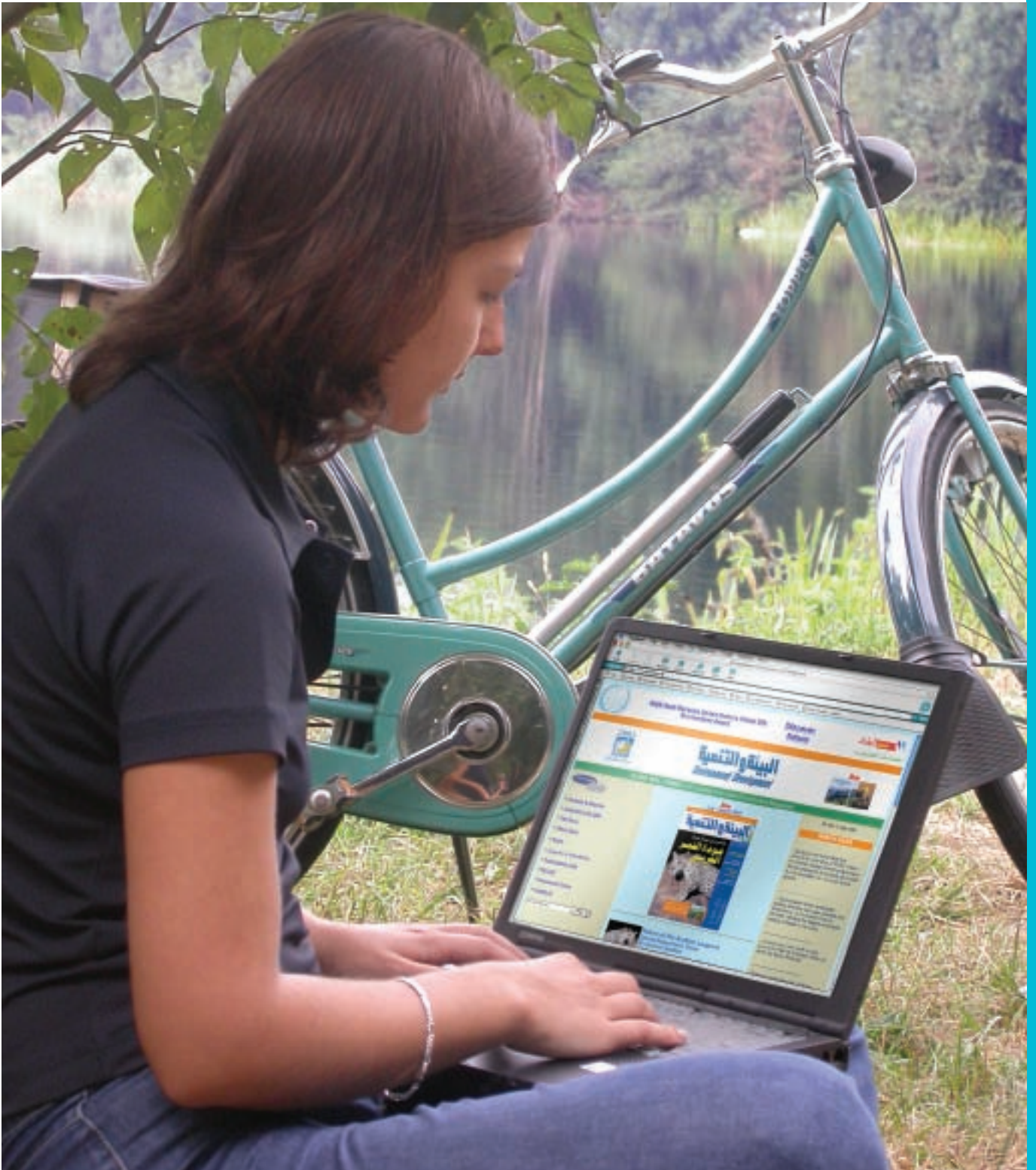


# Environmental Scientific Research

AHMAD GABER



## I. INTRODUCTION

This chapter is intended to study the current state of affairs of scientific research in the environmental field in the Arab region. The issue is important for a number of reasons:

- Arab countries are facing extreme challenges regarding the conservation of natural resources and protecting the environment from pollution.
- Addressing those challenges necessitates recourse of all scientific research tools to identify ideal solutions to each problem.
- Documented world experience has proven that the application of scientific research approaches and tools has achieved satisfactory success in solving complex environmental problems extending across spatial and temporal dimensions.

In this chapter, we try to assess the current situation of scientific research in the Arab region in the field of the environment, based on the first reading of available output of research institutions and researchers concerned with environmental anxiety in Arab world.

## II. FRAMEWORK AND APPROACH

Environmental research has certain distinguishing features that set it apart from other types of research. The most important of these features are:

- Environmental research is carried out in most of the scientific faculties of universities and research centres. These faculties do not necessarily carry a name that refers to a dedicated focus on environmental questions and problems. As such, while environmental research appears at first glance to be a secondary concern at the scientific level, it is the main concern for a number of specialized researchers in these faculties.
- Most environmental research takes a practical approach, aimed at solving real life problems. For this reason we can refer to such research as “applied research” in most cases. In general, scientific research tools are used that were most likely developed to solve problems not directly related to environmental problems.

- Researchers concerned with environmental issues deal with their research subjects from their particular scientific background and hence use their own tools and linguistic vocabulary. As examples, soil pollution with heavy metals is a research subject that draws researchers from the fields of botany, soil, agriculture, irrigation, public health, economy, and law; and the scarcity of water resources is a subject that attracts researchers from the fields of climate, modelling, water resources, agriculture, economy, and law.

If some of these researchers were to be brought together around a specific environmental issue, their cumulative research could be transformed into a type of compound research subjected to multidisciplinary perspectives.

