ERF Policy Research Report

The Environment and the Economy in the Arab World

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Preface

Environmental concerns in the Arab world are very rarely taken into consideration when designing public policies or setting priorities, despite the fact that most Arab countries have established a ministry or specialized body responsible for environmental affairs. There are multiple possible explanations as to why this is so. One is political in nature, especially as regards the distribution of power among those who might benefit from enforcing effective environmental regulation and those who might stand to lose. Another explanation is that poverty is still widespread throughout parts of the Arab world and policymakers in these countries have convinced themselves that environmental concerns can wait. A third explanation is that policymakers are not made sufficiently aware of the cost of environmental degradation or those policy instruments which could mitigate environmental degradation.

To develop a better understanding of the environmental challenges facing the Arab region and how these challenges may be met, ERF has collaborated with the International Development Research Center (IDRC) over the past three years (2008-2011) on a major project to fill the research gap in the area of environmental economics. This project was a major step forward, leading to the production of fresh knowledge on various topics related to the environment at both country and regional levels. It also helped develop a network of researchers and policymakers with a keen interest in this field.

Building on progress to date, this approach paper was commissioned with the aim of identifying a research niche for ERF and accordingly propose a research agenda on the environmental issues and the economy and the challenges they present in the Arab World. This report reveals that there is room for exploring emerging environmental problems in the region. It identifies research areas of policy relevance, impacts on social welfare and areas not covered elsewhere. Academic research is often a prerequisite for sound recommendations addressed to policy-makers. Nevertheless, we have tried to identify directions and priorities of research needed in this field with the intention of going beyond academic research on environmental issues in Arab countries, and including data and policy implementation considerations.

Hala Abou-Ali
Cairo University, Egypt

Alban Thomas
French Institute for Agricultural Research, France

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Abbreviation List

CBA	Cost-Benefit Analysis
CE	Choice Experiment
CO_2	Carbon Dioxide
CVM	Contingent Valuation Method
ESCWA	United Nations Economic and Social Commission for Western Asia
FAO	Food and Agricultural Organization
GEO	Global Environment Outlook
IPCC	Intergovernmental Panel on Climate Change
NO_x	Nitrogen Oxide
PM10	Particulate Matter Concentration
PPP	Polluter Pays Principle
RP	Revealed Preference
SO_2	Sulfur Dioxide
SP	Stated Preference
UNEP	United Nations Environmental Program
UNSD	United Nations Statistical Division
WB	World Bank
WDI	World Development Indicators
WHO	World Health Organization
WTP	Willingness to Pay

CHAPTER 1

Introduction

Many official reports point to the fact that environmental degradation is more severe in the Arab world than in other parts of the world. The reasons that have been put forward are sometimes associated with rapid urbanization, lack of appropriate infrastructures, poor governance, low level of environmental consciousness, etc. Trends in economic development of these countries, the role of oil in many Arab economies and demographic factors among others are however likely to have played a major role as underlying determinants of environmental degradation. Arab countries are very diverse in their environmental situation and their state of development, and part of this heterogeneity can be analyzed through the use of official data and reports from national authorities and international organizations. When it comes to explaining the current situation through an economist's eye, a tool box of environmental economics is needed with its obvious connections to development and public economics. A major purpose of economic analysis is to provide decision makers with recommendations of policies to be implemented and predictions regarding their potential performance, taking into account the change in behavior of social groups that such policies will imply. Research oriented work is by no means in contradiction with this objective, as relevant policy recommendations and expertise need to be backed by sound scientific evidence.

For environmental economists questions of interest include the following:

- How did we arrive at this situation, and are there country specific features that would make remediation more difficult?
- In terms of economic development, what can be said about the relationship between economic structure and growth of these countries on the one hand, and the state of the environment on the other? Can we have a prospective view of future environmental conditions given alternative economic and climatic scenarios?
- What about social preferences for the environment in these countries? Can we identify significant environmental conditions across countries, which may be explained by differences across preferences towards the environment?

Data and previous economic analyses on environmental issues in Arab countries are essential in addressing these questions. However, as the report will demonstrate, these two sources of information are often incomplete or poorly accurate as far as Arab countries are concerned. Scientific articles providing evidence on the state of the environment and the performance of environmental policies in particular are very few compared to other regions of the world. Moreover, a variety of useful environmental indicators are missing at the national level, while some of the available indicators lack accuracy. When individual behavior is to be analyzed, micro-level data is needed on firm and consumer decisions regarding the environment, and there are almost no environment-related databases of this kind for Arab countries. However, with regards to environmental issues this lack of environmental data is not specific to Arab countries alone; the same is also true for many developing and developed countries.

The purpose of this report is not to provide definitive answers to environmental issues, but to identify contributions from environmental economics literature that may be helpful in paving the way towards recommendations to policymakers and stakeholders. The first part of the report will discuss the relationship between economic development and the environment in Arab countries. The various definitions behind sustainability will be introduced and illustrated using country-level data.

Next, governance and institutions will be addressed with reference to green economy. Data issues are addressed in Chapter 3, in which we discuss the various categories of data needed for economic analysis (national indicators, individual level datasets, and environmental indicators). We will try to identify in this chapter the kind of data that is lacking at present, but that which is necessary for conducting future economic analysis. Chapter 4 presents the main environmental issues in Arab countries, with reference to official datasets and reports. This chapter is purely positive and descriptive, leaving normative considerations for further chapters. Topics covered include water use and pollution, air pollution, solid and toxic waste, and agriculture.

Such topics cover most of the environmental challenges identified by Sakmar et al. (2011) for MENA countries: water scarcity and quality, land degradation and desertification, urban and industrial pollution, inadequate capacities for waste management, coastal and marine environmental degradation, air pollution, climate change and weak environmental institutions and legal frameworks. Chapter 5 is devoted to environmental regulation, introducing the most important aspects drawn from the economic literature. We try to illustrate in this chapter the issues of policy design and implementation for each topic discussed in Chapter 4. An important aspect of the present report concerns social preferences towards the environment, and this is addressed in Chapter 6. Methods for eliciting preferences are presented, and applications to environmental topics in Arab countries are proposed. Finally, Chapter 7 concludes with a summary of recommendations in terms of research needs and priorities.

CHAPTER 2

Environment and Development in the Arab Countries

This chapter explores the relationship between economic development and the state of the environment, with the key word being sustainable development. Like most regions of the world, the challenge for Arab countries is to reach a sustainable development path, a "green growth" steady state which would foster economic development to satisfy human needs and aspirations, with a minimal impact on the environment. We start with a short exploration of the concept of sustainable development from an economist's point of view.

2.1 Defining Sustainability

The notion of sustainable development is not new. The concept was implicitly introduced in 1852 in the forest legislation of the Habsburg Empire, but it wasn't until 1987 that it was popularized by the Prime Minister of Norway, Gro Brundtland. According to the Brundtland report, sustainable development should allow the satisfaction of present human needs without compromising the ability of future generations to satisfy theirs. As noted by some authors, this definition is based on a double refusal (no dictatorship either of the present or of the future), and the principle that the commitment of present generations regarding future generations should be considered in terms of abilities and not achievements. Only two years after the Brundtland Report was published, Pezzey (1989) reported more than 60 definitions of sustainable development, and seven years later Dobson (1996) counted more than 300. The fact that the expression has been used intensively to justify many public policies, together with the high number of its definitions, calls for an investigation into the usefulness of such a concept. Although there is no unique definition of sustainable development that is accepted by everyone there is an agreement on the fact that it covers, simultaneously, economic, social and environmental aspects. For economists specializing in sustainable development, one particularly important task is to characterize the optimal paths of economic growth and the design of policies to implement to correct deviations from these paths.

The role of technology is essential in this analysis, and more precisely, the substitutability patterns between natural capital and human-made capital. There is a distinction in the economic literature between research based on the concept of "weak sustainability," which assumes that natural capital can be replaced by human-made capital, and the concept of "strong sustainability," according to which at least some natural capital stocks cannot decrease below some critical minimum levels. In the first case, it is difficult to account for inter-generational equity (i.e., imposing the "dictatorship" of a generation over the others), whereas in the second case, the difficulty lies in the definition of thresholds for natural capital stocks and the indicators of sustainable development.

The concept of sustainability is also applied to economic sectors such as agriculture. In this case, a first approach consists in defining sustainable agriculture in terms of its ability of satisfy the food needs of a growing world population while preserving the environment and the natural resources. The second, and more restrictive approach, does not consider the food security issue and tries to define sustainable agriculture in terms of more sustainable production "practices" than conventional ones. The environmental economist's objective is, in this case, to design and evaluate policies aimed at providing incentives to favor such alternative, more sustainable, practices.

2.1.1 Weak Sustainability

In general, economic research based on the concept of weak sustainability is part of the general framework of the theory of economic growth. The first objective is to determine the optimal paths for the economy as a whole, from the present into the (distant) future. Since we can consider a mapping between the level of available stock of natural capital and production, and a subsequent mapping from the latter to consumer welfare depending on final consumption, the problem amounts to allocating the stock of natural capital between various generations. A well-known criterion to measure welfare over time is the discounted sum of utility levels from the present period to some distant horizon. Utility here is some function of consumption, increasing at a decreasing rate (the additional welfare (or utility) associated with the last unit consumed is less than the additional utility associated with the unit before the last). Adding up discounted utility levels allows one to construct a criterion involving all future generations, which enter the summation with different weights. Specifically, assume the present generation has a weight of 1, the next generation a weight of $1/(1+a)$, the generation after a weight of $1/(1+a)^2$, and so on, where a is the discount rate, which measures the preference for the present. A benevolent planner of this economy will forego one unit of natural capital in the first period, if (1+a) units can be allocated to the second period, which implies that the preference for future generations decreases with the level of the discount rate a. The more distant the generation, the less it will count in the discounted sum of generation-specific utility levels, and this effect is amplified when the discount rate increases. For example, if a=0.1, one unit of natural capital can be given away if it allows for consuming 120 units in 50 years or 14,000 units in 100 years. If a=0.05, one unit of present consumption is equivalent—for the selected criterion—to consuming 130 units in 100 years or 17,000 units in 200 years. These examples illustrate the fact that, unless a is almost 0, the discounted infinite sum of utilities imposes a "dictatorship for the present," which contradicts one of the objectives of sustainable development, more precisely, the equity between generations.

In the above model, the optimal allocation rule of the natural capital stock is the one which makes the marginal rate of change of consumption equal to the discount rate, until the natural capital stock is exhausted. The way to introduce the concept of sustainable development is to let the utility depend not only on the level of consumption, but also on the capital stock (Heal 1998). Consumers will then be assumed to have a higher welfare because of the very existence of the natural resource (this is the existence value), and the optimal path of resource consumption imposes to preserve a given stock of the resource with a consumption decreasing through time (and eventually reaching 0 when the minimum stock is attained). As long as the consumption directly depends on the nonrenewable stock of natural capital, it is impossible to define an optimal path for the economy which would be sustainable. This is only possible if the natural capital can be to some extent replaced by human-made capital. It is therefore possible to consider that natural capital, human-made capital and human capital are combined to produce final goods whose consumption will result in utility from consumption. Proops et al. (1999) compute an indicator of weak sustainability for various regions of the world, considering both a closed and an open (with trade) economy setting. They find that there is a sustainability deficit for the Middle East when trade is not considered. On the other hand, including trade allows the Middle East to gain about 4 percentage points in the sustainability index compared to the closed economy case.

In the special case where natural capital and human-made (or human capital) are perfect substitutes, it is possible to maintain a constant consumption level per head along the optimal path by following Hartwick's rule (Hartwick 1977). This rule states that, at every period, the rent obtained from exploiting the natural capital should be invested in human-made or human capital. Perfect substitution between capital stocks means that the natural capital is not an essential input in the technology of this economy, and there is no reason why natural capital should be preserved. Even under this assumption, Hartwick's rule still imposes the dictatorship of the present and rules out inter-generational equity. An alternative criterion which would account for this principle of sustainable development is the maximin principle (Solow 1974), according to which the benevolent social planner will maximize the utility of the least-favored generation. However, it can be shown that this criterion leads to a zero growth of the economy, as the saving rate will be zero at the steady-state. Another criterion to account for inter-generational equity induces the planner to maximize the infinity limit of utility (Heal 1998), which corresponds to the "green golden rule" of growth. This rule specifies a zero consumption of exhaustible resources and consequently the preservation of the natural capital at its initial level, to maximize the utility of the more distant generations.

The only criterion which satisfies the principles of the no-dictatorship-for-the-present and the no-dictatorship-for-the-future is the weighted sum of the two criteria: the sum of discounted utilities and the infinity limit of utility (Chichilnisky 1996). Heal (1998) shows that the optimal economic path with this criterion implies that the natural capital is preserved at a given minimum level, which is higher (respectively smaller) than the minimum stock associated with the utilitarian (respectively, the infinity utility criterion). With this model, the final path of the economy involves a large proportion of human-made or human capital, resulting in a possible sacrifice of intermediate generations.

2.1.2 Strong sustainability and indicators

Compared to the previous approach the main difference is that with strong sustainability natural capital is an essential input for production (equivalently, it is not a perfect substitute for human-made or human capital). According to Daly (1994), natural and human-made capital stocks are essentially complements and only marginal substitutes. Unfortunately, under the assumption of complementarity, the weak-sustainability approach does not allow one to obtain efficient resource allocations that are sustainable. Toman (1992) suggests considering, among the class of natural resources, the category of natural capital stocks which may be defined as critical, in the sense that their levels should not go below some minimum safety threshold. Regarding the classification of natural resources under this category and the specification of such thresholds, economists have little to say in practice for the moment, and this is an area where further research is needed. Nevertheless, the strong-sustainability approach is somehow associated with the numerous research initiatives devoted to the construction of sustainability indicators (see Chapter 3).

2.2 Development, Governance and Institution

2.2.1 Development

With the exception of oil-rich countries, most countries in the Arab world lie within the low middle income group. For rich countries, environmental degradation would have ended if one believed in the general perception of the environmental Kuznets curve (EKC) (Kuznets, 1955). For rich Arab countries, environmental degradation would have been brought to an end. Unfortunately, this is not the case in any of the Arab countries. As could be seen from Table 2.1 below the EKC does not exist in most of the Arab countries. Moreover, many of these countries are also dependent on their natural resources for their economic development. This dependence may eventually lead to undesirable growth, i.e., the so called resource curse (see Stevens and Dietsche 2008).[1] Furthermore, less aggregative endogenous growth analyses using two-sector models find that structural change from commodity production towards production of services and from physical to knowledge inputs, in conjunction with investments in environmental and natural resource protection, yield feasible sustainable economic growth (López et al. 2004; and López and Toman 2006).

It has been claimed that environmental degradation and economic growth are two forces pulling in different directions, i.e. high economic growth must come at the expense of environmental degradation. However, in what we have experienced in the 21st century, especially in relation to issues like climate change, we know that this is a false dichotomy. Yet, most people today agree that sustainability is a condition for economic growth. Hence, sustainable environmental and economic growth go in the same direction while poor management of the environment would lead to economical drawbacks.

In general and in growth models, welfare is maximized and environmental sustainability is attained while a social planner is taking into account satisfaction of a representative agent's preferences as well as production technology. However, most of these models are aggregated (and distribution issues are not considered) based on the assumption of a representative agent and a

Table 2.1
Environmental Kuznets Curve for Carbon Dioxide (CO_2) in the Arab countries (1981-2005)

Country	Intercept	Inverted U shape curve	Turning point	Ymax	Ymin	EKC
Algeria	2.473 - 0.34Y	Yes	1442.308	7.176	5.530	No
Egypt	0.817 - 0.436Y	Yes	6.514	4,318	2.460	No
Jordan	0.435 - 0.332Y	Yes	3.706	4.360	3.032	Yes
Lebanon	0.935 - 0.908Y	Yes	2.801	20.368	6.565	No
Morocco	-0.407 + 1.176Y	No	?	3,588	2.254	No
Tunisia	0.051 + 0.446Y	No	Monotonic	6.444	3.602	No
Bahrain	1.507 - 2.20Y	Yes	1.984	28.069	16.648	No
Kuwait	3.823 - 3.854Y	Yes	2.697	44.354	22.873	No
UAE	-2.337 + 2.142Y	No	?	90.478	41.862	No
Oman	0.278 - 0.456Y	Yes	1.840	19.544	10.269	No
Qatar	3.039 - 2.376Y	Yes	3.593	77.232	43.705	No
Saudi	0.385 - 2.488Y	Yes	1.168	34.116	18.243	No
12 countries	1.23 - 0.34Y	Yes	37.263	90.478	2.254	Yes

Notes: Y is the per capita real GDP in constant 2005 international dollar.
Source: Adapted from Mhenni et al. (2011).

production function where inputs are labor, capital and the environment. To achieve sustainable development these models are dependent on technical change which would lead to reduced externalities. Furthermore, another group of models assume the substitution of physical capital by human capital being a clean input (López and Toman 2006). Other models assuming economic growth presuppose endogenous technical change being a result of efficient policy instruments leading to lower externalities, i.e., an indirect feedback loops between institutions and the environment. In this line of reasoning, Mohtadi (1996) analyzes long-run economic growth under optimal policy designs where the environment enters into the utility function and the production function. The policy instruments that are considered are production taxes or subsidies and regulations taking the form of quantitative restrictions. The policies are chosen by an actual government rather than a central planner, which induces the market-driven path to mimic the socially-efficient path to achieve first best results. The model is based on a representative agent economy consisting of many infinitely lived agents. One interesting finding is that a combination of quantity controls and optimal tax or subsidy schemes leads to a higher level of social welfare than an optimal tax or subsidy. Bearing in mind the concept of optimality, an important question would be for whom are policies optimal? Reliance on the representative agent implies that growth models simply ignore this very important question. It is here where the distributional factors come into play, across both space and time (i.e., across generations), as factors determining policies and institutions and in turn affecting the consequences of the growth process implemented under such policies and institutions (López and Toman 2006).

2.2.2 Green economy

The blueprint for a green economy by Pearce et al. (1989) was the starting point for the debate on green economy. Green economy is defined as an economy that results in improved human well being and reduced inequalities, while not exposing future generations to significant environmental risks and ecological scarcities. In its simplest expression, a green economy is low carbon, resource efficient, and socially inclusive (UNEP 2011). Nowadays, the concept of green economy has become central in discussions related to sustainable development. This concept has also led to the development of other methods of development such as green GDP as a counterpart to the conventional GDP, which is often criticized of not reflecting the economic reality of a country.[2] This is in general because GDP does not properly account for social and environmental costs and benefits. Nevertheless, the concept of green economy in turn is also criticized to entail risks and challenges, particularly for developing countries, for whom economic development becomes more demanding and the fear arises that the new concept could be used to reinforce protectionist trends, enhance the conditionality associated with international financial cooperation, and unleash new forces that would reinforce international inequalities (UNEP 2011).

On the other hand, because of difficulties in quantifying social and environmental outcomes in measuring sustainable growth, other indices have been developed to assimilate the many component measures of sustainability in a single value e.g., the Environmental Sustainability Index (ESI) and the Ecological Footprint (EF). As will be discussed, ESI provides a basis for evaluating comparative national environmental performance (Srebotnjak and Esty 2005).[3] Furthermore, the ESI builds on the concept of sustainable development, measuring the ability of countries to manage various environmental challenges that reflect natural resource endowments, past and current pollution levels, natural resource use, and societal capacities to address current and future problems (Srebotnjak and Esty 2005). The ESI is a composite index published from 1999 to 2005 that tracked 21 elements of environmental sustainability covering natural resource endowments, past and present pollution levels, environmental management efforts, contributions to protection of the global commons, and a society's capacity to improve its environmental performance over time. It was superseded by the Environmental Performance Index (EPI) in 2006.

