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Maghreb
The Development of the Scientific Research in the Maghreb

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

CERN	Centre Européen de Recherche Nucléaire
CNCPSRT	Centre National de Coordination et de Planification de la Recherche Scientifique et Technique
CNR	National Research Centers
CURS	Centre Universitaire de Recherche Scientifique
GDP	Gross Domestic Product
IAEA	International Atomic Energy Agency
IFC	International Finance Corporation
INRAS	Agricultural Research Centers
MESRS	Ministry of Higher Education and Scientific Research
NMR	Nuclear Magnetic Resonance
OECD	Organization for Economic Cooperation and Development
PERA	Product Engineering Research Association
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	United States Agency for International Development
WDR	World Development Report

This document is based on the findings of two consultant reports (M. Taïeb Bennani (Morocco), M. Belgacem Baccar (Tunisia)), desk studies and a brief mission in Morocco and Tunisia. The authors are Josephine Douek-Hykin, Senior Science and Technology Specialist and Hasso-A. Molineus, Principal Operations Officer. Peer reviewers are: Lloyd Briggs (EC3HR), Jamil Salmi (ESP), and Jacques Gaillard (OSTROM), France.

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EXECUTIVE SUMMARY

INTRODUCTION - SETTING THE SCENE

1. Growing productivity is the engine of development, and the principal driving force of productivity is technological progress. Two key factors influence technological progress: a) investment in human capital and b) the quality of the economic environment. Consensus has gradually formed that a "market friendly" approach to economic development results in substantial gains, and to the extent that markets are distorted, productivity usually suffers. As the importance of "openness" and "competition" has become known, the conviction has also grown that investment in people, if done right, provides the firmest foundation for lasting development. As stated in the World Bank's 1991 World Development Report, "the worldwide spread of economic growth has depended chiefly on the diffusion of a body of knowledge concerning production techniques....the more schooling of appropriate content that a nation's population has, the easier it is to master the new technological knowledge becoming available". The returns from investment in research and development resulting in technological progress can be quite high, for example between 30 to 60% in agriculture. It has been estimated that up to 50% of GDP growth in the more advanced OECD economies since the 1950s can be directly attributed to the outcomes of research and development activity.

2. In this context effective and appropriate scientific research plays a key role in social and economic development and is an important aspect of nation building, especially for middle income countries, such as in the Maghreb, seeking to enter the mainstream of contemporary technology and commerce. As the Maghreb countries intensify their links with the world economy, the need for competitiveness and increased productivity through technical progress will make it even more necessary to strengthen scientific capabilities, including education and training institutions and research and development centers.

3. The purpose of this sector study is to assist in this process by considering issues of national research and development policy, governance (management and institutional organization), and resourcing (manpower, equipment and information). It is also intended to heighten the national awareness of the importance of scientific research as an instrument to increase human well-being through social and economic development.

MAIN CONCLUSIONS

4. The assessment of Maghrebian scientific research focusses on the system's weaknesses rather than its strengths. There are however important strengths which should be recognized in formulating proposals for development. They include the following:

a) A significant number of Maghrebian nationals have undertaken, and others are still active in, prestigious scientific research projects within and outside the region.

b) All three countries have made major investments in education, with resulting improvements in their education output indicators[1], and have therefore laid a solid base for producing qualified researchers in many disciplines; the nucleus of a scientific research community exists.

c) Efforts have been made to prioritize research activities in terms of national development goals, particularly in the agricultural sector where notable progress has been made, and to create some regional institutions, policies and programs.

However, much more needs to be done in priority setting and in the development of research to strengthen the capacities for the adaptation of existing technology.

5. Structure and Management. Despite organizational and institutional efforts to set research priorities directed at achieving national development goals, little progress has been made - with the notable exception of recent developments in the agricultural sector - in any of the Maghrebian countries, towards realizing this overriding objective. The main reason for this in each country has been the failure to define clearly national priorities and to establish an effective, coordinated governance to oversee and direct all national research investments and activities.

6. Funding. At present, funding decisions for research follow historical institutional resource allocation mechanisms, rather than being tied to national research priorities and strategies. It is difficult to identify separate research budgets in the higher education institutions. Actual expenditures for research are rarely monitored or evaluated against specified objectives. Their allocation is therefore not used as an incentive to focus research on national developmental issues. There is no attempt to use funding mechanisms to enhance the efficiency and effectiveness of the research effort.

7. Human and Physical Resource Provision and Training. The recognition of the important role of research in economic and social development in each of the Maghrebian countries has resulted in an effort to create an effective scientific community. Unfortunately, the non-accountable provision of insufficient core funding to both the university and other research institutes, the absence of worthwhile incentives and insufficient capital investment have combined to create a poor research environment overall. These factors all contribute to the less than optimal performance of the sector and the loss of skilled, trained manpower to work overseas. In summary:

a) The present systems of education and training in all three countries is not producing the critical masses needed for productive research except in a few cases.

1/ Unfortunately, however, recent budgetary allocations for education have not kept pace with expanding enrollments with a resultant reduction in quality and output indicators.

b) The majority of researchers in all three countries are employed as civil servants; their conditions of service, pay and promotion prospects are bound by the government code of practice and salary scales in each country. There are few monetary incentives for staff to be highly productive researchers.

c) All three countries are deficient in equipment and physical installations.

d) Active institutional and organizational linkages between members of the research community both domestically and internationally are weak in all three countries. Incentives to cooperate and coordinate are very limited. Multidisciplinary research teams are rare. Links with the industrial sector are almost totally lacking.

e) International cooperation, especially with France, is more widespread than cooperation at the domestic or regional (Maghrebian) level.

8. System Performance - Indicators and Outcomes. The significant constraints identified in terms of current and potential research funding, and the nature and type of necessary human resource development make imperative the careful selection and prioritization of research projects for funding. It also necessitates the close monitoring and evaluation of research progress and performance. Unfortunately, middle income countries like Algeria, Morocco and Tunisia, which can least afford it, generally have weak policy making, planning, implementation and evaluation capacities with respect to research. There is no effective follow-up to ensure that nationally funded research is driven by national needs and is both effective and efficient.

STRATEGY TO SUPPORT RESEARCH CAPACITY BUILDING

9. National Policy Making. Experience, especially in the agriculture sector illustrates the capacity in the Maghrebian countries to formulate and drive national priorities. The first prerequisite for a successful return on the considerable investment in research in the Maghreb should therefore be a system in each country for the formulation and dissemination of a clear, unambiguous national research policy, including objectives, priorities and, where appropriate, targets.

10. Governance - Structure and Management. Organizational or institutional changes by themselves do little to harness the national effort, unless they are accompanied by other measures which change behavior. In fact, too much organizational change, particularly if it is imposed too quickly and without a transparent planning frame, creates uncertainty and instability, resulting in reduced motivation and productivity. However, there are many obvious examples of duplication of effort, underuse of scarce equipment and lack of effective institutional collaboration in each of the three countries, and serious consideration must therefore be given to accepting active collaboration or rationalizing the number of units holding a research management brief. Given the expense of undertaking modern state-of-the-art research and the limited resources available for such tasks, careful consideration must be given to the most

effective use of what is available. One possibility is the concentration of available human and physical resources through the creation of institutional "centers of excellence". Not all universities or research institutes can excel in all disciplines. Depending on existing staff resources, such centers should be identified, fostered or created.

11. Funding: It is not possible, in any of the three countries, to judge whether current expenditures for scientific research are adequate to meet stated objectives. This is the case, because the objective statements are rarely adequate or sufficiently specific to provide measures of performance, and also because of the absence of any reliable data on the amount and effectiveness of expenditure on the sub-sector. Total allocations appear to be of the same order as those of other countries at a similar stage of development; they are, as expected, much below those of most OECD countries and the "tigers" of Asia. It is difficult to ascertain the extent to which these allocations are fully available and utilized, or whether the bureaucratic processes are sufficiently slow to result in loss of funds at the end of fiscal years. Thus allocating more to scientific research will not necessarily result in the acquisition of more knowledge, more technology or more "scientific" output. Before more is allocated, a much greater effort must be made to ensure existing provision is expended to best advantage.

12. Despite the fact that Maghreb industries are unlikely to become a major source of university research funding, those modest opportunities for joint funding that do exist should be exploited and supported. It is important for the well-being of both partners, to create incentives which foster cooperation between industry and academia.

13. The Research Environment. In order to address the deficiencies in the environment policy makers, planners and implementers need to agree on a plan for improvement with targets and timetables. This must relate to priorities which have been determined at the highest level. The result of this analysis might show that an essential first step is to improve much of the existing physical provision by putting into place a program of routine maintenance, repair and equipment consolidation with appropriate staffing and remuneration, including support personnel. Such an assessment will help to identify not only the size of the budget necessary for effective, productive work, but also the knowledge, skills and techniques needed by a range of personnel. These could range from management of research units and project management to maintenance and repair and technical support skills.

14. Also, linkages with other researchers should be reinforced, the large number of expatriate researchers should be made to feel part of in-country networks which should be created and nurtured. Many expatriate Maghrebians remain culturally tied to their roots and would respond very positively if approached in a systematic, well-supported way. A proactive initiative to take maximum advantage of this valuable resource could be attractive and productive.

15. A key element to improving the overall performance of the sector is the development and motivation of appropriate and sufficient human resources. If there are insufficient researchers or they are of poor quality, the best

equipment will not help to produce the desired output. Lack of appropriate support staff can be another constraint. Consequently, even though a nucleus of a scientific community exists in the three Maghreb countries, the size and balance of skills in this community need to be examined. Their conditions of service and incentive structure also need review. Moreover, measurement of research performance must be introduced as part of the review process and tied to funding.

16. Scientific and Technological Development. The transformation of the output of basic research to commercially desirable products is frequently the focus of applied research and development, although the boundaries between these types of activity, and the relationships between them, are changing rapidly and fundamentally. Both researcher and producer are able to profit, if mutually satisfactory links can be established. Such links can be provided through jointly financed research projects of which there are a number of successful prototypes. Such centers may produce commercially exploitable prototypes, adapt imported technology, commercialize innovations and provide other services which result in collaborative efforts between industry and the scientific community. Moreover, expenditures which help to absorb and diffuse technology often justify public funding (e.g. in agriculture). Mixed government/industry/institutions should be established that offer industrial extension (technology search, assessment, negotiation design), and public research (university and other government funded institutes) should be directed more towards commercial needs. Coherent systems of standards, testing and certification also need to be developed.

AGENDA FOR ACTION - NEXT STEPS

17. Policy Making and Governance. To set policy and provide a more effective and efficient system of research, each country should have:

a) A top level government body for formulating national research and development policy and priorities, and for the oversight and coordination of the total activity. In some areas common to all the Maghrebian countries, for example water resources, environmental studies and alternative energy sources, mechanisms could be introduced to identify, sponsor and possibly coordinate mutually beneficial activities.

b) A structure and management system for national research which would implement an agreed set of measures to improve the sector's current identified weaknesses, e.g. improved incentives, funding and evaluation mechanisms; enhancement of the economic relevance of research.

18. The Research Environment: To improve the facilities and physical resources for research, it will be necessary to agree, in terms of national policy and priorities, on plans for achieving the following:

a) an inventory of existing equipment, with location, age and condition;

b) proposals to acquire additional equipment and facilities necessary for an acceptable level of national provision;

c) a program of routine maintenance, repair and updating of equipment;

d) access to appropriate documentation, information systems and data bases;

e) improved access to a greater diversity of international contacts, conferences, and exchanges;

f) a concentration of resources in centers of excellence selected in order to reduce duplication and waste and provide a critical mass of expertise in areas of identified national importance.

19. Human Resources: There are three sources of the human capital that will be required for the short- and long-term development of successful research in the Maghreb: output from the universities and the technician training institutions; the continuing formation of existing researchers and support staff; and experienced Maghrebian research workers from overseas. Detailed proposals need to be developed as follows:

a) University first degree programs and technician training programs should be reviewed to emphasize project work, critical thinking, creativity and team work. Incentives should be provided, including government sponsorship, to encourage applied research and collaborative links between industry, universities and other research centers.

b) Salaries and conditions of service of existing research staff should be reviewed in order to reward performance and encourage development in their discipline and research methods.

c) A proactive initiative to take maximum advantage of the expatriate Maghrebian research force could be attractive and productive.

20. Next Steps. The report's recommendations should first be discussed with those government officials responsible for policy formulation. Should its main conclusions and recommendations find general acceptance, further discussions should subsequently be held with the leaders of the scientific community. A series of seminars could provide a mechanism to see if a consensus could be reached on what needs to be done to improve the development of scientific research in each country. Subsequently, a more detailed action program should be outlined, which may involve the institutional and policy changes included in the recommendations, to create a revised incentive framework allowing the sector to function more effectively and efficiently. Support from the Bank could provide guidance and expertise in selecting, prioritizing and refining these recommendations, to offer the opportunity to study and adapt existing models of national research strategies. In the longer term a country specific action program might be submitted for consideration for World Bank financing, perhaps in collaboration with other official lenders.

THE DEVELOPMENT OF SCIENTIFIC RESEARCH IN THE MAGHREB

I. THE STUDY AND ITS PURPOSE

INTRODUCTION

1.01 As the Maghreb countries intensify their links with the world economy, the need for competitiveness and increased productivity through technical progress will make it even more necessary to strengthen scientific capabilities, including education and training institutions and research and development centers. The purpose of this sector study is to assist in this process by considering issues of national research and development policy, governance (management and institutional organization), and resourcing (manpower, equipment and information). It is also intended to heighten the national awareness of the importance of scientific research as an instrument to increase human well-being through social and economic development.

1.02 The report is in four parts. The first part sets the scene by considering the key elements necessary for the development and implementation of a vigorous, productive research program meeting national needs. This paradigm is intended to serve as a starting point for discussion among those concerned with the development of research policy in the Maghreb. The second section analyses the strengths and weaknesses of the existing research activities: priorities, organization, resourcing, management of human and physical resources, and output measures and indicators. This analysis is based on a review, undertaken with the help of in-country consultants, of the present state of research in the Region. The third part proposes a strategy for improvement, and the fourth suggests next steps and makes a series of recommendations.

1.03 The Gulf War considerably delayed the sector work. Fortunately, suitable local consultants in both Morocco and Tunisia were identified and financed through a foreign (Norwegian) consultant trust fund. However, in Algeria it has so far proved difficult to obtain equally definitive current information, and they have asked for more time to examine their domestic research agenda.

1.04 In order to identify and emphasize proposals for improvement, the assessment of Maghrebian scientific research in the following sections focusses essentially on the system's weaknesses rather than its strengths. There are, however, important strengths which should be recognized in formulating proposals for development. They include the following:

a) A significant number of Maghrebian nationals have undertaken, and others are still active in, prestigious scientific research projects within and outside the region. For example, a Nobel prize was won by staff at the Tunisian Institute Pasteur, and a world renowned researcher in the field of super conductors is an Algerian national.

b) Since independence, all three countries have made major investments in education, with resulting improvements in their education output indicators[1], and have therefore laid a solid base for producing qualified researchers in many disciplines; the nucleus of a scientific research community exists.

c) Efforts have been made to prioritize research activities in terms of national development goals, particularly in the agricultural sector where notable progress has been made, and to create some regional institutions, policies and programs. However, much more needs to be done.

1.05 This paper therefore describes the current institutional framework in the three Maghreb countries with emphasis on its present structure and management and the major perceived issues and weaknesses. It concludes by presenting a possible approach for resolving some of these problems by, in essence, describing what needs to be done to change the sub-sector from being demand- rather than supply-driven.

SETTING THE SCENE

The Purpose of Research (The Macro Setting) (Why?)

1.06 Growing productivity is the engine of development, and the principal driving force of productivity is technological progress. Two key factors influence technological progress: a) investment in human capital and b) the quality of the economic environment. Consensus has gradually formed that a "market friendly" approach to economic development results in substantial gains, and to the extent that markets are distorted, productivity usually suffers. As the importance of "openness" and "competition" has become known, the conviction has also grown that investment in people, if done right, provides the firmest foundation for lasting development. As stated in the World Bank's 1991 World Development Report, "the worldwide spread of economic growth has depended chiefly on the diffusion of a body of knowledge concerning production techniques....the more schooling of appropriate content that a nation's population had, the easier it is to master the new technological knowledge becoming available". The returns on investing in research and development resulting in technological progress can be quite high, for example between 30 to 60% in agriculture. It has been estimated that up to 50% of GDP growth in the more advanced OECD economies since the 1950s, can be directly attributed to the outcomes of research and development activity.

1/ Unfortunately, however, recent budgetary allocations for education have not kept pace with expanding enrollments with a resultant reduction in quality and output indicators.

1.07 Consequently, effective scientific research plays a key role in social and economic development and is an important aspect of nation building, especially for middle income countries, such as in the Maghreb, seeking to enter the mainstream of contemporary technology and commerce. Scientific knowledge has become essential in a widening range of technological and industrial activities to take advantage of domestic resources. There is an increasing need for the development, understanding and application of advanced technologies, as well as for related training, to diffuse these technologies to business, industry and commerce.

1.08 Local scientific development can contribute to more efficient and productive research and development systems. It can also encourage innovation and adaptation that will be useful to domestic industry and technology, and produce the human capital needed for research and enhanced high-tech industrial growth. The case for developing an indigenous science research and technology establishment can be summarized as follows:

a) There is undoubtedly a minimum threshold of scientific knowledge and resources required to ensure proficient performance of scientists, technicians and professionals (doctors, engineers, agriculturists, managers). This threshold is rising continuously with the expansion of scientific knowledge and improvement in technology. In order to benefit from the opportunities offered, a nation must have a functioning scientific community that is able to sustain and motivate national development and relate to international progress.

b) While technological knowledge can be acquired from abroad, it is important to have individuals who can understand, assimilate and, if necessary, transform and adapt this knowledge to local advantage. This, again, requires a minimum quantum of people with a sound scientific background and the support systems to keep them productive and up-to-date.

c) A modern technological society requires more than the ability to perform skillfully; it requires a positive national attitude to invention, discovery and modernization. Science, by its questioning nature, influences the way man looks at the universe. This positive general attitude towards science can be fostered in the population at large only by a local scientific effort.

The Nature of Research (What?)

1.09 Scientific research is any systematic enquiry conducted under rigorous scientific methods. It can offer immediate and long term direct benefits to the whole community, for example by improving crops, health and industry. Research also provides fresh insights into the existing body of knowledge. It is therefore an essential ingredient in maintaining academic and vocational standards and raising the level of understanding of nature and society.