This chapter attempts to observe the current status of scientific research in the several environmental areas in Arab world. It is important to affirm, from the beginning, that the major determinant in this “observation” process is the availability of information. With the same importance, we confess that the available information is certainly not enough to achieve a definitive judgement, apart from recognizing their insufficiency to achieve any of the scientific assessment levels that adhere to the sober-minded assessment approaches of published scientific research.

From another point of view, scientific research in the environment field cannot be considered a discrete field whose situation can be studied in isolation from the condition of scientific research in Arab countries in general. This in turn consists of looking at the sum of several fields, ranging from engineering and fundamental sciences to those in the economic and social arenas. Therefore, this chapter tries to demonstrate the state of scientific research in Arab countries in general, out of published studies, in order to present the reader with a general overview of scientific research in Arab countries compared to other world areas. Subsequently, this chapter will try to recognize – through the “survey” method – the state of scientific research in the environment field in particular. For its data about environmental scientific research, this chapter relied mainly on information available on the internet, and on a sample of the Arab countries including Egypt, Saudi Arabia, Syria, and Tunisia.

### Definition and Classification of Environmental Research

Scientific research on the environment is, as mentioned earlier, a multifaceted activity in which researchers from different backgrounds collectively participate. That is why environmental research and studies are difficult to be defined and classified. In this chapter, the European approach, prepared by European Office for Statistics (EUROSTAT) on environmental pressure indicators (Figure 1), was followed. It classifies the environmental problems into the ten groups (policy fields) shown in the figure, each of which is considered an independent environmental challenge of different dimensions. The European approach tries to present obvious definitions and frameworks for each group to facilitate the classification process. This is the reason why the European approach is more concentrated than approaches followed in other countries. In case of research that may be classified in more than one group, classification was made according to the primary trend of the research and neglecting secondary trends, which is an estimation process in the first place.

The second reason for selecting this approach to classify environmental research is the easiness of linking environmental problems of higher priority to priorities of scientific research. This makes evaluation of the research activity – according to its response to most hazardous environmental challenges – more clear. Using this approach, and the different pressure indicators, in the future, may help to put an integrated system for measuring the state of the environment, identifying scientific research priorities, and achieving an optimal distribution of human and physical resources in each of the countries; such that resource management can become more effective and its goals better realized.

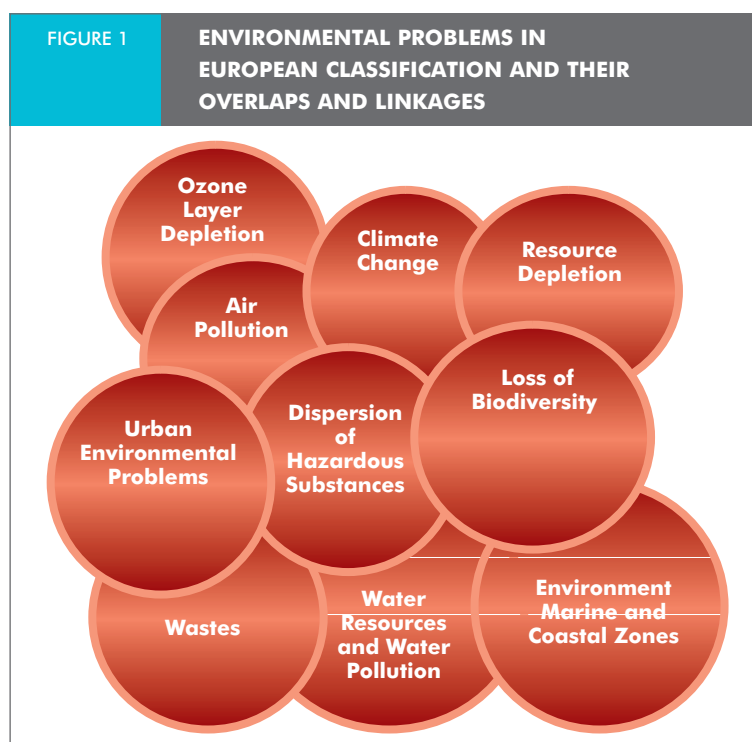
It is worth highlighting that in the European example mentioned above, the main objective of classifying and setting indicators for environmental pressures is to link the state of the environment to European sustainable development indicators in order to enable decision-makers and beneficiaries to more clearly see and appreciate their environmental and development options.

### Research Samples and Data Accuracy Margins

In its observation of the general state of scientific research in the Arab world, this chapter chooses to present the results obtained by some researchers who studied the sources of production (IDRC, 2003) and national research systems in the Arab world (Gaillard et al, 2008) in a detailed manner.

As for the environmental research fields, this research considered the sample of Arab countries chosen as being representative of the general Arab region. In fact, there was no other choice due to a lack of information released to the internet and an absolute absence of information in certain cases. This raises questions about the extent to which Arab research institutes move towards “numeralization” of their databases to facilitate their availability, accessibility, and, consequently, their usage.

Care was taken in selecting the samples to represent (as much as possible) the economic, social, and geographical diversity of the Arab world while taking into consideration problems of information availability and political circumstances. Iraq, for instance, is a good example of



an Arab country that owns oil resources in addition to having an advanced industrial and research infrastructure; however, the occupation conditions and unavailability of online information excluded it from being included in the research sample.