The EPI is a method for quantifying and numerically benchmarking the environmental performance of a country's policies. It is designed to supplement the environmental targets set forth in the U.N. Millennium Development Goals. The 2010 EPI ranks 163 countries on 25 performance indicators tracked across ten policy categories, covering both environmental public health (environmental burden of disease, water, air pollution effects on humans) and ecosystem vitality (air pollution and water effects on ecosystems, biodiversity and habitat, forestry, fisheries, agriculture and climate change). These indicators provide a gauge at a national government scale of how close countries are to established environmental policy goals. The 2010 EPI was formally released in Davos, Switzerland, at the annual meeting of the World Economic Forum on Wednesday, January 28, 2010. Table 2.2 provides a sample of these indicators where a high ESI is a sign of achieving a superior level of environmental sustainability and vice versa. The ESI of the Arab countries ranges between 33.6 and 50.9 in 2005, while the EPI ranges between 33.6 and 67.41 in 2010.

Table 2.3 reports the EPI indicator in Arab countries for the year 2010 where most oil-producing countries are found at the tail of the ranking with lower scores. Several countries had

Table 2.2
Two Environmental Indicators for Arab Countries

Country	Environmental Sustainability Index	Environmental Performance Index		Country	Environmental Sustainability Index	Environmental Performance Index	
	(2005)	(2005)	(2010)		(2005)	(2005)	(2010)
Algeria	46	66.2	67.41	Morocco	44.8	64.1	65.61
Egypt	44	57.9	62	Oman	47.9	67.9	45.87
Iraq	33.6	Na	41	Saudi Arabia	37.8	68.3	55.32
Jordan	47.8	64.1	56.11	Sudan	35.9	44	47.09
Kuwait	36.6	Na	51.13	Syria	43.8	55.3	64.58
Lebanon	40.5	76.7	57.91	Tunisia	51.8	60	60.58
Libya	42.3	n.a	50.14	UAE	44.6	73.2	40.67
Mauritania	42.6	32	33.67	Yemen	37.3	45.2	48.31

Notes: n.a: Not Available.
Data Source: Yale University Center for Environmental Law and Policy.

Table 2.3
Environmental Performance Indices

Country	EPI	Rank	Health	Rank	Ecosystem	Rank
Algeria	67.4	1	67.58	12	67.25	3
Bahrain	42.0	16	83.69	2	0.23	18
Djibouti	60.5	6	51.45	15	69.64	2
Egypt	62.0	4	63.04	14	60.97	5
Iraq	41.0	17	39.57	16	42.42	10
Jordan	56.1	8	76.67	7	35.56	13
Kuwait	51.1	10	83.47	3	18.78	16
Lebanon	57.9	7	77.33	5	38.5	12
Libya	50.1	11	68.09	11	32.19	14
Mauritania	33.7	19	25.97	18	41.36	11
Morocco	65.6	2	73.38	9	57.84	6
Oman	45.9	15	71.28	10	20.47	15
Qatar	48.9	12	87.69	1	10.08	17
Saudi Arabia	55.3	9	66.68	13	43.96	9
Sudan	47.1	14	23.61	19	70.58	1
Syria	64.6	3	73.67	8	55.49	7
Tunisia	60.6	5	77.16	6	44.00	8
United Arab Emirates	40.7	18	81.29	4	0.06	19
Yemen	48.3	13	34.95	17	61.68	4

Source: Djoundourian (2011).

improved their scores, i.e., their environmental performance has improved between 2005 and 2010. However, there are also exceptions where performances for a sustainable environment had deteriorated. As in the case of ESI, EPI is an aggregated variable including several indicators making the task of comparing the countries on the basis of EPI rather difficult. Djoundourian (2011) conducts a comparative study across the Arab world in the Middle East and Africa to determine whether variations exist in environmental performance. This analysis involves various indicators of performance, including the 2010 environmental performance index and the total number of international environmental agreements signed, ratified, or accessed by individual governments. She concludes that the Arab world is at par with the developing world with its environmental performance. Furthermore, her paper empirically shows that economic well-being determines environmental performance, thus providing evidence to support the EKC-type hypothesis.

2.2.3 Governance and institutions

Governance and institutions are two entities that go together while affecting environmental outcomes. It is often not possible to talk about governance without referring to institutions. Good governance depends on effective institutions and for institutions to be effective it requires targeted governance. Furthermore, good governance can be seen as the exercise of economic, political and administrative authority to better manage affairs of a country on all levels, national and local (Saidi and Yared 2002).

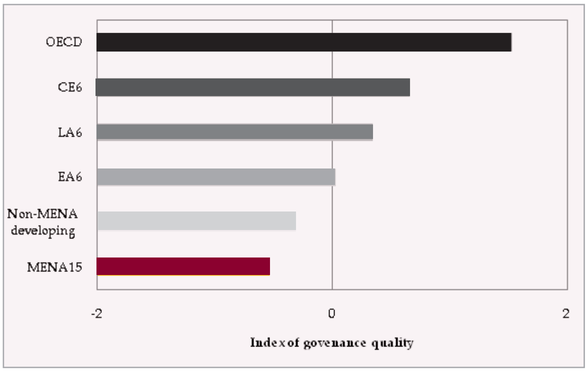
2.2.3.1 Governance and the environment

In general, environmental governance is defined as “the whole range of rules, practices and institutions related to the management of the environment in its different forms (conservation, protection, exploitation of natural resources, etc.)”. What is good governance then? Governance is good when it allocates and manages resources to respond to collective problems, in other words, when a State efficiently provides public goods of necessary quality to its citizens. Hence countries should be assessed on both the quality and the quantity of public goods provided to citizens. If governance does not fulfill these requirements, it is not efficient. However, one of the deficiencies in governance structures that characterize many poor countries is the inability to provide public goods, e.g., water, good public health and education. Although the government must play a vital role as an ultimate guarantor of property rights per se, it has often failed abysmally when acting as a direct owner and manager of natural resources, e.g., public goods (Somanathan and Sterner 2006). Therefore, policy makers and public servants will generally not have the right incentives to manage the resources in a welfare-maximizing fashion. In fact, one might say that it would be naive to expect them to behave in such a way. The problems are compounded by several factors such as poverty and poor training. When property rights are ill-defined, assets are not put to their best use. This results in a reduction of economic activity, wasteful practices, over-utilization of resources, and increased political and social instability (Limam 1999).Although governments remain the most common and authoritative source of governing activity today, non-governmental organizations and the private sector have developed a plethora of initiatives that contribute to meeting public goals such as environmental protection and sustainable development in policy formulation and implementation (O'Neill 2009).

On the empirical side, governance should also correlate with higher incomes and vice versa, i.e., improvement of the environment with income growth is not automatic but depends on policies and institutions. Economic growth creates the conditions for environmental improvement by raising the demand for improved environmental quality and making the resources available for supplying it. Whether environmental quality improvements materialize or not, when and how they do depend critically on government policies, social institutions, and the completeness and functioning of markets. Nevertheless, in line with this reasoning there have been studies to estimate the relationship between governance and positive environmental actions. When it comes to governance in the MENA region, where most Arab countries are located, this is judged to be weak according to the World Bank. Governance in this region is weaker

Figure 2.1

Governance Quality Index across Regions of the World



Source: World Bank (2003).

than similar competitor countries in other regions, and even weaker than all other developing countries. Figure 2.1 illustrates the governance quality index for countries of the OECD, central Europe, Latin, America, East Asia and MENA regions.[4] These weak governance institutions and processes could arguably be associated with disappointing economic performance (World Bank 2011).

2.2.3.2 Institutions and the environment

Institutions, as defined by Young (2003), are systems of rules, decision-making procedures, and programs that give rise to social practices, assign roles to participants in these practices, and guide interactions among the occupants of the relevant roles (Asia-Pacific Network for Global Change Network, 2005). Managing natural resources and the environment requires efficient institutions at all levels, i.e., local, national, regional and global. The role of institutions in natural resource management and environmental protection is being increasingly recognized in the context of global environmental change. Furthermore, Institutions and, more specifically, environmental or resource regimes figure prominently in efforts both to understand the causes of environmental problems (e.g., the collapse of fish stocks and changes in the earth's climate system) and to devise responses to these problems that have a reasonable chance of succeeding (Young 2003).

Inefficient institutions are blamed for environmental degradation and effective environmental management may be seriously handicapped by lack of political, civil and economic liberty; lack of an independent judicial system; and an inefficient or corrupt bureaucracy. Hence, institutions matter. Furthermore, studies show that institutions play a role both in causing and in addressing problems arising from human-environment interactions. But the nature of this role is complex and not easily described. Therefore, the State should primarily focus on creating and defending institutions for sustainable governance. However, as pointed out by Ostrom, Young and others (in Paavola 2007), there is not a single and simple institutional solution for the large variability of environmental problems (one-size-does-not-fit-all problem). The change of institutions or the design of new institutions must be done after a careful mapping of a particular situation (especially knowing the ecological, economic and social characteristics of the problem) and with the use of open social dialogue. From this description it is clear that the empirical evidence is crucial to reach scientific conclusions, which are then transformed into political recommendations. In environmental economics perhaps more than in other fields of the disciplines, data issues are crucial to deal with, in order to reach such conclusions.

CHAPTER 3

Data Availability and Quality

Data issues are essential for empirical economic analysis, and most material in the subsequent sections will be based on available data. In this chapter, we discuss the type of data that is becoming common in environmental studies and analyses. Furthermore, we review the main sources of data, assessing issues of coverage, timing and frequency, and sampling and quality of this data. This will help to better interpret the results of available publications, but also question some facts and motivate a greater attention to issues of comparability, common standards of quality and reliability.

3.1 What is Good Data and Why Do We Need It?

From a very pragmatic viewpoint, data can naturally be defined as "good" when it allows users to address the issue at hand. For economic analysis, data should adequately represent the decisions of economic agents at various scales (individuals and firms, communities, countries, etc.) and periods of time. Representativeness and accuracy are important for statistical information of the quantitative kind, as well as for qualitative sources of data (surveys of experts or consumer panels, etc.), because policy recommendations are mostly drawn from such data sources. Empirical models in economics analyze the behavior of actors, at the individual level or in terms of aggregate information (food consumption of a country, total revenue, etc.) and sometimes construct predictions from actual observations. They also test for economic predictions originating from theoretical models. In environmental economics, consumer and producer behavior are not analyzed for themselves, by in relation to the environment. This means that a special type of additional information has to be collected, to represent the impacts of economic activities on the environment and natural resources, but also in the opposite direction, the influence the state of the environment can have on economic decisions.

Adequate data is needed to provide more accurate predictions and analyses, in the particular setting concerned with the economic analysis. Heterogeneity among economic agents but also across climate and environment-specific conditions is significant in many instances, which means that the use of previous empirical results obtained in another context would rarely make sense. For example, consumer concerns about food safety or producer behavior when faced with water scarcity are different across countries, as well as across institutional settings. Furthermore, investigating the performance of environmental policies requires detailed data on economic decisions of agents impacted by the policies, as well as on the state of the environment, before and after implementation of the policy.

There are four categories of data that are useful for analyzing environmental issues from an economic perspective: global (macro-level) indicators, individual (micro-level) data, ecological indicators, and qualitative information (expert and non-scientific reports). In what follows, we will concentrate on the first three.

3.2 Global Indicators

This first category of statistical information corresponds to the need of analyzing trends in environmental variables as well as inter-country differences. It can also be used to estimate a relationship between economic growth and the environment (Kuznets curve), between environment and trade, etc. In most cases when such data is used, it is not associated with a decision model in a strict sense, but rather with some aggregation of individual decisions in mind. For example, freshwater withdrawals for agricultural production are explained by land devoted to irrigated crops at the national level, but both variables reflect the sum of individual farmer decisions regarding crops and irrigation. On the other hand, the proportion of recycled solid waste in a country may be explained by population density and household average income, but it also depends on national legislation on solid waste management and its implementation by the government, which is in some sense a decision of the country as a whole.

Concerning official databases at the aggregate (national or regional) level, the ESCWA (United Nations Economic and Social Commission for Western Asia) has been publishing a compendium on environmental statistics in 2007 and 2009 (ESCWA 2009). Data is collected from national, regional and international databases using the approach recommended by the UNSD (United Nations Statistical Division). Although Maghreb countries are included in the list, information is not available for Algeria, Morocco, Tunisia, and Libya as the ESCWA region comprises the following 14 countries: Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Sudan, Syria, United Arab Emirates, and Yemen. Agricultural data is collected from the FAO (Food and Agricultural Organization) information systems (e.g., FAOSTAT, http://faostat.fao.org/). For general environmental statistics, the Global Environment Outlook (GEO) portal of the UNEP (United Nations Environmental Program) is also used by ESCWA. The compendium of environmental statistics by ESCWA does not include Maghreb countries in their datasets, but it can be complemented by an African Development Bank report for African countries, including Maghreb (African Development Bank 2011).

The World Development Indicators (WDI) database managed by the World Bank contains a fairly small number of environmental statistics as such (mostly water pollution by source, greenhouse gas emissions, water use, ecosystem areas). On the other hand, data on energy production and consumption, and agricultural production is available to be interacted with environmental data. This WDI database is better seen as a source for analyzing air pollution and country contributions to global warming, in connection with energy consumption.

For reasons related to the severe water scarcity in most countries in the region, databases containing information on water use and availability have been more developed than other natural resources or environmental issues. According to Sakmar et al. (2011), most development efforts in the MENA region have been focused on water because of its vital importance. This might also be true of individual surveys on water household consumption and irrigation. On the other hand, data on biodiversity and ecosystems, as well as some emissions (in particular, nonpoint source emissions) are less frequently found, but this is not just specific to Arab countries.

A unified database, Arabstats (www.arabstats.org), is managed by the United Nations Development Program on Governance in the Arab Region (UNDP-POGAR). It is a repository of statistical indicators for human development in the region, concerning governance and Arab progress toward the millennial goals set by the international community for all developing countries. Although the Arabstats initiative is an interesting one, it is not complete (data from UNDP and FAO is missing) and the sustainability of the data management system is not clear.

3.3 Individual Data

The second category of data is collected at the individual level (individual meaning here an individual decision unit such as an individual, a household, a firm or a farmer, etc.) with the objective of analyzing observed decisions in the economic sense (consuming, producing, investing). Such an analysis is often conducted to evaluate the sensitivity of decision-makers to economic signals or variables (in particular, prices), instruments of economic policies (taxes, subsidies, standards) and is preferably performed on individual data to avoid aggregation biases and in some cases, to exploit population heterogeneity (ability to construct response functions for various subsets of the population, for example). When actual observations on individual decisions are available together with the corresponding relevant information on prices and markets, then underlying preferences of economic agents can be partially recovered (identified) with the confrontation of a suitable decision model and the data. This corresponds to the "revealed preferences" case, in the sense that economic agents actually "reveal" their preferences through their reaction to changes in their economic environment. But individual data of another kind are also necessary when no observations are available on individual decisions on markets. When a market does not exist, which is the case for many environmental goods and services, actual observations on traded quantities and prices in particular are not available and revealed preferences are not identified. In this case, data from individual economic agents need to be collected in a different way, and associated with non-existing markets. This is the "stated preferences" approach, in which actual consumption decisions are replaced by the willingness to pay (WTP) for a particular good or service (see Chapter 6).

Note that there are obvious bridges between both categories of data ("global" and "micro"). First, individuals may react to the level of some variables decided at the national level (price of administered goods, etc.). Second, as indicated before, some statistical information at the national level is computed by aggregating individual observations on production, consumption or investment decisions. Third, the level of aggregation on individual information depends on the kind of indicator which needs to be computed. Some environmental indicators are computed using local and often fairly detailed information on consumption or production practices, and are relevant only at the intermediate level of a river basin, a plain or a small mountain range, in any case a geographically-delimited ecosystem.

3.4 Ecological Indicators

In general—and this is also not specific to Arab countries—environmental indicators or variables related to the use of natural resources are more frequent and probably more accurate when market goods are considered. This is obviously the case of agriculture and industry, for which official data on production and input is readily available at the national level. From some databases concerned with industry in particular environmental indicators of emissions can be computed with a modeling exercise, using actual production or input use levels to provide an estimate of emissions (air pollution from industry or greenhouse gases from agriculture, for example). The most difficult category of indicators to obtain are for biodiversity and ecosystems. One reason is that field measurements of actual biodiversity levels are very costly and the definition of biodiversity in terms of the number of species is at the heart of an on-going scientific debate. Another reason is that ecosystems are by definition local, so that an aggregate indicator at the national level for their "quality" may be irrelevant. Therefore, the few available indicators involve protected (terrestrial and marine) areas by country.

Ecological indicators are sometimes combined with economic and social data to produce a synthetic indicator of sustainability (or sustainable development). A distinction has to be made between ecological indicators specific to a final product, and those associated to a country, a region or an individual producer. A popular example of the first type is the EF, which decomposes the full production and consumption processes of final goods into environmental components (Rees 1992; Wackernagel et al. 2002). Van Vuuren and Bouwman (2005) have computed changes in ecological footprints for various regions of the world, but their analysis is difficult to exploit, as their regions are highly aggregated, and Arab countries are separated into Middle East on the one hand, and North Africa on the other. Alternatively, single-product footprints can also be computed with a Life-Cycle Analysis (LCA) from technical parameters, but their use is different from our purpose.

Sakmar et al. (2011) discuss the need to complement GDP measures of welfare with additional indicators for natural resource stocks and environmental conditions. According to these authors, the System of Environmental Economic Accounting (SEEA) is expected to become an international standard, following the work of the United Nations Committee of Experts on Environmental-Economic Accounting. Furthermore, the Ecological Footprint has been advocated by the Stiglitz Commission in 2008 as particularly relevant to green accounting. Sakmar et al. (2011) provide an analysis of environmental accounting initiatives in MENA countries, taking the Al Basma al Beehiya's EF initiated in the United Arab Emirates as an illustration. This initiative was launched by the UAE in 2007, with the World Wildlife Fund and the Global Footprint Network as core partners. The objective of the project was to provide decision makers with a more robust representation of the UAE's EF, by estimating its sector-specific components to help identify sectors for public intervention and to facilitate environmental planning. Other initiatives in Arab countries include pilot projects for water accounts in Jordan and Bahrain in 2008 and 2005 respectively, and projects of energy accounts in Egypt and Jordan. The conclusion of Sakmar et al. (2011) is that, although the EF approach has been tested in the UAE, much work remains to be done in order to better identify the difficulties in the implementation of an environmental accounting system in Arab countries.

In the second case, environmental impacts of production activities are estimated, and combined with social and economic information on the producer (or the industry) to produce an indicator of sustainability. In both cases however, economic analysis is seldom involved in constructing such indicators, while there is a need for further research into the relevant way of aggregating various indicators from different origins into a single, synthetic one. The major difficulty when using such sustainability indicators is to decide on the relative weight to put for each category: economic, social or ecological aspects. Also, most indicators are constructed by reference to environmental thresholds calibrated from field data, and are therefore rarely transferable from one local context to another. However, the usefulness of sustainability indicators as detection tools for emergency situations as well as for the evaluation of environmental policies is not to be contested. It should be noted that, on the other hand, sustainability indicators appear much less useful in the ex ante evaluation of policies or to discriminate among policy instruments. Environmental policies need such indicators for assessing their actual performance, but these indicators cannot be a policy in themselves because they are unable to solve the problem of allocating scarce resources among economic sectors and/or generations. There is a real danger in considering sustainability and its indicators for a particular sector, while overlooking the rest of the economy. A frequent practice when constructing sustainability indicators is also to design synthetic, single index averaging environmental, social and economic components with arbitrary weights. Such indicators implicitly imply that environmental damages are reversible, because a better score in economic terms can be "compensated" by a better score on environmental criteria for a particular production unit or sector. A better approach would be to construct independent and non-cumulative score-based indicators associated with economic, social and environmental considerations. However, this does not solve the problem of having a high degree of substitution among several components within a particular category (economic aspects, for example), so that an acceptable degree of sustainability can be obtained through implicit compensation across positive and negative environmental impacts.

Two examples of indicators for environmental sustainability have been presented in Chapter 2: the ESI (Environmental Sustainability Index) and the EPI (Environmental Performance Index). The first one is a composite index combining 21 environmental components ranging from natural resource endowments to the society's capacity to improve its environmental performance over time. This index was replaced in 2006 by the EPI, which is a method of benchmarking the performance of environmental policies. It is based on 25 performance indicators over 10 categories covering public health and the state of ecosystems. The benchmark for both indicators is the situation in which a national government succeeds in establishing environmental policy goals.