1.10 In order to study research properly, it is helpful to identify several categories of the activity. Fundamental research seeks to add to the body of existing knowledge without necessarily being concerned with its potential use; it addresses problems posed by nature. Applied research emphasizes the application and development of new theories and techniques to practical problems posed by man. The third category, sometimes known as problem solving, covers the use of specialized techniques for development and testing to provide marketable products (see also Annex 1).

1.11 This categorization is clearly oversimplistic. Among other difficulties, the categories overlap and do not encompass adequately some other valuable forms of scholarly activity such as innovative book writing, state of the art consultancy and refereed papers; these can contribute greatly to high standards of teaching and learning. Attitudes towards the processes of fundamental and applied research -- and the relationship between them -- are changing rapidly, particularly with regard to technological innovation and the growing importance of proprietal research. The research process is no longer seen as a lengthy linear progression from basic to applied research and thence to new products, but rather as a cyclical iterative process involving a complex fusion of a wide range of research knowledge and skills.

1.12 Each of these categories of research has a valid role to play, but their value to the system and their cost vary significantly. It is necessary to recognize and, if possible, quantify this when setting priorities and allocating resources. Few nations can afford to pursue fundamental research across a very wide spectrum of disciplines; no nation can afford to eschew entirely fundamental research. Most nations, however, have special needs, skills and historical predilections which favor particular generic research activities. The very high cost involved in many areas of fundamental and applied research means that research is now increasingly characterized by the selection of areas of concentration and the designation of centers of excellence in appropriate fields of study. This approach is sometimes carried to the point of explicitly fostering international collaboration in selected areas of research.

1.13 Within the academic world, applied research and technological innovation have traditionally been given less support and status. But they are now generally recognized to be as intellectually demanding, and often as costly, as fundamental research, and to afford significantly greater and more immediate local returns. Involvement of academic staff in applied research also increases their knowledge of current industrial developments and practice; it is a prime way of building mutually beneficial links between academe and industry. The growing introduction of market forces into education at university level has also enhanced the status of, and commitment to, applied research and obscures even more the boundaries between the categories.

The Structure of Research (Where?)

1.14 Research activities in most countries are distributed into three broad areas: higher education (universities, grandes écoles), research centers related to industrial and commercial sectors (petroleum, phosphate, textiles and informatics), and national centers (standards, meteorology and environment). The first and last are frequently funded by the government, while the second receives both private and government funding. Traditionally, research has been centered in the universities, but this has shifted with the rate of technical change, the cost of research, its impact on industry, and the changing nature of universities and their mission. This has been accompanied by the growth of research centers serving industry and increase of direct government involvement in national, or even international, areas of research concentration relating to either long-term national needs (renewable energy sources, arid regions), or highly specialized and expensive areas (European CERN program, the European Space Program).

1.15 In any stage of economic development, the relationship between these three areas of research activity is as important as the performance of individual units. In developing countries where resources, particularly skilled manpower, are at a premium, the cooperative links between and mutual support of these centers is of paramount importance. Ensuring this fruitful interaction is a key element of national policy making and management of the research sector.

The Management of Research - (How?)

1.16 The ingredients for success in any type of research program include:

a) medium- and short-term policy development;
b) a management strategy for planning, implementing and monitoring progress;
c) appropriate levels of resourcing and systems of allocation; and
d) designated accountabilities with indicators and incentives to manage and recognize performance.
e) the establishment of a productive research community, with clearly defined roles and responsibilities; and
f) an environment conducive to the development and appreciation of science.

Each of these factors is considered in the following sections.

1.17 The development of a national research policy to support national economic and social growth is the responsibility of the government at the highest level. National policy and imperatives must be stated precisely, concisely and emphatically in order to send clear messages to society, especially to the productive sector and the research community. A policy should be accompanied by a statement of specific priorities and targets and a strategy for their achievement, including, if necessary, the infrastructure for management. Without

such a national plan it is not possible to allocate, at any level, specific targets with incentives, accountabilities and criteria for measuring performance.

1.18 A management strategy for research must be capable of translating national policy into realizable strategies at all levels and of overseeing their implementation and operation. Lack of productivity and success in research frequently stems directly from the absence of overall management. The national research infrastructure must therefore be capable of interpreting national policy at institutional and individual levels in terms of: marshalling, and, if necessary, concentrating, the variety of research activities; setting priorities and targets; allocating resources, roles and accountabilities; monitoring progress and output against targets; and establishing systems of performance criteria, incentives and sanctions to ensure the effective use of available resources.

1.19 The resources required for successful research are primarily a critical mass of staff with the relevant knowledge, expertise, and skills and with access to the necessary facilities, funding and equipment. In most developing countries, some or all of these essential ingredients are in very short supply. The capacity and desirability of government funding research activities must, therefore, be assessed and priorities established. Private funding of research in which the sponsor has no vested or proprietorial interest in the outcome, and government grants to encourage joint industry/education projects are among the alternatives which should be considered. Appropriate methods and criteria for allocating resources are as important as the level of resourcing. Open normative allocation systems can be designed to provide the most effective use of resources targeted at national need, but should be based on the nature of the research, its performance, and national priorities. Continuing funding should be subject to the achievement of goals and objectives agreed at the beginning of the project.

1.20 An important component of research management and resourcing is to set attainment targets, measure performance and provide incentives. Unfortunately, incentives and sanctions at institutional or individual level are rarely found in developing countries' research systems; the funding of university research teams or government research centers is not output linked. The organization and direction of a research unit must recognize and cater for the special nature of the activity and the motivation necessary for success. However, once it has been accorded the necessary authority, responsibilities, targets and resources, it should not be protected from market forces. It should be encouraged to attract proprietary research and should be held accountable for the public funds allocated to it. At the international level all three Maghreb countries are signatories to the Paris and Berne conventions on copyright. Intellectual property rights would need to be appropriately safeguarded when the results of incountry research and development are commercially exploitable and when the researcher wishes to use protected developments. Performance related indicators of effectiveness and efficiency, with incentives reflecting output relevance and value, reinforce national policy and develop in the researcher an awareness of real targets and objectives.

1.21 Staffing (roles and responsibilities). At the national (macro) level it is customary to integrate scientific expertise into the process of government policy making. In countries where the number of appropriately qualified, practicing individuals is limited, they are frequently seconded into advisory or executive positions and hence obliged to fulfill multiple roles. Unambiguous roles and uncompromised responsibilities are necessary to provide good, objective - sometimes unpalatable - advice to the highest level of government. Ministries concerned with education, industry or research, frequently have insufficient professional grade staff. They therefore second or contract practicing academics and researchers to carry out specialist developmental tasks. It is important that these 'part time' functionaries are used properly. They should not be given routine work which could be more effectively carried out by career civil servants, and their roles and relationships must be defined so as to take maximum advantage of their expertise and capabilities. If this does not happen, the national research cadre becomes demoralized and less productive, as its talents and energy are dispersed and diverted away from its true vocation of analytic and creative activity.

1.22 Where public resources are the main source of funding, the bureaucratic process is frequently slow in taking initiatives and responding to requests. Over-centralized procedures are often inefficient and unnecessarily complicated, and suffer from inappropriate manpower and facilities, for example inadequate or outdated information systems. The combination of a majority of contractual staff working in a highly centralized bureaucracy, results in overloaded decision makers and an inflexible immutable research sector which cannot respond to changing needs and thus stifles development. A balance must therefore be drawn between the central oversight of policy and performance and the delegation of responsibilities and freedom of action at all levels.

1.23 Roles, objectives and accountabilities must also be circumscribed at the level of research institution, team and individual (micro level). Research cannot take place in a vacuum and in most cases, but especially targeted and interdisciplinary research, a team of constructively interacting specialists is the key to high performance. Thus good management, access to the latest development in the field, and the availability of appropriate high quality, properly used and maintained equipment are further prerequisites of successful research. Another factor at this level is that to sustain the morale and performance of those engaged in research, and to ensure the most effective and efficient use of scarce human and physical resources, it is crucial to develop and maintain collaborative links between research, pedagogical activities and industry.

1.24 An important element in the implementation of a national research policy and a related management strategy is the widespread awareness of the benefits and contribution that productive research can make towards economic and social development. Such a level of awareness and understanding of the population at large could be achieved by programs in the media (TV and radio), science fairs, and the creation of a series of prizes contributed by industry awarded annually for achievements in the field.

Research Staff - (Who?)

1.25 Modern scientific research requires creative specialists at all levels from the experienced researcher to the instrumentation technician, information scientists and other support staff. The commercial exploitation of research requires distinctly different knowledge and skills. This has important implications concerning the conventional wisdom on the formation of researchers. In order to give the appropriate emphasis and stimulus to research and development which can realistically support economic and social progress, the traditional perception of education and training of research workers must change. More emphasis needs to be given to project management, interdisciplinary teamwork, entrepreneurial skills, finance and marketing, and less to the acquisition of conventional highly focussed and academic doctorates. Facility with widely used languages such as English to ensure access to internationally available information in science and commerce is an essential skill for today's researchers.

1.26 Generation of the scientific research workforce is essential for success. Developing and fostering awareness in society of the methods, importance and potential contribution of results from research to the community also needs to be encouraged. To build capacity and interest in research, curricula content and delivery methods need to be reviewed at all levels and some amendments made to encourage the development of appropriate attitudes and skills. Once formed, the scientific research workforce should have access to productive working conditions, be socially recognized and have adequate rewards. No simple or instant solution is viable; rather, a long-term, consistent commitment in many areas of education and training as well as public enlightenment are needed.

II. EXISTING RESEARCH SYSTEMS IN THE MAGHREB

STRUCTURE AND MANAGEMENT

Main Conclusion

2.01 Despite organizational and institutional efforts to set research priorities directed at achieving national development goals, little progress has been made - with the notable exception of recent developments in the agricultural sector - in any of the Maghrebian countries, towards realizing this overriding objective. The main reason for this in each country has been the failure to clearly to define national priorities and to establish an effective, coordinated governance to oversee and direct all national research investments and activities.

Developmental and Institutional Background

2.02 In all three countries the organization of scientific research has developed around two principal hubs:

a) independent research centers such as the "Institut Pasteur" or the INRAS (Agricultural Research Centers) inherited from colonial times and now attached to an appropriate ministry, e.g. Ministry of Health or Agriculture;

b) faculties, schools and institutes in the universities.

Immediately after independence, little effort was undertaken to foster new scientific research activities or to strengthen existing research capabilities. This was the case, because other developmental needs in education and infrastructure had a higher priority for scarce resources. During the 1960s and early 1970s, some national development plans began to include scientific research in their agenda, although there was only a small allocation of financial and human resources. Even at this early stage efforts were made to coordinate university research activities with the perceived needs of the productive sectors. However, these efforts had generally to be abandoned because of the dearth of national scientific manpower, equipment, lack of interest or level of development by industry, and capacity of the centralized coordinating institutions. During the early years of independence, research priorities were in fact largely determined by the skills and expertise of expatriate researchers and their scientific linkages to the home country.

2.03 However, during the 1970s efforts were made to create national institutions with a mandate to coordinate and manage national research programs, so that, to the extent possible, they supported the drive to industrialize as rapidly as possible. Maghrebian governments understood the links and relationships between highly qualified trained manpower, scientific research and technological development. Industrial "autonomy" became a goal especially for Algeria.

2.04 Each country's approach towards industrial development is reflected in its philosophy towards scientific research. In essence, Algeria, as a centrally planned economy, quickly created national institutions to help develop and coordinate scientific research. Tunisia and Morocco, while retaining the centralist francophone organizational approach, have nevertheless in practice had greater flexibility and individual choice in research; also, their efforts at focussing these research efforts were at a later stage of the nations' development.

2.05 In summary, all three governments developed policies which linked scientific research to economic development objectives, and attempted to ensure coordination at the national level. However, in practice, scientific research was not awarded a high priority, given the other developmental goals. The education ministries' priorities were ensuring that a sufficient number of graduates were produced to fill urgently needed administrative, technical and managerial functions. Other technical ministries focussed on solving immediate operational problems, rather than on the longer term benefits of scientific research. Most importantly, central budgetary funding and allocation mechanisms linked to national research priorities did not exist. No incentive systems were devised, either rewards or sanctions, to encourage the attainment of national goals (see also Annexes 5 A-D).

Country Specific Structural and Management Issues

Algeria

2.06 The insufficiency of trained and experienced Algerian researchers and administrators resulted in continued heavy expatriate involvement throughout the 1960s. Most research projects were managed and staffed by foreign French speaking nationals. Research priorities appeared to be unbalanced and not properly focussed. For example, the Nuclear Studies Institute concentrated on basic research (nuclear physics) as opposed to more applied research which could have benefitted health or agriculture problems; much greater priorities were given to the exploitation of gas and oil as opposed to other minerals and energy forms; long-term water research was thoroughly neglected, and last but not least few links were developed or encouraged with the productive sectors. The situation in the universities was worse than in the non-university research institutes. Very little university research was undertaken in Algeria, because of the dearth of practically everything... equipment, laboratories, professors, researchers, technical staff.

2.07 Eventually, Algeria began to manage and balance more actively its scientific research program. Numerous coordination institutions were established. For the preparation of the first National Plan (1974-1977), the Government decided to create a 'Comité de la Planification de la Recherche Scientifique' with representatives of all ministries with research programs, universities and independent research institutes with a remit to produce a national program of scientific research. The plan and implementation of the program quickly ran into difficulties because, on the one hand, the quantity of research which could be produced by the available human and physical resources

was overestimated and, on the other hand, the management and coordination requirements of such a large research effort were thoroughly underestimated.

2.08 In the 70s and early 80s, the Government pursued a massive program of industrialization by purchasing readymade factories (turn key), often with foreign personnel, in order to operate them properly. This effort was reflected in the area of scientific research in that practically 70% of the non-university research budget was used for the purchase of scientific equipment and expansion of the research infrastructure. By 1981, the number of research centers had increased sevenfold. Parallel to this effort, the universities also experienced a surge in output. For example, the number of postgraduate students registered, increased from 156 in 1962 to 15,300 by 1985. The majority of the research undertaken during this period was concentrated in the medical sciences (40% of budgetary funds) and the natural and technical sciences (43% of budgetary funds). The remaining funds (17%) were allocated for the social sciences. By the late 1980s, however, the Government had realized that the massive importation of technology and equipment did not result in a similar massive transfer of "know-how" nor increased or qualitatively improved research output. Many of the factories and much of the sophisticated equipment still required foreign personnel for their continued operation.

2.09 Algeria continued its attempt to organize bet r and prioritize its research investments. As part of this process a research ministry was created in 1990 with the brief to enhance the effectiveness and efficiency of all publicly funded research, and to link it more closely to national priorities. Despite the country's good intention, most of these changes have not yet had the desired results. This ministry has now been merged into the Ministry of Education. It appears that closer collaboration between the universities, independent research centers and industry did, and still does not, take place, nor was or is there a better integration between applied and basic research. As experienced in the ongoing Science and Technology University Development Loan, there remains little incentive for anyone to coordinate or cooperate.

Morocco

2.10 Morocco's early efforts at coordinating and prioritizing scientific research began shortly after independence in 1962 with the establishment of the "Centre Universitaire de Recherche Scientifique" (CURS). The center's objectives were to promote and coordinate scientific research and help to train researchers. However, the center never really became operational, due to a lack of funds and a rather poorly defined administrative status.

2.11 Continued institutional weaknesses in the scientific research arena resulted in an attempt to do better. Consequently, in 1976, the Government established the Centre National de Coordination et de Planification de la Recherche Scientifique et Technique (CNCPRST) under the Ministry of Higher Education and Scientific Research (MESRS). As the name implies, the center's terms of reference were accordingly broad and all-encompassing. They included: setting national policies and priorities; establishing programs; and coordinating all research activities undertaken by both public and private institutions. It was given the legal right to investigate and enquire into all research activities in Morocco. The CNCPRST's initial priorities were linked to developing the country's natural resources, especially water, soil and minerals, as well as country specific agricultural techniques, and health problems.

2.12 The CNCPRST did not start functioning until 1981, five years after its creation. The major reasons for this delay were its imprecise mandate, insufficient budget for funding significant research activities, and a staff too small even to attempt to coordinate research at the national level. Most research continued to be funded by external aid and followed individual researcher's preferences, and the choice of topic was frequently influenced by the individual's connections with overseas university faculties. University research especially remained tied to foreign priorities (often French), because the majority of funding was through aid programs. Moreover, because the CNCPSRT was the responsibility of the MEN, it had no decision-making powers over other ministries, and so could not carry out its coordination mandate over other technical ministries.

2.13 The 1988/92 Plan again attempted to establish national research priorities (health, water and energy). A national scientific research commission was created specifically to generate ideas and seek concurrence of the scientific community in Morocco. Unfortunately, the final plan did not have a set of clear priorities, a strategy for their implementation, or, most importantly, any budgetary allocation. In summary, Morocco has great difficulties in establishing priorities and in designing a workable strategy for coordinating and harnessing the work of its scientific research community.

Tunisia

2.14 Like Algeria and Morocco, Tunisia also attempted to improve the management and organization of its scientific research sub-sector, but interministerial coordination difficulties and other more urgent developmental problems prevented early attempts at establishing a coherent national program. Institutional responsibility for scientific research was placed with the Higher Education and Scientific Research Directorate in the Ministry of Education and Science. The Ministry's research budget, however, was negligible. A National Commission attempted to prioritize research and induce universities to allocate a greater share of their Budget for research; this was not successful, because the universities are already underfunded for their main purpose of producing graduates. The majority of funds received by the universities and research institutes are received through bilateral (French) and multilateral institution programs. These non-Tunisian funds, however, have done little to develop and reinforce local capacity. 80% of the overseas funds are tied to the use of

overseas experts (71%) and for training overseas (9%), leaving 20% for purchase of equipment.

2.15 Subsequent efforts at creating a 'Conseil National de la Recherche Scientifique' (CNRS), as well as at establishing career grades for researchers has not succeeded in improving the linkage between scientific research and national development priorities. In a unique experiment, however, Tunisia established in 1989 a National Scientific Research Foundation with a regulatory framework, enabling it to raise funds and contract out, through a competitive system, research programs with universities, public and private research institutes. The Foundation was also to set priorities and coordinate the national effort. Unfortunately, the funds allocated for 1991 are limited (US$ 2.8 million), and lengthy bureaucratic procedures have prevented any noticeable improvement in the setting of national priorities. To reinforce the national research effort, and in an attempt to increase links between research and the industrial and commercial sectors, the Government established, in 1990, a Secretary of State for Research in the Prime Minister's office. In conclusion, linking the overall research effort to national priorities and needs remains an elusive goal for Tunisia.

