. Activity must be organised into a 'system'. What does this mean? Medicine familiarised us with the concept: we know we have a nervous system, a digestive system, a blood circulation system, and so on. Any system is partially independent because it has its own particular purpose. It is comprised of organs, each with a specific role. Those organs are interlinked; when one fails, the overall goal will not be met. The system is coordinated; information flows around it in real time to achieve a set of goals. The system is focused; it has an end purpose, and adjusts itself automatically.

Morocco definitely does have the constituent parts of a research system; for example, institutions engaged in research, coordination tools, equipment and funding, and active researchers with deep-rooted values and practices. Ironically, the underlying difficulty may have been that the purpose had yet to be recognised. It was like having eyes, optic nerves and a brain, for instance, without discovering what they were supposed to be used for (i.e. to see).

Officially, of course, research exists in the remit of universities and dedicated institutes. But it must cease to be seen as a by-product (of the education system), an ancillary (for providing services) or a subcontractor (i.e. taking on foreign subjects), and must be recognised as having a specific role.

Many of the experts drew attention to the need to foster clear awareness of the goals of research, incorporate its goals into a clear plan within the institutions, and equip it with its own regulatory mechanisms. They each, in their respective areas of expertise, made a strong case for doing this.

Some of the reasons they put forward are widely accepted; for example, the need to do research in order to ensure up-to-date teaching. But the universities preparing for self-government could also consider it as a means of securing a seal of approval. The quality of higher education is high throughout the Moroccan public education system. What commands attention — on the part of society at large, customers, students seeking recognisable qualifications, and so on — is the reputation of outstanding successes, and the guarantee of tangible achievements.

The experts also presented other, stronger, reasons for cultivating research. If the purpose of research is taken seriously, it can reasonably be expected, inter alia, to:

- improve optimisation of natural resources management and marketing (e.g. geological research and chemistry);
- create new jobs to replace those being lost (Information and Communication research);
- discover unimagined resources (e.g. undersea and natural substances);
- cut down on expenditure on various imported engineering goods and supplies;
- improve risk monitoring (early warning and prevention systems tailored to oceans, geophysics, urban geology, and so on);
- keep agriculture abreast of new developments (e.g. in plant material and pest control);
- generally speaking, embrace the modern-day struggle to combat recurrent scourges (e.g. deforestation and drought) and future ills (e.g. pollution and diseases), and help build the capacity to master complex systems (e.g. water, agriculture and health) through mathematical modelling, for example.

It is well worth reading the experts' suggestions in regard to imaginative research subjects. A good deal of especially well-focused work was already being done but it was often little-known and underexploited. Instead of dwelling on that particular conundrum, the experts sought to identify the chronic obstacles preventing research from fulfilling its potential.

To their own surprise, they found those obstacles to be much the same in all of their various specialist fields. Low awareness as to the purpose of research had given rise to four rectifiable lines of weakness vis-à-vis certain means, critical mass and evaluation, and relations with society and the world of economics. Their opinion, in a nutshell, was as follows.

In regard to the means, beyond the noteworthy efforts they had observed, the experts drew attention to a number of points that remained to be addressed.

- Equipment: universities lacked the equipment required to be able not only to conduct reasonably ambitious research work but also to offer reliable services to local companies ([18]). In addition to the special funding granted recently to the faculties by the ministry — in a move that deserves to continue — three points had to be addressed: maintenance (e.g. budgeting, dedicated technicians, and a central emergency repair unit), sharing (i.e. platforms for very large-scale equipment), and travel allowances for researchers based in remote places (to be funded within the framework of the platforms).

- Documentation: the key to independent research. Without a doubt, only a national-level solution would suffice with collective subscriptions to the major scientific publishers and electronic dissemination. This could be the first task of IMIST.

- Human resources: it is crucial to attract young researchers (PhD students), and probably useful to consider bonuses for productive researchers.

- Administrative procedures: management and oversight needs call for more suitable rules, even governing such details as the procurement of consumables, revised budget itemisations, and so on. Institutional independence — with project or laboratory-specific book-keeping, if possible — could be extremely helpful.

In regard to critical mass

- In some disciplines, the experts' opinions differed as to the 'right size' of grassroots units. Nevertheless, they agreed that existing teams were too small to carry out programmes measuring up to their capacity; to mobilise the wide-ranging skills required for a particular project ([19]), and to move beyond the realm of subcontracting.

- Most advocated the creation of 'laboratories' that were approved — and, hence, evaluated and funded — on the basis of project proposals.

- Unifying their forces was, in their view, the responsibility of the researchers themselves. The experts recommended incentives for voluntary collaborations. They also

[18] They must be equipped with these two concerns in mind, and with a view to promoting the emergence of 'quality-certified' laboratories. Some faculties have set out to construct research buildings and/or to pool annual appropriations in order to acquire large-scale, shared pieces of equipment. This is a good solution. Other efforts need to be agreed upon by the ministry and by the universities themselves to ensure that they genuinely make the grade.

[19] See, for example, the geological map in the report on the earth sciences.

stressed the need for regular evaluation, strict certification, and efforts to publicise the seals of approval awarded in exchange for guaranteed grassroots support and acknowledgement of the manager's duties (e.g. reducing the teaching load).

- The ministry's action in support of Networks of Excellence and Centres of Excellence was well placed. However, the experts stressed that in several areas more attention must be given to ensure that their programmes and their procurement of equipment paved the way for R&D cooperation within the productive sector.

In regard to scientific evaluation

- This is the heart of the research system. It is a must for all of its actors. It sets benchmarks for actual researchers, is a management tool for decision-makers, and it is a powerful means of raising awareness of — and gaining recognition for — national research in the global scientific world.

- Based on their 'research plan', evaluations must cover institutions, laboratories, and the staff assigned to research duties ([20]). The criteria must be unambiguous, relevant, and plain to see.

- First and foremost, an evaluation is not a judgement but a reflection of reality. It must be endowed with positive sanctions. Serving staff should receive a 'productivity bonus', forms of which remain to be determined (e.g. a meaningful career award, an earnings supplement or an arrangement in terms of working hours and duties). Institutions and laboratories could see their budgets adjusted according to their results.