CHAPTER 4

Environmental Issues

This chapter presents the major environmental issues in Arab countries, and is organized in topics. The discussion here is not a normative but rather a positive one, as it aims to describe the state of the environment given official data and reports. Topics cover water use and pollution, air pollution, solid and toxic waste, and agriculture. The main concern for the future is certainly water because of the expected impact of climate change on the availability of this resource. Even though the problem of water scarcity has been there for a long time in Arab countries, the situation had been degenerating for some decades. It is an area where green economy would be the most profitable, but public policies are yet difficult to implement. Other topics are less covered—both in the economic literature and in terms of public data—with the exception of energy issues, although published work related to energy does not always deal with the environment.

To explore the relative share of research devoted to Arab countries in environmental economics, we did a bibliographical analysis of references in scientific journals in economics, environmental or agricultural science. The search concerned published articles in peer-reviewed journals, with keywords environment OR natural resources, and Arab OR MENA OR Maghreb OR Mashrek OR country list. Sources included bibliographical and editor platforms: EconLit, Web of Science, EBSCo, Jstor, Blackwell & Wiley, over the period 1990-2011. This analysis was also complemented by the inclusion of a selection of official reports by international organizations or national authorities, as well as recent working papers on environmental issues (in particular, from the Economic Research Forum (ERF) Working Papers series).

From the 178 publications identified, a necessary word of caution concerns working papers and official reports, whose number is certainly underestimated. As can be seen from the table, most publications (including non-refereed journals, ERF working papers and reports) relate to water, agriculture and energy/air pollution, while the majority of articles published in economic journals concern water and energy or air pollution. There is a clear lack of references on policy con-

Table 4.1

Distribution of Identified Articles on Environmental Topics in the Arab Countries, 1990-2011

Topic	Economic journals	Environment & agr. journals	Non-refereed journals, grey literature	Total
General environment	8	10	7	25
Water	11	7	27	45
Ecosystems	5	2	3	10
Agriculture & fishery	5	4	27	36
Waste	1	5	2	8
Energy & air	14	6	15	35
Policy	6	3	10	19
Total	50	37	91	178

Source: Authors' compilation.

siderations, and on topics related to waste. Note also that for energy and air, many papers are not found in economic journals but rather in journal of environmental science. On the other hand, reports and non-refereed publications are more abundant in water and agriculture than in energy and air pollution. Compared to the vast literature on applied environmental economics, the proportion of papers related to Arab countries is particularly small, even relative to the somewhat limited economic and demographic share of this region in the world's economy.

4.1 Water Use and Pollution

As mentioned above, water is by far the topic which has received the most attention, because of the structural water scarcity in the majority of Arab countries (Dabour 2002). Over the past two decades, climate change projections by the Intergovernmental Panel on Climate Change (IPCC) have significantly increased concerns about the widening gap between resource availability and water use. Data is available over several decades on water stress and resource availability at the country level, and thus trends can be constructed and interpreted.

4.1.1 Looking into the future and exploring past trends

Beaumont (2000) conducted a simulation exercise for Arab countries, taking the year 1995 as a benchmark, and projecting future population and domestic water needs in 2025. Table 4.2 presents simulation results obtained by Beaumont (2000). Even though the range of expected water needs for domestic use is very large (upper bound is 2.5 to 3 times larger than the lower bound), all countries will increase their domestic water needs in a very significant way. This table illustrates the combined use of demographic models and consumption standards in predicting future pressures on water. Domestic consumption will change over time because it is driven (mechanically) by population increase, but Beaumont assumes that all

Table 4.2

Domestic Water Use in the Middle East in 1995 and Estimates of "Minimum" and "Maximum" Water Demand for the Year 2025

Country	Domestic use-million m^3-1990s	Population million 1995	Domestic water m^3/ cap/ yr- 1995	Population million 2025	Minimum water needs million m^3/yr 2025	Maximum water needs million m^3/ yr 2025
Algeria	1120	28.4	39.4	47.2	4720	12060
Bahrain	94.3	0.6	157.2	1.1	110	281
Egypt	3100	61.9	50.1	97.9	9790	25013
Iraq	1280	20.6	62.1	52.6	5260	13439
Jordan	214	4.1	52.2	8.3	830	2121
Kuwait	201	1.5	134.0	3.6	360	920
Lebanon	368	3.7	99.5	6.1	610	1559
Libya	500	5.2	96.2	14.4	1440	3679
Morocco	543	29.2	18.6	47.4	4740	12111
Oman	56	2.2	25.5	6.0	600	1533
Qatar	65.9	0.5	131.8	0.7	70	179
Saudi Arabia	1517	18.5	82.0	48.2	4820	12315
Sudan	800	28.1	28.5	58.4	5840	14921
Syria	530	14.7	36.1	33.5	3350	8559
Tunisia	261.4	8.9	29.4	13.3	1330	3398
Turkey	5200	61.4	84.7	95.6	9560	24426
UAE	500	1.9	263.2	3.0	300	767
Yemen	201	13.2	15.2	34.5	3450	8815

Source: Beaumont (2000)

the population will enjoy a standard of water use comparable with values from developed urban societies. This corresponds to a minimum of 100 m^3 per inhabitant and per year, and a maximum of 225 m^3. Note however that industrial water use and, more importantly, water for irrigation is not accounted for, although the agriculture sector is a major user in most countries. A more advanced modeling exercise would be to predict the impact on agricultural and industrial activities due to this "compliance" with new standards of water use, with the difficulty that domestic water users are generally not located in the same areas as farmers (and sometimes, industries).

Turning now to the past, we can explore trends for available water resources by taking total renewable resources per head over the past two decades. Table 4.3 presents such data over a period of six years between 1982 and 2008.The water stress poverty line is defined by the FAO to be any level below 1000 m^3/capita/year. Most Arab countries experienced a decrease of 50% or more of their renewable resources per head, and almost all are below the water stress poverty line. For example, Lebanon is still above this threshold by the year 2008 but is expected to fall below in the near future. In general, Maghreb countries have faced a lower level of decrease in renewable resources (or, alternatively, a lower rate of increase in the water stress index). The countries with the most dramatic decrease in renewable resources are Qatar, Yemen and the United Arab Emirates (UAE). Once again, it is problematic to use such trends to draw conclusions on future water stress levels and policy recommendations regarding resource

Table 4.3

Water Stress: Total Renewable Water Resources Per Capita (Actual) (m^3/capita/yr), 1982-2008

Country	1982	1992	1997	2002	2007	2008
Algeria	580.7	439.8	399.4	371.5	344.7	339.5
Bahrain	310.2	220.1	191.1	170.6	152.6	149.5
Comoros	2906	2131	1849	1630	1446	1412
Djibouti	824.2	506.8	452.5	393.2	359.7	353.4
Egypt	1226	950.2	864.1	786.1	715.7	702.8
Iraq	5087	3956	3376	2893	2564	2512
Jordan	390.1	255.7	205.3	183.6	157.7	152.7
Kuwait	13.3	10.05	10.88	8.2	7.015	6.852
Lebanon	1595	1425	1242	1155	1082	1074
Libya	177.5	131.9	119.3	107.7	97.26	95.33
Mauritania	7068	5442	4756	4141	3632	3546
Morocco	1405	1128	1046	983.2	928.8	917.5
Oman	1060	707.4	615.7	563.6	513.6	502.7
Palestine	526.4	359.4	296.7	247.1	208.4	201.8
Qatar	209.4	117.4	105.3	84.67	50.97	45.28
Saudi Arabia	221.7	140	125	109.5	97.24	95.23
Somalia	2225	2248	2167	1888	1683	1647
Sudan	2942	2263	1986	1772	1595	1560
Syria	1736	1246	1096	963.4	819.4	791.4
Tunisia	675.6	538.8	501.5	477.5	456.4	451.9
UAE	127.1	72.43	54.92	41.77	34.37	33.44
Yemen	232.4	155	126.2	108.9	94.3	91.64

Data Source: FAO (2011), Aquastat.

Table 4.4

Changes in Water Availability Compared with the Average of (1962-1987) and with Year 1992

	Change in Water Availability (in %)	
Country	Compared to Average 1962-1987	Compared to Year 1992
Algeria	-55.05	-22.80
Bahrain	-66.82	-32.07
Comoros	-63.25	-33.74
Djibouti	-77.94	-30.26
Egypt	-52.66	-26.03
Iraq	-62.49	-36.50
Jordan	-73.03	-40.28
Kuwait	-73.99	-31.82
Lebanon	-39.96	-24.63
Libya	-63.78	-27.72
Mauritania	-60.66	-34.84
Morocco	-47.4	-18.66
Oman	-68.08	-28.93
Palestine	-67.94	-41.90
Qatar	-90.53	-61.43
Saudi Arabia	-72.68	-31.97
Somalia	-52.5	-27.22
Sudan	-59.13	-31.07
Syria	-66.26	-36.48
Tunisia	-44.77	-16.12
UAE	-93.73	-53.83
Yemen	-68.65	-40.87

Data Source: FAO (2011) and authors' own calculation.

enhancement. Indeed, such figures only reflect demographic growth and migrations, combined with external and internal resources of which only rainfall is expected to be modified. Nevertheless, this table gives an interesting indication of the physical availability of water resources.

It is also interesting to compare the trend in renewable water resources presented above with changes in the past. Table 4.4 presents the average change in water availability in 2008 with respect to the average level between 1962 and 1987, and with respect to the year 1992. After accounting for the differences in the number of years between 2008 and the two reference periods (assuming the average 1962-1987 corresponds to year 1974), it is clear that some countries have experienced a recent relative decrease in pressure on water resources (water availability has decreased since 1992 but with a smaller rate than before): Algeria, Morocco, Oman, Tunisia, while other countries have in fact increased their pressure on water resources (Jordan, Lebanon, Palestine, Yemen).

4.1.2 Major water uses, the role of agriculture

As in most countries around the world agriculture is the major user of water resources, both in terms of withdrawals, and in terms of net consumption (that is, water resources extracted for human activities and not returning directly to the environment). Table 4.5 below presents the most recent figures available for the distribution of freshwater annual withdrawals in Arab countries, among agriculture, domestic and industrial use. It is interesting to compare these figures for Arab countries

Table 4.5
Distribution of Annual Freshwater Withdrawals, Selected Arab Countries, Various Years (%)

Country	Year	Agriculture	Domestic Use	Industry	Agriculture Share of GDP
Algeria	2000	63.95	22.51	13.54	10
Bahrain	2003	44.54	49.78	5.68	-
Djibouti	2000	15.79	84.21	0	4
Egypt	2000	86.38	7.76	5.857	17
Iraq	2000	78.79	6.515	14.7	8
Jordan	2005	64.96	30.96	4.081	3
Kuwait	2002	53.87	43.86	2.278	1
Lebanon	2005	59.54	29.01	11.45	6
Libya	2000	82.85	14.1	3.051	5
Morocco	2000	87.38	9.762	2.857	17
Oman	2003	88.42	10.14	1.438	2
Palestine	2005	45.22	47.85	6.938	n.a.
Qatar	2005	59.01	39.19	1.802	n.a.
Saudi Arabia	2006	88	8.999	3	3
Sudan	2000	97.12	2.282	0.599	43
Syria	2005	87.53	8.801	3.672	20
Tunisia	2001	75.96	12.81	3.86	12
UAE	2005	82.84	15.43	1.726	2
Yemen	2000	90	8	2	14
Mediterranean Countries					
Greece	1997	87	10	3	7
Turkey	1997	74	15	11	11
Cyprus	2000	75	19	6	4
Spain	1998	93	4	3	4

Notes: n.a: Not Available.
Source: World Bank (2011).

with the corresponding ones for Mediterranean countries. The table also reports the distribution of water withdrawals for selected Mediterranean countries (Greece, Turkey, Cyprus and Spain), which are similar in terms of land use and climate. It can be seen that some countries have a significant proportion of water withdrawals dedicated to domestic use (Bahrain, Djibouti, Palestine, Kuwait, Qatar), while for others, agriculture is by far the major water user (Algeria, Egypt, Iraq, Jordan, Libya, Morocco, Oman, Saudi Arabia, Sudan, Syria, etc.) The first group of countries can be considered non-agricultural, at least in the sense of intensive water use for agricultural production, while the second has a structure of water use still highly conditional on irrigation. When comparing to the share of agriculture in total GDP, we find that some countries in the second group do not qualify as "agricultural" countries in terms of economic value. This is particularly the case for Libya, Oman, Saudi Arabia and the United Arab Emirates. The explanation of course stems from the low population density of these countries, so that even if agriculture is not a major contributor to national wealth, its impact on water use compared to the limited urban population is still significant. Moreover, one should take into consideration that those countries are oil-rich countries, which may further support the above line of thought.

4.1.3 Wastewater emissions

In terms of quality degradation of water resources by industrial and domestic users, there are very few databases available on polluting parameters other than organic ones. Biological Oxygen Demand (BOD) from industry and communities as well as the distribution of BOD by industry type are available from the World Bank (2011). Table 4.6 presents total BOD emissions, industrial BOD emissions per worker, and the percentage of BOD emissions from major industries. Such origins for BOD emissions are in line with the industrial structure of the countries; for example, Egypt and Morocco have more than 44% and 31% respectively of their industrial BOD emissions from the textile industry, while Lebanon and Syria are characterized by the importance of agro-food industry in total industrial BOD emissions. Unfortunately, even though organic emissions are representative of domestic water use, they are not so for industrial wastewater emissions, which also include nitrogen, phosphorous, suspended solids, and other more toxic pollutants.

4.1.4 Non-conventional water resources

As renewable freshwater resources are limited in many Arab countries and they have been on a declining trend over the past decades as seen above, some Arab countries endeavored to supplement

Table 4.6

Biological Oxygen Demand (BOD) Emissions, Selected Arab Countries

Country	Period	% Glass & Clay	% Chemicals	% Agro-food	% Textiles	% Others	Total BOD Emissions (kg / day)	BOD Emissions Per Worker (kg/wkr/day)
Egypt	1997	8.20	13.88	19.95	31.11	16.44	206539.4	0.1878
Iraq	1998	5.39	29.90	16.94	9.14	-	7654.791	0.2727
Jordan	1995-2007	12.30	17.24	21.30	15.35	22.49	20894.3	0.1826
Lebanon	1998	12.87	5.97	25.54	16.74	26.33	14701.49	0.1884
Morocco	2000-2007	7.0561	8.33	18.00	44.87	15.64	80063.91	0.1683
Oman	1993-2007	20.51	11.38	19.41	15.16	21.31	5406.63	0.1666
Qatar	2000-2006	15.21	11.79	6.84	31.38	17.62	4881.99	0.1352
Saudi Arabia	2006	10.71	11.56	19.95	14.38	29.97	106621.2	0.1751
Sudan	2001	14.23	6.98	57.49	7.99	9.07	38567.33	0.2945
Syria	1996-2007	12.88	7.25	20.99	28.93	22.47	65912.38	0.1626
Yemen	1998-2006	14.62	11.16	37.80	13.39	15.67	22208.95	0.2247

Source: World Bank (2011)

Table 4.7
Desalination Plants in the Arab World, 2010

Country	Capacity (m^3/day)	Production (million m^3/year)
Bahrain	518,596	35
Egypt	431,872	60
Jordan	239,532	40
Lebanon	29,610	47.3
Oman	377,488	109
Qatar	1,197,148	136
Saudi Arabia	7,410,462	1093
UAE	5,730,009	950
Yemen	60,370	25

Source: ESCWA (2009).

available water volumes with reuse or desalination technologies. The latter involves significant energy costs to operate at an adequate scale and at a sufficient quality standard for the final consumer, but costs associated with this technology have been reduced significantly over time. Craig (2009) discusses the various technologies based on alternative energy (wind, solar) and presents the Masdar (UAE) project for solar desalination as a case study. Mezher et al. (2011) provide a comprehensive review of desalination technologies including energy requirements and water production cost, and discuss the desalination policies of Saudi Arabia, UAE and Kuwait. Table 4.7 presents the capacity and production figures for desalination plants in selected Arab countries.

Another source of non-conventional water is based on waste water reuse in agriculture given the fact that it typically uses water extensively, while not having the same quality standards as domestic use (see Kretschmer et al. 2002). There are however health and environmental risks associated with such a non-conventional resource, as wastewater has to be treated before use for irrigation, and this implies the use of chemical products which can be harmful to the environment. Provided that food safety and wastewater treatment safety standards are met, using residential wastewater for irrigation purposes is an interesting alternative to conventional resources. Out of the 20 countries with the largest volumes of wastewater used for irrigation, there are Arab countries (Egypt, Jordan, Syria, UAE, Tunisia, Libya, Saudi Arabia, Qatar and Kuwait), with volumes ranging from 80,000 m^3/day in Qatar to 1,918,000 m^3/day for Egypt (see Scheierling et al. 2010). The World Bank has produced several documents on the monitoring of pathogen reductions achieved by wastewater treatment and health-protection control measures, and is currently supporting ambitious projects for such non-conventional water resources. Table 4.8 presents recent projects

Table 4.8
Wastewater Irrigation Projects Funded by the World Bank in Arab Countries, 1999-2009

Project	Country	Total Cost (US$ million)	Year of Approval
Alexandria Development Project	Egypt	110	2008
Amman Water and Sanitation Management Project	Jordan	136	1999
Conservation of Medicinal and Herbal Plants Project	Jordan	14	2003
Ba'Albeck Water and Wastewater Project	Lebanon	50	2002
First Water Sector Development Policy Loan	Morocco	100	2007
Water Sector Investment Project	Tunisia	258	2000
Tunis West Sewerage Project	Tunisia	72	2007
Second Water Sector Investment Project	Tunisia	163	2009
Sana'a Water Supply and Sanitation Project	Yemen	28	1999
Rural Water Supply and Sanitation Project	Yemen	29	2001
Urban Water Supply and Sanitation Project	Yemen	150	2003
Sana'a Basin Water Management Project	Yemen	30	2003

Source: Scheierling et al. (2010).

devoted to wastewater use in irrigation, funded by the World Bank.

4.2 Air Pollution

Air pollution has many causes. Purely anthropogenic factors, such as industry, road traffic and fuel wood etc., all release polluting particles into the air and contribute to deteriorating air quality. Moreover dust particles, whether of natural origin and/or partially human from bush fires or practices that lead to desertification affect air quality. As discussed in the data chapter, most available data on air pollution relates to the emissions of greenhouse gases. However, data on acidifying gases, primary particles and stratospheric ozone depleting substance is also available. The country-level emission inventories are available for the Arab region starting 1970 to 2008 at the sector level on http://edgar.jrc.ec.europa.eu/. This series may allow carrying out trend analysis within and between countries.

4.2.1 Trends in air pollution

Panopoulou and Panteledis (2009) examine convergence in carbon dioxide emissions among 128 countries for the period 1960–2003 by means of a new methodology introduced by Phillips and Sul (2007). Contrary to previous studies, their approach allows the examination of evidence for club convergence, i.e., identify groups of countries that converge to different equilibria. Their results suggest convergence in per capita CO_2 emissions among all the countries under scrutiny in the early years of their sample. However, there seem to be two separate convergence clubs in the recent era that converge to different steady states. Interestingly, they also find evidence of transitioning between the two convergence clubs suggesting either a slow convergence between the two clubs or a tendency for some countries to move from one convergence club to the other. Figure 4.1 depicts trends in per capita CO_2 emissions for years 1960 to 2007. We classify the Arab countries according to high, middle and low income. It is apparent that CO_2 emissions increase not only over the years but between income groups. It is also apparent that the emission levels do differ between countries within the same income groups. For instance by examining panel (a) of the figure it is observed that Oman and Saudi Arabia pollute way less per capita than the remaining countries of the group (Bahrain, Kuwait, Qatar). It should be further noted that series of data on nitrous oxides and other greenhouse gases are measure in CO_2 equivalent.