FUNDING

Main Conclusion

2.16 At present, funding decisions for research follow historical institutional resource allocation mechanisms, rather than being tied to national research priorities and strategies. It is difficult to identify separate research budgets in the higher education institutions. Actual expenditures for research are rarely monitored or evaluated against specified objectives. Their allocation is therefore not used as an incentive to focus research on national developmental issues. There is no attempt to use funding mechanisms to enhance the efficiency and effectiveness of the research effort.

Present Methods of Funding

2.17 Expenditures for scientific research rarely appear as line items in budgets. As a result, there is little hard information available. The dispersion of the national effort between universities, the education ministry and other ministry research institutes, and professional research institutes, permit only an approximate estimation of actual expenditures in the sub-sector. For example, a large part of the research effort currently being funded in all three Maghreb countries is undertaken in the university system, yet most faculty departments have no regular allocation to either the recurrent or investment budgets, specifically for research activity. University academic staff automatically receive a special salary supplement for research, whether they are active researchers or not. This can be as much as 50% of their salary.

2.18 Rough estimates show that the three Maghreb countries appear to allocate between 0.25% and 0.70% of their GNPs to scientific research. In 1989 these estimates were 0.25% (US$ 30 million) for Tunisia, 0.25% (US$ 110 million) for Morocco, and 0.5% (US$ 270 million) for Algeria respectively. These

estimates include significant salary costs (including scholarships), in the case of Tunisia and Morocco about 80% of the total budget (see Annex 6A and 6B). Scientific research institutes are unable to carry out research in a planned and systematic manner, because they lack budgets to purchase essential equipment and/or necessary consumables. Budgeted funds are not always fully allocated during a fiscal year, foreign exchange allocations are frequently unobtainable because of the government's unwillingness to allocate foreign exchange for these purposes. Consequently actual research expenditures are probably only a half or a quarter of the official estimates. There are many examples of a university or research unit ordering equipment and publications to be paid from its foreign currency allocation. The items never arrive because there is insufficient foreign exchange. However, this reason is not communicated to the ordering institution that believes the overseas agency is not fulfilling its order.

2.19 By far the largest contributor of funds for scientific research is the respective national treasury. A very small amount of funds for scientific research come from private sector sources. About 75% of funds allocated to scientific research come from government budgets, and most of these funds (75%+) are used for salary expenditures with little or no provision for recurrent expenditure on consumables or documentation. The investment budget is frequently non-existent, and where there is one, it is not possible for researchers to plan on the basis of a known regular level of funding to replace obsolete equipment or purchase newly developed items. Moreover, bilateral and multilateral funds financing scientific research follow similar expenditure patterns, with one or two notable exceptions in the agricultural sector. The majority of these funds are used to finance personnel costs, in the form of either technical assistance or scholarships for Maghreb nationals to travel overseas. Little is provided for equipment or consumables. France, the largest source of bilateral funds for scientific research for the Maghreb countries, spends about FF 25 million p.a. (US$ 5 million) for technical assistance, training and scholarships; approximately FF 11 million for Algeria, and about FF 7 million each for Morocco and Tunisia.

2.20 The picture is brighter for agricultural research. In Morocco and Tunisia, agricultural research receives approximately half of the overall expenditures budgeted for the research sub-sector; in Algeria a smaller but nevertheless significant proportion of the research budget is allocated to agriculture. Given the sector's importance in the Maghrebian countries' economic development efforts, this is not surprising. Moreover, much of the bilateral and multilateral funds available for research are allocated to this sector. In fact, donors provide not only large amounts of technical assistance, training and scholarships, but also, more importantly, funding for equipment and materials. In addition, the World Bank has, in each of the three countries, Agricultural Research and Extension Projects under implementation which seek to address institutional and funding weaknesses. Consequently, the agricultural research budgets of the three countries are beginning to reflect a more managed and focussed approach. Their agricultural research programs are prioritized, goals/objectives are carefully determined, results are monitored, and their respective budgets show a better balance between recurrent and investment expenditures.

Country Specific Funding Issues

Tunisia

2.21 Of the US$ 30 million officially estimated to be committed to scientific research, US$ 27 million come directly from government budgets, and US$ 3 million are spent by industry (essentially large public enterprises). However, given that half of the public resources available for research are allocated to the agricultural sector, and another quarter goes to non-university research institutes, the Ministry of Education and Science, which claims 85% of the research staff, is left with the remaining 25% of the available funding, about US$ 7 million, and as noted above, most of these funds are used to pay for salaries. Official budgetary allocations for research equipment, consumables and materials are practically non-existent. In the university system, non-recurrent expenditures for 1990 were estimated to be about US$ 2 million, allocated in a somewhat random fashion. Only the non-university research institutes have modest budgetary line items for non-salary recurrent research expenditures.

2.22 There is, however, one notable exception in Tunisia for research funding. In 1980 a small scientific research fund was created to encourage the development of scientific research projects in the context of technology. This fund has had an annual budget of US$ 2 million for financing research projects on a competitive basis. Over the 10 years of its existence, it has financed about 652 projects, 586 in the universities and 66 mixed university/industry projects. Unfortunately, to date the overall results have been negligible. A major reason is that individual project financing was limited to two years, with no possibility of an extension or rollover provision, and as a result many projects ran out of recurrent funding before the equipment and materials ordered even arrived. This also highlights the extended bureaucratic process that has to be followed for ordering and acquiring equipment and materials. Nevertheless, university institutes have been able to purchase some research equipment and materials with these funds which have been used for projects that enable staff to complete the work for their doctoral theses.

Morocco and Algeria

2.23 There is no meaningful expenditure data available for Morocco and Algeria. Morocco budgeted in its 1981-85 Plan about 1.0 billion Dirham (US$ 125 million, of which 34% was spent for mining and energy; 19% for agriculture; 17% for "planning"; 13% for education and 14% for other sectors. In Morocco the CNCPRST has managed international contracts, during the period 1983-92, from four major agencies (USAID, World Bank, UNESCO and UNDP) to the value of 45 million Dirhams (US$ 5.2 million).

HUMAN AND PHYSICAL RESOURCE PROVISION AND TRAINING

Main Conclusion

2.24 The recognition of the important role of research in economic and social development in each of the Maghrebian countries has resulted in an effort to create an effective scientific community. Unfortunately, the non accountable

provision of insufficient core funding to both the university and other research institutes, the absence of incentives and insufficient capital investment, have combined to create a poor research environment. These factors all contribute to the less than optimal performance of the sector and the loss of skilled, trained manpower to work overseas.

Human Resources, their Education and Training

2.25 All three Maghreb countries have made significant strides over the last two decades in educating and training their human resources. Since independence, school enrollment rates have increased significantly at all levels. Adult illiteracy stands at 59% for females and 46% overall in Tunisia, the comparable figures are 63% and 50% for Algeria and 78% and 67% for Morocco. However, in Tunisia there is now 100% gross enrollment in primary education, 96% in Algeria and 67% in Morocco (1991 WDR). In Morocco there are a number of actions that are currently underway to improve this figure. The number of university graduates has increased quite significantly in all three countries (200+%) over the last decade, as has the number of researchers. To a great extent (70 to 90%), these researchers are concentrated in the university establishment, and to a lesser extent in the non-university research institutes (see also Annexes 7 and 8).

Table 1
Size of the Research Community 1991

Researchers	Morocco	Tunisia	Algeria
University	6,187	4201	3,525
Non-university	2,712	466	5,400
Population (1989) (in millions)	24.5	8.0	24.5
Number of researchers per '000 of population*	0.4	0.6	0.3 - 0.5

* For comparison: Portugal: 0.4, France: 2.0, Japan: 4.2

2.26 The present systems of education and training in all three countries is not producing the critical masses needed for productive research, except in a few cases. The time taken for a university researcher to become fully trained is too long, the average time to prepare and present a doctoral thesis (8-10 years) is longer than it takes for some high-tech developments to become obsolete. The number of researchers produced is low, for example, while in 1990/91 5120 Tunisians were enrolled for graduate studies in the universities, only 65 doctorates were awarded in 1988/89 (see also Annex 9). All three

university systems face similar problems: high repeater rates, excessive uniformity and rigidity in course design, no regular revision of curricula and teaching methods, insufficient qualified academic staff and a negligible support staff in crucial areas such as libraries, laboratories, computer services and overall maintenance. The present training provision for many of these necessary support staff is inappropriate or too small. Where it does exist, the successful individual, when employed in the public sector, is not accorded a status and salary commensurate with his/her potential contribution to the nation's development.

2.27 As a result of the relatively poor conditions for training as a researcher, many potential doctorate students go overseas for their training. Many never return, especially because their home country research environment is not conducive to remaining in touch with the latest developments in their field. The few active research institutes in these countries do not appear to be involved in training their own research cadre and support staff, as is frequently the case in the UK and the USA, where staff can be employed in junior grades and work towards gaining either a higher degree by external registration or qualify by exam to become members of a professional body and become researchers and managers.

Research as a Career

2.28 The majority of researchers in all three countries are employed as civil servants. Their conditions of service, pay and promotion prospects are bound by the government code of practice and salary scales in each country. These have little flexibility; the grade (level) is frequently determined by qualification and number of years experience with no provision to reward particularly imaginative or successful work. There are no specific financial incentives for staff who are productive researchers. The conditions of service include tenure for the whole working life without, in the case of the universities, prescribing any particular commitment to productive research. In the universities, all senior professional staff automatically receive a bonus payment for research (in Tunisia and Morocco the 'prime de recherche') regardless of research productivity. Having successfully completed and defended a thesis, there is no subsequent evaluation of research performance or additional reward. In the research institutes, the government salary scales are again inflexible. The only difference is the title, for example in Morocco university staff are called 'lecturer researchers', while in the research institutes they are 'researchers'. Again, however, there is no monitoring of, or accountability for, research productivity. There is therefore no explicit career path for researchers once they have become fully qualified, nor are there particular rewards for productivity.

The Research Environment

2.29 The study has shown that the essential ingredients described in chapter I for the creation of an environment conducive to creativity are frequently missing. One such ingredient, support personnel, be they appropriately trained technicians, instrument specialists, librarians, or

information and computer specialists, has essential contributions to make. These staff frequently undertake repetitive tasks, maintain equipment and provide general support without which the overall productivity and job satisfaction of researchers is severely impaired. An illustration of the effect of competent support staff is a comparison of the amount of use of two expensive spectrophotometers (nmr) (replacement cost about US$ 250,000) bought at the same time by the same department; in one case, in which there was appropriate technician, maintenance and budgetary support, the machine worked continuously and satisfactorily for 15 years; in the other case, where there were no proper maintenance arrangements and the equipment was used by untrained staff, it functioned for only 3 years. In Tunisia, the current ratio of support to research personnel in the fundamental, technical and medical sciences is about 1 to 18. Morocco has similar ratios. In most OECD countries' research centers, these ratios are, on average, about 1 to 2 (see also Annex 10). In the Maghreb, only the agricultural research centers appear to have an adequate ratio of support to research personnel.

2.30 The research environment is deficient in equipment and physical installations in all three countries. As in the case of the financial data, complete up-to-date equipment inventories do not exist. In Morocco, a recent in-country study on the state of buildings, their maintenance needs and equipment provision of 11 universities concluded that there was a complete absence of reliable equipment inventories in practically all 11 universities, and that the existing equipment was poorly maintained and often not appropriate for the research program proposed. An exception to this has been the equipment and instrument maintenance programs funded by UNESCO and IAEA managed by CNCPRST between 1985 and 1990. Health and safety matters were not addressed, and unsuitable, cramped and unhealthy facilities which would not meet national safety standards were also reported. It was not possible to estimate the value of the equipment which was installed. Except for having an estimate of the technical equipment investment (US$ 20 to 30 million), much of which is obsolete or non-functioning, the Tunisian situation is similar. In both countries, costly equipment is frequently underutilized and poorly maintained.

2.31 Continuing access to the current state of the art is another essential ingredient for successful scientific research. Good, up-to-date documentation (periodicals), access to international data banks, and contacts with the international scientific community provide the foundation for this knowledge base. Both Morocco and Tunisia have national documentation centers which provide a domestic network of information as well as access to overseas scientific data banks, including those of the French and Italian national research centers (the CNRS in France and the CNR in Italy). Not all researchers in the countries are aware of these in-country and overseas data sources, in some cases when they are, they do not always have the equipment or funds to access the data. These centers do, however, provide a useful service.

2.32 In addition to these national centers, most university and non-university research centers have some scientific documentation. The number of periodicals, however, varies considerably; for example, the science faculty of the University of Tunis subscribes to 500 periodicals, the department of dentistry at Monastir to only 23. In Morocco, the average number of texts held per student varies between 0.8 (Medicine/Pharmacy) to 26.7 for the engineering

students. The norm is 50 per student. The organizational efficiency of the individual collections leaves much to be desired. In some cases periodical collections are organized by faculties, in others by departments, or kept by individual researchers or research teams. One reason for this is the very small provision of library staff and suitable library facilities. There is also little modern photocopying equipment, although this reduces breaking copyright laws relating to reproduction of articles appearing in international journals and texts. Thus, despite the availability of documentation, its quality and quantity is insufficient and in many cases could benefit from rationalization and improved accessibility, and facilitate increased research productivity (see also Annex 11).

Research Linkages

2.33 Another important factor influencing the overall research environment is the existence of active institutional and organizational linkages between members of the research community, both domestically and internationally. Domestic linkages between the individual scientific communities are weak in all three countries. Incentives (e.g. seed funding for joint university/ industry projects) to cooperate and coordinate are very limited. Multidisciplinary research teams are rare. Most researchers in Morocco and Tunisia work alone or in little departmental groups. In Tunisia, based on an analysis of 146 university research teams, a typical research team consists of 7.5 persons, 5 of which are departmental faculty staff and 2.5 are doctoral students. These data do not include technicians and other support staff. Some scientific associations and journals have been established in Morocco and Tunisia (23 publications and several science associations) which help the dissemination and exchange of information.

2.34 Unfortunately, links with the industrial sector are almost totally lacking. A few of the larger public enterprises have their own research teams, and there is very little interaction between them and their respective national scientific communities. In most cases, the private industrial sector is not sufficiently interested, sophisticated or large enough to make use of the existing national research capacity. Government does not or does not sufficiently (Tunisia) foster such linkages. Linkages between the already established technological development centers, industry and the research community must be strengthened.

2.35 International cooperation, especially with France, is more widespread than cooperation at the domestic or regional (Maghrebian) level. For Morocco, more than 80% of all international cooperation contacts are with France. In Tunisia, practically all research teams, irrespective of their discipline, maintain a close long-term collaboration with their French counterparts. A significant number (about 15%) of the research staff employed by the French National Research center (CNRS) are Maghrebian nationals. The "French connection" still predominates (see Annex 12). Overall international connections are weaker than they probably should be when compared to Egypt or Saudi Arabia (see Annex 13). Scientific exchanges with other Arab speaking or developing countries remain weak. Recent efforts to create Maghrebian scientific institutions such as a Maghrebian University and Academy of Science in order to

promote cooperation are still in their infancy. Morocco is taking advantage of the UNESCO program (TOKTEN) for funding the establishment of links between expatriate Moroccan researchers and researchers in Morocco. A small number of scientific exchanges do however exist with Belgium, Germany, UK, USA, Canada and Japan, as part of a range of bilateral cooperation programs.

SYSTEM PERFORMANCE - INDICATORS AND OUTCOMES

Main Conclusion

2.36 The significant constraints identified in terms of current and potential research funding, and the nature and type of necessary human resource development, make imperative the careful selection and prioritization of research projects for funding. It also necessitates the close monitoring and evaluation of research progress and performance. Unfortunately, middle income countries like Algeria, Morocco and Tunisia, which can least afford it, generally have weak policy making, planning, implementation and evaluation capacities. There is no effective follow-up to ensure that nationally funded research is driven by national needs and is both effective and efficient.

Performance Measurement - Incentives and Penalties

2.37 Measuring performance is necessary, although difficult. The use of output indicators to measure scientific research output is frequently contentious, especially when applied to university research that falls in the fundamental category. The most commonly used measures of fundamental research, the number of publications in local (see Annex 14), national or international journals and citation indices, are difficult to assess reliably. Some major professional journals require membership to publish; this is difficult to achieve when there is a lack of foreign currency. The alternative of publishing in collaboration with a national of the country can result in the overseas author not being listed as the primary author, and hence being less likely to appear in the citation index. The number of papers presented at national and international professional meetings is another measure.

2.38 Performance indicators for applied research are perhaps easier to determine. At the university and national level, the output of doctoral theses is often used. Output measures for applied research in addition to publication include: predevelopmental results that are sufficiently promising to merit piloting; patentable results such as improvement in a manufacturing process by improving the efficiency of a machine; reducing pollution by adapting the process or introducing an extraction system into an industrial process; identifying alternative cheaper, locally available materials to substitute for more expensive and/or imported items; and, in agriculture, a more drought resistant seed with a high germination rate. Problem solving using specialized techniques for development and testing to provide marketable products or improve a system is easier to assess, since it is usually only undertaken by contract. As discussed in chapter I, there may well be an overlap between these categories' spinoffs, for fundamental research can accrue from applied work and vice versa. Thus, although not easily, all categories of research output performance can be measured.

2.39 Some preliminary performance data are available for the research communities in Tunisia and Morocco. This indicates that they are certainly active, although the true level of activity is difficult to compare on an international scale. A recently published study undertaken by the 'Laboratoire d'Evaluation et de Prospective Internationale' of the C.N.R.S. in Paris on jointly published French-Moroccan articles, mostly in French journals, reinforced the lower visibility of the Moroccan author. In a sample of 24 co-authored French/Moroccan articles, the citation index did not identify the Moroccan co-author. In response to a questionnaire, 135 Tunisian research teams in science and engineering indicated that they had published 1.2 articles per year, per team in international journals. Such results are encouraging, even if this particular sample is somewhat biased towards those who are active in research. Another measure of performance, the number of successful doctoral theses, is low. Both Morocco and Tunisia have moved away from the requirement that to become a full professor a 3rd cycle doctorate as well as the Doctorat d'Etat has to be obtained. In Morocco a single doctorate will be required for entry to a university career with promotion dependent on research and teaching performance. As stated earlier, Tunisia produces about 30 doctoral theses a year and Morocco about 70. For the academic year 89/90, Tunisia produced about 0.11 doctorate theses per professor per annum and Morocco about 0.03, compared with the comparable figure for France of between 0.2 and 2.85, depending on the discipline.