- A credible evaluation system needs the support of representatives from a structured scientific community. Such structuring cannot be done to order. It can come about only through an internal movement, inside the community itself. But it could be a key policy initiated on the part of the authorities to encourage and facilitate every effort to achieve that end by supporting academies, associations, national journals, and conferences. The authorities themselves need to have competent representatives trusted by their peers at hand to advise them in each major field.

Linked to the evaluation issue is the sensitive matter of the choice of research subjects, as follows.

- The experts recalled the dual purpose of research: the advancement of knowledge, and social utility. Irrespective of the goals pursued, the same two questions were raised: what was its relevance, and was it effective? Only the criteria differed. At one end of the spectrum — basic research — the relevance consisted of the 'hot' fronts of world science, while effectiveness was measured in terms of citation of the work in other publications. At the other end — development and prototypes — the relevance consisted of being close to a local need (or even creating demand), while effectiveness depended on whether the results genuinely were taken on board by a socio-economic operator within a reasonable time frame.

[20] Clearly, the frequent case of staff no longer actively involved in research — and merely providing consulting services, supervising students or preparing a personal thesis — is awkward. In this regard, solutions have been proposed. Indirect (yet verifiable) services to research can be taken into account.

- The choice of subjects requires first-hand knowledge of the advancement of science in the world, and reliable information on the downstream opportunities; for example, markets (local or global), users, and 'buyers'. A good subject was developed on a Moroccan comparative advantage in a promising niche.

- From that point of view, one must be wary of the subcontracting of foreign science. It is, of course, possible to take advantage of it. Morocco needs to remain connected to cutting-edge science, not to reinvent it. But routine and slavish subcontracting must be avoided. An independent strategy needs to be introduced. It is important to know the place it affords in the scientific division of labour, and in the major technological challenges. It is also important to see if it serves merely to sustain a practice or is geared to updating and upscaling — whether it boils down to the consolidation of world science or provides access to it being cutting edge and to the global marketplace.

3.1.3.6 Relations with the productive sector

This is a key section of almost every single field-specific report.

The experts noted the mutual non-appreciation of the two realms: research and society, and especially research/business. This came as no surprise to them; the situation was much the same as elsewhere ([21]). Naturally, the two worlds were pursuing different interests ([22]). But there were areas where their interests overlapped. The questionnaire for Moroccan laboratories showed those areas to be more extensive than expected in this country. Yet their (often enduring) collaborations were largely informal, improperly free of charge, and linked to random relationships between individuals.

Nevertheless, the experts stressed that it was impossible to consider performing high quality research — especially in cross-disciplinary, technical fields — without a relationship with a productive sector that would carry the project through to its conclusion (e.g. development, new product or process).

Meanwhile, a number of misconceptions needed correcting, as follows.

- Researchers are not always willing or in a position to identify the right (applied) research subjects ([23]).

- Public science does not have to put all of its resources, as a matter of urgency, immediately into application and development ([24]).

- There is nothing shameful or damning about entering into relationships with potential customers by offering them ongoing training, doing small-scale applied research work for them or arranging to sell a laboratory's products ([25]).

- Routine service provision, however, does not amount to research nor does consulting work and the supervision of tutorials.

[21] The European Commission has devoted a great deal of thought and energy to fostering closer ties in a number of strategic areas.

[22] First and foremost, entrepreneurs seek to consolidate the production system rather than to innovate, especially at the technical level. Researchers remain anxious primarily to publish their work in the best journals.

[23] Several experts (e.g. in physics, and mechanical engineering) recommended carrying out a carefully prepared strategic review of company needs that are not always voiced or considered. Information must be circulated widely among researchers.

[24] A reasonable share of funding needs to be devoted to maintaining a research base, a think tank, and a means of monitoring international developments.

[25] Some higher education institutions appropriately finance some of their *research* with the resulting profits.

According to the experts, current difficulties between the research and business communities stemmed from the lack of benchmarks on both sides, and from a culture of excessive gratuitousness. In regard to benchmarks, researchers were dispersed and lacked visibility, and the equipment at their disposal did not lend them the credibility they needed to develop partnerships. At the same time, many were unaware of the expectations and demands of potential users. A number of customers doubted whether they had the capacity to do what was necessary to become operational.

However, their services were used within the framework of private consultancies or as a gesture of goodwill; for example, by taking in PhD students, unfunded, whose work would later on serve as reference material. As a matter of fact, awareness of the need for studies was low, even on the part of the public services. Studies were used but it was not customary to pay for them, except in the case of engineering. Nor was it customary for researchers to work for money or on mission-oriented research projects.

Something can be done to remedy such misconceptions. To begin with, plans could be made to grant certain laboratories a seal of approval, and to equip them in such a way as to enhance their credibility. It would be useful to bring a 'strategic assessment of company needs' to the attention of researchers, and to publicise both the seals of approval granted and the successful collaborations.

Meanwhile, effort could be made to establish fairer contract-based relationships, which would call for a specialised unit to assist in negotiating and signing agreements. Criteria could be incorporated into the researchers' evaluation regarding any form of dissemination they have accomplished (e.g. R&D). They should be allowed to earn profit from it or to upgrade their equipment. In place of academic disparagement or indifference to applications, a bona fide evaluation would take into account the scope of research operations carried out. Seeking and securing contracts would be a positive move, and the time devoted to collaborations would serve as an indicator of an institution's activity.

3.1.4 CONCLUSION

Clearly, the experts came to take an interest both in the scientific community they were scrutinising and in a country capable of gaining considerably from the sometimes impressive scientific capacity in place. Some teams truly have achieved a great deal with the limited means at their disposal.

It was no mean feat on the part of a team from the National School for Mining Engineering (Ecole Nationale de l'Industrie Minérale: ENIM), for instance, to have taken charge of several sheets of the geological map of Morocco, and then mounted an international consortium to compensate for the skills it lacked. It was quite an achievement on the part of a young female volunteer to have persuaded local authorities to pay — no matter how small a sum — for appropriate studies in earth sciences. And, furthermore, for a signal processing laboratory to have established itself as one of the leading 'European' groups specialising in knowledge, and reproduction of techniques and materials used by classical, popular arts. Who would have thought that Morocco had the asset of a leading expert in decision-making mathematics (one of the most sought-after fields of expertise in the world) and top-notch clinicians, cited by global medicine?