Air pollution emerges as a serious problem in the Arab countries facing not only major cities, but also many medium-sized cities and industrial towns. The urban population is subject to air pollution with gases, particulates and lead levels often exceeding guidelines of the WHO. Another important feature of air pollution in the region is particulate matter (PM). The WHO recently reduced its guideline limits to an annual average ambient concentration of 10 $\mu g/m^3$ of PM2.5 and 20 $\mu g/m^3$ of PM10 in response to increased evidence of health effects at very low concentrations of PM. By examining Table 4.9, we can conclude

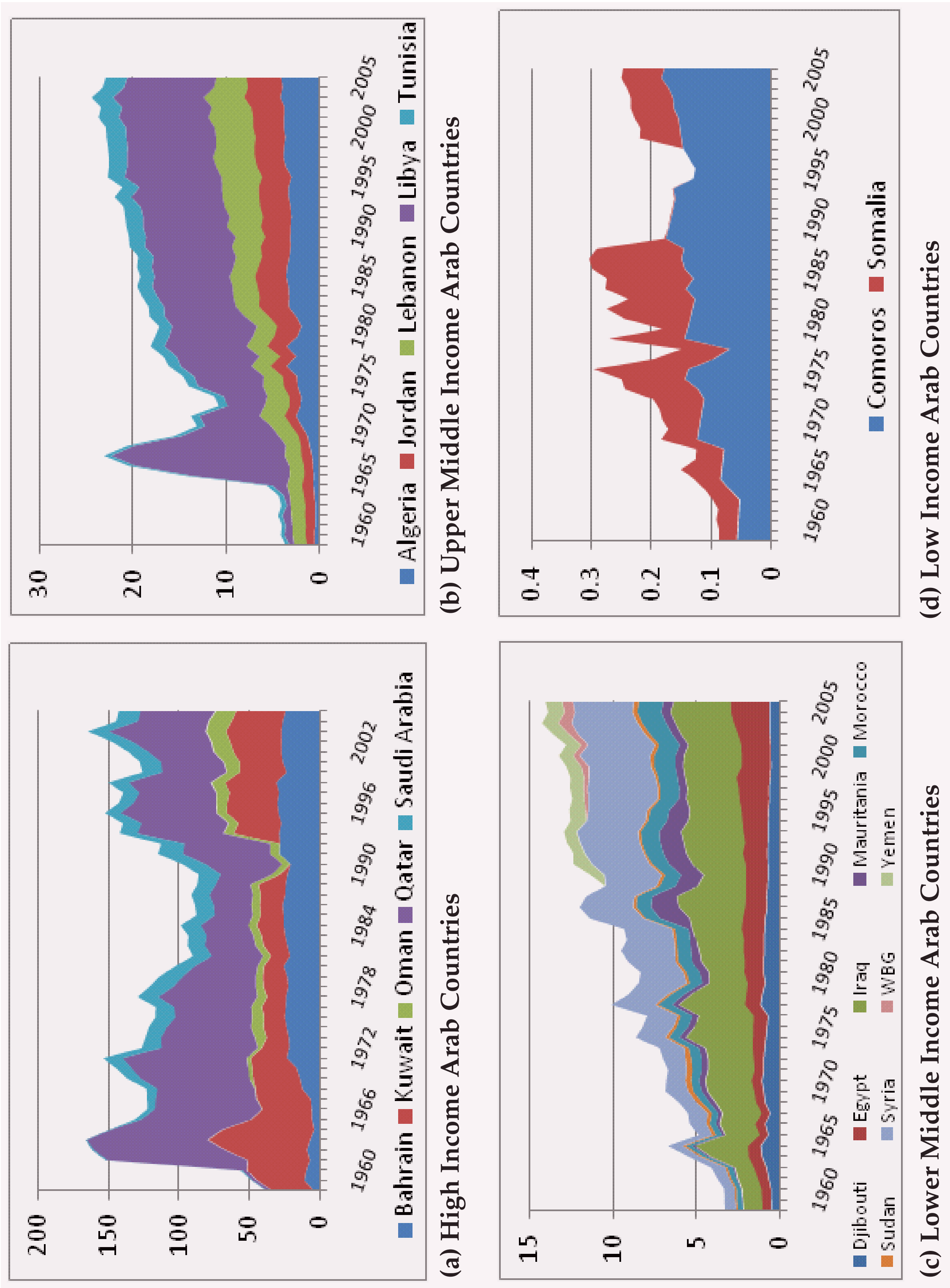
Table 4.9

Particulate Matter Concentration (PM10), Country Level for 1990-2008 (micrograms per cubic meter)

Country	1990	1995	2000	2005	2008
Algeria	112.57	98.79	83.24	69.68	69.25
Bahrain	75.11	67.42	52.49	52.91	48.70
Comoros	83.09	72.11	59.36	41.00	34.49
Djibouti	69.31	61.67	47.22	47.74	48.94
Egypt	212.29	166.24	124.84	116.70	96.86
Iraq	163.93	200.34	165.62	176.96	138.14
Jordan	106.79	79.03	66.03	49.05	32.64
Kuwait	77.14	129.02	123.50	102.37	95.13
Lebanon	63.85	50.76	44.44	37.32	35.58
Libya	100.50	119.70	98.46	90.95	76.04
Mauritania	144.86	118.00	115.27	92.55	67.83
Morocco	38.49	42.30	35.53	29.41	27.36
Oman	135.65	136.12	112.97	103.88	93.76
Qatar	70.81	65.32	58.78	43.46	35.28
Saudi Arabia	157.26	164.78	150.15	118.36	103.88
Somalia	93.58	69.65	51.24	38.39	31.25
Sudan	282.24	230.98	207.17	190.79	159.32
Syria	145.20	140.00	102.64	73.97	69.27
Tunisia	70.54	53.47	47.76	30.65	25.94
Yemen	n.a.	111.64	94.99	76.50	67.32
Arab World	148.43	135.51	112.92	101.74	87.21

Notes: n.a: Not Available.
Source: World Bank (2011).

Figure 4.1
CO_2 Emissions Per Capita by Income Groups 1960-2007 (metric tons per capita)



that the urban population in Arab countries is undoubtedly exposed to higher concentrations of PM than the WHO guideline limits or European and US standards which amount to 40 and 50 µg/m[3], respectively for PM10. The table illustrates a series of available estimates suggesting that in 2008 annual PM10 ambient concentrations in these countries range from around 26 µg/m[3] in Tunisia to about 160 µg/m[3] in Sudan. Furthermore, following the air quality standards of the US EPA (2006) one can classify some of the countries as a complying group (Bahrain, Comoros, Djibouti, Jordan, Lebanon, Morocco, Qatar, Somalia, Tunisia) and the remaining countries as a non-complying group.

4.2.2 Major sources of air pollution

Tables 4.10 to 4.12 show the sectoral distribution of carbon dioxide (CO_2), sulphur dioxide (SO_2) and nitrogen oxide (NO_x) emissions for 2008. As in most countries of the world, industrial activities are the major sources of pollution. Table 4.10 below presents the most recent figures available for the percentage distribution of CO_2 annual emissions in Arab countries among public electricity

Table 4.10

Carbon Dioxide (CO_2) Emissions by Country and Main Source Category for Year 2008

Country	Public Electricity and Heat Production	Other Energy Industries	Manufacturing Industries and Construction	Road Transportation	Residential and Other Sectors	Fugitive emissions from Oil and gas	Cement Production	Peat Fires and Decay of Drained Peat Land	Other
Algeria	21.43	9.96	9.42	17.29	20.75	11.16	6.56	0.01	3.43
Bahrain	37.02	16.52	27.20	9.49	0.83	0.10	0.58	0.00	8.26
Comoros	5.92	0.19	1.72	18.77	63.66	0.00	0.00	0.00	9.74
Djibouti	34.95	0.14	21.04	9.82	27.10	0.00	0.00	4.21	2.73
Egypt	30.51	7.67	18.72	17.41	10.82	1.51	8.48	0.01	4.89
Iraq	24.56	4.09	20.16	26.71	7.99	11.18	1.93	2.89	0.50
Jordan	40.19	3.19	12.16	24.70	11.40	0.00	8.02	0.00	0.36
Kuwait	44.23	20.82	10.96	13.44	0.69	4.55	1.18	0.00	4.14
Lebanon	45.81	0.00	9.39	22.24	10.03	0.00	12.11	0.02	0.40
Libya	44.73	4.16	3.51	21.08	4.68	13.23	4.41	0.06	4.13
Mauritania	21.80	0.15	12.47	32.50	16.96	0.00	3.97	3.82	8.33
Morocco	26.77	1.08	12.64	15.94	34.61	0.00	8.01	0.03	0.92
Oman	25.73	10.62	10.37	5.97	2.83	6.08	2.68	35.43	0.29
Qatar	21.09	30.46	20.99	10.03	0.44	7.60	2.58	0.00	6.82
Saudi Arabia	39.60	11.83	10.60	25.71	1.07	2.16	3.36	0.00	5.67
Somalia	10.79	0.24	4.14	28.67	19.71	0.00	0.00	26.53	9.91
Sudan	16.28	3.25	4.10	42.96	5.51	0.38	0.83	25.23	1.45
Syria	42.88	3.85	14.95	21.64	7.53	3.11	4.16	0.02	1.87
Tunisia	34.40	0.77	13.17	18.68	15.91	2.94	11.81	0.01	2.31
UAE	48.75	1.28	28.40	12.71	2.22	1.19	4.16	0.00	1.30
Yemen	16.24	13.62	9.96	21.43	24.22	9.06	4.82	0.01	0.64
Cyprus	46.87	0.00	14.32	24.18	4.58	0.00	9.09	0.00	0.97
Greece	46.81	3.25	8.22	18.62	12.13	0.01	6.06	0.13	4.77
Spain	29.42	5.23	13.98	29.91	10.17	0.10	3.86	0.04	7.29
Turkey	34.38	2.98	13.12	14.58	21.51	0.00	7.87	0.11	5.44

Source: Authors' calculation based on EC-JRC/PBL (2011).

and heat production, other energy production, manufacturing industries and construction, cement production, road transportation, residential and other sectors, fugitive emissions from oil and gas production, peat fires and decay of drained peat land and other sources. It is interesting to compare these figures for Arab countries with the corresponding ones for Mediterranean countries. The table also reports the distribution of emissions by source for selected Mediterranean countries, namely, Cyprus, Greece, Spain and Turkey, which are fairly similar in terms of land use and climate. It can be seen that most countries have a significant proportion of CO_2 emissions generated from public electricity and heat production, while for others road transportation is the major polluter (Iraq, Mauritania, Somalia, Sudan). Another group of countries has residential and other sectors as major polluters (Comoros, Morocco, Yemen), while Oman lies in a category of its own with peat fires and decay drained peat-land being the major source of pollution.

Table 4.11 presents the most recent figures available for the percentage distribution of SO_2 annual emissions in Arab countries by source namely, industrial sector, road transportation,

Table 4.11
Sulfur Dioxide (SO_2) Emissions by Country and Main Source Category for Year 2008

Country	Public Electricity and Heat Production	Other Energy Industries	Manufacturing Industries and Construction	Road Transportation	Residential and Other Sectors	Chemicals Production	Metals Production	Savanna Burning	Other
Algeria	6.48	9.21	28.43	9.41	39.12	0.50	6.70	0.00	0.14
Bahrain	0.68	0.49	0.88	14.47	9.62	0.00	73.87	0.00	0.00
Comoros	11.86	0.38	3.56	2.20	81.06	0.00	0.00	0.00	0.93
Djibouti	68.46	0.12	19.89	0.58	10.87	0.00	0.00	0.00	0.09
Egypt	52.72	3.28	22.96	3.12	12.68	1.23	0.31	0.00	3.70
Iraq	74.81	6.20	12.71	1.75	4.44	0.00	0.00	0.00	0.09
Jordan	49.81	8.93	26.48	2.41	11.77	0.01	0.01	0.00	0.58
Kuwait	84.79	10.80	3.47	0.51	0.24	0.20	0.00	0.00	0.00
Lebanon	85.86	0.00	7.78	0.62	2.77	2.90	0.00	0.00	0.07
Libya	88.59	2.52	3.95	2.17	2.73	0.00	0.02	0.00	0.02
Mauritania	62.50	0.21	18.65	1.95	16.11	0.00	0.00	0.07	0.51
Morocco	72.92	0.00	13.22	1.96	5.84	1.82	4.07	0.00	0.17
Oman	31.48	14.87	14.57	1.42	19.18	0.00	18.45	0.00	0.03
Qatar	0.52	1.36	62.57	24.80	8.85	0.00	0.76	0.00	1.15
Saudi Arabia	73.08	4.26	19.58	2.18	0.82	0.04	0.01	0.00	0.03
Somalia	12.94	0.20	4.24	1.26	75.49	0.00	0.00	5.43	0.44
Sudan	10.12	1.19	1.71	1.13	4.09	0.00	0.00	81.60	0.17
Syria	75.06	4.25	13.52	1.23	5.04	0.69	0.00	0.00	0.21
Tunisia	38.42	1.37	10.29	2.50	9.49	36.27	0.00	0.00	1.65
UAE	19.70	0.02	44.81	11.36	17.39	0.00	6.70	0.00	0.01
Yemen	39.84	31.32	12.41	0.88	15.44	0.01	0.00	0.00	0.10
Cyprus	89.69	0.00	8.49	0.27	1.55	0.00	0.00	0.00	0.00
Greece	78.40	2.43	6.82	0.02	7.01	0.66	0.15	0.00	4.50
Spain	44.95	6.89	16.18	0.22	16.58	3.92	0.94	0.00	10.34
Turkey	52.68	2.47	20.00	1.44	17.56	0.47	2.74	0.00	2.65

Source: Authors' calculation based on EC-JRC/PBL (2011).

residential, chemical and mineral productions, savanna burning and other sources. The table depicts residential and other sectors as the main source of SO_2 emissions in Algeria, Comoros and Somalia, while manufacturing industries and construction are the major source in Qatar and the UAE. For Bahrain and Sudan the main source of SO_2 emissions are metal production and savanna burning, respectively. However, all the remaining countries have a significant proportion of SO_2 emissions generated from public electricity and heat production.

Table 4.12 below portrays the most recent figures available for the percentage distribution of NOx annual emissions in Arab countries by source. Arab countries with the exception of Somalia and Sudan may be ranked into two distinct groups according to the major source of pollution. The first group has road transportation as the major source of NOx emissions (Algeria, Comoros, Egypt, Iraq, Morocco and Tunisia). The second group has the public electricity and heat production as the major source of emissions (Bahrain, Djibouti, Kuwait, Lebanon, Libya, etc.). It is interesting to see that the Mediterranean countries (included for comparison purposes) are also distributed across the same two groups.

Table 4.12

Nitrogen Oxides (NOx) Emissions by Country and Main Source Category for Year 2008

Country	Public Electricity and Heat Production	Other Energy Industries	Manufacturing Industries and Construction	Road Transportation	Other Transportation	Residential and Other Sectors	Manure in Pasture/ Range/ Paddock	Savanna Burning	Other
Algeria	23.25	4.71	7.62	47.10	0.00	11.56	1.54	0.00	4.22
Bahrain	46.51	2.94	22.42	25.15	0.00	0.46	0.03	0.00	2.49
Comoros	2.41	0.07	14.09	46.26	5.64	21.55	4.56	0.00	5.42
Djibouti	68.98	0.13	8.68	14.50	1.26	4.16	2.07	0.04	0.17
Egypt	26.38	1.43	13.49	38.02	7.02	5.85	1.21	0.00	6.61
Iraq	28.97	2.33	7.71	57.01	0.00	1.49	0.33	0.00	2.16
Jordan	39.03	6.24	10.43	38.88	0.53	3.53	0.70	0.00	0.67
Kuwait	55.68	11.21	8.59	22.82	0.00	0.30	0.09	0.00	1.32
Lebanon	71.10	0.00	7.00	16.10	0.00	3.62	0.38	0.00	1.80
Libya	53.41	1.65	1.73	39.43	0.02	1.16	0.30	0.00	2.29
Mauritania	44.70	0.09	4.71	31.29	2.79	5.12	9.96	0.34	0.99
Morocco	34.79	0.23	9.53	37.11	0.00	11.40	2.72	0.00	4.22
Oman	62.86	6.39	13.46	11.87	0.00	1.97	0.54	0.00	2.90
Qatar	35.80	5.27	18.19	34.40	1.10	0.28	0.08	0.00	4.88
Saudi Arabia	49.43	3.73	7.98	37.27	0.02	0.31	0.12	0.00	1.14
Somalia	2.28	0.05	5.66	10.32	0.94	34.57	27.35	15.52	3.31
Sudan	1.28	0.12	0.20	2.67	0.03	0.74	1.20	93.45	0.32
Syria	43.70	2.15	9.86	33.24	0.67	2.40	2.20	0.00	5.78
Tunisia	33.98	0.55	8.55	41.02	1.79	8.20	2.19	0.00	3.71
UAE	49.32	0.19	19.38	29.22	0.00	1.02	0.14	0.00	0.73
Yemen	43.17	19.46	6.17	19.78	0.00	5.70	2.98	0.00	2.73
Cyprus	63.88	0.00	10.31	22.33	0.00	1.55	0.31	0.00	1.63
Greece	48.29	3.38	7.05	17.66	16.19	4.42	0.61	0.00	2.39
Spain	32.32	2.22	8.32	36.10	13.55	3.51	0.40	0.00	3.58
Turkey	26.49	1.06	10.23	37.07	5.89	8.81	0.61	0.00	9.84

Source: Authors' calculation based on EC-JRC/PBL (2011).

How the nature of firms' ownership may affect the environment in an economy seems to be a legitimate question in this context. Conventional wisdom and theoretical conjectures are divided on this important question. Talukdar and Meisner (2001) estimate a reduced-form random-effects model using data from 44 developing countries over nine years (1987-95) to identify any systematic empirical relationship between the relative level of private sector involvement in an economy and the environmental performance of the economy in terms of its emissions of industrial CO_2. They control for both observed and unobserved cross-country heterogeneity along various institutional and structural dimensions such as the scope of financial market, industrial sector composition and level of foreign direct investment. The regression results indicate that the higher the degree of private sector involvement in a developing economy, the lower its environmental degradation. In addition, the latter is likely to be further reduced in the presence of a well-functioning domestic capital market and through increased participation be developed economies in its private sector development. The fact that public electricity and heat production are found to be the most polluting sectors in the Arab countries corroborates the findings of Talukdar and Meisner (2001).

4.2.3 Impacts of air pollution

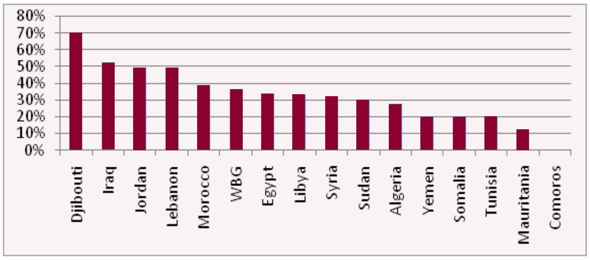
Guesten et al. (1994) studied ozone formation in the greater Cairo area in 1990 in a 3-week measurement period performed at three sites (Shoubra EI-Kheima, Mokattam Hill, Helwan), covering a north-south direction of 27 km, and in 1991, from the beginning of April until the end of October, by measurement of the seasonal variation of ozone at one site at EI-Kobba. They identify a sinusoidal shape in the level of pollutant with peak values of 120 ppb and daily mean value of 50 ppb throughout the year. Ozone is produced predominantly over the industrial area in the north and in the center of Cairo and is transported southward by the prevailing northerly winds. Contrary to many urban areas in Europe and in North America, fairly high average ozone levels of 40 ppb are observed during the night throughout the spring and summer. This may imply that health hazards and crop damage are higher in the greater Cairo area than in Central Europe.

Sandstrom and Forsberg (2008) assert that coarse particles (PM10) seem capable of being deposited in the bronchial passages and so appear to have an impact on respiratory conditions, leading to asthma, chronic obstructive pulmonary disease, pneumonia and other respiratory ract infections. Moreover, finer particles (PM2.5) appear to be more linked to cardiovascular problems, since they can reach the pulmonary alveoli. Furthermore, they raise concern about windblown Saharan desert dust causing increased mortality due to its toxicity. This may be of concern for large areas of the Arab countries that periodically encounter high levels of windblown desert dust and warrants further attention.