2.40 The absence of national evaluation and monitoring systems for research is caused by the ad hoc creation of research facilities, the lack of a sufficiently large dynamic, interactive and productive scientific research community, and an incentive structure which rewards excellence. Research scientists strive for proper status and professional recognition. In all three Maghrebian countries, draft texts giving researchers a well defined status and career progression have been prepared but not yet implemented. As a result of this, many researchers are relatively poorly remunerated and increase their income by taking supplementary jobs, with the result that they spend less time on research. Other professions (doctors, engineers, lawyers) with similar levels of education are better paid and enjoy higher social status. Moreover, in the university community, once a researcher has successfully passed from "assistant" via "maitre assistant" and " maitre de conférence" to " professeur", there are no subsequent incentives to continue active research; that some staff remain active is a tribute to their real and continuing interest in the subject.

2.41 The amount of time devoted to research depends on a number of factors, which include the nature of the research facilities, the recurrent budget provided by the institution, and other tasks that are required of the individual. For example, in the universities in Tunisia, a breakdown of a typical university lecturer's workload as given in Table 3 shows that few academics are able to spend more than half their working week on research. In Morocco lecturers typically have a higher lecturing load and hence even less time to undertake research.

Table 2
Sample breakdown of University academic staff 40 hour working week

Grade	Professor	Maitre de Conf.	Maitre Asst.
Lecturing (Class contact)	4.5	5	9
Lecture related work (marking, revising notes)	4.5	5	9
Administration	8	5	2
Supervising research students (2 hrs/wk/stdt.)	6	6	2
Own research/updating	17	19	18

2.42 This situation may be compared with that of academic staff who focus on research in American universities. Such staff generally spend less time teaching than their third world colleagues (27% vs. 37%), and more time on research (57% as against 34%). Because of the better quality and greater provision of necessary facilities, all full time researchers in America, whether in a university or research center, spend more time actually conducting research than their colleagues in the developing world. The level of recurrent and investment budgets for research in the US is also much higher, but there is also the need to demonstrate productivity and accountability.

2.43 The foregoing analysis of the major issues affecting research productivity in the Maghreb suggests that there needs to be a major review and revision to improve performance in the sub-sector. The following chapter of this study presents a strategy to build capacity and hence improvement.

III. STRATEGY TO SUPPORT RESEARCH CAPACITY BUILDING

INTRODUCTION

3.01 As part of their nation building activities, the three Maghrebian countries have recognized the need for a successful and effective national research policy. Since independence, each of them has formulated policies for the structure and governance of research which have been targeted at their national development plans. However, as discussed in the preceding chapters, none of them has yet put into place an effective capacity for national policy making, implementation, monitoring and evaluation of their activities and investments in the research subsector.

3.02 As outlined in chapter I, successful national research usually exhibits a number of common characteristics. These are: a commitment by the government to research, with an unambiguous statement of national policy and priorities; an appropriate governance for government-funded research, with clearly defined roles and responsibilities at all levels; setting realistic targets and strategies for their attainment; and a reliable assessment of, and mechanisms for, disbursing, the funding and facilities required to achieve the national objectives, and finally the introduction of an adequate monitoring and evaluation system. The recommendations outlined below are organized according to the major themes as reflected in the previous chapters. They must not, however, be viewed in isolation; the successful resolution of the overall problem will require its many aspects to be tackled simultaneously.

NATIONAL POLICY MAKING

3.03 Experience in the agriculture sector illustrates the capacity in the Maghrebian countries to formulate and drive national priorities. In other cases, however, the lack of top level support and authority for policy makers, or attempts to make one institution or group responsible for sector policy determination and coordination has not worked well. The absence of a clear statement, at the highest level, of national policy and priorities has often led to an uncoordinated effort with concomitant overlap, waste and lack of productivity, and even internecine battles for dominance. The first prerequisite for a successful return on the considerable investment in research in the Maghreb must therefore be a system in each country for the formulation and dissemination of a clear, unambiguous national research policy, including objectives, priorities and, where appropriate, targets.

GOVERNANCE - STRUCTURE AND MANAGEMENT

3.04 Organizational or institutional changes by themselves do little to harness the national effort, unless they are accompanied by other measures which change behavior. In fact, too much organizational change, particularly if it is imposed too quickly and without a transparent planning frame, creates uncertainty and instability, resulting in reduced motivation and productivity. However, there are many obvious examples of duplication of effort, underuse of scarce equipment and lack of effective institutional collaboration in each of the three countries, and serious consideration must therefore be given to accepting active collaboration or rationalizing the number of units holding a research management brief. Other factors relating to the governance of the sector which also make an important contribution to research productivity include: the need for responsible institutions to have clearly defined and non-overlapping mandates; freedom, with accountability, for the institutions and their staff to function in a well-defined and disseminated policy environment; mechanisms, with incentives, to encourage collaborative and inter-disciplinary research; open, performance-based procedures for the regular and adequate allocation of resources.

3.05 Given the expense of undertaking modern state-of-the-art research and the limited resources available for such tasks, careful consideration must be given to the most effective use of what is available. One possibility is the concentration of available human and physical resources through the creation of institutional "centers of excellence". Not all universities or research institutes can excel in all disciplines. Depending on existing staff resources, such centers should be identified, fostered or created. They should be given the freedom to operate an incentive structure not only through salaries but also by providing excellent working conditions and opportunities to develop and retain links with counterparts throughout the world. They would therefore succeed in attracting talented staff and further resources. In this way, truly operational centers of excellence would be established. These centers could be organized in a number of ways, around multidisciplinary research themes or as centers of excellent provision which could serve a range of disciplines as well as multidisciplinary topics. For example, some areas of agriculture require the same facilities as certain areas of life, earth and physical sciences. Water-related research and environmental problems which benefit and require input from a multitude of disciplines (chemistry, biology, geology, engineering, economics) are another example. It is not so much which particular organizational set-up is chosen that matters most, but the need to ensure that it is properly endowed, both in terms of physical and human resources, and that it has an appropriate legal status[1], so that the management has the necessary flexibility to fund and encourage the most productive operations.

1/ In Tunisia, for example, this could take the form of the EPIC (Public Enterprise having an industrial and commercial character).

FUNDING

3.06 It is not possible, in any of the three countries, to judge whether current expenditures for scientific research are adequate to meet stated objectives. This is because the objective statements are rarely adequate or sufficiently specific to provide measures of performance, and also because of the absence of any reliable data on the amount and effectiveness of expenditure on the subsector. Total allocations appear to be of the same order as those of other countries at a similar stage of development; they are, as expected, much below those of most OECD countries and the "tigers" of Asia. It is difficult to ascertain the extent to which these allocations are fully available and utilized, or whether the bureaucratic processes are sufficiently slow to result in loss of funds at the end of fiscal years. The effect of a priori control of expenditure is exacerbating this loss of funds and the extent to which limited a posteriori control could be introduced to reduce this and prove a more effective use of available funding could be considered. Thus, allocating more to scientific research will not necessarily result in the acquisition of more knowledge, more technology or more "scientific" output. Before more is allocated, a much greater effort must be made to ensure that existing provision is used to best advantage.

3.07 In addition, before deciding whether to increase scientific research budgets, there needs to be a much clearer understanding of present actual expenditures. In order to do this, present expenditure needs to be documented in such a way that the actual current cost of research is available. Based on this work, an efficient and effective budgetary system should be established at all levels, ranging from the national institutions responsible for implementing research development plans to the operational research units, be they faculties, centers, institutes or teams. The preparation of such budgets should include estimated costs for both investment (capital) and recurrent (salaries, consumables, minor items of equipment, maintenance) categories. They should be estimated for the total estimated life of the project, which in some cases will be several years. For projects of long duration there should be a breakdown by stage. Funding units may decide to allocate firm funding for the first phase, subsequent funding being dependent on achieving stated objectives at the first stage. All budget requests should be broken down to specify those parts of the project which require local currency and those which require foreign exchange. Allocation of a budget against agreed targets and objectives is an essential element of project preparation, conformity to national priorities is another.

3.08 Unlike investment in the more traditionally productive sectors of a national economy, the benefits from investment in scientific research are more diffuse and difficult to quantify both in terms of benefit to the economy and to society at large. Consequently, like education and health, scientific research is mainly funded through public money. On average, over half of total expenditures on research and development are funded by the government in France, USA and Italy, for example (Japan is the exception with 21%). Throughout the world, most university research is funded by the public purse and not by industry. Even in the most market-orientated economies, university research is usually funded by the government, 87% in the USA, 96% in France and 98% in Italy, whilst industry funds a comparatively small percentage ranging from 1% to 7%. It is not realistic to expect developing country industries, which are, in most

cases considerably weaker than those in industrial countries, to sponsor substantial parts of university research.

3.09 Despite the fact that Maghreb industries are unlikely to become a major source of university research funding, those modest opportunities for joint funding that do exist should be exploited and supported. It is important for the well-being of both partners, to create incentives which foster cooperation between industry and academia. These can take many forms and such initiatives could be supplemented or sponsored by earmarked government funding and fiscal advantages or contributions in kind. The development of programs of this type could give added credibility and emphasis to applied research, could relate directly to real industrial and commercial problems, and could reduce the number of gifted university researchers leaving academia for better paying jobs in industry.

3.10 Expenditures which help to absorb and diffuse technology, often justify public funding (e.g. in agriculture). Mixed government/industry/ institutions should be established that offer industrial extension (technology search, assessment, negotiation design) and public research (university and other government funded institutes) should be more directed towards commercial needs. Coherent systems of standards, testing and certification also need to be developed.

TURKEY: INDUSTRY RESEARCH COOPERATION

The strategy of the Government of Turkey for industrial technology development (ITD) has been to support firm-level productivity growth within competitive markets through (a) investing in the Metrology, Standards, Testing and Quality System (MSTQ), (b) funding research and development activities and (c) strengthening the framework for capital market activities. Despite gains made in these three areas, weaknesses persist, constraining the performance of the Turkish economy. To ease these constraints, the Turkish Government and the World Bank Group have developed a project with three components. The first component will bring the MSTQ system to OECD standards by (a) capacity building in the key public sector institutions and (b) fostering private participation in developing the system. The second component finances a Foundation that will use seed capital to catalyze private sector investment in ITD (especially applied research). The third component aims to develop a venture capital industry by (a) removing tax constraints and (b) financing through the IFC a role model company.

BOX 1

3.11 Consideration should also be given to funding research units in two parts. The first would be a regular "core funding" element, which provides basic necessities for running the unit, including basic costs for space and equipment, some proportion of salaries and routine maintenance. The second part would be project specific funding allocated against specific project proposals which meet with agreed national policy and priorities. Eligible categories within such a project could include both investment and recurrent budget. The latter would request fixed term staff of all levels, consumables, documentation, and travel, the former major items required for successful implementation of the project.

INDUSTRY/UNIVERSITY LINKS - THE SLOVENIAN EXPERIENCE:

THE INTERNATIONAL CENTRE FOR CHEMICAL STUDIES, LJUBLJIANA

The Centre has developed during the past eighteen years. It now has a staff of thirty, five of whom are funded by the university and are professors and lecturers. The remaining 25 are funded through income earned by sale of services including the development of new manufacturing processes and literature searches. This income is topped up by a one third matching government contribution. About 5% of the Centre's income is from bilateral and other donor agencies; this is used mainly for seminars, conferences and teacher training.

Many of the commercially successful ventures have involved tying basic and applied research together to solve an existing industrial problem or to suggest an alternative process to one currently used. Overall the results of the Centre lead to productive investment in Slovenia.

A strength of the Centre is the methodological and systematic approach to problem solving. These developments now form part of the undergraduate program for many students.

BOX 2

THE RESEARCH ENVIRONMENT

3.12 In order to address the deficiencies in the environment as identified and analyzed in the previous chapter, the policy makers, planners and implementers need to agree on a plan for improvement with targets and timetables. This must relate to priorities which have been determined at the highest level. The result of this analysis might show that an essential first step is to improve much of the existing physical provision by putting into place a program of routine maintenance, repair and equipment consolidation with appropriate staffing and remuneration, including support personnel. The preparation of an inventory is an obvious step in this process; it should not only list existing hardware, but also include information as to whether it works, and its present and potential use. The inventory data need to be discussed not only within individual faculties but also across institutions with similar interests,

irrespective of their line ministry. The results of such discussions will help to identify not only the size of the budget necessary for effective, productive work, but also the knowledge, skills and techniques needed by a range of personnel. These could range from management of research units and project management to maintenance and repair and technical support skills.

3.13 Access to documentation and data bases is, at present, limited in all these countries. These limitations should be addressed and proposals made to reduce them. Present provision should be made accessible to more of the research community. Linkages with other researchers should be reinforced and the large number of expatriate researchers should be made to feel part of in-country networks which should be created and nurtured. Many expatriate Maghrebians remain culturally tied to their roots and would respond very positively if approached in a systematic, well-supported way. A proactive initiative to take maximum advantage of this valuable resource could be attractive and productive. A program of foreign currency grants to entice their active contribution to research development in their "home" country could be part of the package. It could have as activities eligible for funding a program of regular visits, participation as a team member or leader in an in-country research project, and acting as an objective peer reviewer or adviser for a research proposal. Some countries offer prestigious expatriates part-time appointments as faculty where they spend part of each year in the country doing research and giving lectures. Like this the 'brain drain' can be reduced and turned to advantage.

USING ESTABLISHED EXPATRIATE PROFESSIONALS TO SUSTAIN DEVELOPMENT

THE SRI LANKAN EXPERIENCE

Sri Lanka, like many other developing nations, has suffered from the brain drain of many talented individuals. There are some interesting examples in Sri Lanka as to how this has been turned to advantage. Noteworthy among these is the creation of an Institute of Fundamental Sciences conceived and created through the efforts of a Sri Lankan working overseas. This Institute has now been running for eight years. Last year the budget was 40 million rupees ($ 1 million), of which 40% was from the Sri Lankan Government. It undertakes a mixture of basic and applied research as well as problem solving, and has students working for higher degrees, with access to state of the art equipment and information bases.

The ingredients for success include acceptance of the expatriate by in-country specialists, ability to obtain appropriate funding regularly and reliably, capacity to deliver within deadlines.

BOX 3

HUMAN RESOURCES

3.14 A key element to improving the overall performance of the sector is the development and motivation of appropriate and sufficient human resources. If there are insufficient researchers or they are of poor quality, the best equipment will not help to produce the desired output. Lack of appropriate support staff can be another constraint. Consequently, even though a nucleus of a scientific community exists in the three Maghreb countries, the size and balance of skills in this community needs to be examined. If it is to play a meaningful role in each country's development, expansion and strengthening of this resource should only take place within a defined framework of priorities and objectives. University and school curricula should be revised to include content and methods, e.g. project and other practical work, to foster creativity and encourage enquiry and problem solving skills. The training of researchers - including taught Masters and research doctorates - should include components on project management, creativity and entrepreneurship. Awards and incentives for schools, universities and industry should be introduced to identify and develop individuals and groups with such skills.

3.15 Another part of the incentive structure is the enticement, for qualified staff, of good, well-defined career progression in scientific research. Good performance must be rewarded, and a career structure should be in place which will provide such rewards equitably and efficiently. Each country should create a career structure which would enable university and non-university researchers to have a defined status and appropriate reward. In addition to this, consideration also needs to be given to the balance of different levels and types of research personnel. Research teams should have adequate technical support staff, who, in turn also need to have appropriate career progression. Such progression would relate to successful achievement against stated objectives and meeting predetermined targets which are periodically assessed and reviewed. The reward structure may include not only access from the government for research funding, but also the ability of the research team to seek private sector contracts and retain part of the income.

PERFORMANCE MEASUREMENT AND ACCOUNTABILITY

3.16 Measurement of research performance must be introduced as part of the review process and tied to funding. The traditional measurement tools should be reviewed as discussed in chapter II. The outcome of this should be widely disseminated and used as a basis to set achievement targets for those research activities which are funded in the future.

SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT

3.17 As discussed in chapter I, collaboration between local scientific research and industrial production serves to create more efficient and productive systems. The transformation of the output of basic research to commercially desirable products is frequently the focus of applied research and development, although the boundaries between these types of activity, and the relationships between them, are changing rapidly and fundamentally. Both researcher and

producer are able to profit, if mutually satisfactory links can be established. Such links can be provided through jointly financed research projects of which there are a number of successful prototypes in the UK (Teaching Company Scheme), the US (Industry/University Cooperative Research Centers), and Germany (the Frauenhofer Institutes), and a recently approved activity in Turkey funded through a Development Fund, or through intermediate institutions such as technology centers (see illustration in boxes below). These centers can provide the critical bridge between the scientific and industrial communities such as the Product Engineering Research Association (PERA) in the UK. Such centers may produce commercially exploitable prototypes, adapt imported technology, commercialize innovations and provide other services which result in collaborative efforts between industry and the scientific community. Care needs to be taken, so that all partners (Government, industry and universities) understand each other's agendas, timetables and needs.

THE U.S INDUSTRY/UNIVERSITY COOPERATIVE RESEARCH CENTERS (IUCRC)

The US Government, through the National Science Foundation (NSF) Directorate for Engineering, has run this scheme for the past thirteen years. The objectives of the scheme are to:

- establish cross-disciplinary research centers to improve the flow of fundamental engineering and scientific research between universities and industry;

- strengthen links between university researchers and industrial counterparts to focus research on current and projected industry needs; and

- increase the capacity of students to synthesize, integrate and manage engineering and technological systems.

The NSF acts as a catalyst by providing seed funding, operational expertise and matching industry research and development needs with academic institution research interests and expertise. There are now 50 IUCRCs, each with a defined research area and nearly 300 firms participating in the scheme. The Centers have five years to become self-sustaining by generating sufficient income from industrially relevant research. While receiving Government funding, each Center is regularly evaluated and reports to the NSF.

Each Center has an Industrial Advisory Board of representatives of member organizations, a Center Director and an Academic Policy Committee. In 1990, the total funding for these Centers was about $52 million, half of which came from industry.

BOX 4

UNIVERSITY/INDUSTRY RESEARCH PROJECTS

THE UK TEACHING COMPANY SCHEME

This scheme has now been in existence for more than ten years. It is directed towards bringing together academic researchers and manufacturing industry with an identified problem which cannot be solved in the short term, but is likely to benefit from research and prototype development.