Not enough can be said in tribute to the 300 or so researchers responsible for producing nearly one-third of all catalogued Moroccan science or the young scientists striving to gain recognition for their wealth of original, up-to-date ideas in the eyes of a sometimes awe-struck socio-economic world.

Equally clear is the fact that in the past few years the Department of Research has embarked upon a vigorous agenda of initiating the right kinds of projects, and has aimed to overcome the handicaps still affecting national research. Whether in terms of funding, equipment, pooling and development of human resources, cooperation or evaluation, the bottlenecks have been identified, and efforts are being made to improve efficiency.

Everyone involved is anxious to find the best ways to secure recognition for, and the reproduction and optimisation of, the country's outstanding existing capacities — a goal that the experts, too, have strived sincerely to help achieve.

3.1.5 ANNEX

Highlighted below are the agenda items for discussion at the cross-disciplinary workshops organised within the framework of the National Workshop on the evaluation of the Moroccan scientific research system (May 2003).

- **Underlying purpose of research: planning and indicators**

  - underlying purpose of research at various types of institutions, and its incorporation into a clear plan within the institutions;
  - evaluation of the institutions;
  - panel of indicators.

- **Organisation of research**

  - what is a 'laboratory'? — creation, approval, and side effects (e.g. funding, privileges and responsibilities of a 'laboratory director');
  - calls for tender and forms of structuring (e.g. centres of excellence and networks as well as scientific journals and associations);
  - evaluation of programmes and institutions.

- **Human resources**

  - researcher profession (e.g. status and careers) with case studies (e.g. research administrators, technicians and engineers);
  - effective contribution to research, evaluation, and incentives;
  - newcomers to the profession (e.g. fellowships for public sector and industrial);
  - continuous training of researchers, sabbaticals, bridges, and redeployment.

- **Budgets and funding**

  - basic support (exclusively for approved 'laboratories' or proportional to results?);
  - bids for tender, incentive budgets, and so forth;
  - own resources (e.g. funding earned through continuous training, service provision and consulting) and R&D contracts (e.g. assistance in seeking, negotiating and managing contracts);
  - monitoring procedures (e.g. a priori, a posteriori, and government procurement).

- **Equipment**

  - technical platforms (e.g. sharing and management of heavy equipment, and the agency in charge);
  - scientific information (e.g. travelling to conferences, access to journals, IMIST, and MARWAN);
  - procurement and maintenance (e.g. technicians and maintenance budget).

- **International cooperation**

  - cooperation agreements;
  - purpose (e.g. financial aid, updating, and upscaling);
  - 'subcontracting'.

- **Relations with the productive sector**

  - service agreements (e.g. continuous training, analysis, and consulting regulations);
  - applied research, development and demonstration, researcher and institution profits-sharing, evaluation of the work, and efficiency problems (e.g. deadlines, means, commitment to responsibility, and sound and stable quality);
  - industrial fellowships, research contracts, and intellectual property;
  - interface and meetings, and clubs, incubators and dissemination units.

The debates were underpinned by the experts' reports, the backgrounders produced for the evaluation, and various other documents prepared for the workshop by the Department of Research. The recommendations have been published by the Department of Research.

3.2 LESSONS LEARNED AND FOLLOW-UP

Said Belcadi and Ahmed El Hattab

3.2.1 INTRODUCTION

In 2003, experts from the European Union carried out an evaluation of the Moroccan national research system on the request of the government's authority in charge of scientific research. It covered the fields of the exact sciences, life sciences, and engineering.

This chapter seeks to pinpoint the lessons learned from that evaluation to determine the extent to which its recommendations have translated into action, and to see how useful those recommendations have been for sustaining the work of building the national research system.

Before we begin, it is worth adding a few words about the original intentions. The approach adopted tallied with the government's political will, stated on many occasions from 1998 onwards, to make research a core component of the country's development policy. Making this decision a reality would call for the construction of a credible, efficient and sustainable *system* geared toward achieving clearly defined national priorities.

This would mean having to examine, first of all, the existing research system in order to determine whether it had the capacity and means of a national structure, whose components played a hands-on, interactive role in the country's scientific, technological, economic, social and cultural development. In other words, did it meet the expectations of the government, the institutions, researchers and academics, socio-economic actors, and civil society?

This was the time when the option of an *external* evaluation entered the frame. The minister who took the initiative explained the kind of achievements that could be expected: fostering of an actual culture of evaluation in Morocco; enhancing recognition and awareness of the value of Moroccan research at national and international levels (e.g. persuading decision-makers and economic operators here and elsewhere that instead of a 'luxury' it could in fact serve as a 'lever of development'); and, through the *experts' external view*, making it possible to assess the strengths and weaknesses of existing capabilities objectively, and within a context of international competition.

Therefore, the main outcomes expected from the evaluation would be:

- a diagnosis designed to raise awareness of the system's components, performance, and impact on development and knowledge production;

- a clear idea of its strengths and weaknesses across the board;
- a set of relevant recommendations, the implementation of which would make it possible to bolster and build on its strengths, and to overcome its weaknesses.

At the end of the day, the evaluation carried out by the European experts definitely can be deemed to have helped answer some of the questions raised. In addition to a number of substantial reports, which still serve as a useful source of discipline and major field-specific reference material, it delivered coherent analyses that, taken together, produce a straightforward assessment and some clear suggestions. Furthermore, it brought out the system's strengths and weaknesses, tying them in with a few selected areas of interest; for example, regulatory authorities, human resources, infrastructures, funding, and influence on socio-economic development.

3.2.2 MAIN LESSONS LEARNED

Before going any further, it must be noted that this was the first time the system's components — its researchers, institutions, programmes and projects, infrastructures, and so forth — had ever undergone any institutional evaluation, be it internal or external. The operation carried out by the European experts, therefore, represented a new — and risky — experience whose focus may have seemed either hopelessly inadequate or overly ambitious to those concerned. However, which could also, if successful, be a crucial means of gaining knowledge of the system and assuring its future.

To limit the risks, meticulous groundwork was conducted, including the construction of wide-ranging, additional data through a bibliometric survey, a questionnaire for laboratories, and analysis of an abundance of documentation amassed by the ministry. More importantly, perhaps, a good deal of attention was also paid to details pertaining to all of those in charge, especially the heads of institutions. And the approach of the experts during their field visits laid great stress on interviews and patient, on-site consultation with front-line researchers in their laboratories. The main lesson to be learned here is that the operation's success — not just in achieving its objectives but also engaging the stakeholders — certainly did have much to do with the groundwork, and with the personal qualities of the operators.

