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

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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

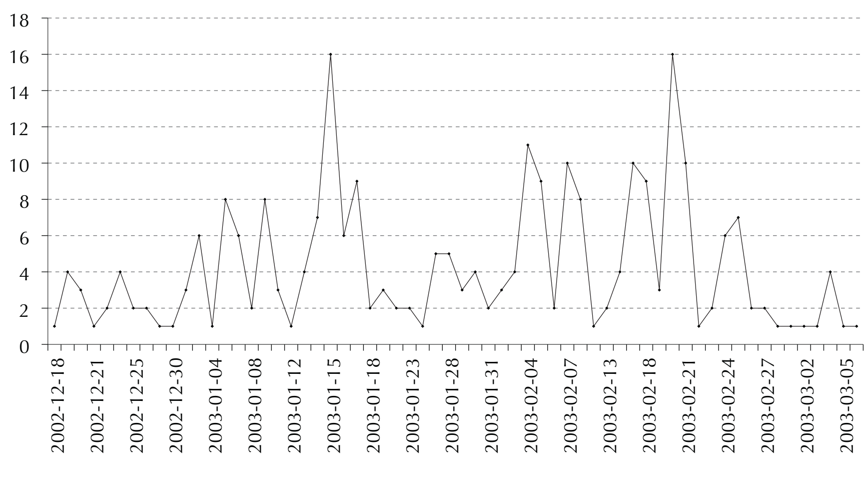
Preparing and carrying out the questionnaire/survey was greatly facilitated by two earlier studies on scientific research in Morocco ([8]). The first was on the history, development and institutionalisation of scientific research in Morocco ([9]), and the second was a bibliometric study on Moroccan scientific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

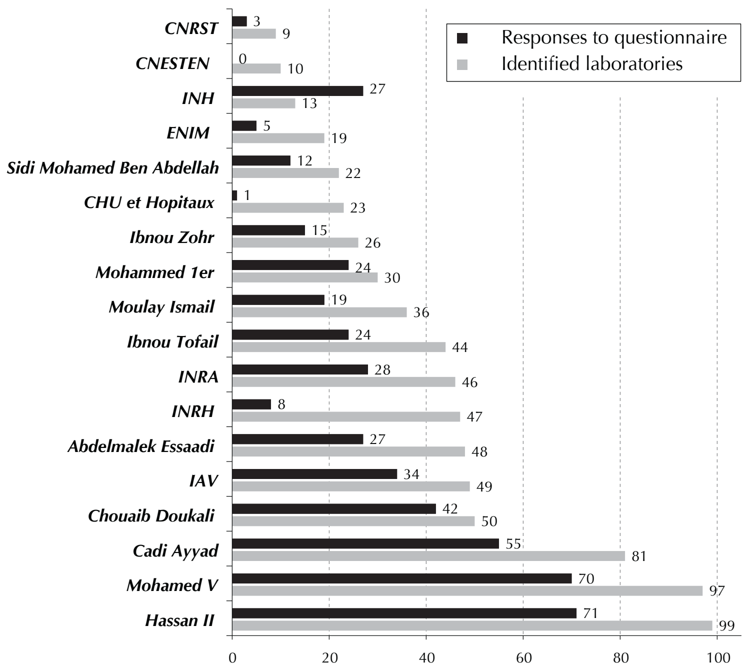
Table 1. Number of questionnaires received and number of laboratories that participated in the survey

	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

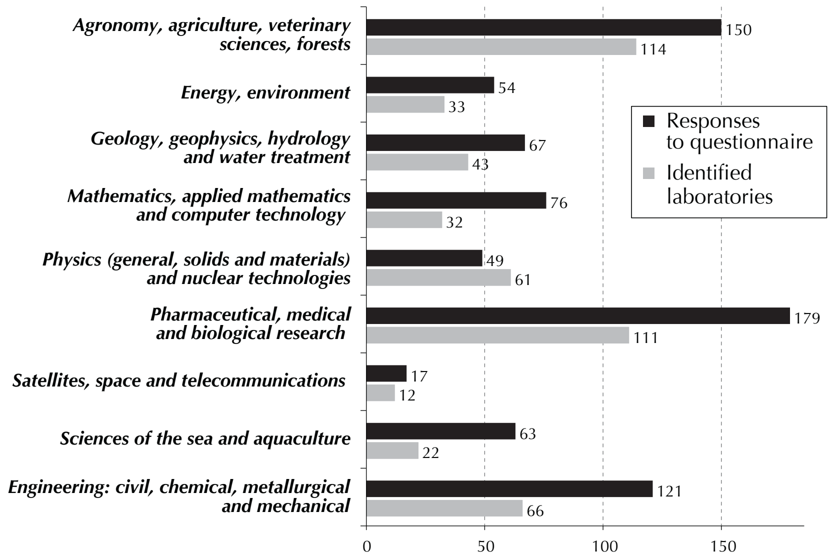
	University	Public institutes	Other establishments	Total
Identified laboratories	71 %	20 %	9 %	100 %
Laboratory in survey	73 %	18 %	9 %	100 %

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?

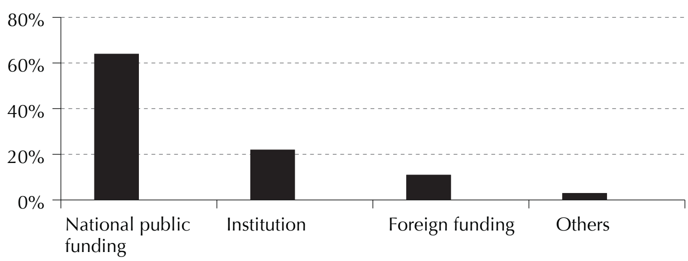
Type of institution	Yes	No	Yes and No	No response
Institutions of higher education	21	12	0	1
Universities	118	59	3	11
Research institutes	18	19	1	0
TOTAL	**157**	**90**	**4**	**12**
%	**59.7**	**34.2**	**1.5**	**4.6**

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**

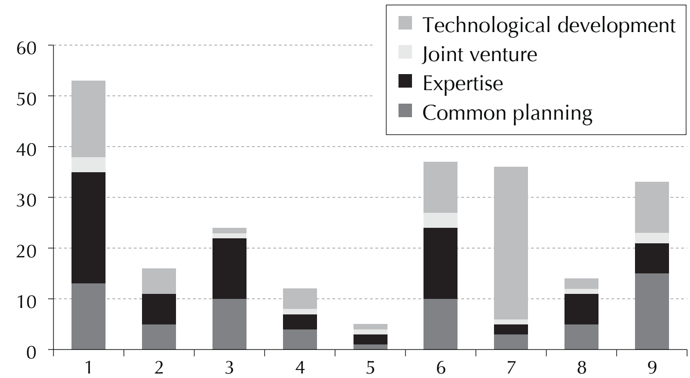
These general averages, per scientist, hide very varied situations. A large number of laboratories publish very little, while a small number of them publish a lot and in very different types of publications. Half (49 %) of the laboratory directors said that they capitalised their research findings by 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.