The British Government manages the scheme through the Science and Engineering Research Council (SERC) and provides up to 80% of the initiating funding depending on the nature of the project. Schemes are approved for two to three years in the first instance. Subject to satisfactory progress and achievement of targets, an extension can be given, although the industry contribution to the total cost is expected to increase. Eligible expenditures can include salaries for a project manager, trained researchers, trainee researchers (MSc, PhD), technical and other support staff; capital items of equipment to be used in the project; periodicals; and a consumable budget for running the project.

Each project is managed by a Project Committee comprising representatives from each of the three partners, industry, academia and the SERC. Within the framework provided by the scheme, the Committee is responsible for managing and monitoring the project. It has considerable freedom of action in order to provide flexibility and responsiveness, including some authority for virement between budget headings. Government funding ranges from £150,000 ($270,000) for a small three year project to schemes involving several senior researchers and costing over £1 million ($1.8 million). Since its inception the success of the scheme has resulted in its rapid expansion; there are now over 400 projects.

BOX 5

3.18 Problem solving by the research community for industry can be another useful joint activity; this can range from the analysis of expensive imported chemicals to identifying altenatives that are available in the country. Seeking alternative routes in production processes, working with locally available materials, and, where promising marketable results are obtained, subsequently helping local enterprises with production start up, are other aspects of this type of synergism. This type of activity could be pump primed by start up government funding on a matching basis or by other fiscal incentives. For this kind of initiative to be successful, the management, funding and progress monitoring structure must be responsive and flexible to ensure that such "creative undertakings are fostered.

IV. AGENDA FOR ACTION

4.01 The analysis has clearly shown that the important role of research and development in meeting changing economic and social needs is recognized in all the Maghrebian countries. However, in spite of the desire to set up a national research system targeted at national development, this has not yet happened as a result of recent initiatives and seems unlikely to do so. Major deficiencies remain, for example the lack of overarching policy for research, inadequate management and monitoring, with consequent absence of accountability and targets, insufficient funding for the acquisition of equipment in science and technology and no recurrent budget for consumables. In those teaching establishments that also have a research mission, the wholly inadequate provision of equipment for teaching means that the capacity to undertake applied research and problem solving is minimal. In general, research and academic staff can only maintain their research activity through cooperative links with research teams overseas.

4.02 Specific recommendations to remedy these deficiencies, in accordance with the strategy outlined above, can be grouped under three main headings: (i) policy making and governance; (ii) the research environment; and (iii) human resources. Each of these is itemized in the following sections.

4.03 Policy Making and Governance. To set policy and provide a more effective and efficient system of research, each country should have:

a) A top level government body for formulating national research and development policy and priorities, and for the oversight and coordination of the total activity. In some areas common to all the Maghrebian countries, for example water resources, environmental studies and alternative energy sources, mechanisms should be introduced to identify, sponsor and possibly coordinate mutually beneficial activities. Quite often science today needs such expensive instruments and support facilities that no country can reasonably fund it on its own.

b) Appropriate legislation to allow institutions and individuals to benefit financially from the results of their research.

c) A structure and management system for national research to:

   (i) interpret and implement national policy and priorities to the level of the institution and individual;

(ii) develop funding mechanisms to drive national imperatives, including performance-based funding, competitive project based funding, and institutional, team and individual incentive schemes, i.e., make researchers more accountable to their users by forcing them to increase their share of revenues from private contracts;

(iii) devise and implement a valid and reliable information system as the basis for decision making, including the development of project monitoring and evaluation criteria systems and output measurements;

(iv) develop institutions and incentives which improve links between industry, research and academia including the capacity to register intellectual property rights and to ensure their proper use;

(v) develop and present to the government, proposals, including fiscal incentives, to support and encourage private investment in research and development;

(vi) maintain international exchanges and collaboration;

(vii) attract Maghrebian researchers, currently working overseas, to return and/or participate in the national research effort (see Box 1 on page 35); and

(viii) raise the level of consciousness of the population at large of the benefit of science to the community.

4.04 The Research Environment: To improve the facilities and physical resources for research, it will be necessary to agree, in terms of national policy and priorities, on plans for achieving the following:

a) an inventory of existing equipment, with location, age and condition;

b) proposals to acquire additional equipment and facilities necessary for an acceptable level of national research provision;

c) a program of routine maintenance, repair and updating of equipment;

d) access to appropriate documentation, information systems and data bases;

e) improved access to and create diversity of international contacts, conferences, and exchanges;

f) a concentration of resources in centers of excellence, selected in order to reduce duplication and waste and provide a critical mass of expertise in areas of identified national importance.

4.05 Human Resources: There are three sources of the human capital that will be required for the short and long term development of successful research in the Maghreb: output from the universities and the technician training institutions; the continuing formation of existing researchers and support staff; and experienced Maghrebian research workers from overseas. Detailed proposals need to be developed as follows:

a) university first degree programs and technician training programs should be reviewed to emphasize project work, critical thinking, creativity and team work. Curriculum content also needs to be regularly reviewed and updated. Incentives should be provided including government sponsorship, to encourage applied research and collaborative links between industry, universities and other research centers. Postgraduate programs should be diversified and include formal studies of research methods and management;

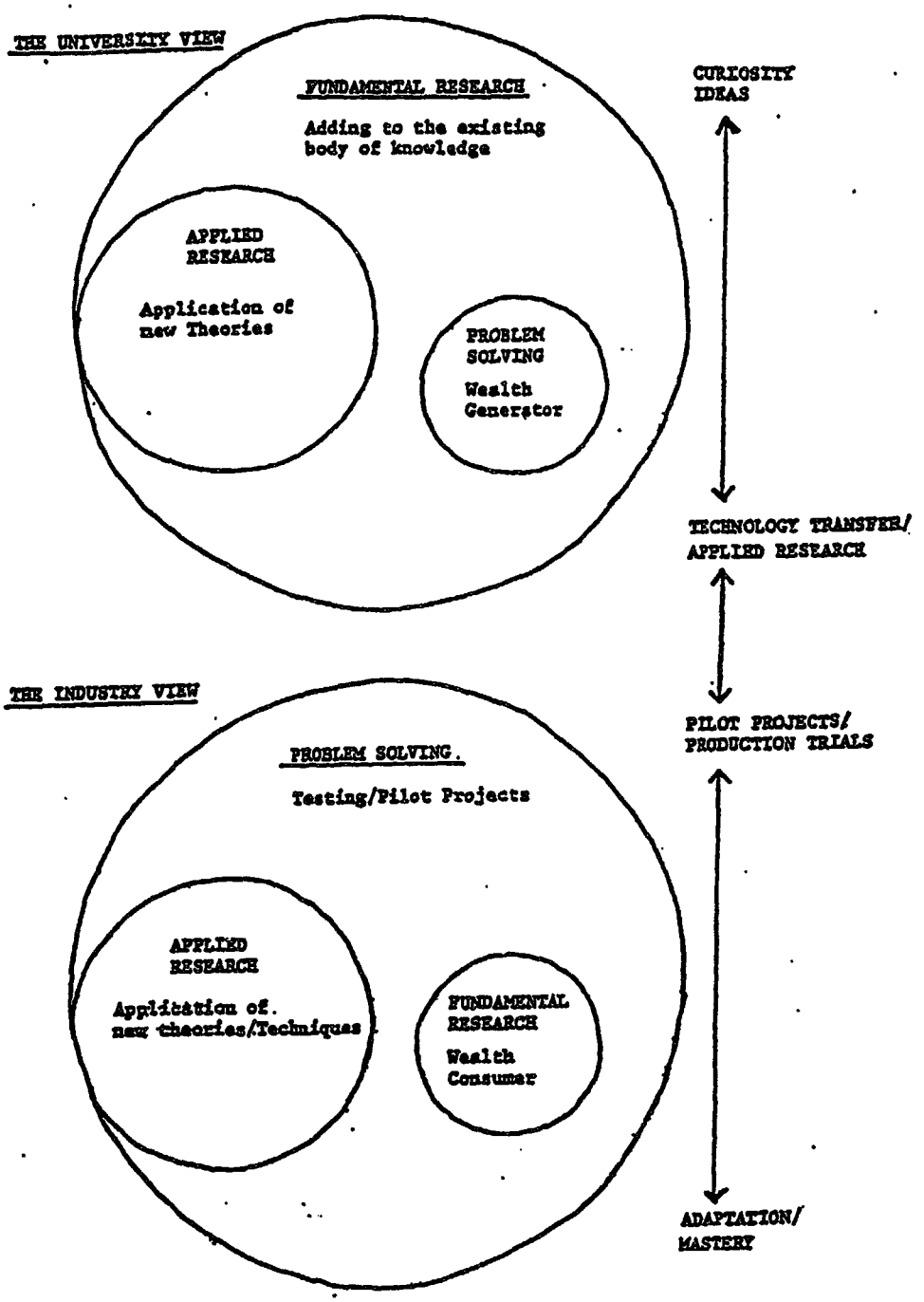
b) salaries and conditions of service of existing research staff should be reviewed, in order to reward performance and encourage development in their discipline and research methods. Formal updating and retraining should be available, including the proper use, maintenance and repair of equipment for technician support staff;

c) a proactive initiative to take maximum advantage of the expatriate Maghrebian research force could be attractive and productive. It could include: a program of foreign currency grants to entice their involvement in research development in their "home" country; funding for regular visits to participate as team members or leaders in in-country research projects; and acting as an objective peer reviewer or adviser for a research proposal.

4.06 The report's recommendations should first be discussed with those government officials responsible for policy formulation. Should its main conclusions and recommendations find general acceptance, further discussions should subsequently be held with the leaders of the scientific community. A series of seminars could provide a mechanism to see if a consensus could be reached on what needs to be done to improve the development of scientific research in each country. Subsequently, a more detailed action program should be outlined which may involve the institutional and policy changes included in the recommendations, to create a revised incentive framework allowing the sector to function more effectively and efficiently. Support from the Bank could provide guidance and expertise in selecting, prioritizing and refining these recommendations, the opportunity to study and adapt existing models, and in the longer term a country specific action program might be submitted for World Bank and donor financing.

ANNEX 1

SYNERGISM BETWEEN RESEARCH AND PROBLEM SOLVING



Source: VALLIN (J.), 1986
Source: UNESCO, corrigé National Science Fondation (NSF), 1986
Source: Gaillard J. and Waast R., (1988), La Recherche Scientifique en Afrique. La Documentation Francaise, No. 148.

ANNEX 2 (1/2)

COMPARATIVE DATA ON POPULATION AND RESEARCHERS IN AFRICA AND THE WORLD

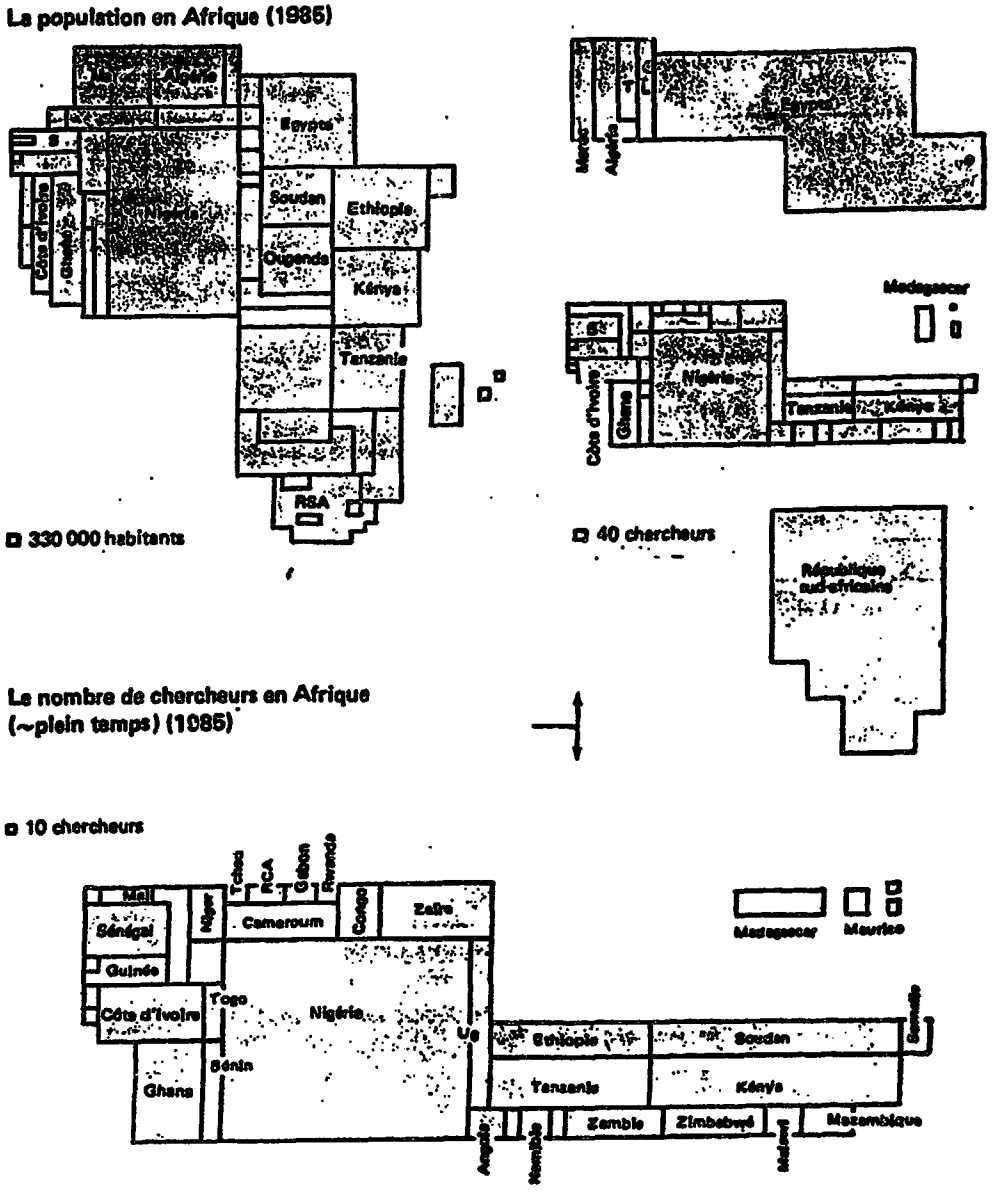


Figure 1. — Répartition des effectifs de chercheurs en Afrique et dans le monde.

Source : VALLIN (J.), 1986.

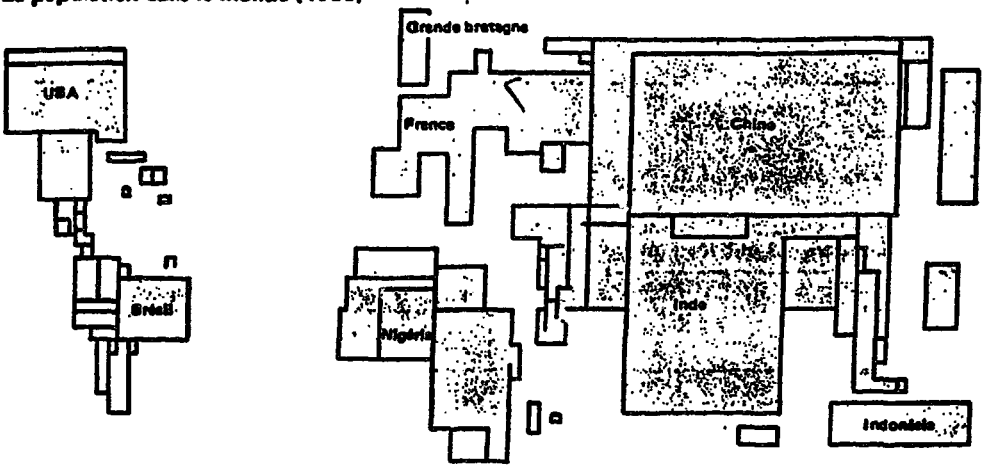
Source : UNESCO, corrigé National Science Foundation (NSF), 1986.

Source : Gaillard J. and Waast R., (1988), La Recherche scientifique en Afrique. La Documentation française, No. 148.