Therefore, the evaluation was well received not only by the research regulatory authorities but also by the national scientific community. Researchers saw it as an opportunity to demonstrate the value of their scientific work to proven experts, and to share their concerns about the problems stemming from the day-to-day management of their work. The positive response was such that many of the researchers and academics that were not given the chance to meet the expert evaluators did not, as a rule, hesitate to voice their displeasure.

The regulatory authorities, for their part, were pleased to have unprecedented access to a body of indicators and succinct information capable of giving them a clearer grasp of the national research system. The lesson here lies in the advantages of incorporating the tools used into an easily updatable reporting system — an invaluable instrument for guiding the direction, planning, programming, and funding of research activities.

Generally speaking, the evaluation revealed how important it was to improve the organisation of the system, its structures, and infrastructures. It drew attention to the need for optimising its human resources, coordinating its activities, boosting its funding, and fostering better relations with its socio-economic environment. A number of major programmes have since been launched to address those issues. One of the first strives, as recommended, was giving a seal of approval to a limited number of accredited teams, laboratories, and research centres. The goals of this programme, which (as we shall see later) is now at quite a relatively advanced stage, are to raise the system's profile and performance levels, and to facilitate intervention on the part of the regulatory authorities in such a way as to make it more efficient and productive.

As for the universities, the lessons revolve around the fact that the evaluation has served to stimulate a renewed interest in research, and greater awareness of its role in regional development. Indeed, a good many academics are trying to streamline their research themes to the needs of various socio-economic sectors, especially those established in the vicinity of their universities. This is reflected clearly in the universities' new research plans of action, which stem from another of the evaluators' recommendations. The universities have sought to use those statements as a means of boosting the niches of excellence revealed in the evaluation.

With all of these points of view in mind, the evaluation fully achieved its objectives. Its analysis of the national research system was convincing. It brought to light both the system's strengths and weaknesses. Not only did it offer guidelines for upgrading the system but the final reports also provided a wealth of suggestions for creative and workable measures. Now we need to look at what has been done to follow up on the guidelines and recommendations put forward by the European experts, and at the impact, these have had on efforts to improve the efficiency of the national research system.

The recommendations have been — and shall continue to be — of use primarily to the government research authority, of course, as a means of guiding its action. Nevertheless, they have also helped universities and other education and/or research establishments, together with the researchers themselves, to anticipate and prepare for the changes that the system is undergoing. Meanwhile, others likely to benefit include the businesses involved in collaboration, co-operation, and partnership-based relationships with the system's various components.

3.2.3 FOLLOW-UP

This section deals with how the government research authority has used the guidelines and recommendations put forward by the European experts in order to improve the efficiency of the national research system. Here, is a brief reminder of the main thrust of the wealth of suggestions contained in the evaluation.

The main recommendation was to promote the function of research for its own good. A variety of measures were suggested; incorporating a research-specific section into the plans of action that the state was to broker with individual establishments; setting up research-specific institutions, including a ministry with its own authorities, evaluation committees, and vice-chairpersons specialising in each establishment; fostering the vision and a strategy for choosing subjects where Morocco has a comparative advantage, not just in the 'traditional' fields but also in pioneering niches; and curtailing its subordination to education, short-term needs, and global outsourcing.

Five main fields of action were specified:

- enhancing human resources by confronting problems of the profession's appeal and status, doctoral fellowships, and incentives for encouraging researchers to work;
- capacity-building (e.g. pooling heavy equipment, daily deliveries of 'hot' documents to the researchers' desks, and adapted management procedures);
- fostering critical mass — first and foremost, by organising 'laboratories', financing networks and Networks of Excellence, supporting the construction of specialist communities, and so forth;
- evaluating of staff, programmes, and establishments with unimpeachable ad hoc committees, and positive measures such as adjustable budgets and career plans;
- improving relations with the world of economics and civil society by laying down markers for actors on all sides (e.g. equipping, endorsing and raising the profile of exemplary laboratories, organising forums and frameworks for meetings such as clubs, interfaces and incubators, publicising successful cooperation efforts, and giving prominence in evaluations to R&D).

These suggestions can initially be said to have helped establish solid guidelines and targets for the implementation of projects contemplated under the five-year plan, 2000–2004. Next, they contributed to the preparation of an action plan for the period 2004–2007, revolving around three main priorities:

- organisation and structuring of research, while improving working conditions for Moroccan researchers;
- setting up of national research infrastructures and technological platforms;
- promotion of quality and excellence, while fostering a culture of evaluation and self-evaluation.

Let us now consider the projects and achievements linked to that action plan.

3.2.3.1 Structuring (first priority of the 2004–2007 action plan)

The evaluation had clearly shown the progress achieved since 1988 with the setting up of an interdepartmental standing committee for scientific research and technological development, and the restructuring of the Centre National de Coordination et de Planification de la Recherche Scientifique et Technique (National Centre for Coordination and Planning of Scientific and Technical Research (CNCPRST)). It stressed that greater efforts were required in terms of organisation, coordination and structuring, and underscored the need to upgrade and mobilise human resources. The 2004–2007 action plan converted those recommendations into a number of programmes.

3.2.3.1.1 Structuring research at universities

This, the key programme — crucial to improving the efficiency of the national research system — focuses on the structuring of research at universities and other institutions of higher education. Launched after a national workshop held on 24 May 2004, it was decided it would form a four-tiered structure: teams, laboratories, study and research centres, and interuniversity networks. The characteristic features and modi operandi of these components have been standardised in administrative and scientific terms. And those meeting the standards are recognised by the universities in the way of accreditation, making them eligible for funding based on project proposals. Several universities have completed this programme, and have already allocated funding to their research structures.

This structuring work certainly has had a positive impact on research management at universities. The institutions now have a clear idea of their capacity — for example, human resources, equipment, infrastructures, and research themes — that facilitates the planning and programming of scientific activities. Universities and the social and economic sectors concerned are no longer liaising with individuals but with organised bodies recognised by the various official authorities, and managed by bodies duly set up and controlled by regulations ratified by the appropriate authorities.