As shown in the previous section, the energy sector is one of the major driving forces generating air pollution, since it provides the fuel used for urbanization, industrialization, power plants and the transport sector. Exposure of city dwellers to noxious doses of industrial and vehicle emissions and other harmful pollutants, particularly in congested metropolitan areas, induces the contraction of respiratory diseases, such as asthma, bronchitis and emphysema. The situation is exacerbated by rapid urbanization and the use of antiquated technologies and inadequate control measures to curtail air pollution. About 56.4% of the population of the Arab world lived in urban areas in 2010 (World Bank 2011). Larsen (2012) estimates the cost of environmental degradation due to outdoor air pollution in urban areas in 15 countries of the Arab League (Algeria, Djibouti, Egypt, Iraq, Jordan, Lebanon, Libya, Mauritania, Morocco, Somalia, Sudan, Syria, Tunisia, West Bank and Gaza, and Yemen). An estimated one-third of the total population of these 15 countries—or over 100 million people—live in 218 cities with populations over 100 thousand inhabitants in 2010, and 17%—or over 50 million people—live in 21 cities with populations over 1 million. The proportion of the national population living in cities with over 100 thousand inhabitants ranges from 12% in Mauritania to 70% in Djibouti (Figure 4.2). The proportion of the population living in cities with over 1 million inhabitants reaches over 40% in Lebanon and over 30% in Iraq.

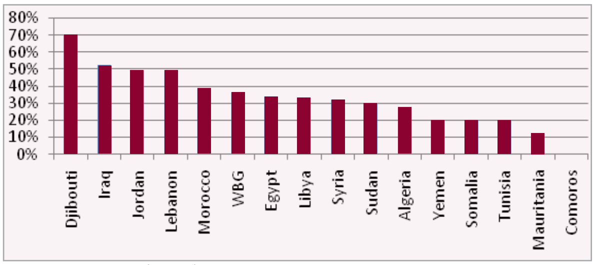
Figure 4.3 depicts Larsen (2012) estimates of mortality from exposure to PM2.5 in large cities of the 15 countries. Estimated annual mortality from PM2.5 totals 53,000 premature deaths in cities > 100,000 inhabitants in the 15 countries in 2008. This is equivalent to 8% of all annual deaths in these cities, ranging from less than 2% in Somalia

Figure 4.2
Percent of National Populations Living in Cities > 100,000 Inhabitants, 2010 Estimates



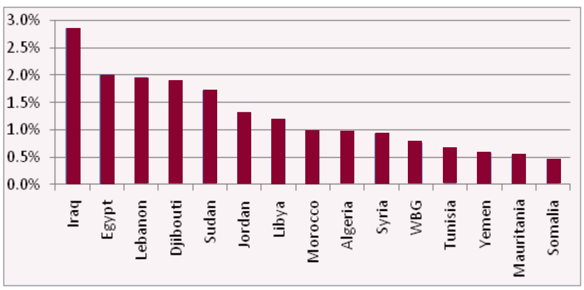
Source: Larsen (2012).

Figure 4.3
Mortality from PM2.5 in Cities > 100,000 Inhabitants (% of all deaths in the cities)



Source: Larsen (2012).

Figure 4.4
Estimated Annual Cost of Health Effects from PM Outdoor Air Pollution (% of GDP in 2008)



Source: Larsen (2012).

to nearly 12% in Egypt. He further estimates annual cost of health effects from PM pollution in cities > 100,000 inhabitants to amount to US$10.9 billion in 2008. The cost ranges from an equivalent of nearly 0.5% of national GDP in Somalia to 2.9% in Iraq (Figure 4.4). It should be noted that the three counties with the lowest cost have low population shares living in large cities, and low to moderate PM concentrations and cardiopulmonary and lung cancer mortality rates. The five countries with the highest cost have high population shares living in large cities and/or high PM concentrations, and moderate to high cardiopulmonary and lung cancer mortality rates.

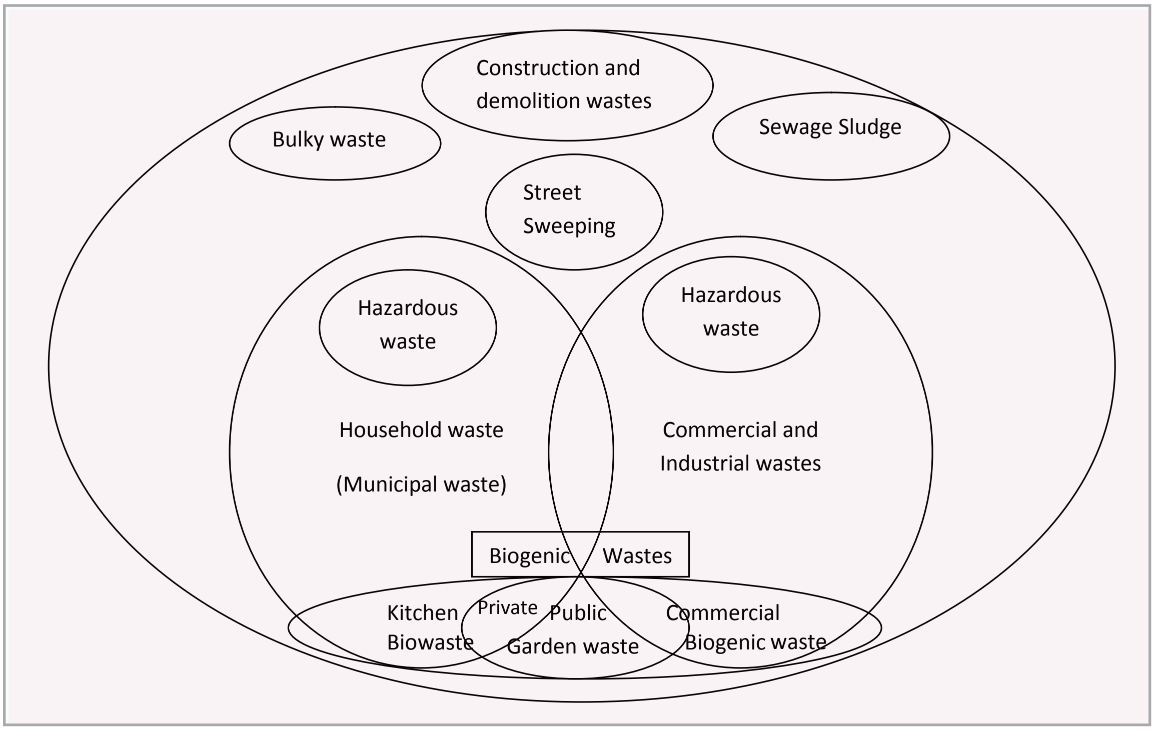
4.3 Waste Management

As previously discussed, a green economy is characterized by a sustainable increase in investments directed towards green (environment-friendly) activities that results in improved human wellbeing, reduced environmental risks and resource conservation. Waste varies in form between solid, liquid, and gaseous states. In this section we will be covering solid waste which has many sources and forms as shown in Figure 4.5. Solid waste may be classified by source as municipal, industrial, agricultural, construction and demolition, and medical. Alternatively, it may be classified by content as non-hazardous, hazardous, bulky and biogenic. The goal of solid waste management (SWM) is to manage waste to meet public health and environmental concerns, as well as to conserve natural resources through reuse and recycling of waste materials. The concept of integrated solid waste management and utilizing waste as a resource has been spreading in the Arab region. However, solid waste management practice in many parts of the region can be described as under-planned activities with sporadic service coverage. In most areas of the Arab world, SWM activities are performed by municipalities. Subcontractors are commonly contracted for specific activities such as collection and transportation. Private sector participation has been increasing over the past decade but remains limited with regards to the volume of collected waste. An informal sector is present in a few of the Arab countries and lives on recyclables from waste collected. Many of the countries in the region lack a strategy for SWM and regulations to govern activities in the sector. Al-Qaydi (2006) discusses the policy of Dubai government for managing industrial solid waste.

4.3.1 Solid waste, incineration and landfills

One of the main problems of the sector of solid waste in the Arab countries is the lack of common definition. This stands as a barrier in the development of common data related to the sector and hence a hindrance to form an objective evaluation of the real problem and to propose solutions. It is

Figure 4.5
Estimated Annual Cost of Health Effects from PM Outdoor Air Pollution (% of GDP in 2008)



Source: Council of Europe, 2007.

Table 4.13
Combustible Renewables and Waste (% of Total Energy)

Country	1971	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008
Algeria	0.26	0.18	0.10	0.07	0.07	0.22	0.28	0.24	0.20	0.21	0.13
Bahrain	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Egypt	8.39	6.83	5.24	3.67	3.32	3.37	2.89	2.36	2.29	2.22	2.15
Iraq	0.61	0.49	0.26	0.13	0.13	0.10	0.10	0.08	0.08	0.08	0.08
Jordan	0.21	0.14	0.07	0.08	0.06	0.07	0.06	0.08	0.07	0.08	0.08
Kuwait	0.19	0.14	0.03	0.04	0.08	0.04	0.00	0.00	0.00	0.00	0.00
Lebanon	5.66	5.49	4.59	4.01	4.59	2.73	2.64	2.54	2.98	3.53	2.71
Libya	6.18	3.11	1.81	1.25	1.10	0.79	0.84	0.88	0.90	0.90	0.90
Morocco	5.19	5.02	5.34	5.36	4.57	4.64	4.26	3.54	3.51	3.30	3.20
Oman	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Qatar	0.32	0.10	0.06	0.08	0.07	0.02	0.01	0.01	0.01	0.00	0.00
Saudi Arabia	0.01	0.01	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00
Sudan	80.35	82.20	84.16	84.17	81.78	86.12	81.73	72.82	73.93	70.82	68.01
Syria	0.04	0.06	0.10	0.03	0.02	0.04	0.03	0.03	0.03	0.03	0.03
Tunisia	25.06	20.39	15.39	13.69	12.90	12.92	12.78	13.62	13.64	13.64	13.60
Yemen	6.67	7.67	4.72	3.97	3.06	2.25	1.62	1.17	1.12	1.07	1.03

Source: World Bank (2011).

possible to find sporadic country level data that describes the amount of generated waste. However, data is not comparable across countries. On the other hand, waste incineration has the potential of producing energy that can be converted to electricity. Table 4.13 presents a sample of existing series on combustible renewables and waste as a percentage of total energy production in selected Arab countries.

4.3.2 Hazardous waste

Hazardous waste is generated by several economic and services sectors in the Arab countries and is a combination of agricultural and industrial residues as well as municipal solid residues. Hazardous waste also includes medical and e-waste. In the field of hazardous waste, management varies between Arab countries which generate no less than 300 thousand tons per year. The bulk of hazardous waste in most Arab countries is produced in heavy and medium industries. Furthermore, a large portion of hazardous waste results from oil-related activities such as oil drilling, refining, transportation and utilization. Massive quantities of hazardous waste are generated from military operations mainly from land and marine mines and expired ammunition. Some agricultural activities further contribute to hazardous waste production through expired or invalid fertilizers and pesticides and their empty packs. Waste is also generated from hospitals, health treatment units, private clinics, pharmacies and drug stores. Garbage and municipal waste contain some hazardous waste of such materials as expired medicine, chemicals, paints, insecticides and their empty containers, consumed dry batteries, and electrical and electronic equipment. Despite that, a limited number of Arab countries developed strategies for the sound management of hazardous waste and systems to follow up on the implementation of such strategies. Spreading awareness about the dangers of hazardous waste is still very limited on all levels in the Arab world. Therefore, the priority for management resides in raising awareness and collecting related data, while implementing pilot projects and defining a regulatory and legal framework that regulates the proper way of handling them.

4.4 Ecosystems and Biodiversity

The way ecosystems and biodiversity are affected by human activities is one of the most difficult issues to deal with for environmental economists. Whereas water overuse and quality degradation of air and water are more or less easy to relate to agricultural and industrial production as well as to some consumption patterns, impacts on ecosystems are far more complex to observe. One exception is landscape, which is easily observed but probably more difficult to represent with statistical data, and which has well-known characteristics in terms of necessary habitat and species reproduction. To the extent that benefits of natural landscape for wildlife and flora are well known to ecologists, it is possible to identify the loss of biodiversity or ecosystem-based services by inspecting land uses and in particular, land allocated to agriculture or development. Regarding biodiversity, the difficulty is to assess its value of existence separately from the "market" value of some of its components, which are transformed to final goods or production inputs. Given the prohibitive cost of monitoring a wide range of species at the national level, existing statistical datasets are only available on endangered species which are easier to identify. Such figures are helpful for analyzing trends of biodiversity loss over time, but they need to be compared with the census of existing species in any given country. This last kind of data is unfortunately not available, as identification of the total population of existing species would be a tremendous task.

Arab countries are generally expected to be characterized by less ecosystem-based services and biodiversity. This statement however overlooks the fact that although many of these countries are located in semiarid latitudes, some biodiversity hotspots do exist (forest areas in Lebanon, natural parks in Jordan, coastal zones, host endemic species, etc.).Crude indicators for ecosystems and biodiversity in most countries include forest and permanent pasture areas, as well as protected areas and the number of endangered species. Table 4.14 presents the proportion of protected terrestrial and marine areas in Arab countries. Some of these countries have a particularly important proportion of terrestrial protected areas, like Saudi Arabia (38%), Jordan (10%), Oman (9%), Bahrain and Egypt (8%). With the exception of Mauritania, most countries above also have significant protected marine areas: Bahrain (12%), Djibouti (18%), Jordan (22%), and Oman (10%).

Table 4.15 provides information on the number of threatened species, and as mentioned above,

Table 4.14
Protected Areas (% of Total Surface Area), 2004 and 2008

Country	Terrestrial protected areas (% of total surface area) 2008	Marine protected areas (% of total surface area) 2004	2008
Algeria	5	0	0
Bahrain	8	0	12
Djibouti	0	18	0
Egypt	8	0	10
Iraq	0	8	0
Jordan	10	0	22
Kuwait	1	2	2
Lebanon	0	0	0
Libya	0	0	1
Mauritania	1	1	31
Morocco	1	0	2
Oman	9	10	1
Qatar	1	0	1
Saudi Arabia	38	0	1
Somalia	1	1	0
Sudan	5	0	0
Syria	1	0	1
Tunisia	2	0	0
UAE	0	0	0
Yemen	0	0	3

Source: World Bank (2011).

Table 4.15
Threatened Species in 2010

Country	Bird	Fish	Mammal	Plant
Algeria	11	33	14	15
Bahrain	4	8	3	0
Comoros	8	6	5	5
Djibouti	6	15	8	2
Egypt	10	36	17	2
Iraq	18	11	13	0
Jordan	10	13	13	1
Kuwait	9	11	6	0
Lebanon	7	21	10	1
Libya	4	21	12	2
Mauritania	9	30	15	0
Morocco	10	45	18	31
Oman	10	24	9	6
Qatar	5	11	2	0
Saudi Arabia	14	22	9	3
Somalia	11	26	15	21
Sudan	14	17	15	18
Syria	13	33	16	3
Tunisia	7	31	13	7
West Bank & Gaza	8	0	3	0
Yemen	14	21	9	159

Source: World Bank (2011).

such figures would need to be matched with to existing species, in order to be useful in comparing countries. It should be noted that threatened species are the number of species classified by the International Union for Conservation of Nature (IUCN) as endangered, vulnerable, rare, indeterminate, out of danger, or insufficiently known.

Zamora et al. (2007) analyzes the relationship between traditional grazing, farming activities and biodiversity, by comparing biodiversity richness across three types of habitats in Mediterranean countries. They show that open mosaic areas are the richest and the most temporally heterogeneous habitats, suggesting that the maintenance of traditional human activities in these areas is to be favored, as a significant diversification agent, in order to avoid loss in biological diversity.

4.5 Agriculture

Agriculture is a sector of choice when considering sustainability and the relationship between economic activity and the environment. A major concern for future generations is the satisfaction of food security objectives for a growing population, when agriculture is still highly dependent on the exploitation of natural resources (soil, water, air, mineral resources, etc.) The significant growth in agricultural production worldwide has been achieved through a more intensive use of natural resources, and has implied an increase in the range and degree of environmental damage in most parts of the world. Therefore one major issue is the ability of countries (or groups of countries) to define their objectives in terms of sustainable agriculture.

4.5.1 What is sustainable agriculture?

Three initial concepts of sustainable agriculture have been proposed by Douglass (1984). The first one defines such sustainability in technological and economic terms as the potential to satisfy the food demand of the world population. The second concept is almost exclusively based on the protection of natural resources and the environment, according to which, for example, the growth of agricultural production over the last decades could not be considered sustainable, given the degree of environmental damages involved. The third concept is not only based on environmental considerations, but also on a set of social values associated with agricultural and rural life styles according to which technical progress would not only harm the environment, but also rural communities (see Ruttan 1993). More recent definitions of sustainable agriculture combine the three dimensions (see, e.g., Rigby and Caceres 1997) and, regarding the environmental dimension, share the view that present agricultural practices are not environmentally sustainable.

To satisfy future food needs while protecting the environment may be the greatest challenge to come for all economies, and it is a challenge not only for scientists but also for economists. They have to verify that environmental damages are "internalized" in agricultural production costs, for two reasons. First, if an input is undervalued because damages are not internalized by producers through a change in price or in cost of access, farmers are likely to overuse it. This is typically the case for irrigation water from ground or surface sources. Second, the relative scarcity of production inputs will favor technological change in the direction of overusing more abundant (and therefore cheaper) resources and of saving on more expensive ones (theory of induced technological change, see Hayami and Ruttan 1985).

Sustainable agriculture is often considered, in a somewhat reductive manner, in light of alternative, more sustainable production practices. This view is consistent with country-specific analyses and allows to temporarily put aside issues of international trade (and its relationship with the environment). Most studies using this approach are conducted at the farm level and develop some sort of multi-criteria analysis to compare alternative practices with conventional ones. From an economist's point of view, a question to address is the design of policies or the structure of markets which would promote adoption of more environment-friendly practices. Although there are exceptions to consider (altruistic behavior for example), farmers will not spontaneously adapt their farming practices unless they are given incentives or are forced to do so by legislation or regulation. We will discuss this issue in Chapter 5.

We focus in this section on the environmental dimension of sustainable agriculture, by looking at input and natural resource use in Arab countries.

4.5.2 Agricultural land

Agricultural land as the key production factor for crops and livestock is associated with harmful environmental impacts through specific production practices (fertilizer and pesticide use, overuse of water by irrigation, intensive grazing, etc.), but it is also a factor of sustainability as an activity preserving landscape and rural life. With the demographic expansion of Arab countries and the associated increase in food demand, arable land per capita has been steadily decreasing in these countries over the past 45 years (Table 4.16). In the best scenario, arable land per capita has diminished by half over the period 1965-2007, while some countries have experienced a more severe decrease (in particular, Iraq, Jordan and Syria). It is clear from these figures that agriculture in Arab countries cannot sustain food needs alone, and that food imports plays an important role, even in countries with a relatively important share of agriculture in the GDP (Mubarak 1998).According to Sulser et al. (2011), the 2007–2008 food crisis has severely undermined food security and agricultural sustainability in the Arab region, where uncertainties are compounded by water scarcity. The authors point to the major role of agricultural research, expanded irrigation, improved natural resource management and enhanced market efficiency to improve food security. The downward trend in arable land per capita is a complex combination of demographic growth, migration to urban areas, conversion of land to artificial land uses, and soil erosion.