The four selected Arab countries are Saudi Arabia, that represents the economic development model which depends on a high endowment of oil and mining resources in a desert environment suffering from water shortage; Egypt, with the largest population, which is concentrated in the Nile wadi and Delta (creating more acute pressures on the environment); Syria, as an Arab example of a controlled economy built on agriculture and industry; and, finally, Tunisia, as an example of an Arab Maghreb sub-region that has a diverse economy which depends on a combination of agriculture (one third of the population), tourism, and mining resources. The four countries, with their combined population of 132 million represent about 44% of the Arab world's total population, and contain a large part of its different resources. The primary remark at the regional Arab level is the multiplicity of principal research languages (multilingualism): French is used in Tunisia, English in Egypt, and Arabic in Syria. From one point of view, such a degree of external openness facilitates knowledge transfer, but on the other hand, multilingualism makes pan-Arab collaboration in environmental research a more difficult task.

### **Research Questions**

This chapter attempts to answer the following questions:

- What is the current situation of scientific research in general in the Arab world? What are the major deficiencies, and how could these be corrected?
- What are the environmental fields focused on by scientific research in the Arab world? Which fields get less concern?
- Are researchers of specific scientific backgrounds interested in some fields more than others?
- What is the extent of inter-disciplinary cooperation? Does it satisfy scientific research needs?
- What are the items of consideration in devel-

oping the scientific research system in its existing configuration, and what are the possibilities of this system to play an effective role in achieving sustainable development and environment conservation?

- Has any research network been established at the local or regional level in any field of environmental research?

### **III. THE GENERAL STATE OF SCIENTIFIC RESEARCH IN THE ARAB WORLD**

In this section, the general state of scientific research in the Arab world will be presented. The production process of scientific research is basically a transformative process that has inputs (human and financial resources) which are transformed (through managerial and financing systems and educational and research institutes) into outputs (research, studies and patents). Similar to any other transformation process, the productivity of scientific research can be measured by measuring the efficiency of transforming inputs into outputs.

#### **Inputs of Scientific Research**

In general, the two basic indicators of scientific research inputs are the number of researchers (absolutely, or as a percentage of population) and rate of expenditure (as an absolute rate, or a percentage of domestic national product). Regarding the first, the number of researchers in the Arab world approximated the number in the rest of the world's regions in 1998; however, as a percentage of population, it is relatively lower, although the difference is small (UNESCO, 1998). According to the same study, the number of researchers in Arab world increased at an annual rate of 6-7% from 1994 to 1998, which is double the population growth rate.

As for the rate of expenditure on scientific research as a percentage of domestic national product (Gross Expenditure on R&D, GERD), the performance of Arab world is almost shameful, standing at 0.2% compared to the world average of 1.4%. This regional rate is the least in the whole world, even when compared to the southern desert areas in Africa (UNESCO, 1998). The comparison is especially striking when comparing the expenditure on scientific



research in the Arab world, with its 300 million habitants, to those in Israel, with a population of six million.

Looking at these figures holistically, we can deduct that scientists in Arab world are many and their number is increasing, but they suffer a shortage of resources. This, in fact, is a problem faced by nearly all Arab scientists.

It is worth mentioning here two major phenomena. The first is an Arab scientific diversity that calls for integration. For example, Egypt brings together the biggest research base, and Saudi Arabia has the largest domestic national product with a much smaller research base. What is meant here is that Arab integration has established bases in the field of scientific research, and Arab scientific cooperation will yield positive returns for all participants, if only the existing potential were to be utilized. As such, it is not only an emotional invitation out of place in today's world, as some critics counter.

The second phenomenon is the "brain drain." It deserves precise research and serious discussion. Although we cannot devote much attention to this issue, we shall only mention that in the year 2000, the number of Egyptian researchers working in the United States alone reached 12,500 (half of them were specialized in basic and engineering sciences). The number of Lebanese researchers was 11,500. Most other Arab countries suffer a similar situation (Gaillard et al, 2008). Of course this phenomenon cannot be isolated from the financing crisis mentioned before, as well as many other factors.

### **Outputs and Productivity of Scientific Research**

There are two basic world indicators for scientific research outputs: the number of studies and the number of patents. While the Arab world's share of the former is low, its contribution in the latter is entirely negligible, which may refer to a complete absence of any relationship between scientific research and the actual production of an economy. This in turn may be interpreted as indicating that the main motivation of scientific research is job promotion, and as such it is an individual effort that is not institutionalized (IDRC, 2003; Gaillard et al, 2008).

As for productivity indicators, one of the few surprises is that the Arab world beats even North America in the ratio of the amount of published research to the rate of expenditure on scientific research. However, with respect to the ratio of the amount of published research to the number of researchers, the productivity of the Arab world is the least of all regions, even when compared to the southern desert area in Africa (UNESCO, 1998).

## **IV. SCIENTIFIC RESEARCH IN ENVIRONMENTAL FIELDS**

This section presents results of the modest survey research made by us as an attempt to explore and assess the state of scientific research in environment fields. A presentation of the results in those Arab countries selected within the research is shown in this section.

### **Saudi Arabia**

Information was collected mainly from Saudi Research Database (Qabas) of King Abdel Aziz City for Science and Technology. Most research and studies were prepared by the universities of King Saud, King Abdel Aziz, and King Fahd for Petroleum and Minerals. Lesser contributions were made by King Faysal University, Girls Faculty of Education, King Abdel Aziz City for Science and Technology, and King Khaled University.

The number of research studies observed since 2000 to date reached 87. It was noticed that

there is no definite link between most of the different research either in one field or in different fields, except in the case of repeated studies. There is no common research between different departments, which points to few inter-disciplinary studies.

Saudi research classification (Figure 2) points to a small share of worldwide problems (i.e. that do not affect one specific geographic area alone) out of the scientific research: 2% only were on climate change, 1% each on ozone layer depletion and resource depletion, while 18% of the scientific studies were devoted to studying the loss of biodiversity. Research on water resources and water pollution, and wastes represented 50% from the total published research.