Another result of the structuring work is the greater recognition given to research. Most universities have now appointed a specialised vice-president, and the faculties have appointed associate deans. Specific budgets have been earmarked. The prevailing trend is one of sharing available means, and creating synergies and critical mass. In some places, negotiations have been initiated to promote results-based funding.

An institutional policy is emerging. The universities took this into account when drafting their first ever research action plans in 2004. Those plans, themselves, have contributed to the structuring in that they focus on research projects that tackle priority themes, on the upgrading and/or procurement of scientific equipment, and on the creation of new research and/or service structures.

Indeed, the action plans do the following:

- cover every discipline, with an emphasis on multidisciplinarity;
- concern basic and applied research;
- take account of local and regional problem-solving needs in areas to do with environment, sanitation, health, business competitiveness, water management, land use planning, cultural heritage and history, information technologies, agriculture, and so forth.

In addition, these action plans have provided for and enabled capacity-building in terms of scientific laboratory equipment, computer networks, and scientific and technical documentation. Some have included a commitment to creating new infrastructures; for example, research buildings, and technological platforms (including analysis and measurement centres, maintenance centres, and computer centres). Several have established interfaces for the dissemination of research results. A few have set up research centres, and online resource centres.

It is also worth noting that the structuring of research at universities is about to move into a new phase with the forthcoming establishment of doctoral schools. This project will accredit host laboratories, together with relevant training courses, and will standardise their procedures through the adoption of national academic standards.

3.2.3.1.2 Restructuring of the Networks of Excellence

Further to the recommendations of the National Workshop in May 2004, another project was launched to improve the administrative and scientific procedures and working conditions of Networks of Excellence.

The European experts had visited a few of these networks, such as Réseau National des Sciences et Techniques de la Mer (REMER) (National Network of Marine Science and Technologies), Pôle de Compétences Sciences et Technologies de l'Information et de la Communication (STIC) (Information and Communication Centre of Excellence), and Pôle de Compétences Neurogénétique (PCNG) (Neurogenetics Centre of Excellence, and had appreciated their conception.

The aim here is to help foster the emergence of quality research on interesting topics conducive to the country's scientific, technological, economic and social development. This development will come about through the pooling of human, financial and material resources needed to enable the Networks of Excellence to eventually attain higher levels of excellence. The ministry's role is to facilitate this synergetic pooling of resources by granting the networks the funding required to meet their operating and equipment needs.

The aim of restructuring the Networks of Excellence is to establish new rules for their partnership with the ministry. What stands out most about that relationship today is that the centres are to be seen not as permanent fixtures but as contractual partners. They will exist, have their operating budgets renewed, and be granted new subsidies, only if they meet a number of requirements over a period of three years.

In other words, the survival of a Network of Excellence will depend on the results it manages to produce in meeting its specified contractual conditions. Its performance will be subjected to a yearly evaluation, when its operating budget comes up for renewal, and during and at the end of its contract.

3.2.3.1.3 Closer relations between universities and businesses: disseminating research, and promoting development research and innovation

The evaluation carried out by the European experts highlighted the weakness of linkages between research and socio-economic needs and, hence, the negligible use being made of research results by potential users, especially in industry. The government research authority has gone to considerable lengths to rectify that situation, and build solid and lasting bridges between public research operators and the various economic stakeholders. This has involved two courses of action: on the one hand, the introduction of a system of incentives to encourage investment in development research; and, on the other hand, the creation of mechanisms to facilitate knowledge, skills and technology transfers to companies.

With respect to the incentives, a national innovation plan has been drawn up, revolving around three main kinds of incentives: tax relief, assistance for skills recruitment, and aid to settling (subject to a transfer of technology or to an investment in development research). In return for tax and land-related benefits, four companies have signed agreements with the State for the relocation of certain development-research activities:

- STMicroelectronics in the field of electronic components;
- Matra Automobile Engineering in the field of automobile design;
- Lead Design in the field of electronic integrated circuits (intellectual and physical design);
- Teuchos — a subsidiary of the European Safran group — in the field of components for space and avionics systems (R&D and design).

As for the mechanisms facilitating knowledge, skills and technology transfers to businesses, four structures have emerged for the dissemination of research:

- Réseau Marocain d'Incubation et d'Essaimage (RMIE) (Morocan Network for Incubation and Spill over);

- Réseau de Génie Industriel (RGI) (Industrial Engineering Network);
- Réseau de Diffusion Technologique (RDT) (Technological Spreading Network);
- university-business interface structures.

RMIE strives to generate employment through the creation of pioneering companies. It comprises 9 business incubators encompassing 28 funded projects (chosen from 60 proposals submitted to its selection committee). Three companies are in the final stages of start-up. And the incubation process is beginning to bear fruit. The first spin-off company, Société NABATOP (Cadi Ayyad University, Marrakech), has been up and running since September 2005, working on the utilisation of cactus derivatives in the food-processing and cosmetics industries.

RGI sets out to provide companies with support in their efforts to improve productivity through assistance schemes, and organises technical training courses for industrial engineering.

RDT, which is run by the Department of Industry in partnership with the Department of Higher Education, Professional and Management Training, and Scientific Research, seeks to promote innovation and technological development within companies.

The university-business interface structures, for their part, developed rapidly after a national workshop organised in March 2004. There are currently 20 such structures in place at institutions of higher education, staffed by 180 resource people, who have already undergone initial training for the professionalisation of their work within the structures, for a budget of MAD 1 million ([1]).

3.2.3.2. Improving working conditions (first priority of the 2004–2007 action plan, continued)

Efforts made within the framework of the first priority of the 2004–2007 action plan to 'improve the working conditions of Moroccan researchers' have aimed, inter alia, at introducing a full time researcher status, and encouraging Moroccan researchers living abroad to participate in the development of scientific research in their homeland.

3.2.3.2.1 Human resource enhancement: full time researcher status

As far as the full time researcher status is concerned, the government research authority has set out to raise awareness among decision-makers at every level, including the prime minister, government, and parliament. The matter was raised at the meeting of the

[1] MAD 10 = EUR 1

'Comité Permanent Interministériel de la Recherche Scientifique et du Développement Technologique' on 21 February 2006. Committee members agreed that it was a matter of paramount importance for completing the structuring of research at national level, and for motivating researchers working at public research establishments. Hopefully, a satisfactory solution can be found with all due haste for this thorny and critical issue — albeit concerning a rather small corporate body.