Land degradation is mainly due to intensive agricultural practices and livestock overgrazing, resulting in a loss in arable land over time, but also in a decrease in crop yield for areas planted with crops. Figure 4.6 presents average crop yield

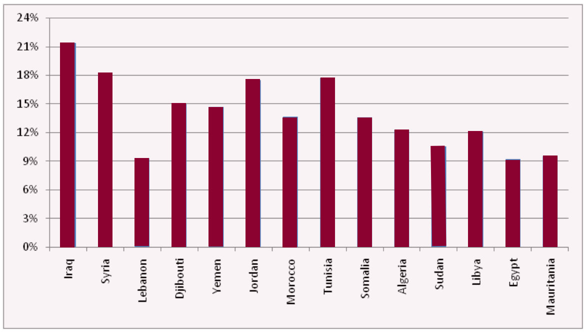
Table 4.16
Arable Land Per Capita (Hectares Per Person), 1965-2007

Country	1965	1970	1975	1980	1985	1990	1995	2005	2007
Algeria	0.520	0.455	0.427	0.365	0.313	0.28	0.266	0.229	0.221
Bahrain	0.005	0.005	0.004	0.006	0.005	0.004	0.003	0.003	0.003
Djibouti	0.009	0.006	0.004	0.003	0.002	0.002	0.002	0.001	0.002
Egypt	0.082	0.077	0.068	0.051	0.046	0.04	0.044	0.039	0.038
Iraq	0.556	0.475	0.424	0.374	0.322	0.307	0.248	0.193	0.174
Jordan	0.245	0.188	0.161	0.137	0.105	0.057	0.06	0.034	0.025
Kuwait	0.002	0.001	0.001	0.001	0.002	0.002	0.003	0.006	0.006
Lebanon	0.094	0.096	0.085	0.075	0.071	0.062	0.052	0.035	0.035
Libya	1.057	0.865	0.706	0.572	0.464	0.414	0.387	0.295	0.284
Mauritania	0.266	0.242	0.145	0.138	0.172	0.201	0.219	0.163	0.143
Morocco	0.510	0.462	0.421	0.385	0.353	0.351	0.331	0.266	0.258
Oman	0.031	0.029	0.025	0.019	0.019	0.019	0.016	0.024	0.022
Qatar	0.014	0.009	0.012	0.017	0.022	0.021	0.029	0.02	0.016
S. Arabia	0.255	0.237	0.223	0.197	0.198	0.209	0.2	0.151	0.141
Somalia	0.287	0.26	0.233	0.153	0.159	0.155	0.159	0.162	0.115
Sudan	0.845	0.776	0.693	0.603	0.524	0.472	0.524	0.502	0.478
Syria	1.175	0.887	0.68	0.583	0.466	0.384	0.328	0.244	0.236
Tunisia	0.687	0.623	0.608	0.5	0.423	0.357	0.317	0.272	0.270
UAE	0.035	0.031	0.021	0.016	0.018	0.019	0.018	0.016	0.016
Yemen	0.225	0.208	0.192	0.163	0.135	0.124	0.105	0.061	0.062

Source: World Bank (2011) - World Development Indicators.

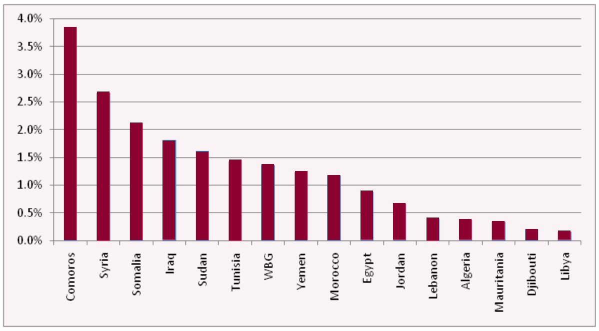
losses due to land degradation in 2007. With the exception of Lebanon, Egypt and Mauritania, all Arab countries experience crop yield loss above 10%, but the heterogeneity of country-specific loss rates is not very large (from about 9% for Egypt to about 21% for Iraq). A more remarkable figure is the cost of such land degradation as a proportion of GDP. As can be seen in Figure 4.7, countries like Comoros, Syria and Somalia are faced with a cost of land degradation of more than 2% of their GDP. For the most impacted countries, this decrease in agricultural productivity is comparable to the expected impact of climate change on crop yield due to increased water stress.

Figure 4.6
National Average Crop Yield Losses Due to Land Degradation



Source: Larsen (2012).

Figure 4.7
Estimated Annual Cost of Agricultural Crop Land Degradation (% of GDP in 2007)



Source: Larsen (2012).

According to Chatterton and Chatterton (1984), overgrazing of pastures, particularly in the spring period of seed production, is the major reason for land degradation in the MENA region, and using cereal grain to increase livestock production can cause further degradation of rangeland areas. These authors provide several case studies to illustrate alternative models of grazing management developed from local grazing traditions. Abdelfattah (2009) suggests management options for several land degradation types in the case of Abu Dhabi (UAE).

4.5.3 Irrigation water

Irrigation water is usually considered to supplement insufficient rainfall, in order to achieve a minimum yield on a given land area, and also for coping with required quality standards imposed by the agro-food sector. A major share of water in Arab countries is allocated for agriculture and Arab countries generally extract too much water given the recharge rate of natural bodies (by rainfall or external water flows). It is interesting to compare Arab countries in terms of the average water use for irrigation, with the total population (rural and urban) of these countries. Table 4.17 presents water withdrawal for agricultural purposes per capita from 1985 to 2005. It can be seen that, although agricultural land per capita has decreased dramatically over the years (see above), the volume of irrigation per capita has decreased less, and in some cases has even increased (Algeria, Egypt, Sudan, United Arab Emirates). We can therefore conclude that irrigation has been more intensive as a production input to agriculture over the years when controlling for demographic growth.

4.5.4 Fertilizer and pesticide use

The FAO has been producing country-level data on fertilizer and pesticide use in agriculture from 2002 onwards. In order to examine the intensity of use of major fertilizers and pesticide, we divide total nutrients by the area of agricultural land (assuming such inputs can be used not only on crop land but also on temporary pastures, although to

Table 4.17

Water Allocation for Agriculture: Agricultural Water Withdrawal Per Capita (m^3/Person/Year)

Country	1985	1990	1995	2000	2005
Algeria		106.793		129.155	
Bahrain		273.86		261.534	228.77
Egypt			794.109	840.77	
Iraq	2453.553	2083.613	2116.501		
Jordan	174.357	197.428			112.945
Kuwait			179.8	210.671	
Lebanon			257.905	243.884	191.102
Libya	510.416	980.618	844.149	670.361	
Morocco		396.014	366.745	381.932	
Oman		601.027		512.034	462.437
Palestine				53.69	52.872
Qatar			408.868	340.458	295.898
Saudi Arabia		903.331			879.688
Somalia	122.357			443.591	411.435
Sudan		549.252	544.725	1033.407	
Syria			837.369	826.345	817.185
Tunisia		334.543	273.067	226.382	
UAE			579.059	703.818	809.972
Yemen		219.27		168.301	

Source: FAO (2011), Aquastat.

a much lesser extent). Table 4.18 presents the average use of nitrogen (N), phosphate (P) and potash (K) fertilizers, and pesticide per hectare, over the period 1995-2009.

While some countries use on average very low levels of fertilizers, reflecting more extensive agricultural practices, figures for Bahrain, Egypt and Qatar are far higher than the average European consumption of fertilizers per hectare. Such intensive use of fertilizers in these countries is likely to have significant negative impacts on the environment, in terms of nitrate contamination of surface and ground water. As expected, nitrogen application rates are more important than phosphate and potash, with the exception of Jordan. This identifies countries with intensive fertilizer practices as producing higher-value crops (vegetables, fruits) compared to grain or cattle. The same can be said about pesticide use, which is remarkably high in the case of Jordan, whereas most countries have much lower application rates (when data is available).

Table 4.18
Average Fertilizers and Pesticide Consumption Per Hectare, 1995-2009

Country	Nitrogen (kg N/ha)	Phosphate (kg P/ha)	Potash (kg K/ha)	Pesticide (kg/ha)
Algeria	0.8494	0.7433	0.5286	0.0524
Bahrain	845.0551	3.3851	6.5000	-
Egypt	371.1441	56.1025	13.3261	-
Iraq	11.5211	3.5262	0.0085	0.0964
Jordan	32.8419	50.2715	105.4139	17.2709
Kuwait	88.3545	0.0000	0.4966	-
Lebanon	19.0148	21.3284	5.2900	-
Libya	3.4365	1.8787	0.2138	-
Morocco	8.5869	4.0814	1.9717	0.4957
Oman	5.7974	0.7760	5.1126	-
Qatar	316.3735	0.1515	8.0783	-
Saudi Arabia	1.1201	0.6046	0.0585	0.4813
Sudan	0.4335	0.1046	0.0189	-
Syria	17.8119	7.7886	0.6037	-
Tunisia	5.5543	4.6542	0.2194	0.1609
UAE	63.2638	3.2034	8.5953	-
Yemen	0.5468	0.0063	0.0480	1.5126
Total	105.3945	9.3298	9.2049	3.9166

Source: FAO (2011) and authors' calculations.

CHAPTER 5

Economic Incentives and Regulatory Regimes

When considering policies aimed at preserving the environment and promoting a more sustainable exploitation of natural resources, the role of economists is to provide decision makers with information about the relative costs and benefits of policy options, and to discuss several criteria of choice. The efficiency criterion is often put forward (reach the predetermined objective at the lowest possible cost for society), but income redistribution effects should also be accounted for. For example, promoting alternative production practices in agriculture through compensatory payments (as in Europe) leads to a higher burden put on the consumers (as tax payers), while penalizing conventional agricultural practices would have a negative impact on farmers' profit in the case of environmental taxation. The latter case corresponds to the so-called "Polluter Pays Principle" (PPP), and is often preferred by economists on several grounds. First, polluters would make their decisions based on a set of "complete" prices (including the social cost of environmental damages). Second, a policy of complete costs will favor technological change towards more environment-friendly technologies. However, policies based on PPP require sufficient information on damages and their associated costs, and policies based on this principle may need to be designed to fit to local conditions (Hrubovcak et al. 1999).

5.1 The Motivation for Public Regulation Policies

The role of the State in environmental conservation has long been recognized by economists, not only because of the long-run nature of required policies, but mostly because of the nature of the "goods" to be protected. Compare for instance human health with the state of the environment. Individuals perceive their own health as something which should be preserved because health is synonymous with individual welfare as well as a necessary condition for economic activity (in particular, a source of income). Most individuals therefore perceive their health as a "private good" to be preserved, and consequently are willing to devote part of their income to health protection, either through direct expenditures or through social security schemes when delegation to the State is possible. In reality, some private actions taken to preserve one's health have indirect effects on other individuals (protection behavior during epidemic outbreaks, etc.) but this is expected to be seldom accounted for by individuals when taking their own decisions, unless within their own household or family. The State has therefore no particular interest in protecting human health above the required standard perceived by individuals, or determined by organizations such as the WHO, unless a particularly poor level of health is jeopardizing the country's activity (or the public budget).

However, private benefits from a better state of the environment are often more difficult to perceive. Moreover, the negative impacts of economic activities (use of natural resources, pollution) are not always easy to observe and, when this is the case, are often seen as inevitable to maintain economic development. Therefore, the WTP for environmental protection is expected to be low in the majority of cases when the notion of having to pay for environmental degradation itself is not contested. Regarding natural resources as inputs in production or goods which can be consumed or disposed of freely has been the general view until very recently. Problems however appear when the environmental impacts of economic activities are not uniformly distributed across the population or industries, so that some categories of agents must be protected from significant environmental degradation. Moreover, even if damages to the environment are perceived as impacting the population, this can be in a distant future with virtually no changes in the actual behavior of economic agents today. The role of the State can be in such instances to design environmental policies to promote the conservation of natural resources and sustainable management of the environment, when its objectives include the preservation of social welfare. Public intervention is therefore justified on the grounds that, in the laisser-faire situation, the socially-optimal state of the environment would not emerge by the sole decisions of private agents, or the natural resources would be threatened with decline or even extinction in the longer run.

In a more recent trend of legislative reforms, some States have proclaimed that (some) country's natural resources belonged to the nation's assets and had the right to be protected as such. The fact that the State is the only actor with sufficient power to propose and implement policies to protect the environment does not mean that private agents cannot act in favor of the environment. Recent initiatives by private companies or associations of citizens have been witnessed, most of them having to do with the development of environment-friendly "niches" for specific consumer goods, or producer differentiation through eco-labeling for instance.

Table 5.1 presents the year of establishment of environmental laws in Arab countries, to illustrate that very few of them had initiated such laws before the year 2000. It is a well known fact that

Table 5.1
Year of Establishment of Environmental Law (if it exists) by Country

Country	Entity in charge of environment	Year
Algeria	Ministry of regional planning and environment	2001
Bahrain	Ministry of housing, municipalities, and environment	1996
Djibouti	Ministry of home, urbanism, environment, and land planning	Expected
Egypt	Ministry of environmental affairs	1994
Iraq	Ministry of environment	1997
Jordan	Ministry of environment	2006
Kuwait	Environment public authority	2001
Lebanon	Ministry of environment	2002
Libya	Ministry of health and environment	2003
Mauritania	The Ministry of environment and sustainable development	2000
Morocco	Minister of energy, mining, water, and environment	2003
Oman	NA	2001
Palestine	Ministry of environmental affairs	1999
Qatar	Ministry of environment	2002
Saudi Arabia	Presidency of meteorology and environment protection	1992
Somalia	Ministry of environment	NA
Sudan	Ministry of environment and physical development	2001
Syria	Ministry of local administration and environment	2002
Tunisia	The ministry of environment and sustainable development	2003
UAE	Ministry of environment and water	1999
West Sahara	NA	2004
Yemen	Ministry of water & environment	1995

Source: Djoundourian (2011). NA: Not available.

it may be years or even decades before an established environmental law is actually implemented and enforced by authorities.

5.1.1 Environmental priorities and regulatory objectives

Some lessons can be drawn from this introduction to the issue of economic incentives and regulatory regimes. First, a typology of environmental goods and services is necessary, in order to determine their contribution to the overall social welfare (or equivalently, the loss in social welfare that would be implied by environmental degradation). To be really helpful, this typology should aim at ranking the environmental goods and services in terms of benefits for society. Because of budget constraints and also possibly because of political economy considerations limiting their economic impact on some sectors of the economy, environmental policies should be targeted with respect to a list of ordered priorities. Obviously, the environmental benefits are not the only criteria to consider. Other considerations include the cost of public programs, the negative impacts in terms of market distortions, the associated costs of implementation, management and control, etc. This means that a single criterion for ranking environmental priorities may not exist as such.

Second, once the environmental priorities and qualitative objectives have been determined, the public decision makers should make the policy objectives more precise in terms of quantitative objectives, e.g., reducing air emissions by 30%, protecting 20 endangered species, etc. This definition of a quantitative objective is of course complex and in many cases one can suspect that the target does not correspond to the ultimate goal which should be the only one to exist, namely the socially optimal state of the environment. In any case, the decision makers in charge of environmental affairs should have an idea of the state of the environment which is optimal from the society's viewpoint in order to make quantitative objectives more precise and in the right direction. This is especially important when conflicting interests may exist across population categories or environmental components. Environmental economists are in charge of supplying decision makers with values for various environmental goods and services, which can be used to evaluate the socially optimal environmental level. A major difficulty facing them is then to estimate social values for environmental goods and services, and this point will be discussed in Chapter 6.

Third, the nature and level of instruments contained in the environmental policy need to be determined given the objectives and the budget. The economics of natural resource and environmental management provides indications regarding the properties of possible economic instruments, depending on the objective, the local or national setting in terms of property rights and the properties of the environmental good or service.

5.1.2 Public goods

One aspect often overlooked is that, while many sectors of the population may have a negative impact on the environment because of their activities, some others can in fact have a positive impact. In such a case, one may define such positive activities as participating in the supply of "public goods" by economic agents. The question is then symmetric to the one associated with degradation of the environment: what policies should be designed to promote an optimal level of supply for such "public goods"? The economic theory defines a public good by two properties: non-rivalry of consumption, and non-excludability of its consumers/users.

The first property means that the use of a particular good by an agent does not undermine its use by another agent, and the second property states that no user can be excluded from access to the benefits of the good. For example, agriculture is considered a sector producing various non-market goods, some of which having the characteristics of public goods: environmental goods such as landscapes and biodiversity, soil functionality, resilience to some natural disasters, or non-environmental goods (rural vitality and social fabric, food security, animal welfare). The public nature of such goods varies along with the degree of non-excludability and of non-rivalry, spanning from pure private goods (food products, bio-energy) to club goods (possible exclusion and non-rivalry for only a limited number of agents, e.g., private natural spaces) and to impure public goods (excludable only at high costs and non-rivalry, e.g., landscapes).

The two properties above defining a public good (non-excludability and non-rivalry) imply that no market will achieve an optimal level of provision. Non-exclusion allows consumers to adopt a "free-rider" behavior (enjoying the public good for free), while non-rivalry entails a WTP by consumers that would be much less than the marginal cost of optimal provision of the public good. Hence, public goods are generally not supplied at the socially-optimal level because of the moral hazard problem (the tragedy of the commons): no consumer would pay for the others' benefit without being certain that they would behave in an equally virtuous manner.

Public goods can either be global when their benefits extend over national borders or local when benefits are confined within a given area.

For instance, the aesthetic quality of a landscape benefits mainly residents, whereas food security and biodiversity concern the whole world population and are better thought of as global public goods. The optimal level of public good provision, which yields the maximum consumer welfare, is defined according to the Bowen-Lindahl-Samuelson (BLS) theorem. This theorem states that the marginal cost of supplying the good should be equal to the sum of the marginal WTP by consumers benefiting from this good (Foley 1970). Applying this rule may prove difficult depending on the local or global nature of the good: the more global the public good, the more sophisticated the mechanisms to achieve its optimal provision are expected to be.

It was mentioned above that an alternative way of providing environmental goods was to rely on markets in which consumers have a positive WTP for differentiated goods. These consumers would pay the additional cost of producing the environmental good in the form of a higher price generally associated with such goods (e.g., organic farming). However, such voluntary contributions to public goods, including the consumer expenditures of labeled products, do not usually constitute an optimal way of financing the provision of public goods. This is due to the non-rivalry property, as each self-interested consumer ignores the welfare level of the others. Consequently, public intervention is required, by applying the BLS rule to such environmental goods and services.

5.2 Economic Instruments for the Environment

Reaching the optimal state of the environment (or equivalently, the optimal provision level of a public good) can in principle be achieved by various instruments or policy measures. The first category of instruments concerns regulatory "command-and-control" policies, which impose a direct planning on private production (or consumption) activities. This is the case of emission standards, technological standards, permits to produce, etc.

The second category is represented by "market-based" instruments which aim at promoting a different behavior of economic agents by modifying the relative costs and benefits associated with their decisions. Included in this category are subsidies or compensatory payments (for example, to compensate for the cost of modifying the production technology), and environmental taxes.

Consider the problem of environmental degradation through polluting activities. According to the economic theory of externalities, there exists a difference between the level of pollution which is optimal from a private view point, and the one which would correspond to the level pollution desired by society. The latter is characterized by preferences of goods and services, but also of environmental "quality," and there exists a theoretical pollution level associated with the social optimum as a compromise between the satisfaction of human needs through the consumption of market goods and services, and the consumption of non-market environmental goods. If environmental degradation does not modify significantly the producer's profit, the producer will not account in his economic decision-making the environmental impact of his activities, and the level of private pollution will be higher than the socially-optimal level. The most well-known policy then relies on the PPP, which consists in making the polluter "internalize" the damage (external effects) associated with her activity. More precisely, such internalization entails the design of a mechanism to make environmental degradation more costly to the producer. If this mechanism succeeds in bringing the level of pollution towards the socially-optimal level, the associated additional cost is assimilated to a Pigovian tax. The most well-known property, probably, in environmental economics is the following one: The level of the tax which leads the polluter to internalize perfectly the damage originating from his activity corresponds to the marginal damage to society.

5.2.1 Criteria of choice for policy instruments

Public economics provides numerous recommendations on the choice of instruments by extent and type of uncertainties affecting the implementation of the intervention. In practice, many forms of intervention exist and they are often implemented in some sort of a combination. Their implementation is not normally calibrated with reference to an optimal level, as this level is unknown. Public intervention generally replaces an objective derived from a political compromise. So, many forms of public intervention are observed, including some for one and the same environmental objective (see Table 5.2). For example, compensation in the form of agri-environment payments can correspond to a subsidy for compliance with the regulations. Intervention by the public authorities can also consist of guaranteeing a system of standards and certification to serve consumer information and its credibility to indirectly remunerate some environmental services through the market for a joint product. This is then an indirect action by the public authorities on the provision of public goods, mobilizing the WTP of each category of consumer by means of segmenting the market between conventional goods and organic goods, for example.