Viewed from the perspective of the contribution of different disciplines towards environmental research, it seems that researchers concerned with botany and civil engineering have the most interest in environmental research (Figure 3); especially in the two fields of biodiversity, for the first, and water resources and water pollution, for the second. They are followed by research in chemical engineering (Wastes), environmental design (Urban environmental problems), chemistry (Wastes and

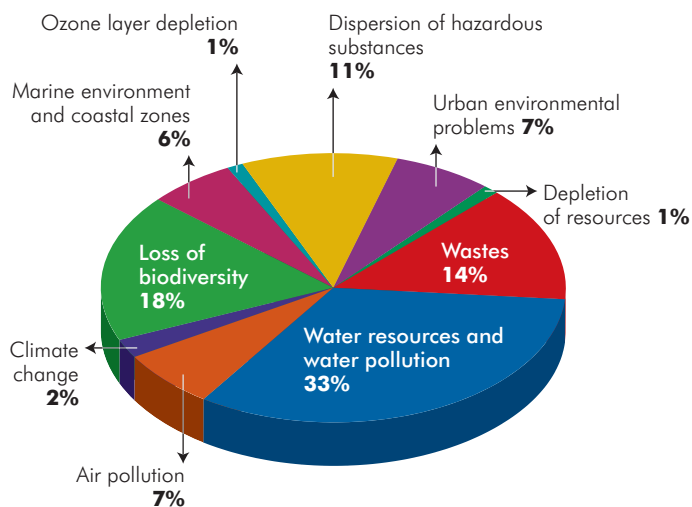
dispersion of hazardous substances), meteorology (Water resources and water pollution), and geology.

Saudi Arabia has recently established a group of research centres of excellence (in 2007), some of which have a tight and direct relationship with the environment such as the Renewable Energy Research Center of Excellence of King Fahd University for Petroleum and Minerals and the Environmental Studies Center of Excellence of King Abdel Aziz University. The latter has an ambitious plan that focuses on certain research areas in participation with experts of different disciplines. It also plays a coordination role between various agencies that participate in its activities. Although due to the juvenility of the centre, it is difficult to assess its actual role so far, its vision and plan are promising.

In order to give the reader a closer idea about Saudi research subjects, here are some research titles in the different areas:

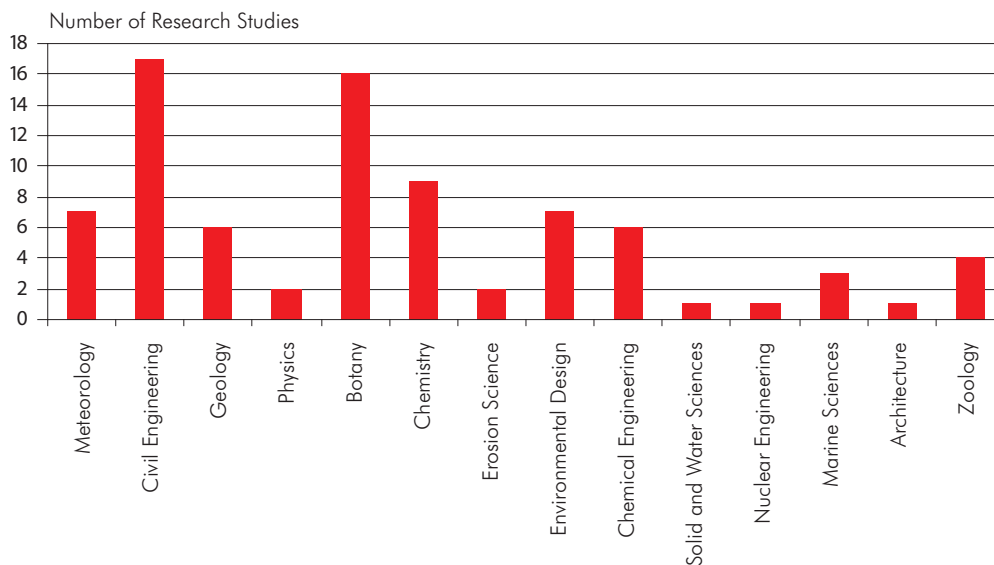
- *Air Pollution* – Studies of air polluters and their effects on the environment and public health in Yanbu industrial city.
- *Climate Change* – Clean production of hydrogen via laser-induced methane conversion.
- *Loss of Biodiversity* – The application of molecular genetics to the conservation of Arabian gazelles.
- *Marine Environment and Coastal Zones* – Study of environmental pollution in Tarout Gulf area using remote sensing technology and geographic information systems (GIS).
- *Ozone Layer Depletion* – Thermodynamic study of the formation, decomposition, and oxidation of methane in the soil atmosphere.
- *Depletion of Resources* – Use of dates in the production of degradable biopolymers.
- *Dispersion of Hazardous Substances* – Bioremediation of some heavy metals from contaminated regions by Actinomycetes.
- *Urban Environment Problems* – Drawing urban growth boundaries and their implications on the Saudi cities.
- *Wastes* – Treatment of liquid industrial wastes using green algae.
- *Water Resources and Water Pollution* – Assessing groundwater capabilities in Asfan valley with respect to quantity and saltness under draught and rain conditions.