ANNEX 2 (2/2)

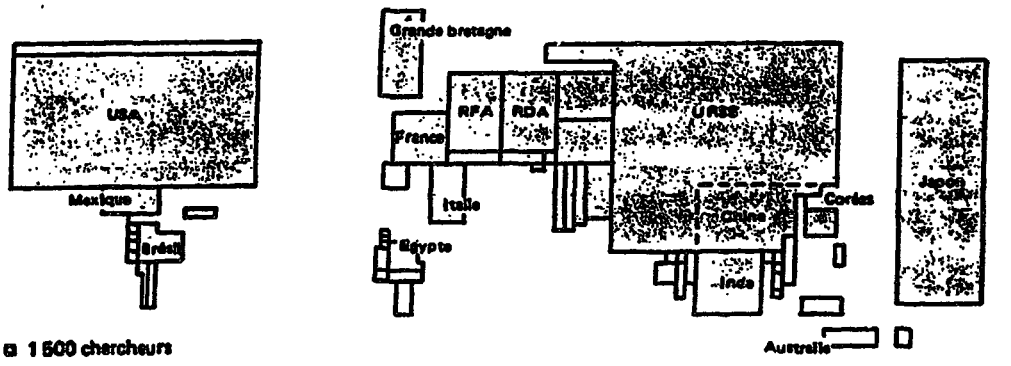
COMPARATIVE DATA ON POPULATION AND RESEARCHERS IN AFRICA AND THE WORLD

La population dans le monde (1985)



▫ 2 millions d'habitants

Le nombre de chercheurs dans le monde (~plein temps) (1985)



▫ 1 500 chercheurs

ANNEX 3

SCIENTIFIC RESEARCH EXPENDITURES IN PERCENT OF GNP FOR SELECTED COUNTRIES

Country	Percent of GNP
Algeria	0.5/1
Morocco	0.3 /1
Tunisia	0.3 /1
South Korea	1.5 /2
India	1.0 /2
Mexico	0.7 /2
Portugal	0.45 /2
Turkey	0.64 /2
Yugoslavia	0.88 /2
France	2.34 /3
Italy	1.25 /3
Japan (1987)	2.87 /3
USA	2.80 /3

/1 1980 Estimates
/2 1986 Estimates (OECD)
/3 1989 Estimates (OECD)

ANNEX 4

TABLE 1: UNIVERSITY RESEARCH FUNDING BY SOURCE

Country	Government	Other
France	96.4	3.6
Italy	98.0	2.0
Japan	55.5	44.5
US	86.9	13.1

Source: OECD 1985

TABLE 2: TOTAL RESEARCH AND DEVELOPMENT EXPENDITURES BY FINANCING SOURCE

Country	Government	Industry	Other
France	52.5	41.2	6.3
Italy	55.3	40.3	4.4
Japan	21.3	68.7	10.0
US	51.0	47.1	1.9

Source: OECD 1985

ANNEX 5A

ORGANISATION AND STRUCTURE OF THE RESEARCH SECTOR IN ALGERIA, MOROCCO AND TUNISIA

	ALGERIA	MOROCCO	TUNISIA
MACRO POLICY FORMULATION	- National Planning Council (CNP) - Ministry of Universities - Ministry of Research - Technical Ministries (Agriculture, Industry, etc.)	- Ministry of National Education - Ministry of Finance - Technical Ministries (Agriculture, Industry, etc.)	- Ministry of Planning - Ministry of Education and Research - Secretary of State for Research - Technical Ministries (Agriculture, Industry, etc.)
POLICY IMPLEMENTATION/ MONITORING/EVALUATION	Does not exist	Does not exist	Does not exist
PROGRAM IMPLEMENTATION	- 14 Universities (3 of which are Science and Technology universities) - Numerous specialized Research Institutes - Major Public Enterprises (e.g. SONATRACH)	- 11 Universities (16 Faculties in the Natural Sciences and Medicine; 18 Faculties in the Social Sciences/Humanities; 16 other Faculties/Institutes - 16 Specialized Research Institutes - 6 Engineering Schools - 283 Research Laboratories/Teams (55% in the Natural Sciences) - Major Public/Private Enterprises (e.g. O.C.P.) - About 9000 Research Personnel (5200 in the University System)	- 6 Universities (11 Faculties in the Natural Sciences and Medicine 12 Faculties in the Social Sciences/ Humanities) - 44 Schools and Institutes - 14 Specialized Research Institutes - Major Public/Private Enterprises (e.g. S.T.E.G, C.P.G.) - About 4700 Research Personnel (4200 in the University System)

LIST OF RESEARCH UNITS - MOROCCO

Etablissement	Laboratoires de recherche
FACULTE DES SCIENCES – MARRAKECH (CHIMIE)	Chimie de Coordination Chimie Organique Appliquee Chimie des Substances Naturelles et Heterocycles Chimie Physique Chimie du Solide Mineral Chimie Theorique Electrochimie et Chimie Analytique Spectroscopie Moleculaire
FACULTE DES SCIENCES – MARRAKECH (PHYSIQUE)	Lab. de Physique et des Couches Minces Lab. de Mecanique des Fluides et d'Energetique Lab. d'Automatique et d'Etudes des Procedes Lab. d'Hydrodynamique et d'Aerodynamique Experimentale Lab. d'Electronique et Instrumentation Lab. de Physique Nucleaire
FACULTE DES SCIENCES – MARRAKECH (MATHEMATIQUES)	Analyse Fonctionnelle Geometrie Differentielle Analyse Numerique et Optimalisation Probabilite et Processus Stochastiques Analyse Harmonique Computer Algebras Equations Derivees Partielles Probabilites et Statistiques
FACULTE DES SCIENCES – MARRAKECH (BIOLOGIE)	Biochimie Ecologie Vegetale Ecologie Terrestre Hydrobiologie Microbiologie Physiologie Animale Physiologie Vegetale Parasitologie Algologie Ecologie Humaine
FACULTE DES SCIENCES – MARRAKECH (GEOLOGIE)	Geologie Appliquee Sedimentologie Petrologie Biostratigraphie et Paleontologie Geologie Structurale
FACULTE DES SCIENCES – TETOUAN (MATHEMATIQUES)	Grp: Statistiques Grp: Equations Differentielles Grp: Algebre
FACULTE DES SCIENCES – TETOUAN (PHYSIQUE)	Physique du Solide et Electronique Atomique et Nucleaire Energetique
FACULTE DES SCIENCES – TETOUAN (CHIMIE)	Chimie du Solide Chimie Organique Bioelectrochimie Electrochimie Chimie Physique

LIST OF RESEARCH UNITS - MOROCCO

Etablissement	Laboratoires de recherche
FACULTE DES SCIENCES – TETOUAN (BIOLOGIE)	Electro-neurophysiologie Neuro-pharmacologie Biologie Cellulaire et Moleculaire Biologie Vegetale
FACULTE DES SCIENCES – TETOUAN (GEOLOGIE)	Petrologie structurale Sedimentologie Biostratigraphie Paleontologie
FACULTE DES SCIENCES – EL JADIDA (PHYSIQUE)	Physique de la matiere condensee Energie Solaire
FACULTE DES SCIENCES – EL JADIDA (CHIMIE)	De Catalyse De Physico-Chimie des Materiaux De Spectroscopie Theorique Chimie Organique Chimie Analytique et Traitement des Eaux
FACULTE DES SCIENCES – CASA II (PHYSIQUE)	Grp. de Physique Theorique Lab. de Mecanique des Fluides LAIC: Lab. d'Automatique et d'Informatique de CASA Grp. de Recherche en Microelectronique et conception des systemes integres (LMCSI) Grp. de Physique du solide Traitement d'Images Physique Automatique et Moleculaire Lab. d'Electronique et d'Electromagnetisme (LEEM) Lab. d'Electronique et d'Hyperfrequences Lab. de Physique Nucleaire de CASA
FACULTE DES SCIENCES – CASA II (CHIMIE)	Chimie Organique Chimie de Solide Chimie Physique
FACULTE DES SCIENCES – OUJDA (PHYSIQUE)	Physique des Materiaux Mecanique et Energetique Electronique et Electronique Industrielle Physique de la Matiere Condensee
FACULTE DES SCIENCES – OUJDA (CHIMIE)	Chimie Organique Physique Chimie du Solide Minerale
FACULTE DES SCIENCES – OUJDA (BIOLOGIE)	Biochimie Physiologie Animale Biologie Animale Biologie et Physiologie Vegetale Microbiologie Genetique
FACULTE DES SCIENCES – OUJDA (GEOLOGIE)	Petrographie et Metallogenie Geophysique Sedimentologie Paleontologie Geologie Structurale
FACULTE DES SCIENCES – KENITRA (CHIMIE)	Lab. de Mesure Physique

LIST OF RESEARCH UNITS - MOROCCO

Etablissement	Laboratoires de recherche
FACULTE DES SCIENCES – FES (MATHS ET INFORMATIQUE)	Algebre Analyse Numerique des E.D.P. Topologie Differentielle Statistiques Analyse Fonctionnelle Informatique Didactique Analyse Harmonique
FACULTE DES SCIENCES – FES (PHYSIQUE)	Physique Theorique Mecanique des Fluides et Energetique Optique–Spectroscopie (L.O.S.) Lab. d'Electron. Signaux–Syst. et Informatique Physique de l'Etat Solide Physique Nucleaire
FACULTE DES SCIENCES – FES (CHIMIE)	Chimie Organique Chimie Minerale Appliquee Chimie Physique Didactique
FACULTE DES SCIENCES – FES (BIOLOGIE)	Physiologie Animale Biochimie Biotechnologie Physiologie Vegetale
FACULTE DES SCIENCES – FES (GEOLOGIE)	Paleontologie Sedimentologie Petrologie Geologie Structurale et Appliquee
FACULTE DES SCIENCES – AGADIR (MATHEMATIQUES)	Analyse convexe et probabilite Algebre
FACULTE DES SCIENCES – AGADIR (PHYSIQUE)	Equipe Energie Solaire et des Materiaux Equipe Electronique et Acustique Ultrasonore
FACULTE DES SCIENCES – AGADIR (CHIMIE)	Chimie Organique Chimie Physique I Catalyse Chimie Physique II Physique Chimie Minerale
FACULTE DES SCIENCES – AGADIR (BIOLOGIE)	S.E.R. Biologie Vegetal S.E.R. Biologie Animale S.E.R. Biochimie, Genetique et Microbiologie
FACULTE DES SCIENCES – AGADIR (GEOLOGIE)	Geologie Appliquee (Hydrogeologie, Metallogenie et Ceramique) Pal–Sedim. (Paleontologie, Sedimentologie, Stratigraphie) Petrologie et Geologie Structurale Petrologie Generale
FACULTE DES SCIENCES – CASA II (PHYSIQUE)	Physique Theorique Physique des Solides Electronique

LIST OF RESEARCH UNITS - MOROCCO

Etablissement	Laboratoires de recherche
FACULTE DES SCIENCES – CASA II (CHIMIE)	Chimie Theorique et Spectroscopie Moleculaire Chimie des Substances Naturelles Chimie Organique Chimie du Solide Chimie – Physique Generale
FACULTE DES SCIENCES – CASA II (MATHS)	Analyse Fonctionnelle
FACULTE DES SCIENCES – CASA II (BIOLOGIE)	Biologie et Physiologie Animale Biochimie Microbiologie
FACULTE DES SCIENCES – RABAT (PHYSIQUE)	Conception et Systemes Electronique et Etudes des Systemes Automatiques Electronique et Traitement du Signal Energie Solaire Mecanique et Materiaux Physique et Materiaux Physique Theorique Spectronomie Physique Appliquee Thermodynamique Groupe de Magnetisme
FACULTE DES SCIENCES – RABAT (CHIMIE)	Chimie Nucleaire et Radiochimie Chimie Organique Heterocyclique Chimie Physique Appliquee: Chimie Analytique et Electrochimie Chimie Physique Appliquee: Cinetique et Catalyse Eterogene Chimie Physique Appliquee: Corrosion–Electrochimie Chimie Physique Generale Chimie des Plantes Chimie du Solide Appliquee Chimie Theorique Cycloaddition Reactivite des Systemes Solides/Gaz Spectroscopie Infrarouge
FACULTE DES SCIENCES – RABAT (BIOLOGIE)	Biochimie Microbiologie Botanique Physiologie Animale Physiologie Vegetale Zoologie et Biologie Generale
FACULTE DES SCIENCES – RABAT (GEOLOGIE)	Geologie Structurale Paleontologie Petrographie Sedimentologie et Geologie Marine
FACULTE DES SCIENCES – RABAT (MATHEMATIQUES)	Groupe d'Algebre et Theorie des Nombres Groupe d'Analyse Complexe et Geometrie Analytique Groupe d'Analyse Numerique Groupe d'Analyse Variationnelle et Optimisation Integrale Groupe des Equations aux Derivees Partielles et Geometrie Differentielle Groupe des Equations Differentielles

LIST OF RESEARCH UNITS - MOROCCO

Etablissement	Laboratoires de recherche
FACULTE DES SCIENCES – RABAT (MATHEMATIQUES) (suite)	Groupe de Geometrie-Analyse Groupe d'Informatique Groupe de Modelisation et Evaluation de Performances des Systemes Informatiques Groupe de Probabilites et Statistiques
FACULTE DE DROIT – RABAT (SC. ECONOMIQUES)	Informatique
FACULTE DES LETTRES ET DES SCIENCES HUMAINES – RABAT (LA FACULTE)	Lab. d'Informatique
FACULTE DES LETTRES ET DES SCIENCES HUMAINES – RABAT (DEP. LANGUE ET LIT. ARABE)	Lab. de Langue
FACULTE DES LETTRES ET DES SCIENCES HUMAINES – RABAT (HISTOIRE)	Inst. d'Histoire et d'Archeologie
FACULTE DES LETTRES ET DES SCIENCES HUMAINES – RABAT (GEOGRAPHIE)	Lab. de Geomorphologie Lab. de Cartographie Lab. de Geographie Rurale Inst. de Geographie Humaine
FACULTE DES LETTRES ET DES SCIENCES HUMAINES – KENITRA (LANGUE ET LITT. ARABE & LANGUE ET LITT. FRANCAISE & LANGUE ET LITT. ANGLAISE)	Lab. de Langues
FACULTE DES LETTRES ET DES SCIENCES HUMAINES – CASA I (LANGUES VIVANTES)	3 Laboratoires
FACULTE DES LETTRES ET DES SCIENCES HUMAINES – CASA I (GEOGRAPHIE)	Geomorphologie Grp. d'Etudes et de Recherches sur la ville de CASA.
FACULTE DE LETTRES ET DES SCIENCES HUMAINES – MOHAMMADIA (LANGUE ET LITT. ANGLAISES)	1
FACULTE DE LETTRES ET DES SCIENCES HUMAINES – MOHAMMADIA (GEOGRAPHIE)	1
FACULTE DE LETTRES ET DES SCIENCES HUMAINES – FES (LANGUE ET LITT. ANGLAISES)	2 groupes de langues 1 de langue
FACULTE DE LETTRES ET DES SCIENCES HUMAINES – FES (LANGUE ET LITT. FRANCAISES)	G.R.E.L. (Groupe de Recherche en Linguistique) G.R.E.L.E.S. (Groupe de Recherche et Litterature et Semiologie
FACULTE DE LETTRES ET DES SCIENCES HUMAINES – FES (LANGUE ET LITT. ARABE)	Lab. de Recherche en Langue Arabe Groupe de Recherche en Terminologie de la Critique Arabe Groupe de Recherche en Lit. Marocaine

LIST OF RESEARCH UNITS - MOROCCO

Etablissement	Laboratoires de recherche
FACULTE DE LETTRES ET DES SCIENCES HUMAINES - FES (GEOGRAPHIE)	Lab. de Geographie Physique (Geomorphologie) Lab. des Cartes et de Dessin Lab. de Dessin et de Tirage
FACULTE DE LETTRES ET DES SCIENCES HUMAINES - MEKNES (LANGUE ET LITT. ANGLAISE)	2
FACULTE DE LETTRES ET DES SCIENCES HUMAINES - TETOUAN (LANGUE ET LITT. ANGLAISE)	2
FACULTE DE LETTRES ET DES SCIENCES HUMAINES - AGADIR (LANGUE ET LITT. ANGLAISE)	Lab. (pour formation seulement)
FACULTE DE LETTRES ET DES SCIENCES HUMAINES - AGADIR (GEOGRAPHIE)	Lab. de Geographie Humaine Lab. de Geographie Naturelle
CENTRE UNIVERSITAIRE - BNI MELLAL (GEOGRAPHIE)	1
INSTITUTS DE RECHERCHE UNIVERSITAIRE - I.S. (PHYSIQUE DU GLOBE)	Physique du Globe
INSTITUTS DE RECHERCHE UNIVERSITAIRE - I.S. (ZOOLOGIE ET ECOLOGIE ANIMALE)	Zoologie et Ecologie Animale
INSTITUTS DE RECHERCHE UNIVERSITAIRE - I.S. (TELEDETECTION)	Sciences de la Terre
INSTITUTS DE RECHERCHE UNIVERSITAIRE - I.S. (BOTANIQUE ET ECOLOGIE VEGETALE)	Botanique et Ecologie Vegetale
INSTITUTS DE RECHERCHE UNIVERSITAIRE - I.S. (GEOLOGIE)	Geologie
INSTITUTS DE RECHERCHE UNIVERSITAIRE - I.S. (GEOMORPHOLOGIE ET CARTOGRAPHIE)	Cartographie
ECOLE MOHAMMADIA D'INGENIEURS - CENTRE DE CALCUL CENTRE NATIONALE DE G. SANITAIRE	
ECOLE MOHAMMADIA D'INGENIEURS - DEPART. G. CIVIL	Lab. DPC Lab. d'Analyse des Systemes Hydrauliques
ECOLE MOHAMMADIA D'INGENIEURS - DEPART. G. ELECTRIQUE	Lab. d'Automatique et d'Informatique Industrielle Lab. d'Electronique et de Communication Lab. d'Electrotechnique et d'Electronique de Puissance
ECOLE MOHAMMADIA D'INGENIEURS - DEPART. G. INFORMATIQUE	Lab. G. Logiciel Lab. de Reseaux et de Systemes
ECOLE MOHAMMADIA D'INGENIEURS - DEPART. G. MECANIQUE	Lab. de Conception et de Fabrication Mecanique Lab. d'Energetique

LIST OF RESEARCH UNITS - MOROCCO

Etablissement	Laboratoires de recherche
ECOLE MOHAMMADIA D'INGENIEURS – DEPART. G. MINERAL	Lab. du Genie des Procedes Lab. de Geophysique et de Geologie Miniere Lab. d'Hydrogeologie et de Geologie de l'Ingenieur Lab. du Genie Miniere et de la Valorisation des Matieres Premieres
ECOLE MOHAMMADIA D'INGENIEURS – DEPART. E.G.T.	Lab. d'Etude et de Recherche en Mathematiques Appliquees Lab. d'Instrumentation et de Mesure
ECOLE ROI FAHD DE TRADUCTION ET D'INTERPRETATION – DEPART. COMBINAISON LINGUIST.	2 Lab. de Langues 1 Lab. de Simulation (Interpretation Consecut. et Simult.)
E.N.S.E.M. – CASA (ENSEIGNEMENTS GENERAUX)	Centre de Calcul
E.N.S.E.M. – CASA (GENIE ELECTRIQUE)	Automatique Electrotechnique et Electronique de Puissance Instrumentation Electronique et Maintenance
E.N.S.E.M. – CASA (GENIE MECANIQUE)	Centre Universitaire de Microscopie Electronique Atelier de Fabrication Mecanique Conception Mecanique Science des Materiaux et Traitement Thermique Machines Thermiques Resistance des Materiaux et Calcul des Structures Mecanique des Fluides Analyse Physico-chimique
E.S.T. – CASA (GENIE CHIMIQUE)	Lab. des Analyses Chimiques Lab. des Systemes et Methodes Chim. Lab. d'Energetique Lab. de Mecanique des Fluides
E.S.T. – CASA (GENIE MECANIQUE)	Lab. d'Automatique Specialisee Lab. de Fabric. Automat. par Ordinat. Lab. de Metrologie
E.S.T. – CASA (GENIE ELECTRIQUE)	Lab. d'Industrie Electrique et Inform. Electron. et Controle Electrotechnique
E.S.T. – FES (GENIE MECANIQUE)	Lab. de Fabrication Mecanique Lab. de R.D.M. Lab. de Metrologie Lab. Moteurs
E.S.T. – FES (GENIE ELECTRIQUE)	Lab. d'Electronique Lab. de Construction Electrique Lab. d'Informatique Lab. d'Informatique Industrielle Lab. d'Automatique et de Pneumatique Lab. de Physique Lab. d'Electrotechnique
E.S.T. – FES (GENIE CHIMIQUE)	Lab. de Chimie Lab. d'Analyses Lab. des Operations Unitaires Lab. des Procedes Industriels