3.2.3.2.2 Participation of expatriate Moroccan researchers

The Global Forum of Moroccan Competences Abroad (FINCOME) has been set up in response to the government research authority's strategy to encourage experts living abroad to contribute to the development of scientific research in Morocco by playing an active part in efforts to build the national research system.

3.2.3.3 Infrastructure (second priority of the 2004–2007 action plan)

With regard to the second priority of the 2004–2007 action plan, three major achievements deserve to be highlighted in the field of establishing national infrastructures and technological platforms:

- UATRS technical support units for scientific research;
- Institut Marocain de l'Information Scientifique et Technique (The Institute for Scientific and Technical Information (IMIST));
- MARWAN network.

3.2.3.3.1 Technical support units for scientific research

UATRS technical support units boast a collection of modern, heavy-duty scientific measurement and analysis equipment managed by highly qualified staff — for example, academics, engineers and technicians — and made available to the scientific community and economic operators.

Since 2005, two such units have been operating in the fields of chemical analysis and physical chemistry (i.e. materials characterisation), and another unit is due to come on board in 2007 in the field of life and health sciences.

The first two contain nearly a dozen pieces of sophisticated equipment, as highlighted below.

- For elemental analysis:

  - CHNOS organic analyser;
  - spectrometer with plasma torch;
  - X-ray fluorescence spectrometer.

- For molecular analysis:

  - mass spectrometer with CPG;
  - mass spectrometer with HPLC;
  - raman infrared spectrometer;
  - Nuclear Magnetic Resonance (NMR).

- For structural analysis:

  - scanning electron microscope with EDX;
  - transmission electron microscope with EDX;
  - X-ray diffractometer for single crystals;
  - X-ray diffractometer for powder.

The benefits of these units are beyond dispute. They have allowed researchers and academics to broaden the scope of their work to include highly specialised subjects related to environment, food-processing, materials, energy, health, pharmaceutics, biotechnology, and so on. Such subjects previously went unstudied due to the lack of necessary equipment. Therefore, research has taken a significant step forward in quality terms and become a bona fide tool for development. This has not only boosted its usefulness for academics but also its credibility in the eyes of socio-economic operators.

3.2.3.3.2 The MARWAN network

Significant improvements in quality have also been made through the MARWAN computer network. Devoted exclusively to higher education and research, MARWAN serves to connect 85 higher education institutions. Transmission speeds have increased from 2 to 34 Mbps, and are soon to be boosted to 155 Mbps. It has also been linked up to the European GéANT (Gigabit European Academic NeTwork) network.

Real-time access to scientific and technical information is crucial to progress in research and knowledge production. With “MARWAN” — and, once it is up and running, IMIST — researchers and academics have a modern tool for securing access to information at the national and international level.

3.2.3.3.3 The Institut Marocain de l'Information Scientifique et Technique (IMIST)

IMIST's role is to gather and process scientific and technical information, and to disseminate it not just to the scientific community but to socio-economic operators. It is due to be fully operational in 2007. In the meantime, it is already providing users with access to a database on national expertise, and publishing specialised newsletters that enable users to keep track of the latest scientific and technological developments.

In the eyes of the European experts, subscription to online sources of scientific and technical literature was the first task to be undertaken, and the main way to help researchers. For the time being, however, plans to achieve that goal remain on the drawing board.

On the other hand, another goal — also suggested by several of the experts in their reports — has been added to the agenda: the compilation of the first ever catalogue of theses. This should make it possible to gain a clearer idea of Moroccan scientific production, and provide a better focus for research, especially concerning the future doctoral schools.

Generally speaking, IMIST will enable the national research system to address one of its main weaknesses as identified by the experts: unavailable and scattered scientific and technical information.

3.2.3.3.4 Specialised research structures

Also within the framework of the second priority of the 2004–2007 action plan — and in the interests of research capacity-building and structuring — the national research system has been bolstered by the establishment of specialised research structures. This initiative is in keeping with the expert evaluators' recommendation that the government authority capitalise on strengths and achievements, and to exploit the niches of excellence found at certain universities.

The Institut des Plantes Aromatiques et Médicinales (Aromatic and Medicinal Plants Institute) at Sidi Mohamed Ben Abdallah University in Fez, for instance, will help promote applied and development research in the fields of pharmacology, cosmetics and food-processing, with a view to optimising Morocco's abundant plant heritage. The Centre d'Etudes et de Recherche sur l'Eau et l'Energie (Water and Energy Research Centre), which is being set up at Cadi Ayyad University in Marrakech, will make it possible to coordinate human capacity and expertise in water and energy research at national research organisations and universities. It will become a national reference point for the management of those two increasingly scarce resources, and a key tool to assist in decision-making.

3.2.3.4 Quality and excellence (third priority of the 2004–2007 action plan)

About the third priority of the 2004–2007 action plan, the national research system has made great progress since 2004. This priority sets out to promote quality and excellence, and develop a culture of evaluation and self-evaluation.

3.2.3.4.1 Research fellowships

Progress has materialised in a research fellowships programme set up to promote quality and excellence in doctoral studies. Starting in 2006, a three-year grant worth MAD 2 300 per annum will be awarded each year to each student of the 600 best Diplôme d'Etudes Supérieures Approfondies (DESA) post-graduate diploma holders in any discipline, enabling them to pursue a PhD. This programme contributes to the structuring of research by helping promote excellence and focus attention on priority themes. Furthermore, it makes it possible to address another weakness pinpointed by the expert evaluators: the ageing academics population, especially at universities.

3.2.3.4.2 Prizes for excellence in science and technology

Quality and excellence are also being promoted through the awarding of two prizes from 2006 onwards: one to reward outstanding work in research or innovation; and the other to honour researchers and academics for having contributed throughout their careers to the country's scientific and technological development. Both prizes are material rewards, and the latter includes a medal as well.

3.2.3.4.3 CNRST associated units

Another factor contributing to the promotion of quality and excellence in the Moroccan scientific community is the establishment of CNRST associated units in 2006. These units are being set up on the basis of a call for proposals sent out to every nationally accredited research institution. Therefore, only institutions with the best track record, and the capacity to generate added value for the national research system will be eligible for CNRST support.