A popular way to represent policy measures in environmental economics is to distinguish between two categories of policies: market-based and command-and-control. Tradable emission permits, environmental taxes and subsidies are found in the first category, while the second category contains non-tradable emission authorizations or bans, technological standards and self-reporting (transmission of information). Taxonomy of the possible measures has been proposed by Russell and Powell (2002), according to criteria related to objectives and means of the policies. This has the advantage of going beyond the usual and sometimes artificial distinction between regulatory measures (command-and-control) and incentive-based instruments (market-based). Table 5.3 presents such taxonomy.

It should be noted that some instruments denoted as incentive-based (e.g., subsidies), can indirectly impose a particular technical specification, as would a command-and-control instrument. Market-based incentive-driven instruments are popular among economists because of some of their theoretical properties. Their purpose is to modify, more or less durably, the behavior of users by acting on the relative costs of access to natural resources on the one hand and other economic goods on the other. In the case of competing resources of modes of access to resources, these instruments will modify the cost and therefore the profitability (for a producer) or the utility (for a consumer) of a natural resource or a particular

Table 5.2
Assessment Criteria for Environmental Policy Instruments

Static Considerations	
	Efficiency
	Information Needs
	Ease of Control and Enforcement
Dynamic Considerations	
	Flexibility Regarding Changes in the Context
	Incentives for Technological Innovations
General Institutional Requirements	
	Regulator: neutrality, technical capabilities (data collection and management, expertise, modeling, budget management, monitoring and control)
	Users: experience with markets, trust in regulation, technical capabilities (production and consumption decisions)
Political Dimensions	
	Implications for Redistribution
	Ethical Message conveyed by the Instrument
	Perceived Equity
Risks perceived a priori	
	For the Regulator: objective not reached, technological lock-in, possible perverse effects of the instrument
	Users: false convictions, « ratcheting down » of requirements

Source : Russell and Powell (2002).

Table 5.3
Taxonomy of Environmental Policy Instruments

	Specification of the objective	**Non specification of the objective**
Specification of means	Authorizations and bans	Subsidies for capital equipment
	Technological and performance standards	Technical assistance specific to a particular technology
		Allocation of non-tradable permits
		Minimum standard of care
Non specification of means	Performance standards	Tradable permits
	Voluntary agreements	Taxes
		Subsidies of operating costs
		General technical assistance
		Information reporting

Source: Adapted from Russell and Powell (2002).

mode of access. The simplest case to consider is environmental taxation in production activities.

5.2.2 Environmental tax and natural resource conservation

Consider an environmental regulator wishing to promote a reduction in the overall level of resource extraction, from a given population of producers. If the regulator has complete information about production technology, he can set a tax on extracted levels of the natural resource so as to increase the relative cost of access to the resource with respect to other production inputs. For a given technology, producers will adapt to this change in costs by substituting more or less other inputs to the natural resource, in order to maximize profit from production. The solution to this profit-maximization is such that the relative benefit in terms of output brought by the natural resource with respect to other inputs is equal to the ratio of unit costs. The latter being constant, it is then clear that imposing a unit tax on extracted levels of the resource will lead to an adjustment of the relative input levels. Since the production function is assumed to be concave, the input demands will be non-decreasing in their unit costs, and the marginal impact of the tax rate τ on the extracted resource level will lead to a possibly non proportional adjustment of the demand for the natural resource. For a given specification of technology, it is therefore possible to determine the exact level of the unit tax such that the extracted level will be equal to the one chosen by the regulator.

The application of the production model described above illustrates several difficulties in the implementation of a regulation policy based on an environmental tax. First, the regulator must have complete information about the production technology. The simple model above can be extended to accommodate for several outputs and inputs (natural resources). However, the sensitivity of the demand for the natural resource to multiple factors (climate, in particular), makes the construction of a representative and exhaustive model of production very difficult. Second, the model implies that producers already react to the "cost signal" when accessing the natural resource. In other words, the demand function for the natural resource as an input with respect to its own price of access cost must already exist. There are cases however, in which such a demand function is not relevant (the natural resource may be charged through a fixed payment, a collective allocation system may impose a cost of access not proportional to extracted level, etc.) A possibility is then to construct a demand function from constraints imposed on the access to the natural resource (quotas), and to compute the value for a producer associated with the relaxation of the constraint.

Given the difficulties associated with imperfect information on the technology and/or individual extraction levels, other policy instruments may be considered. Even if imperfect (second-best) from a theoretical point of view, they nevertheless allow to influence the behavior of users in the direction determined by the regulator. The practical difficulty is then to choose between an optimal policy (from a theoretical viewpoint) associated with high control and management costs, and a second-best, inefficient policy which would be easier to implement. In the case of a quantitative resource management policy, a second-best instrument allowing reducing the management costs of the policy is the indirect taxation of the resource use. More precisely, as resource extractions are difficult and/or costly to verify on an individual basis, an alternative measure consists in increasing access cost indirectly through output obtained from the resource, or through the associated production inputs. Assuming a relatively homogeneous technological mapping between the resource level and output, it is in principle possible to design a tax on the resource or on the output level.

5.2.3 Quotas

An alternative instrument to environmental taxation is a system of permits (quotas) on the natural resource, attributed to individual users. Such permit or quota can be limited in time or in space, and can be temporarily or indefinitely suspended. The important point is that regulation does not exert itself through an increase in the access cost to the resource, but by means of a limitation of use. In some well-defined cases, the consequence for an individual user in terms of a change in (production or consumption) practices will be identical to the one obtained through taxation. In practice however, the information is asymmetric in favor of the user, and theoretical results are available on the relative properties of the tax and the permit in such case.

Depending on the legal nature of property rights and rights of use of the natural resource, permits can be allocated once and for all or traded on a market. In the latter case, regulation reduces to the allocation of the initial permits and to the control of compliance associated with the permits. A market for tradable permits has the advantage of letting users determine more or less automatically the equilibrium price according to their valuation of the resource. More precisely, users valuing the resource at a low level can benefit from their permits by selling them to users whose valuation is higher. At the equilibrium, users whose WTP (marginal utility or profit) is greater than the unique market price will pay for permits, and the natural resource will be exploited in priority by users who value it the most. This efficiency of markets for permits is only valid under the assumption of perfect competition, with relatively homogeneous market participants. More recent research has shown that, given the particular features of some natural resources (water, for example), the flexibility brought about by the market with respect to a command-and-control or a taxation policy is not as important in practice (Tietenberg 2004).

5.2.4 Cost-benefit analysis

Public projects for the environment and natural resources often imply costly investments over a long period of time, implying that such policies should be evaluated with regard to their long-run benefits. Deciding on which public projects to finance may therefore take several years because of the need to collect information on those benefits and to evaluate the multiple sources of uncertainty. In order to compare water supply projects aimed at increasing water availability and its having various life times, it is necessary to consider an appropriate method to prioritize competing projects in the face of limited public budgets. The Cost-Benefit Analysis (CBA) has been used for several decades in the US, Great-Britain and Scandinavian countries, as a tool for assisting decision makers in domains such as public health, road safety, and the environment. It is recommended by most international organizations (WHO, UNEP, etc.) and is compulsory in the US for projects with expected impacts above US$10 million.

The Cost-Benefit Analysis is a normative tool, helping the design of a socially efficient system of managing the environment, collective risks, etc. It does not deal with the positive aspects of tax design, liability rules, social acceptability of policy measures, etc. CBA consists in combining scientific and technological information with social preferences associated with future outcomes, whose benefits and costs can be assessed. The comparison between costs and benefits of policy options provides the decision maker with a relatively simple decision criterion, because CBA ranks these options according to the difference between expected total benefits and costs for each project.

Consider for example a project aimed at improving water availability through the creation of an artificial reservoir. The components needed to perform a CBA are:

- The probability that the future water availability will drop below some predetermined threshold (a minimum flow rate, for instance), p
- The loss associated with the event above, or more generally, the value for society such a risk, L
- The cost of the public project allowing to avoid this risk, C
- The probability that the public project will become fully effective, q.

In this case the CBA method will evaluate expected benefits from the project (probability of success multiplied by the avoided loss to society) multiplied by the probability of the negative outcome, and compare it with the cost of the project, i.e., $pqL \lesseqgtr C$. In order to account for long-term benefits, assume to simplify that the probability of success is 1 for the public project. The cost of the latter is denoted M, with annual benefits for society of g from d years onwards. In order to compare the current (upfront) cost of the project with future benefits, we introduce a discount rate denoted r, with $\delta=1/(1+r)$. The sum of discounted benefits from period d is:

$DG^g(g)=\sum_{(i=d)}^{(+\infty)}\delta^i\ g=\delta^d/((1-\delta))\ g$ *(since* $\delta<1$*),and the project will be accepted if* $M/g<\delta^d/(1-\delta)$,

where M/g is the cost-benefit ratio. The important point in this simple example is that the choice of the discount rate influences whether the project will be accepted or not.

In this simplified example, the benefits for society appear as a synthetic expression with an obvious sign. In reality however, the consequences of implementing the project can be beneficial for some sectors or population categories, and harmful for others. Alternatively, the project can yield benefits for economic activities but be detrimental for ecosystems. It is therefore essential to carefully decompose all the consequences of the project's implementation for each sector of the economy (and possibly various social groups), and to propose a criterion for weighting associated values. CBA is by construction oriented towards citizens, because information on preferences is obtained directly from them (stated preferences) or from observing their choices (revealed preferences) (see Chapter 6).

The general principles of CBA can be detailed as follows. First, the general rule is to accept any project which would lead to benefits higher than the cost. With CBA a decision is always evaluated with reference to an alternative decision (the status quo, or postponing the decision to a future period, etc.) whose outcomes are also evaluated. Second, all benefits and costs need to be compared, which implies that one is able to convert them into monetary values. All hypotheses need to be justified and CBA has to be first evaluated by (multidisciplinary) experts. Finally, the computation of costs and benefits for a given situation may depend on the objective of the decision maker.

Whittington et al. (2008) applied CBA for evaluating the relevance of a major project for mobilizing water resource in Ethiopia. This project concerned a multi-purpose dam to be built in Ethiopia with a shared interest from other Blue Nile countries (Ethiopia, Sudan, Egypt). The expected life time of the dam was 75 years. On the benefit side, the project was designed to generate hydropower energy in Ethiopia, as well as increase the availability of water to farmers both in Ethiopia and in downstream countries, and limit the risk of floods by regulating the flow rate. Finally, a positive outcome from the project was the reduction of CO_2 emissions because of the substitution of energy sources in favor of hydro-electricity. On the cost side, apart from the investment in capital and operating and maintenance costs, the opportunity costs of flooded land devoted to the dam had to be accounted for. Furthermore, population living on the site of the dam had to be relocated and new means of subsistence to be identified for this population. Finally, with such a massive project, there was a catastrophic risk to be evaluated on the cost side. Table 5.4 presents the evaluation of the main cost and benefit components associated with the project. With a discount rate of 3% per annum, the benefit-cost ratio is 3.7, and it reduces to 1.8 when the discount rate is 6%. This is usual in cost-benefit analyses, as the benefits tend to take longer to materialize than the costs—in particular the fixed cost of the project. In other words, discounting future periods affects benefits more than costs. Besides, the catastrophic risk was estimated at 0.01%, whereas the reduction of flood risk was estimated at 50%. With less optimistic (or more pessimistic) figures, the benefit-cost ratios obtained would have been less favorable to the project.

Table 5.4
Benefits and Cost Components of the Multi-purpose Dam in Ethiopia, Selected Values of the Discount Rate

	Discounted value (million US$)		
Discount rate	**3%**	**4.5%**	**6%**
Benefits			
Hydropower generation (incl. downstream)	9 643	5 958	3 907
Downstream irrigation in the Sudan	2 630	1 625	1 066
Reduction in carbon emissions	1 446	894	586
Reduction in flood risk (50%)	123	77	52
Total benefits	13 842	8 553	5 610
Costs			
Technical capital	3 115	2 946	2 791
Operation and maintenance	511	330	225
Carbone missions due to project	80	76	72
Re-housing of displaced population	22	22	22
Catastrophic risk (0.01%)	14	10	7
Total costs	3 743	3 384	3 117
Benefit-cost ratio	3.7	2.5	1.8

Source: Whittington et al. (2008).

5.3 Water

Contrary to most other goods or resources, water is essential for many consumption and production activities. In economic terms, perfect substitutes for water are rare for most uses (irrigation, residential use, etc.) which implies some significant economic value for water. However, the essential nature of water does not always make it a particularly costly resource. For economists, the value of water depends first on the way it is used, and therefore on a set of conditions (e.g. season, localization, characteristics of the resource). The value of water is therefore not unique and will depend on two types of factors related to its characteristics and its conditions of access. For instance, residential use will entail a better quality standard and characteristics such as pressure for tap water, whereas irrigation or industrial water use will require a safer mode of access.

It is sometimes argued that water should be made available at no cost, because it is a natural (and a universal) good. This argument misses the fact that the provision of water (in particular, through collective networks) entails a cost for the community, as does every other service. If this cost is not adequately recovered by the service supplier (public or a private operator), the quality of the service is likely to suffer, which would result in a more dramatic situation than when the user is paying for the service. This problem is particularly visible in many developing countries in which the lack of financial resources by public water operators has lead to a massive underinvestment and ultimately to a substandard water network unable to supply water with minimum quality standards.

Another point concerns the misperception of water scarcity. Throughout history, populations have settled along river streams and developed activities which were consistent with such proximity. With the rapid development of industry and/or urban areas however, water needs have been increased not only in terms of volumes, but also in terms of availability across areas within countries. This increasing discrepancy between aquatic resources and the localization of needs has led to the development of collective water networks in many parts of the world, thereby introducing a modified perception of resource scarcity. Indeed, there exists a wide gap between the resource level which is theoretically available (through ground water and river streams) and the level which can practically be delivered by the network. The latter is sometimes responsible for dramatic shortages, although the characteristics of the area (or the country) may lead users to believe that water is abundant.

The seemingly homogeneous feature of the water resource and the focus on its quantitative management may lead one to believe that every policy aimed at reducing water use is moving in the right direction. In reality however, several steps should be taken before a policy implementation is considered. First, one needs to evaluate accurately the trends in future water needs (corresponding to human activities), and to compare them with the theoretical water availability. In particular, the potential impact of climatic change is one of the many parameters to account for in this analysis. Second, the capacity of existing infrastructures should be evaluated as well, and in particular their capacity to provide the resource with limited losses and at the lowest possible cost, which implies an economic assessment of a possible infrastructure upgrading. Finally, the quantitative management of the resource should proceed from the definition of a precise objective, and on the basis of an operational criterion.

5.3.1 Water pricing schemes

A study by Bos and Wolters (1990) on the pricing of irrigation water has shown that, out of 12.2 million irrigated hectares in the world, about 60% were associated with area-based payment, and only 25% with a volumetric charge (proportional to extracted volumes). Even if the former has less incentive power, the area-based payment is preferable if the policy implementation costs are high. In some countries, payments may be conditional on the type of crops, as in Mexico, Peru and Turkey, to discourage water-intensive agricultural practices. Concerning the indirect mode of charging water, where withdrawals are not observed but assumed proportional to other production inputs (energy in particular) or on output level, the issue is the possible asymmetric information between the producer and the regulator on production technology or cropping practices. This is the case of the Philippines, where payments are based on crop yield and climate season.

The method to use for charging irrigation water ultimately depends on farmer characteristics and on local conditions which may lead to a fairly heterogeneous relationship between water use and land or production level (Bontemps and Couture 2002). In any case, the adopted solution will have to take into account implementation and management costs of policy measures, which can in some cases offset the theoretical advantages of some instruments (Johansson 2000). Table 5.5 presents the properties of various instruments for managing water demand through tariffs or charges.

Some regions in semiarid or drought-prone settings have adopted a hybrid system of water quotas and tariffs, in which a maximum water volume is first allocated, at the scale of a (small)

Table 5.5
Pricing Modes for Water

Mode	Implementation	Potential efficiency	Efficiency horizon	Demand management
Volumetric (uniform price)	Difficult	First best	Short run	Easy
Indirect, based on observed inputs or output	Less difficult	Second best	Short run	Fairly easy
Area-based	Easy	None	-	Via restrictions on crop types
Two-part tariff	Fairly complicated	First best	Long run	Fairly easy
Water markets	Difficult	First best	Short and long run	Depends on market types

Source: Adapted from Johansson (2000).

watershed, to a community (association of users). A water-sharing rule is then decided within the community of users, accompanied by a system of water charges (possibly fixed fees) for individual farmers. In the Egyptian Nile Delta area for example, operation and maintenance (O&M) responsibilities have been delegated to water user associations at the level of the tertiary canal (mesqa), and at the secondary canal level, irrigation and drainage O&M activities are expected to be delegated to Water Boards, following an amendment of Law 12/1984 on water user associations (Mohamed and Jagannathan 2009).

The advantages of such a system is that it protects the resource if payment is proportional to withdrawals, it allows for a transfer of maintenance costs to users, and it is better accepted by water users because of its lesser impact on revenue. This system however has drawbacks: it can be very inefficient in the case of water shortages, as it then leads to a homogenous reduction in water quotas, and it lacks flexibility in the long run when technology is modified.

Al-Damkhi et al. (2009) provide evidence on the deterioration of the quality of water resources in Kuwait, which is partly explained by wasteful consumption of water. They propose implementing a sustainable management system in Kuwait, raising public awareness about water scarcity while shifting the goal of water management from increasing supply to improving supply reliability and quality with the use of clean technologies. Gohar and Ward (2010) examine the potential for irrigation water trading to improve the efficiency of Egyptian agricultural water use. They develop a catchment scale framework and characterize the hydrologic and economic impacts of water trading, under restrictions imposed by food security, technical and institutional constraints. Their results suggest that developing water markets among Egyptian farmers can increase the economic performance of irrigation water use in Egypt, by raising farm income by 6.3 to 7.9% every year.

Concerning domestic water use, most Arab countries are characterized by average water price below marginal cost, with irrigation fees being less than fees for domestic use. Furthermore, in many cases, full irrigation costs are not covered by water fees, as only pumping (variable) costs are charged to the final user. Table 5.6 presents ranges of water prices for irrigation and residential uses in Arab countries.

Egypt does not have a generalized tariff system for irrigation, while Lebanon has adopted an area-based payment scheme. In Morocco and Tunisia irrigation is partly managed by volumetric pricing, and only Jordan has an increasing block rate system with irrigation quotas (see below). Yet, when irrigation or domestic water prices increase in a significant way, some studies have identified a significant elasticity of demand for water. For example, tariff increases in Tunisian irrigated perimeters led to a reduction of water demand corresponding to a price elasticity between-0.07 and -0.34, depending on the region and the type of crop. Massive tariff increases can however have detrimental consequences for the environment. In Morocco and Tunisia for example, farmers faced with such increases were led to bore their own well and substitute water from the collective network with private (groundwater) sources. For residential water use, some countries have adopted increasing block rate structures: Palestine, Jordan, Egypt (Alexandria), Morocco and Tunisia

Table 5.6
Irrigation and Residential Water Prices in Selected Arab countries

Country	Conventional water tariff ($/m3, unless otherwise noted)	Domestic water tariff [a] ($/m³)	Marginal cost of raw water supply ($/m³)
Algeria	0.03	0.16 - 0.52	0.26
Bahrain	0.01-0.23	0.07- 0.22	Pumping cost
Egypt	NA-Annual land tax (About $3/fed/yr)	0.04	NA
Iraq	5-12% supply cost	0.01	NA
Jordan	Area-based fee	0.70	0.32
Kuwait	Pumping cost	0.58	NA
Lebanon	NA-Annual land tax ($6-330/ha/yr)	0.12-0.42	NA
Libya	Pumping cost	0	NA
Morocco	0.02-0.06 Pumping cost < 0.18	0.24-0.95	0.02-0.11
Oman	Pumping cost	1.30	NA
Palestine	NA	0.23	NA
Qatar	Pumping cost	No charges for nationals	NA
Saudi Arabia	Pumping cost	0.03 - 0.04	NA
Syria	NA- Annual levy	0.06 - 0.17	NA
Tunisia	0.07	0.3- 0.4	0.09-0.16
UAE	Pumping cost	1.00	NA
Yemen	Pumping cost: 0.05-0.2	0.04	Pumping cost

Source: Jeuland (2012).