LIST OF RESEARCH UNITS - MOROCCO

Etablissement	Laboratoire de recherche
CENTRE NATIONAL DE COORDINATION ET DE PLANIFICATION DE LA RECHERCHE SCIENTIFIQUE ET TECHNIQUE (CNCPRST)	
LABORATOIRE D'INSTRUMENTATION SCIENTIFIQUE (LIS)	Lab. d'instrumentation
LABORATOIRE D'ASTROPHYSIQUE ET GEOPHYSIQUE (LAG)	Laboratoire d'astrophysique et geophysique
LABORATOIRE DE TRAITEMENT D'IMAGE ET DE TELEDECTION (LATIT)	Laboratoire de traitement d'image
LABORATOIRE DE DROIT DU COMMERCE INTERNATIONAL (LDCI)	
LABORATOIRE D'INFORMATIQUE ET ET DE MATHEMATIQUES APPLIQUEES (LIMA)	
LPEE	Lab. genie civil, hydraulique
CNESTEN	Etudes nucleaires
CERPHOS	Lab. Extraction, utilisation et applications - Phosphates
CDER	Lab. Energies renouvelables
INSTITUT PASTEUR	Sante - Vaccins
INRA	Lab. de Recherche et developpement agricole

LIST OF RESEARCH UNITS - TUNISIA

Etablissement	Laboratoires de recherche
FACULTE DES SCIENCES DE TUNIS	Topologie
	Analyse non lineaire
	Theorie du Potentiel
	Conception des Systemes Logiques
	Mecanique de Fluides
	Comportement Mecanique des Materiaux
	Micro-Ondes
	Physique du Solide
	Matiere Condensee
	Spectroscopie Ramann et Raytegh
	Physique Atomique et Moleculaire
	Semi-conducteurs
	Rayonnement Thermique
	Physico-chimie des Phosphates
	Cinetique, Materiaux et Catalyse
	Chimie Analytique et Electrochimie
	Chimie de Surfaces
	Substances Naturelles
	Chimie des Materiaux
	Chimie Minerale et Cristallographie
	Synthese Organique
	Industrie Minerale
	Synthese de Derives Fluores
	Electrochimie Appliquee
	Biologie et Ecologie Vegetales
	Morphogenese experimentale
	Physiologie de la Nutrition Animale
	Physiologie Vegetale
	Ressources Genetiques
	Genetique Appliquee
	Geologie Dynamique
	Geologie Miniere
	Geologie et Ressources Naturelles
	Pedologie Hydrologie
	Paleontologie
	Physiologie et Ecologie Vegetales
	Biologie Membranaire
FACULTE DES SCIENCES DE MONASTIR	Physique du solide
	Physique des materiaux
	Physique structurale
	Semiconducteurs
	Electrochimie des solutions
	Chimie minerale moleculaire
	Agrochimie
	Synthese asymetrique
	Phosphates organiques
	Chimie macromoleculaire
ECOLE NORMALE SUPERIEURE DE SIZENTE	Physique du Solide
	Thermodynamique et Flotation
	Elaboration de Nouveaux Materiaux
	Valorisation des Phosphates et Saumures
	Synthese Macromoleculaire
	Valorisation des Sous Produits Agroalimentaires
	Biologie et Physiologie Cellulaires
	Genetique et Biochimie
	Endocrinologie
ECOLE NATIONALE D'INGENIEURS DE TUNIS	Electronique, Informatique et Telecommunications
	Corrosion et Traitements de Surface
	Analyse et Syntheses de Systemes Dynamiques
	Teledetection Aerospatiale
	Liants et Materiaux
	Modelisation et Calcule de Structures
	Hydrauliques
	Mathemathiques Appliquees
	Energies Renouvelables
	Chimie des Materiaux
	Electrotechnique Industrielle
	Traitement du Signal et Systemes

LIST OF RESEARCH UNITS - TUNISIA

Etablissement	Laboratoires de recherche
ECOLE NATIONALE D'INGENIEURS DE GABES	Genie des Procedes Energetique Genie Chimique Reacteurs Chimiques et Electrochimiques Automatique Informatique Industrielle Chimie des Engrais
ECOLE NATIONALE D'INGENIEURS DE SFAX	Mathematiques Appliquees Automatisme et Informatique Structure et Proprietes du Solide Genie Electrique Microelectronique Mecanique des Fluides Cultures in Vitro Physiologie Animale Biochimie
ECOLE NATIONALE D'INGENIEURS DE MONASTIR	Electrotechnique et Electronique de Puissance Energetique Mecanique des Solides Productique Integree et Communication Thermique
ECOLE NORMALE SUPERIEURE DE L'ENSEIGNEMENT TECHNIQUE	Genie Electrique Electrotechnique Microprocesseurs Physique des Semiconducteurs Physique des Materiaux Machines Electriques Materiaux Routiers Automatique Commandes Adaptives
ECOLE SUPERIEURE DES POSTES ET TELECOMMUNICATIONS	Electronique Traitement du Signal Informatique Industrielle
INSTITUT SUPERIEUR TECHNIQUE DE GABES	Fabrication Mecanique Electronique de Puissance Robotique Informatique Industrielle Moteurs Thermiques Modelisation des Organes de Transmission et de Levage
FACULTE DE MEDECINE DE SFAX	Biologie Medicale: Bacteriologie, Virologie Biologie Medicale: Immunologie Pharmacologie Epidemiologie Cancerologie
FACULTE DE MEDECINE DENTAIRE DE MONASTIR	Medecine Dentaire Anthropometrie Toxicologie Moleculaire Synthese organique Chimie des Materiaux
FACULTE DE PHARMACIE DE MONASTIR	Pharmacologie Hematologie Biologie Clinique Parasitologie Bacteriologie Virologie Plantes Medicinales Pharmacocinetique Biologie Humaine Analyse et Controle des Medicaments Maladies Genetiques Pharmacie Industrielle
FACULTE DES SCIENCES ECONOMIQUES ET DE GESTION DE TUNIS	Groupe de Recherche en Finances (G.R.E.F.)

LIST OF RESEARCH UNITS - TUNISIA

Etablissement	Laboratoires de recherche
FACULTE DES SCIENCES ECONOMIQUES ET DE GESTION DE SFAX	Laboratoire de Langues Sciences de Gestion Marketing Econometrie Economie Spatiale, Regionale et Urbaine Informatique de Gestion Economie Appliquee
FACULTE DE DROIT ET DES SCIENCES POLITIQUES DE TUNIS	Droit Administratif
FACULTE DES SCIENCES JURIDIQUES, POLITIQUES ET SOCIALES DE L'ARIANA	
FACULTE DES LETTRES DE LA MANOUBA	Geographie Physique Geographie Rurale
ECOLE NORMALE SUPERIEURE DE SOUSSE	Recherche Geographique sur le Sahel Biogeographie
INSTITUT DE PRESSE ET DES SCIENCES DE L'INFORMATION	Communication Institutionnelle
INSTITUT NATIONAL SCIENTIFIQUE ET TECHNIQUE	Valorisation des Eaux Usees et de Dechets Urbains Chimie de l'etat solide Dynamique des fluides Semi-conducteurs et composants electroniques Microbiologie Industrielle Biotechnologie Cartes Geologiques Biologie et Physiologie des plantes oleagineuses Nutrition minerale des plantes Culture in Vitro
CENTRE DE BIOTECHNOLOGIE DE SFAX	Production de sucre Production de cellulases Production de lysine Depollution des margines Multiplication du Palmier Dattier Production de plants de pommes de terre
INSTITUT REGIONAL DES SCIENCES INFORMATIQUES ET DES TELECOMMUNICATIONS	Telecommunications Informatique et Arabisation Calcul numerique et modelisation
INSTITUT DES REGIONS ARIDES DE MEDENINE	Conservation des eaux et du sol Zootechnie Economie pastorale Comportement et performance du Dromadaire Lutte contre l'erosion Defence de cultures Ecologie Pastorale Agro-economie
INSTITUT NATIONAL SCIENTIFIQUE ET TECHNIQUE D'OCEANOLOGIE ET DE PECHE	
CENTRE D'ETUDES DE RECHERCHES ET PUBLICATIONS	Economie Quantitative Microeconomie Appliquee Politique Economique et Modelisation Filieres inter-industrielles et emploi Dynamique economique Economie informelle Economie Regionale Finances Publiques Marketing Management P.M.E. et leure adaptation Maitrise de l'Energie Pensee Autrichienne Relations Econo. internationales Demographie Droit compare

LIST OF RESEARCH UNITS - TUNISIA

Etablissement	Laboratoires de recherche
CENTRE D'ETUDES DE RECHERCHES ET PUBLICATIONS (cont.)	Droit de l'Homme
	Securite Sociale
	Droit Social
	Droit International
	Droit Prive
	Citoyen et statue inegal
	Droit et Environnement
	Droit et Informatique
	Lexique Juridique
INSTITUT PASTEUR	Hematologie Immunologie
INSTITUT NATIONAL DE NUTRITION ET DE TECHNOLOGIE ALIMENTAIRE	Nutrition Experimentale
	Histologie Alimentaire
	Technologie Alimentaire
	Biophysique ppliquee a la Nutrition
	Nutrition et Diabetologie
	Nutrition Appliquee et Dietetique
	Physiopatologie
	Endocrinologie
	Biologie Clinique
	Medecine Dentaire
CENTRE TECHNIQUE DES MATERIAUX DE CONSTRUCTION DE LA CERAMIQUE ET DU VERRE	Beton
	Produits de Carriere
	Energie
	Ceramique
	Chimie
CENTRE TECHNIQUE DES INDUSTRIES MECANIQUES ET ELECTRIQUES	Mecanique des Materiaux
	Electronique Automatique
	Materiaux Plastiques
	Controle non. Destructif
SOCIETE TUNISIENNE D'ELECTRICITE ET DE GAZ - DEPARTEMENT RECHERCHE ET DEVEL.	Electricite
COMPAGNIE DES PHOSPHATES DE GAFSA CENTRE DE RECHERCHE	Chimie Analytique
	Geologie, Mineralogie
	Chimie des Phosphates
	Mecanique des Sols, Mecanique des Roches
	Enrichissement des Minerais

LIST OF RESEARCH UNITS - ALGERIA

Ministère de l'Education Nationale (MEN)

Université d'Alger **
Université d'Annaba *
Université de Batna *
Université de Blida *
Université de Constantine **
Université d'Oran **
Université des Sciences Islamiques de Constantine
Université de Setif *
Université de Sidi Bel Abbes
Université de Tizi Ouzou *
Université de Tlemcen *
Université des Sciences et de la Technologie Houari Boumedienne, Alger **
Université des Sciences et de la Technologie, Oran **
Institut National d'Enseignement Supérieur, Bechar [1]
Institut National d'Enseignement Supérieur, Bejaia
Institut National d'Enseignement Supérieur, Chlef
Institut National d'Enseignement Supérieur, Guelma
Institut National d'Enseignement Supérieur, Mascara
Institut National d'Enseignement Supérieur, Mostaganem *
Institut National d'Enseignement Supérieur, Oum El Bouaghi
Institut National d'Enseignement Supérieur, Tiaret
INESSM Alger **
INESSM Annaba
INESSM Constantine
INESSM Oran **
INESSM Tlemcen
INPS *
ISMAL *
ITO
CREAD **
ENA
ENP **
ENS *
ENSET[1]
ENV *
EPAU*
ESC *
INA **

LIST OF RESEARCH UNITS - ALGERIA

Ministère de la Culture et de la Communication

ANAPSMH Agence Nationale d'Archeologie et de Protection des Sites Historiques*
CNEH Centre National des Etudes Historiques *
Musée National des Beaux Arts [1]
Musée National de Bardot
Musée National des Antiquités
Musée National des Arts et Traditions Populaires
Musée National du Djihad *

Ministère de l'Education

IPN Institut Pédagogique National*

Ministére délégué à la Formation Professionelle

CERPEQ Centre d'Etudes et de Recherche sur les Professsions et Qualifications*

Ministère de la Santé (MS)

CHU Alger Centre *
CHU Alger Est
CHU Alger Ouest *
CHU Bab El Oued
CHU Annaba *
CHU Blida
CHU Constantine **
CHU Oran **
CHU Setif
CHU Sidi Bel Abbes *
CHU Tizi Ouzu
CHU Tlemcen *
CPMC Alger
Hôpital Ait Idir *
Hôpital El Kettar
INSP
Institut Pasteur

LIST OF RESEARCH UNITS - ALGERIA

Ministère des Affaires Sociales

INHS (Institut National d'Hygiène et de Sécurité) *
Institut National de Travail (INT)

Ministère de l'Energie

CERHYD	Centre de Recherche pour la Valorisation des Hydrocarbures et Dérivés *
SONATRACH	Centre de Recherche et de Développement
IAP	Institut Algérien des Pétroles *
INHC	Institut National des Hydrocarbures
SONELGAZ	Unité de Recherches en Simulation Numérique UER

Ministère de l'Industrie et des Mines

ENDMC-URST	Entreprise Nationale de Développement et de Recherche des Materiaux de Construction
ENEDIM	Entreprise Nationale de Développement des Industries Manufacturières [1]
ENEL-URST	Entreprise Nationale des Industries Electrotechniques
ENIE	Entreprise Nationale des Industries Electroniques
ENTC-UR	Entreprise Nationale de Télécommunications
PMA	Entreprise Nationale de Production de Matériels Agricoles[1]
SIDER	Entreprise Nationale de Sidérurgie[1]
FERPHOS-CERAD	Entreprise Nationale du Fer et du Phosphate
ONIG	Office Nationale de la Géologie
SAIDAL-URMTP	Unité de Recherche en Médicaments et Techniques Pharmaceutiques
INELEC	Institut National d'Electricité et d'Electronique*
ENSI	Entreprise Nationale des Systèmes Informatiques

LIST OF RESEARCH UNITS - ALGERIA

Ministère des Postes et Télécommunications

CERT	Centre d'Etudes et de Recherches Techniques *

Ministère de l'Equipement

ANAT-URAT	Agence Nationale de l'Aménagement du Territoire *
CNERU	Centre Nationale d'Etudes et de Recherches en Urbanisme *
CGS	Centre National de Recherche Appliquée en Génie Parasismique *
CNERIB	Centre National d'Etudes et de Recherche Intégrée en Bâtiment
CTTP	Centre Technique des Travaux Publics [1]
LTPC	Laboratoire Technique des Travaux Publics Centre
LTPE	Laboratoire Technique des Travaux Publics Est [1]
LTPO	Laboratoire Technique des Travaux Publics Ouest [1]
ENTP	Ecole Nationale des Travaux Publics
LEM	Laboratoire d'Etudes Maritimes [1]

Ministère de l'Intérieur

CRAAG	Centre de Recherche en Astronomie, Astrophysique et Géophysique *

Ministère de l'Agriculture

ANN	Agence Nationale de Conservation de la Nature [1]
CNIAAG	Centre National d'Insémination Artificielle et de l'Amélioration Génétique
INPV	Institut National de la Protection de Végétaux
INRAA	Institut National de la Recherche Agronomique d'Algérie
INRF	Institut National de Recherche Forestière *
INSA	Institut National de la Santé Animale
ITA	Institut Technologique de l'Agriculture
ITAFV	Institut Technique de l'Arboriculture Fruitière et de la Vigne *
ITCMI	Institut Technique des Cultures Maraîchères et Industrielles [1]
ITDAS	Institut Technique de Développement de l'Agriculture Saharienne [1]
ITEBO	Institut Technique de l'Elevage Bovin et Ovin
ITGC	Institut Technique des Grandes Cultures
ITPE	Institut Technique des Petits Elevages

LIST OF RESEARCH UNITS - ALGERIA

Ministère des Transports

ONM	Office National de la Météologie
IHFR	Institut Hydrométéorilogique de Formation et de Recherche

Ministère Délégué à la Recherche, la Technologie et l'Environnement (MDRTE)

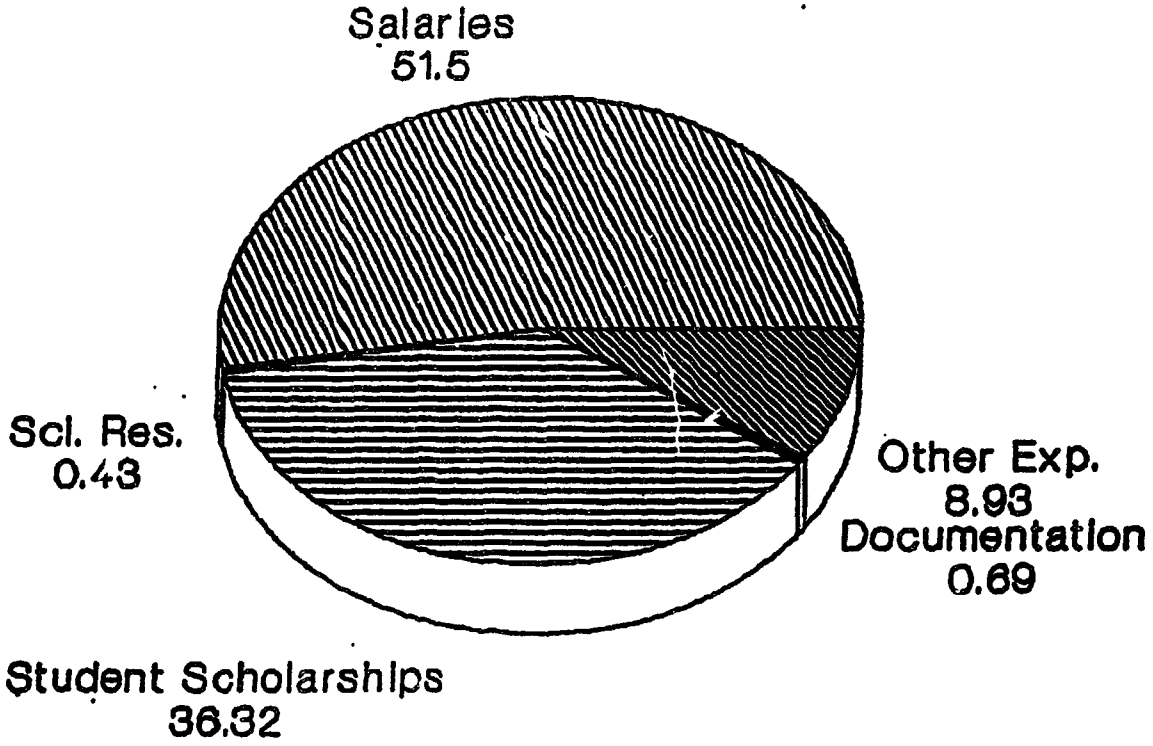
CDER	Centre de Développement des Energies Renouvelables *
CDM	Centre de Développement des Matériaux *
CDSE	Centre de Développement des Systèmes Energétiques
CDTA	Centre de Développement des Techniques Avancées **
CDTA-UDTS	Unité de Dévelopement de la Technologie du Silicium *
CDTN	Centre de Développement des Techniques Nucléaires *
CDTN-URGN	Unité de Recherches en Génie Nucléaire *
CERIST	Centre d'Etudes et de Recherches en Information Scientifique et Technique *
CND-UDTS	Unité de Développement des Techniques de Soudage et de Contrôle Non Destructif *
CNTS	Centre National de Télédétection et de Surveillance *
CREM	Centre de Recherches et d'Exploitation Minières
CRS	Centre de Radioprotection et de Sûreté *