3.2.3.5. Evaluation and self-evaluation (third priority of the 2004–2007 action plan, continued)

According to the reports drawn up by the European experts, evaluation is one of the main weaknesses of the national research system. Although singled out as one of the responsibilities of the government research authority — and part of the remit of CNRST — not a single institutional structure has thus far been set up to undertake such a task. That said, efforts have been made to fill the gap as far as evaluation and self-evaluation are concerned.

3.2.3.5.1 CNRST scientific committees

According to law no. 80-00, CNRST must have a scientific board to assist its director in decision-making. CNRST also has specialised-discipline and field-specific scientific committees, whose assigned tasks include the evaluation of CNRST-funded projects and programmes.

3.2.3.5.2 Annual reviews of research achievements

As far as self-assessment is concerned, the government research authority publishes an annual review, taking stock of achievements in terms of the organisation, structuring and funding of research.

3.2.3.5.3 National survey of scientific and technological capabilities

An annual national survey will be carried out among all national-level research operators, including public research institutions, universities, and non-university institutions of higher education. It will focus on research structures, infrastructures, human resources, funding, and scientific production. A special form has been prepared based on the Frascati Manual. The survey will provide the government research authority with an annual overview of Moroccan research. The main aim is to be able to make the most accurate assessment possible of public research spending, and if possible, to gauge its impact on the efficiency of the national research system. A bibliometric review may be added.

3.2.3.5.4 Evaluation of the national research system in the fields of social and human sciences

This new wide-ranging evaluation is extremely important. On the one hand, it will round off the operation already carried out by the European experts in the fields of the exact sciences, life sciences, and engineering. On the other hand, it will give the government authority the information and data needed to take stock of a much-handicapped sector of research.

Phase one of the evaluation, which is already under way, involves the pre-testing of a questionnaire to be sent to researchers and academics. Also in place is the drafting of interview guidelines designed to help those conducting the survey to organise meetings with the people in charge of research structures and institutions.

The survey covers the areas of historical sciences (i.e. prehistory, archaeology, and history), social and political sciences (i.e. ethnology, anthropology, sociology, and political science), philosophy, linguistics and communication, literature and the arts (e.g. musicology), economics and management sciences, law and jurisprudence, geography and regional development, religious studies, and educational sciences (e.g. didactics, educational technology, and educational psychology).

3.2.3.5.5 External evaluations

A Network of Excellence and a pilot programme for the setting up of interface structures have been subjected to an external evaluation carried out by foreign experts.

3.2.3.6 National strategy and vision for research

While the 2004–2007 action plan has helped sustain the work of building the national research system, since its launch it has been hampered by a lack of specific national policy-making based on a long-term strategy and vision. Therefore, the government research authority has assigned a scientific committee of Moroccan experts to develop such a strategy and vision by the year 2025.

The national research system currently has two documents establishing the main thrusts of national research policy for a period of 20 years. The strategy and vision draw, to a large extent, on the results of the evaluation of the system carried out by the European experts in the fields of the exact sciences, life sciences, and engineering. They also take into account the economic, social and cultural data describing where Morocco stands in 2006, and where it is likely to be in 20 years time.

The major thrusts of the strategy revolve around the governance and funding of the national research system, mobilising of human resources, dissemination of research findings, and international cooperation. Special attention has been paid to the promotion of research in the social and human sciences.

The strategy development process has provided an opportunity to update the national research priorities. Some of those already set forth have been retained, including improving quality of life, knowledge, preservation and enhancement of natural resources, socio-economic and cultural development, information science and technology, agriculture in difficult conditions, business competitiveness and innovation, and basic research. New priorities include risk management, and biotechnologies.

3.2.3.7 2006–2010 action plan

The strategy and vision have been distilled into an action plan for 2006–2010, geared to upgrading, inter alia, the governance, structures, means, and working methods of the national research system. It will involve capitalising on the system's achievements by continuing with the actions that produced those achievements, improving the focus of those whose results have been questionable, and putting forward new courses of action likely to have positive impact.

The actions that have been planned can be divided into five categories:

- aimed at upgrading the governance of the national research system (11 actions);
- linked to the strengthening and improved mobilisation of human resources (9 actions);
- linked to the funding and financial management of research activities (6 actions);
- aimed at improving the scientific and technological yield of such activities (9 actions);
- seeking to improve infrastructures for science, R&D, and innovation (13 actions).

3.2.4 CONCLUSION

Today, the evaluation carried out by the European experts in 2003 does not appear to have been either a mere publicity stunt or a flight of fantasy. It has had a definite impact, and continues to serve as a source of inspiration for action.

It established a methodological benchmark that has inspired new approaches of evaluation (e.g. social and human science 'system') and external reviews (e.g. projects or programmes). It provided a solid base of documentation, which remains a frequently consulted source of reference material.

The evaluation developed analysis tools that, once updated and adapted to current needs, can be reused (e.g. questionnaires, and bibliometric indicators).

Moreover, it provided a clear and acceptable diagnosis of the state of research, together with creative and workable proposals that have been re-examined on many occasions to help plot a course of action.

Most importantly, the operation initiated a platform for dialogue, which has continued to foster consensus to this day, between the research authorities and front-line researchers. It has made it possible to establish, without question, the quality achieved by Moroccan research. Furthermore, it has helped point out, without evading any issue, the changes needed to sustain its rapid expansion, whether the responsibility for this lies with the authorities or with the researchers themselves.

The fact that it was an external evaluation is what gave the operation its leverage. And the professionalism of its organisers, and quality of the experts selected, did much to ensure that it would be well received; the respect they showed the researchers, without seeking to court popularity, made a big impression.

Clearly, the measures taken since have not amounted to a mechanical application of the experts' recommendations. They have transposed, and even (at times) distanced themselves from them, thus reflecting the changing circumstances. Yet, the main thrust has remained the same. The final reports still have much to offer today, especially when there is so much riding on the question of which strategies to develop for choosing the right research subjects and niches. They make a case, backed by examples, for taking into account not just the specific — current and foreseeable — needs linked to the country's distinctive nature but also the advancement of science in the world, and global economic competition.

REFERENCES

Mina Kleiche-Dray

Official references

B.E.P.M. (1955), Bulletin de l'Enseignement Public au Maroc, 42 (1955), no spécial hors série.

B.I.M. (1947), 'Comité franco-marocain de la Recherche Scientifique', Bulletin d'Information du Maroc, no 5, 31 mars 1947, pp. 26-27.