FIGURE 2 SAUDI ENVIRONMENTAL RESEARCH IN THE PERIOD FROM 1998 TO 2007 CLASSIFIED ACCORDING TO FIELDS



Source: Saudi Research Database "Qabas" of King Abdel Aziz City for Science and Technology in 2007

FIGURE 3

**CONTRIBUTION OF DIFFERENT DISCIPLINES IN SAUDI ENVIRONMENTAL RESEARCH IN THE PERIOD FROM 1998 TO 2007**


Source: Saudi Research Database "Qabas" of King Abdel Aziz City for Science and Technology in 2007

## Syria

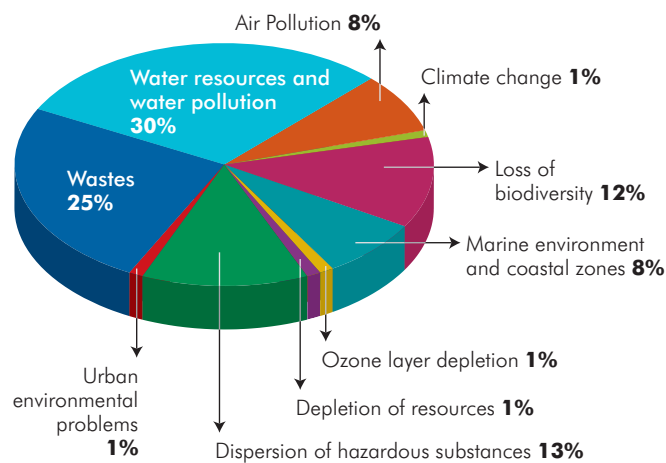
In the case of Syria, information was collected from scientific periodicals dealing with engineering and science subjects and published by the main Syrian universities. The biggest share was for the Damascus, El-Baath, and Tishreen universities; and a small ratio for Halab University. The number of observed research studies from the year 2000 until now reached 75. As above, the remark about the absence of links between different research undertakings, and the scarcity of inter-disciplinary researches, is repeated.

Few differences exist vis-à-vis the Saudi example, and almost the same remarks are repeated (Figure 4): activities of more world-wide character which are not related to one geographic site have only 1% share; these areas are climate change, depletion of resources, and ozone layer depletion. It increases to 12% in the area of biodiversity loss. And through the same sequence the ratios of wastes, and water resources and water pollution areas reach 55% of the total amount of research. The largest difference between Syrian and Saudi environmental research lies in that of urban environmental research: in Syria these are fewer than in Saudi Arabia; the difference, however, is little.

The following are some titles of Syrian research studies in different environmental fields:

- *Air pollution* – Study of distribution and dispersion of gaseous pollutants in Damascus.
- *Climate Change* – Study of emissions produced from gas burning in vehicles.

FIGURE 4

**SYRIAN ENVIRONMENTAL RESEARCH STUDIES IN THE PERIOD FROM 1998 TO 2007 AND CLASSIFIED ACCORDING TO FIELDS**


Source: Scientific Periodicals of Damascus, El-Baath, Tishreen, and Halab Universities

- *Loss of Biodiversity* – Contribution in studying biodiversity of Ascomycetes and Basidiomycetes in Barada basin.
- *Marine Environment and Coastal Zones* – Contribution in the study about distribution of perfume hydrocarbons (PAHs) in sedimentaries and water of Banias city shores.
- *Ozone Layer Depletion* – Study into destroying gases that are environmentally harmful to catalysts (Hexafluoride Ethane and Tetrafluoride Methane).
- *Depletion of Resources* – Selecting building and plastering materials through their environmental specifications.
- *Dispersion of Hazardous Substances* – Study of soil pollution with Cadmium in Qatena area, and treating the soil.
- *Urban Environmental Problems* – Environmental management in small and medium enterprises: case study in the old city in Halab.
- *Wastes* – Absorption of pollutants in the dispersed phase (experimental and mathematical questionnaire).
- *Water Resources and Water Pollution* – Using bacterial flora as an indicator for water pollution in the South Kabeer river.

### **Egypt**

Survey research in Egypt is confined to the Faculty of Engineering at Cairo University which is considered the largest and oldest engineering college in the Arab world for many reasons. The first is the multiplicity (in addition to the diversity) of Egyptian environmental research authorities; unfortunately, this makes the collection (or even survey) of their research a more difficult task. The second reason is the important role of engineering research in the environmental field (which is of more applied nature). Therefore, the data drawn upon was taken from the Periodical of the Faculty of Engineering at Cairo University.

Before presenting the research results of the Faculty of Engineering at Cairo University, it is worth attempting to present in brief some other Egyptian research authorities and their role in conducting environmental research, in order to provide a more comprehensive overview of the environmental scientific research system in Egypt. We try to select authorities of administrative nature and diverse research specializations to clarify the extent of multiplicity of Egyptian research authorities working in environment field.

### **The National Research Centre**

The National Research Centre is one of the biggest and oldest research centres in the Arab world. It comprises about 4,000 researchers, 1,000 of them holding doctorate degrees and working in 52 laboratories within 13 sections, including one section specialized in environmental sciences research. This centre consequently possesses the infrastructure and human resources necessary to produce inter-disciplinary environmental research. However, a proper evaluation of its functioning requires more independent research.

### **Water Research Centre**

This centre consists of 12 specialized research institutes working in numerous fields and aiming to achieve the focal objective of the centre which is realizing the optimal use of water through maximizing water supply and minimizing water losses. Although all Water Research Centre branches take into consideration the environment and its conservation in producing their studies and research, some of these institutes are more directly concerned with environmental research in particular, such as: the Environment and Climate Research Institute which concerns itself with climate change at the local and regional levels and its impacts on water resources; the River Nile Research Institute; the Water Management Research Institute; the Drainage Research Institute which focuses on water recycling and re-use in irrigation; the Coastal Research Institute; and the Groundwater Research Institute which works towards the management of groundwater reservoirs and making use of them.

### **Desert Research Centre**

This centre aims to provide adequate information to decision makers regarding desert land reclamation plans (as deserts represent more than 95% of Egyptian lands) and making use of desert resources. The administrative structure of the centre consists of four main sections: water resources and desert soil, cultivating dry lands, breeding of cattle and poultry, and economic and social studies.