Number of researchers

1 = 0 chercheurs
* = < 11 chercheurs
** = > 100 chercheurs

ANNEX 6A

HIGHER EDUCATION RECURRENT BUDGET ALLOCATION - MOROCCO

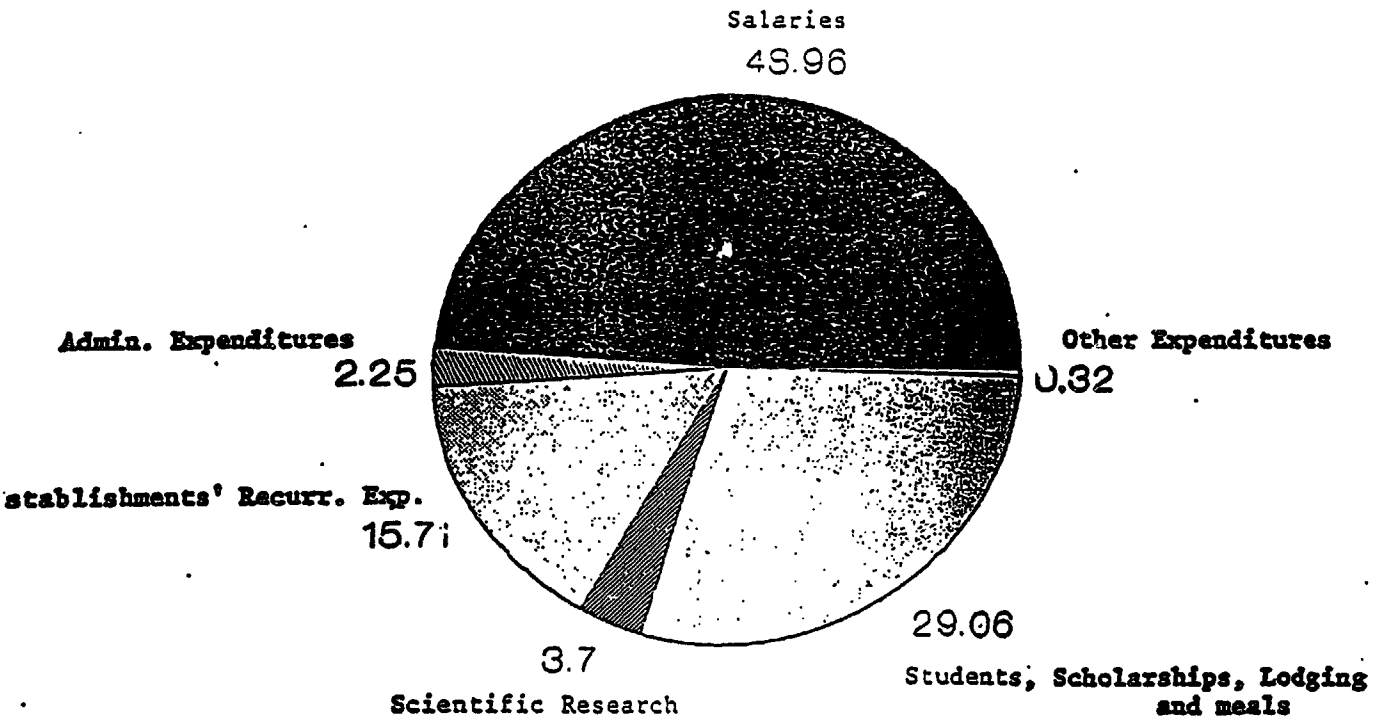


SOURCE: World Bank estimates

ANNEX 6B

CHART 2: HIGHER EDUCATION RECURRENT BUDGET ALLOCATION

TUNISIA



SOURCE: World Bank estimates

NUMBER OF RESEARCHERS BY DISCIPLINE IN MOROCCO

* UNIVERSITY SECTOR

DISCIPLINE	1980	1990
Original learning	60	87
Arts	448	1747
Law	443	666
Sciences	515	2282
Medicine and Pharmacy	396	709
Dentistry		73
Engineering sciences	135	227
Education sciences	93	128
Technologies	-	74
Special Research Institutes	81	194
TOTAL	2171	6187

* Non university sector: (professional staff training only)

Majoring in scientific and technical studies	1126
Majoring in economic, legal and social studies	547
Majoring in pedagogic studies	1039
TOTAL	2712

ANNEX 8

SCIENTIFIC RESEARCH - SELECTED INDICATORS
NUMBER OF RESEARCHERS/1 PER '000 OF POPULATION

Algeria (1984) /2	0.3 - 0.5
Morocco (1989) /2	0.4
Tunisia (1989) /2	0.6
Portugal (1987) /3	0.4
France (1987) /3	2.0
Italy (1987) /3	1.2
Japan (1987) /3	4.2
USA (1987) /3	3.3

/1 R & D Scientists and Engineers, Researchers or University Graduate
/2 World Bank Estimates
/3 OECD/World Bank Estimates (1987)

ANNEX 9

NUMBER OF THIRD CYCLE THESES AND STATE DOCTORATES (1988/89) (*)
TUNISIA

UNIVERSITY	Number of Third Cycle Theses	Number of State Doctorates	Total
EZZITOUNA	2	-	2
TUNIS I	9	1	10
TUNIS II	27	-	27
TUNIS III	18	1	19
CENTRE (Sousse)	-	-	-
SUD (Sfax)	1	-	1
TOTAL	57	2	59

(*) Figures extracted from statistical survey of November 15, 1989.
State Doctorates in medicine not taken into account.

ANNEX 10

SCIENTIFIC RESEARCH - SELECTED INDICATORS
HIGHER EDUCATION SUPPORT RATIOS
NUMBER OF SUPPORT STAFF PER RESEARCHER

Algeria	Not available
Morocco /1	0.06
Tunisia /1	0.06
Portugal (1984) /2	0.59
France /2	0.66
Italy /2	0.32
Japan /2	0.28
USA	Not available
Germany (1983) /2	1.41

/1 World Bank estimates (1990)
/2 OECD (1985)

ANNEX 11

NUMBER OF PUBLICATIONS PER STUDENT IN MOROCCO

University Faculties	Average number of publications per student
ARTS AND HUMANITIES	7.2
LAW AND ECONOMICS	5.76
SCIENCES	1.72
ENGINEERING	26.68
MEDICINE AND PHARMACY	0.8
DENTISTRY	3.78

	Minimum	Maximum
International Norms	50	75

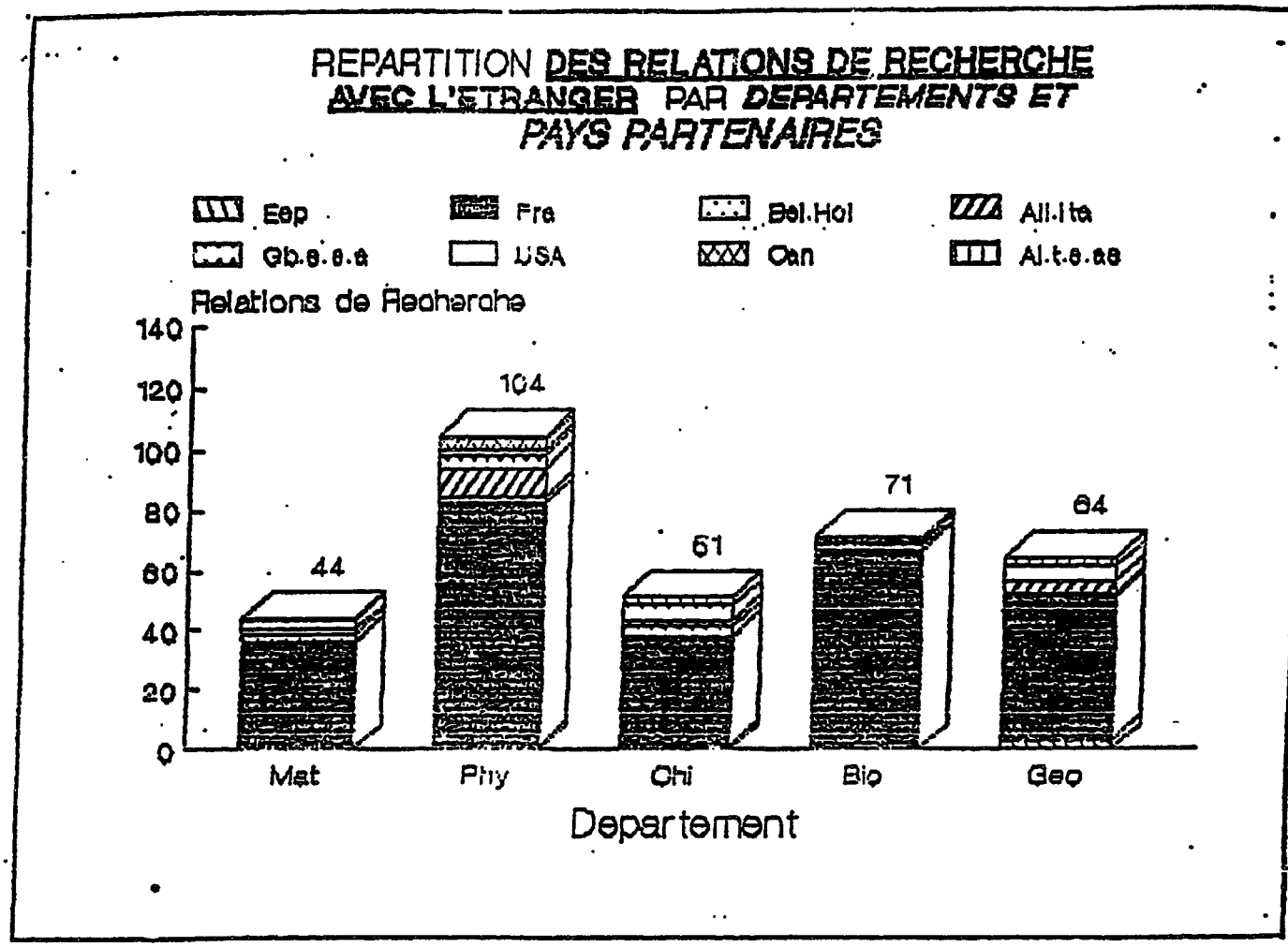
Source: Direction de l'enseignement supérieur et de la recherche scientifique, 1990.

CORRELATION OF SCIENTIFIC COOPERATION BETWEEN 9 SELECTED ARABIC COUNTRIES AND THE 8 MOST SCIENTIFIC PRODUCTIVE COUNTRIES IN THE WORLD

	USA	Great Britain	Russia	Japan	Germany	France	Canada	India
Algeria	13	8	7	1	3	230	5	27
Saudi Arabia	239	149	0	5	21	22	53	14
Egypt	469	188	11	23	156	102	61	10
Iraq	52	82	3	7	4	7	10	23
Jordan	67	32	1	0	19	4	0	0
Kuwait	70	47	0	2	5	7	26	6
Libya	29	20	1	0	4	6	6	15
Morocco	28	8	0	0	10	241	4	1
Tunisia	20	4	0	0	10	314	3	1

Note: The data represent the number of published scientific articles with joint authorship in the two countries indicated. The scientific articles are drawn from a data base of over 3,000 mainstream journals.

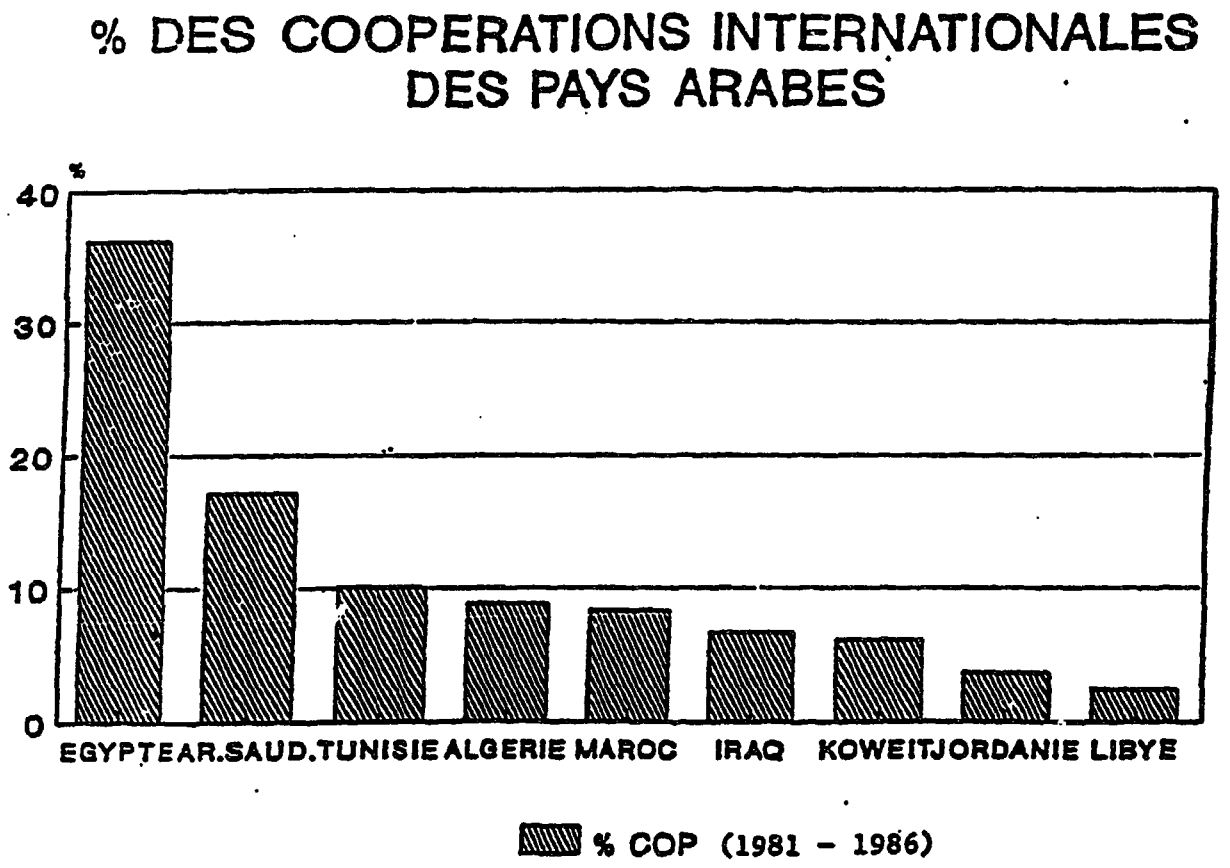
Source: CNRS-LEPI MEV-MAC 1981-1986



RESEARCH LINKS WITH SELECTED INTERNATIONAL PARTNERS
BY UNIVERSITY FACULTIES IN MOROCCO

Source: CNRS - LEPI MEV - MAC 1981 - 1986

INTERNATIONAL COOPERATION FOR SELECTED ARAB COUNTRIES
(% of Scientific Projects)



Source: CNRS - LEPI MEV - MAC 1981 - 1986

LIST OF RESEARCH PUBLICATIONS ISSUED
BY HIGHER INSTITUTES OF LEARNING IN MOROCCO

-"Revue de la Faculté des Lettres". en arabe = Fac. de Rabat
-"Revue de la Faculté des Lettres". en arabe = Fac. de Fes
-"Revue de la Faculté des Lettres". en arabe = Fac. de Mohammadia
-"Revue de la Faculté des Lettres". en arabe = Fac. de Tetouan
-"Revue de la Faculté des Lettres". en arabe = Fac. de Marrakech

-"Hespéris" (départ d'Histoire). Fac.Lettres-Rabat
-"Revue de Langue et léttérature Française", par départ de L.LF. Fac.Lettres-Rabat.
-"Revue de géographie du Maroc"=RGM= par départ.géographie.Fac.Lettres-Rabat
-"Revue d'études espagnoles" (en espagnol)= départ de langue espagnol. Fac.Lettres-Rabat.
-"Revue juridique, politique et économique du Maroc". Fac.Droit-Rabat
-"Revue marocaine de Droit et d'Economie du développement".Fac.Droit-Casa
-"Revue de Droit et d'Economie". Fac.Droit-Fés.
-"Revue marocaine de Droit comparé". Fac.Droit-Marrakech
-"Al Mayadine" (Domaines). Fac.Droit-Oujda.
-"Revue Maroc Médical" -Fac. de Médecine et Pharmacie-Rabat.
-"Médcine et Santé"- Fac. de Médecine et Pharmacie-Casa.
-"Attadriss" éditée par la Fac. des sciences de l'Education-Rabat.
-"Bulletin des Sciences". Institut Scientifique.
- Revue"OUALILI"- de l'Ecole Normale Supérieure de Meknès.
-"Revue de l'INSEA"- éditée par l'INSEA.
- Revue"Gestion et Société"- éditée par l'ISCAE.
-"Bibliographie Nationale"- éditée par la BGA (Bibliothèque Générale et Archives).
-"IDEST" du Centre National de Documentation

EDITIONS BY VARIOUS ASSOCIATIONS

-"L'Informatiste" -Revue de l'Association des Informatistes Marocains.
-"Revue de l'AMADEIA.
-"Kitab Al Maghreb" -"Livre Marocain"- éditée par une association privée: "l'Association Marocaine d'édition et de diffusion" de M. Mohamed HAIJJI.

Source: CNRS - LEPI MEV - MAC 1981 - 1986

ANNEX 15

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