C.N.R. (1997), Annuaire des Unités de Recherche au Maroc, Rabat: Ministère de l'Enseignement Supérieur, de la Formation des Cadres et de la Recherche.

D.I.P. (1950), 'Bilan 1945-1950', La Recherche Scientifique, Rabat: Direction de l'Instruction Publique, pp. 9-10.

MESFCRS (janvier 1999), Préparation du plan quinquennal, 1999-2003, Commission spécialisée Recherche Scientifique, Développement Technologique et Ingénierie, p. 16.

Ministère Délégué à la Recherche (2003), Atelier national sur l'évaluation du système de le recherche scientifique dans les domaines des sciences exactes, sciences de la vie et sciences de l'ingénieur — 26 et 27 mai 2003, Hay Riad, Rabat, Vol. 1: Allocutions et Synthèse générale (61 pages), Vol. 2: Rapports d'évaluation (554 pages), Vol. 3: Système national de recherche scientifique (163 pages), Rabat, MESFCRS.

Secrétariat d'Etat Chargé de la Recherche Scientifique: Etat des lieux de la Recherche Scientifique et Technique au Maroc, décembre 1998 (Rapport non publié).

Secrétariat d'Etat Chargé de la Recherche Scientifique (juin 2000), La Recherche Scientifique — Situation à la veille du XXIème siècle.

Bibliographical references

Arvanitis, R. et Gaillard, J., (1992), Les indicateurs de science pour les pays en développement / Science Indicators in Developing Countries. Colloques et Séminaires. Paris, Editions de l'ORSTOM.

Bonneuil, C. et Petitjean, P., (1996), 'Recherche scientifique et politique coloniale. Les chemins de la création de l'ORSTOM, du Front populaire à la Libération, 1936–1945' in Petitjean P. ed. Les Sciences coloniales, Figures et Institutions, Paris : IRD, pp. 113-160.

CNER (1997), De nouveaux espaces pour l'évaluation de la Recherche, Paris: Documentation Française.

Doghraji, A., (1993), La production scientifique agricole à l'IAV, Rabat, Mémoire ESI.

El Masslout, M., (1999), La mission inachevée de l'Université marocaine, Casablanca: Toubkal.

Gaillard, J. Krishna V.V. & Waast, R., eds (1997), Scientific communities in the developing World. New Delhi: Sage.

GERARD, E. & Kleiche, M., (2002), Les sciences humaines et sociales au Maroc : repères sur leurs composition et production, Rabat: CJB/IRD.

Kleiche, M., 'L'Institut pasteur de Tanger (1913–1956)', communication au colloque INERM/IRMC, La Méditerranée Médicale entre modernité et tradition XIXe et XXe siècle, Hammamet, juin 1994, p. 10.

Kleiche, M., (2000), La Recherche Scientifique au Maroc, Paris: IRD, p. 103.

Laberge, P., (1987), Politiques scientifiques du Maghreb: l'implantation du système scientifique dans les sociétés maghrébines de 1830 à 1980, Thèse de Ph.D., Montréal: Université de Montréal.

Laredo, P., et al., (1999), A report of the PSR project of the EUTSER programme, Paris: CSI.

Merton, R.K. & Gaston, J., eds, *The Sociology of Science in Europe*, Carbondale: Southern Illinois University Press et London: Feffer and Simons, 1977, pp. 383.

Moatassime, A., (1978), 'La politique de l'enseignement au Maroc, 1957 à 1977', Maghreb-Machrek, 79, pp. 20-46.

Paye, L., (1957), L'Enseignement et la société musulmane. Introduction et évolution de l'enseignement moderne au Maroc, Thèse de doctorat, Tunis: Université de Tunis, p. 482.

Rocheteau, G., (2000), Rapport d'évaluation des Programmes d'Action Intégrés (PAI), Paris: GRET.

Solla Price, D.J., (1963), *Little Science, Big Science*, New-York : Columbia University Press.

Squali, M. & Merrouni, M., (1981), 'La question de l'enseignement au Maroc**',** in Bulletin de l'Enseignement Supérieur Marocain BESM, no quadruple 143 – 144 – 145 – 146.

Vermeren, P., (1996), 'Emergence et apogée de la contestation étudiante contre l'état au Maroc (1963–1974)', Cahiers du CERES, série histoire, 6, pp. 297-305 (Tunis).

Vermeren, P., (2000), 'Ecole, élite et pouvoir au Maroc et en Tunisie au XXe siècle', Rabat: Alizés, p. 582.

Waast, R. et Rossi, P.L., (2001), Les sciences en Afrique, Synthèse bibliométrique Paris: IRD, p. 172.

European Commission

Evaluation of a national research system: Morocco

Luxembourg: Office for Official Publications of the European Communities

2009 — 164 pp. — 250 x 17,6 cm

ISBN 978-92-79-12957-5
doi 10.2777/36998

How to obtain EU publications

Publications for sale:

- via EU Bookshop (http://bookshop.europa.eu);
- from your bookseller by quoting the title, publisher and/or ISBN number;
- by contacting one of our sales agents directly. You can obtain their contact details on the Internet (http://bookshop.europa.eu) or by sending a fax to +352 2929-42758.

Free publications:

- via EU Bookshop (http://bookshop.europa.eu);
- at the European Commission's representations or delegations. You can obtain their contact details on the Internet (http://ec.europa.eu) or by sending a fax to +352 2929-42758.

KI-NA-24036-EN-C

During 2002–2003, the European Commission’s Directorate-General for Research and Technological Development (DG RTD) financed an external evaluation of the Moroccan national research system, a requested initiated by Morocco. This book states how the evaluation was carried out, and summarises its outcomes.

The assessment process lasted one year. Several tools were used, including bibliometrics, questionnaires to the stakeholders, and visits to the laboratories by a team of international scientific experts. The diagnosis consequently made remains authoritative in Morocco.

The reach of such an assessment is wide in scope. The *methodology* is transferable, able to be applied in many other countries. It proved more efficient than customary surveys (i.e. usually limited to desk studies, followed by a rapid visit to the headquarters). Furthermore, DG RTD wanted it to be made public and disseminated.

doi 10.2777/36998

ISBN 978-92-79-12957-5

9 789279 129575

Publications Office