### **Institute of Environmental Research and Studies, Ain Shams University**

This institute is considered a school for graduate studies in environmental fields, hence it focuses on the preparation of scientific cadres in the environmental field. This institute adopts a comprehensive approach based on systemic thinking for

environmental research. The centre's seven sections comprise different and numerous aspects of environmental fields: environmental human sciences, educational sciences and environmental information; environmental economic, legal, and administrative sciences; and environmental fundamental, medical, engineering, and agricultural sciences. The institute accepts graduates of different scientific backgrounds, thus providing a rare chance for researchers to familiarize themselves with numerous and different perspectives on their research topics.

### Agricultural Research Centre

Although the activities of this centre are not explicitly concerned with environmental scientific research, due to the nature of agricultural activities, environmental concerns are an integral part of its research. The centre clearly recognizes this fact; therefore it established a soil, water, and environment research institute to be one of the 16 institutes affiliated to this centre. The activities of this institute comprise many fields such as: environmental impact assessment of agricultural projects, production of fertilizers and environmentally safe bio-disinfectants, and assessment and monitoring of the impact of urban expansion on agricultural lands.

### Faculty of Engineering, Cairo University

As previously mentioned, the Faculty of Engineering at Cairo University is considered the main scientific research centre in Egypt. The number of research studies undertaken reached 127 since 2000 until the present. Our earlier remarks about an absence of links between independent research studies and an absence of inter-disciplinary research are repeated here. Figure 5 presents the environmental research studies conducted by the Faculty of Engineering at Cairo University classified according to environmental field within the period from 2000 to 2004. Analyzing the data shown in Figure 5 reveals that the shares of most environmental fields are similar to those we outlined earlier, except some differences that may be attributed to the applied nature of the Faculty of Engineering; such as the following:

- Scarcity of research on the loss of biodiversity (1%).
- Increased amount of research concerned with urban environmental problems (20%).
- Decreased amount of research on the depletion of resources (6%).

As for the contribution of different specializations (sections) to environmental research studies, the following sections occupy the leading positions:

- Public Works Section (mainly for water resources and water pollution).
- Architectural engineering (urban environmental problems, and marine environment and coastal zones).
- Chemical engineering (distributed over different fields).

The lowest sections in producing environmental research studies are: mechanical engineering (power, production, and other mechanical specializations), while the computer and communication sections have no contributions to environmental research at all.

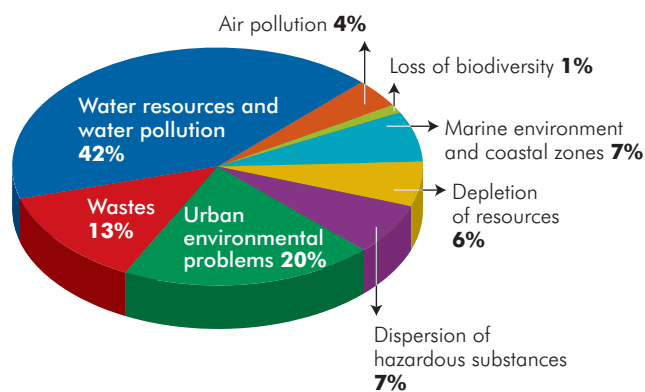
Figure 6 presents the sectoral contribution of the Faculty of Engineering at Cairo University to environmental research within the period from 2000 to 2004.

Below are some titles of research studies conducted by the Faculty of Engineering at Cairo University in different environmental fields:

- *Air pollution* – A study of air pollution inside road tunnels.
- *Marine Environment and Coastal Zones* – Integrated coastal zone management – An approach to the protection and development of the coastal environment in Egypt.

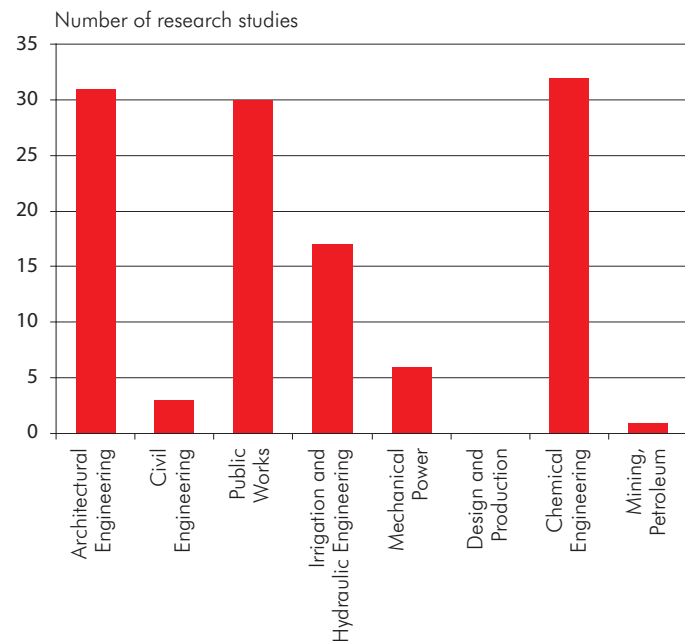
FIGURE 5

### ENVIRONMENTAL RESEARCH CONDUCTED BY FACULTY OF ENGINEERING IN THE PERIOD FROM 2000 TO 2004 CLASSIFIED ACCORDING TO FIELD



Source: Cairo Engineering College Scientific Magazine

**FIGURE 6** CONTRIBUTION OF FACULTY OF ENGINEERING, CAIRO UNIVERSITY SECTIONS TO ENVIRONMENTAL RESEARCH IN THE PERIOD FROM 2000 TO 2004



Source: Faculty of Engineering, Cairo University Scientific Magazine

- *Resources Depletion* – Assessment of rapeseed oil as an alternative fuel for diesel engines.
- *Dispersion of Hazardous Substances* – Degradation of pesticides wastewater using new surfactants.
- *Urban Environmental Problems* – Industrial zoning and urbanization contribution to Egypt's urban planning.
- *Wastes* – Modelling and simulation of a fixed bed absorber for the removal of phenol from industrial effluents.
- *Water Resources and Water Pollution* – Water resources development in the Blue Nile basin in Ethiopia and its impacts on Egypt.

### Tunisia

The number of research studies observed in Tunisia reached 58 since 2000 until the present (IRSIT, Université de 7 Novembre; Sécheresse). The two fields of ozone layer depletion and resources depletion were given more importance compared to other countries; while the two fields of water resources and water pollution, and wastes were given the same share (combined

these occupy 48% of the total amount of research). The share of the climate change field was slightly higher at the expense of urban environmental problems. Positively, 25% of environmental research conducted in Tunisia was interdisciplinary; this indicates the existence of a higher degree of coordination between researchers of diverse scientific backgrounds.

Figure 7 presents Tunisian researches conducted within the period 2000-2007 classified according to environmental field.

Below are some titles of Tunisian research studies in different environmental fields:

- *Air Pollution* – De-pollution of atmospheric emissions of wood pyrolysis furnaces.
- *Climate Change* – Variabilité climatique rapide lors du dernier Interglaciaire enregistrée dans les sédiments littoraux du Sud-Est Tunisien.
- *Loss of Biodiversity* – Biodiversité et évolution des plathelminthes parasites des Elasmobranches.
- *Marine Environment and Coastal Zones* – Contribution à l'étude des poissons pélagiques des eaux Tunisiennes.
- *Ozone Layer Depletion* – Variability of aerosol optical thickness and atmospheric turbidity in Tunisia.
- *Depletion of Resources* – Analysis by simulation of a solar still integrated in a greenhouse roof.
- *Dispersion of Hazardous Substances* – Degradation photocatalytique de colorants dans l'eau.
- *Urban Environmental Problems* – Loisir et Espaces verts.
- *Wastes* – A study on treatment and reuse of textile wastewater.
- *Water Resources and Water Pollution* – The role of membrane technologies in supplying drinking and industrial water in Tunisia.

### V. RECOMMENDATIONS

The remainder of this chapter attempts to put forth some recommendations and suggestions which may contribute to finding the remedy of those aspects found to be deficient and to achieving an optimal utilization of available capabilities. These recommendations represent a group of ideas brought up for discussion and can be used as a basis for setting a plan for improving

environmental scientific research conditions in Arab countries according to the individual conditions faced by each country.

### Setting a Strategy for Environmental Scientific Research

Despite the existence of strategies for scientific research in most Arab countries, no strategies are available for environmental scientific research. The importance of setting such strategies refers to the nature of environmental concerns and worries, as there is a big diversity of theoretical and applied sciences related to environmental field, and consequently the required resources (human or physical) are scattered among different and diverse institutions and faculties. The current sum total of the research undertaken by these institutions is not adequate to achieve the objectives of effective environmental action; if these resources are managed in a more planned and integrated manner, their synergy will achieve a level of production larger in quantity and better in quality. Besides, setting clear strategies for environmental scientific research shall contribute to determining clear priorities for research and rectifying any defaults or shortcomings in some research fields, especially those related to international long-range sustainability such as climate change, ozone layer depletion, and natural resources depletion which were previously mentioned.

A key question now remains to be answered: who is responsible for setting these strategies? The answer to this question is *all*, because environmental concerns are the responsibility of the whole community: citizens and governments, scientists and religious figures, state authorities, civil community, and the private sector. As all of these have the right to participate in setting objectives and priorities, they should also participate in sharing the costs of achieving these objectives.

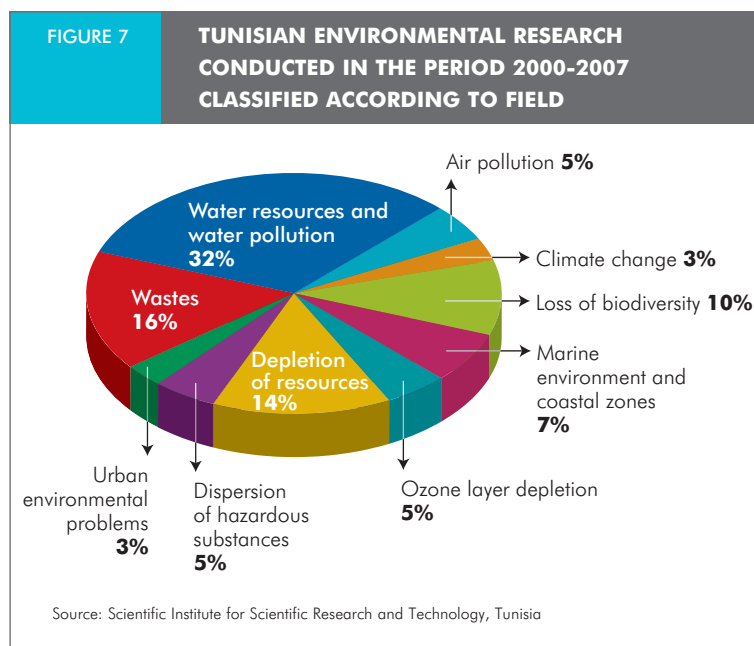
The first step for setting the strategy – once priorities and objectives have been identified – is to ascertain the available resources to enable their optimal management and utilization. For example, research authorities and entities should be surveyed. The same applies for their capabilities such as: the number, specialization, and level of researchers; laboratories and devices and their condition; and financial resources allocated for research (for example, in Egypt the

largest portion of the allocated budget goes to salaries and the small remaining portion is spent on actual research).

We recommend planning applicable research through a centralized mechanism to ensure that the research is more related to the reality and priorities of plans for environmental action; in some cases, researchers devote themselves to solving problems which are not given priority as regards plans for environmental action at all, or such plans do not even exist. This planning certainly does not mean the suppression of the innovative spirit of researchers. Consequently the strategies should be dynamic and open for discussion in order to be able to adapt themselves to any scientific or economic changes while leaving a reasonable margin of freedom in determining research points. From the administrative point of view, it is recommended to set a management system linking research finance with clear set of standards that make the assessment of proposed research points a straightforward process that is not overly consuming of either time or effort, in order not to add further bureaucratic burdens to the scientific research authorities.

### Centres of Excellence

The idea of centres of excellence is essentially one of a pooling of available resources regarding a top priority field or crucial problem into one centre,





which is thus responsible for coordinating efforts and managing the resources to achieve a set of specific and ambitious objectives. As a clear example, many authorities participate in the research of alternative energy sources. These authorities possess several resources which, if combined together in a single centre of excellence, would be able to directly cooperate without the need for a mediator.

### **Research Networks**

Research networks are also one of the ways for achieving strategic objectives via gathering researchers of different scientific backgrounds in one research network which focuses on a specific topic or issue. Thus inter-disciplinary research studies are able to inclusively cover different aspects of the researched issue in a holistic manner. In this manner research will yield bigger returns and possess more capabilities for developing solutions and satisfying knowledge gaps.

An example of such a research network in the environmental field is the Collaborative Mercury Research Network (COMERN) in Canada which aims at monitoring and understanding the exchange and sedimentation of mercury in environmental systems to enable interpretation of increased mercury levels in Canadian lagoons. Researchers from all scientific fields related to this topic participate in this research network. These researchers represent 14 universities, 3 research centres, 3 governmental authorities, 12 civil community organizations, and 7 industrial partners (companies). The network sets, within its plan,

specific research proposals and suggestions which are considered a “way map” to achieve the network’s objectives. The network plan includes all details related to the research: starting from administrative frameworks and communication systems, until organizing intellectual property (copyright) and publication methods.

Regarding the Arab countries covered by our research, there currently exists no model for research networks (according to the available information), despite the existence of several environmental concerns and fields that need to be addressed in a comprehensive and inter-disciplinary manner. A famous example of such environmental worries or fields is the black cloud in Cairo with its diverse scientific, social, and economic dimensions.

### **Financing Problems and the Industrial Sector**

Although the research delivered in this chapter does not include clear information on the deficiency of scientific research finance in Arab countries, there is no doubt that the Arab countries need to develop their financial resources in order to be able to conduct and produce high level research. Most scientific research finance in Arab countries currently comes from the government and international donations.

As for governments, there is a wide consensus on the necessity of increasing the general budget share for scientific research if there is any desire

to embark upon a path of sustainable development. Many experts have written on this topic, but it is one in which concrete action depends on the prevailing notions of political interest. As for international donations, although they currently play an important role, they cannot be considered a sustainable and reliable resource to depend on, given their relevancy in political matters and their role in political negotiations.

At the same time, the industrial sector in Arab countries has largely been shunning and disclaiming its responsibility towards scientific research, even as regards corporate social responsibility which is currently limited to supporting football clubs and congratulating chiefs on national feasts. Although this disregard is disapproved in the case of scientific research in general, it is considered a crime in the case of environmental research when taking into account the role of the industrial sector in environment pollution.

The question now is how to motivate the industrial sector to assume its role in financing environmental research. The simple answer is providing obvious economic incentives. If environmental pollution penalties become more costly than providing scientific research finance (while assuming the ability of research corporations to provide economic alternatives for pollution sources), and if taxes imposed on corporations participating in scientific research finance were reduced, we would surely observe a great change in investors' priorities and choices.

Some concerned stakeholders may see that increasing the value of penalties imposed on pollutants shall negatively affect Arab competitiveness in attracting foreign investment. The only reply to this idea is that the mission of maintaining natural resources and the environment easily prevails when compared to unsustainable levels of national economic growth. The principle "who pollutes pays" is almost irrefutable, especially as it captures the often-ignored environmental externalities of economic activities.

Although the industrial sector largely neglects financing environmental scientific research, it should not be considered to be solely responsible for this neglect. Environmental scientific research institutions do not currently seek to adequately market the results of their research and their rel-

evance and usefulness for the industrial sector (with the exception of the Egyptian and Saudi petroleum sectors which have relations with some scientific research centres). Environmental scientific research institutions also do not undertake adequate communication with the industrial sector in order to ascertain the environmental problems it faces and provide tailored solutions matching its needs.

In some cases, it may be appropriate to establish companies that transform the results of research or patents into income-generating economic projects. Researchers and their corporations would participate in these projects. These companies would increase the revenues of research corporations, in addition to providing additional incentives to researchers who live off meagre incomes in most Arab countries. The idea of establishing companies for researchers and research corporations is not an unprecedented innovative idea, as it has already been widely applied all over the world.

### **Databases and Electronic Resources**

The benefits of databases for environmental research at the regional and Arab level are obvious and diverse. Databases reduce the possibility of the wasteful repetition of the same research through different authorities. It also facilitates searching for experts or professionals in any field in other research institutions or even in other Arab countries, to benefit from their experiences. Finally, for environmental policy and strategy makers, it facilitates effective decision making on sound knowledge bases.

Despite the existence of Arab research databases such as the Saudi Data Base (Qabas) and the Egyptian Bibliographic Database for Sciences and Technology (STEB) which is under construction, the available information at these databases is classified according to colleges rather than according to research fields.

As regards electronic sites for research corporations, a considerable number of these does not reach the required level, thus giving off a bad impression to any site visitor who may be a potential research or industry partner. Therefore the development of these electronic sites should be given top priority.

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