(Chohin-Kuper et al. 2002).

5.3.2 A cross-country comparison of irrigation management policies

It is interesting to note that the incentive power of policy instruments for regulating water use is not necessarily positively related with the average water scarcity at the country level. In Egypt and Libya, implementing incentive-based or command-and-control instruments is not considered a priority in managing demand, and water supply policies are employed instead, even when this may jeopardize the sustainability of water resources in arid settings. On the other hand, Morocco and Tunisia have developed volumetric pricing and have initiated the creation of water agencies. In these two countries, plans for programmed price increases were decided upon, which is interesting for economic actors as a signal is sent in advance indicating the resource scarcity. In the past, price reforms have led to a significant decrease in water use in Tunisia: a 400% increase in water price between 1990 and 2003 was followed by an immediate decrease in water withdrawals. At the same time, a massive effort was undertaken to generalize water meters in farms. However, announced price increases have not always been followed in practice, which has sent bad signals to operators in the water sector. Lebanon is known to be a country experiencing fewer problems with potential water availability, but this impression is misleading. Public networks need upgrading to cope with a rapid increase in water demand from all sectors, and actual water availability is moving gradually away from potential availability. The progressive adoption of two-part tariffs has been decided, in particular for new irrigated watersheds in South Beqaa.

Jordan is one of the Arab countries with the severest threat of a permanent discrepancy between water supply and demand. Increasing block tariffs are applied but unit block prices are too low to be really incentive-driven. However, this is the only Arab country in which a generalized system of increasing block rate associated with a quota for irrigation applies. In both Lebanon and

Jordan, policies of price increases have been announced (Chohin-Kuper et al. 2003). Morill and Simas (2009) present a legal analysis of water laws in Arab countries. Every Muslim has to right to drink (shafa), including his livestock, but the right to transfer or sell water varies depending on the religious group. Water can be sold on a volumetric basis and not as a lump sum transfer for Shi'ites, while for some Sunnis selling or transferring water is restricted.

In Egypt, water is not charged for the resource itself, but the State is allowed to recover water system management costs. Jordan has a well developed system of water tariffs and charges, including charges for drilling the resource and renewing withdrawal permits for well extension and maintenance, etc. Irrigation tariffs are imposed on a volumetric basis except for volumes below 150,000 m^3/year, according to an increasing block rate system: 25 Fils /m^3/year from 151,000 to 200,000 m^3/year, and 60 Fils/m^3/year for over 200,000 m^3/year. For drinkable water, the charge is 250 Fils/m^3 from wells, and is less for water extracted from wells designated as non-drinkable. In Lebanon, according to the law, users of residential, irrigation and industrial water are subject to a volumetric charge. However, tariffs are fixed by law and as a consequence are very difficult to revise, implying that actual water charges often do not correspond to the delivery and treatment costs (see Abdulrazzak and Kobeissi 2002). In Morocco, water charges can be enforced against the operator of a water intake, while Tunisia also provides for water charges when water withdrawals do not correspond to a public nature (general interest projects).

It is interesting to compare the state of water management policies in Arab countries with ones from some developed countries that also face increasing scarcity issues. In Greece for example, quantitative restrictions apply in periods of scarcity, but only water from small municipal networks is charged (at a very low level) for irrigating farmers. In Spain, public authorities realized that the country was lagging behind in terms of water management and needed to manage water resource in a more efficient way. The most frequent system consisted of a coupling between land and water rights, and an area-based fixed payment for water withdrawals (Garrido 1999). A recent procedure has been implemented to allow for modifying water rights so as to encourage volumetric pricing. The country has adopted the method of quota allocation to communities or individual farmers with volumetric charges, with an annual revision of their quotas. There is also an overcharge for communities which do not respect their quotas. Reforms are gradually extending beyond small-scale implementations of local projects, and some experiments have been conducted with two-part tariffs associated with a water quota in farmer co-operatives of the Guadalquivir river basin (Berbel and Gomez-Limon 2000). The performance of the current system is also better because of modern irrigation techniques (40% of irrigation systems use sprinklers or drop irrigation).

In New-Zealand, water withdrawal permits are required and a fixed payment applies to farmers where the set amount is based on water distribution costs. Given the increasing resource scarcity, a modification of the pricing system will admittedly be necessary in the future to move towards volumetric pricing. In the US, irrigation is often subsidized and moving towards incentive-based pricing seems difficult because of its likely impact on the market for farmland. California is an exception, with a 1992 law establishing a water price based on type of use, and the end of automatic renewal of subsidized-tariff contracts. In Southern Italy, an ambitious policy has recently been implemented, with water quotas around 2000 m^3/ha associated with two-part tariffs for water, allowing for a "double penalization". This system has been recently delegated to local water agencies in charge of deciding the quotas as well as any subsidy system which may be adapted to the local situation. Australia is certainly the developed country which has implemented the most ambitious reforms (Turral et al. 2005). A new management system allows allocating water to the most efficient users by decoupling water rights from land rights. Water rights are now converted into tradable permits and the allocation of available volumes has been optimized by the move to this type of market. Concerning water pricing, several principles have been adopted: relationship between unit price and distribution costs, no discrimination among farmers and no price distortion allowed between Australian States. Finally, withdrawals have recently been capped and the level of water fees has increased following several drought episodes which affected the country.

Turkey has adopted volumetric pricing since 1993 for irrigation. A global water volume is allocated to each hydrological district, which charges a fixed payment by irrigating farmer, to cover maintenance costs. Although the tariff has a poor incentive power, it is generally considered fair. Costs are covered and the quality of the service is gradually improving.

5.3.3 Supply-side water management

According to Sowers et al. (2011), governments in MENA countries have put a low priority on adaptive strategies regarding water scarcity, and have concentrated instead on large scale supply-side projects (desalination, dams, inter-basin water transfers, etc.) and importing virtual water (Al-Sadek 2010). A major challenge for Arab countries is to close the gap between limited water resources and the increasing demand for water from competing users. Policies which can be implemented concern not only demand management through pricing or quota allocation, but also supply-side management. In fact, many Arab countries have defined policies for augmenting supply before demand management was considered. This was the case in Egypt until the 1990s, where investments in water supply projects have been significant. As shown by Mohamed and Jagannathan (2009), water resource management is considered a cornerstone of national security and, as such, is financed from the national budget. However, water charges for delivery from public infrastructure only partly cover delivery and treatment costs. Examples given by Mohamed and Jagannathan include farmers on the Nile Delta paying only the marginal cost of water delivery to the farm but not the conveyance costs from the river system, and residential users paying water tariffs representing only 20% of treatment and delivery costs. There is therefore a high degree of dependence of water utilities on the public budget, which does not provide incentives to improve the quality of service to residential users because tariffs are kept artificially low. Social acceptability of a tariff increase is also likely to be low, as improvements in quality of service are not expected by a large fraction of residential users. For example, residential water tariffs in Cairo, Egypt, are among the lowest of all large cities in developing countries, and domestic users actually pay only for between 10 and 25 % of water supply and sanitation (Mohamed and Jagannathan 2009). In cities like Alexandria, cost recovery reaches 50% for water supply and 10% for sanitation.

Heavily subsidized water utilities may not only be inefficient, but may also increase inequalities between poor and non-poor households, and between communities. First, water tariffs are generally higher in rural and small-medium communities than in large cities, and the quality of service is often less satisfactory, which means that poorer households and farmers may need to depend partly on private-sector water vendors and wastewater removal companies, at higher rates than in larger cities (Zeggagh et al. 2010). Second, subsidized increasing-block tariffs may be poorly targeted and benefits accrue to non-poor households, of smaller size and which may afford water-saving appliances. Non-targeted subsidies also benefit richer farmers who often use the most water (Mohamed et al. 2009).

5.3.4 Concerted water management

Several authors have criticized the systematic use of economic instruments, on the grounds that they were poorly adapted to the management of a resource with strong local stakes and an intrinsic value remote from the principles of a market economy. It is claimed that water allocation rules based on concerted and collective participation and a decentralized organization are better suited to water resource management. It is important to note that the numerous experiences of participatory and concerted water management throughout the world cannot be transposed to any setting, because they are conditional on very specific requirements: the relative importance of stakeholders, the influence of the general or the local government, etc. In rural settings remote from preexisting collective networks and with actors relatively homogenous in size such allocation mechanisms have been proved to be efficient, as shown by Ostrom (1992/1993). However, most concerted decisions of water allocations are characterized by the absence of a volumetric pricing system, and correspond in fact to an implicit system of quota allocation. The latter acts as a constraint on the production capacities of the most efficient producers, namely the ones who can value the resource relatively more than average. Unless a market for tradable use permits is established, allocation rules which do not account for heterogeneity in private water valuation can lead to inefficient decisions for the community. The question to be asked is then: are allocation rules based on "non-market" mechanisms which are less efficient in theory preferable to economic instruments which are more interesting in theory but which may be also inefficient once transaction and implementation costs are accounted for.

As documented by Louati and Bucknall (2009), Tunisia has a long experience of self-managed water systems. From the early 1900s, irrigation unions were first created in the wadis of Central Tunisia, and developed in the southern Tunisian oases. These associations were converted in 1987 to communal interest groups to develop public water resources and construct and maintain public water works. They started to be monitored by regional committees in 1992 to ensure the proper implementation of regional water-conservation programs. In 1987 the management of all drinking water supply systems and borehole irrigation on public land was transferred to farmer groups (GIC).

Blomquist, Dinar and Kemper (2005) have analyzed the implementation conditions and the performance of eight systems of concerted watershed management, in various countries (Spain, Poland, Australia, Brazil, Canada, Costa Rica and Indonesia). These authors have examined the way such systems succeeded in improving resource management when confronted with changes in the context. They conclude that, although the management of the resource has generally improved, significant problems remain in most cases because of the difficulties these management systems face in rapidly adapting to new issues (salinity, increased risks of flooding, rapid increase in water withdrawals, etc.). Implementing participation-based management systems implies modifications in the relative power of stakeholders, which can be a source of conflict and additional problems, ultimately jeopardizing the implementation of the system in some cases. Political economy considerations play an important role in the water sector, and reforms aiming at achieving more decentralization and concertation with an active participation of stakeholders is likely to take a long time. Abdellaoui (2009) provides an example of conflict management in the Moroccan irrigation perimeter of Bitit. He shows that several components are essential when considering conflict resolution in watershed management, in particular a clear water allocated rule internalized at the farmer level and a free water market to update water rights.

5.3.5 Management of water quality

In the management of water quality, two categories of emissions are generally considered: point source emissions from industry and local communities, and nonpoint source emissions from agriculture (and some industries). Policy measures can be either market-based or command-and-control, and asymmetric information may lead the environmental regulator to favor regulation modes based on specific contract-based systems. Several questions need to be addressed at this stage: a) Are actual policy measures compatible in economic instruments recommended by the theory? b) Are these instruments set at their optimal level? c) Are some of these instruments redundant?

Environmental tax systems are currently used in many countries in the world for regulating point source pollution from industries and local communities. Several problems need to be dealt with in practice when considering implementation of a Pigovian tax. First, it is necessary to know the social damage function in order to equate the unit tax to marginal damage. Second, such a tax should be computed in principle for each polluter, who may have several polluting parameters attached to his activity. Third, if the environmental regulator's objective is also to limit the fiscal burden on (some) polluters, in order to limit inflation or to avoid penalizing some industries for example, then the tax level will be suboptimal.

Another policy instrument for managing water quality through the regulation of wastewater emissions is the subsidy for end-of-pipe abatement or adoption of clean technologies. Such subsidies are generally part of a contract between an environmental regulator and an individual polluter, specifying the nature of technical capital to be invested (abatement or clean technology) as well as a subsidy on fixed costs or, in some cases, operating costs. A particular aspect of such contracts for regulating point source pollution is the bilateral relationship between the regulator and the individual polluter, whose characteristics are not always known to the former. An important stream in the economic literature deals with the properties of contracts as regulatory instruments (Laffont and Martimort 2001). Depending on whether asymmetric information is associated with an unobserved action of characteristic of the agent (the polluter), there will a moral hazard or an adverse selection issue. The objective of the principal (the environmental regulator) when asymmetric information is present, is to maximize social welfare under the individual-rationality constraint (the profit of the agent must be at least equal to the one under status quo) and the incentive-compatibility constraint (the contract mechanism must allow for a truthful revelation of his true "type" by the agent). In the case of regulating industrial wastewater emissions, the polluter can be characterized by some efficiency index in the abatement activity, or any unobserved parameter reflecting his production technology (see Thomas 1995).

Egypt, Jordan, Morocco, and Yemen are the most advanced Arab countries in terms of water quality management (Morill and Simas 2009). In Egypt, surface and groundwater are protected under the Protection of the Nile from Pollution Law of 1982. The Ministry of Water Resources and Irrigation (MWRI) is responsible for providing producers and communities with wastewater discharge licenses, while the Ministry of Health is responsible for monitoring wastewater effluent emissions. Non-treated effluent emissions are not allowed, and treated wastewater emissions from animal or human sources (local communities, farms) are restricted to non-drinkable water bodies only. Water quality standards are defined from Executive Regulations for five kinds of water bodies. The Egyptian law establishes a mutual fund supplied by fines and cost recovery schemes. In Jordan, the emission of any kind (dumping, disposal, etc.) of a substance with harmful effects in the environment is prohibited, as is the storage of pollutants close to water resources. The Jordanian law provides that any producer whose activity is detrimental to the environment should equip with abatement facilities, so as to comply with environmental standards established by the Ministry. The regulatory regime is different however for the Jordan Valley, where the Water Authority has the right to alter water sources that have been polluted. In Morocco, the administration fixes quality standards for water according to its final use, with a distinction between residential wastewater and polluted water. A pollution permit is delivered by the Catchment Basin Authority, after public inquiry, and is associated with a fixed fee. Moroccan law forbids several harmful activities (wastewater or solid waste emissions into dry wadis, etc.), but there does not seem to be any generalized incentive-based emission tax. A permit system also exists in Yemen, for production activities affecting the biophysical characteristics of water. Special regulations are expected to apply to protected water zones.

Concerning water fees for urban wastewater, only a few Arab cities have distinct fees from water supply when the wastewater treatment activity is covered by user fees: Algiers, Alexandria and Cairo, Casablanca and Rabat, Damascus and Tunis. Wastewater fees are combined with the overall domestic tariff in the case of Amman, Muscat and Dubai (Jeuland 2012).

5.4 Air

In 2010, approximately one-third of the Arab countries' population live in 218 cities with populations over 100 thousand inhabitants (Larsen 2012). The major issue related to urban concentration of population and industrial activity is outdoor air pollution, with PM being the single pollutant category associated with the most harmful health effects. The population living in cities with more than 100 thousand inhabitants is certainly exposed to PM concentrations well above WHO guideline limits of a yearly average concentration of 10 $\mu g/m^3$ of PM2.5 and 20 $\mu g/m^3$ of PM10.

Policies to control outdoor air pollution and PM emissions in particular may use the WHO standards as a benchmark for action, but unfortunately, data on actual PM concentrations in major Arab cities is still scarce and not available for medium-sized urban communities. The first action to be taken is probably to set up a system for monitoring air quality in all medium- to large-size cities in order to assess the trends in concentration of PM and other air pollutants. Such a system has been in operation, for example in Cairo, for more than a decade, and in some parts of Greater Beirut.

Although most of outdoor air pollution originates from motor vehicles, a proportion of PM is also due to some farming practices (burning crop residues) and industries (cement factories, coal-fired power plants, etc.) The latter emission sources are to some extent of a nonpoint source nature: monitoring industrial emissions is technically feasible while farming practices may be less easy to identify. Command-and-control policies to restrict burning of crop residues are best implemented provided alternative arrangements can be found for the farmers to take benefits from the available biomass after harvest (renewable energy programs in particular). Industries can be subject to command-and-control regulations as well, but a system of tradable emission quota may be preferred because such emissions have global impacts which depend less on the identity of the polluter.

There exist some experiences of voluntary agreements in Arab countries related to industrial air pollution. Maradan and Zein (2012) analyze the case of the Moroccan cement industry, which committed to environmentally upgrade its operations in 1997 to reach European environmental standards by the year 2003. The cement producers union signed a 6-year voluntary agreement with the Moroccan Ministry of Environment committing to limit as much as possible its negative environmental impacts. This voluntary agreement allowed the cement industry to benefit from a "grace period" before the Moroccan Ministry of Environment could implement its new regulation on industrial emissions. Over the last decade, the Moroccan cement industry invested MAD 2.5 billion in environmental protection, resulting in a decrease in environmental impact from 1.41% to 0.19% of total environmental degradation. All cement plants in Morocco are now certified ISO 14001, and the adoption of effective filtration systems has led to a significant decrease in emissions.

Turning to air pollution due to motor vehicles, several Arab countries have adopted ambitious policies to curb down PM emissions among others. Faiz et al. (1995) propose four types of strategies which can be considered to regulate urban pollution in developing-world cities: a) improve vehicle technology through vehicle replacement scrapping, inspection and maintenance; b) promote substitution to cleaner fuels; c) control and manage traffic; and d) improve urban transportation (mass transit) infrastructure. This implies that policy measures involving motor vehicle scrapping programs, on-road and during license renewal inspections, and area taxes are eligible, probably in that order, before investing in mass transit infrastructure. Abou Ali and Thomas (2011) explore the Egyptian regulatory policy for air pollution, based on a series of measures aimed at reducing car traffic, reducing the emission rate of individual vehicles and extending mass public transit in Greater Cairo. They show that there is some evidence (still to be confirmed by complementary empirical analyses) that the policies implemented from 2007 have started to have an impact in terms of PM concentration reduction.

5.5 Solid Waste

Solid waste poses several major problems for developing countries, including health hazards from uncollected waste and from collected but poorly disposed waste, and the economic burden of waste disposal to urban areas (Pearce and Turner 1994). According to Pearce and Turner (1993), a solid waste management policy should include several stages:

- Reduce waste at the source, until marginal benefits of source reduction are equal to marginal cost.
- Balance in an optimal way solutions in terms of landfill, incineration and recycling.
- Manage non-collected waste.
- Design regulatory policies to secure waste reduction and an optimal level of disposal.

In most developing countries, the technological choice would be between recycling and landfills. According to Mrayyan and Hamdi (2006), although Jordan became the first country in the Middle East to adopt a national environmental strategy, waste disposal is still uncontrolled and the collection rate remains low. Difficulties experienced in managing waste in countries such as Jordan are due to absence of adequate policies, of facilitating legislation, and of environmental awareness of the public. The authors assess the management practices of solid waste in the Zarqa Governorate in Jordan, and evaluate the activities of solid waste collection, storage, transport, disposal and recycling in developing countries. Poorly suited technologies and lack of funding are identified as additional drawbacks. The authors suggest that enforcing existing regulations and implementing environmental awareness programs are needed to achieve a sustainable management path for solid waste.

5.6 Agriculture

Agriculture is a major user of water resources in most countries, and section 5.2 above has already discussed economic and policy instruments devoted to irrigation. There are however other aspects of environmental regulation concerning agriculture than the quantitative management of water withdrawals. We discuss in this section the regulation of nonpoint source emissions from agriculture, with both local and global impacts on the environment.

As was discussed above, policy instruments such as the emission tax or the emission standard are poorly suited to the case of nonpoint source emissions. In agriculture, such emissions consist mostly of nitrates and pesticide in water bodies (local impacts), but also of greenhouse gas emissions (global impacts). In this category, methane (CH4) originates from cattle and nitrogen protoxide (N20) from nitrogen fertilizer application; those two gases having a higher marginal impact on global warming than CO_2.

5.6.1 Nonpoint source pollution: local and global aspects

Various solutions have been proposed to better control nonpoint pollution from agriculture (see Ribaudo et al. (1999) for a review of these methods). First, it is possible to regulate the origin of this pollution, i.e. not the direct environmental impact itself, but rather the pressure on the environment (the potential pollution), through a change in the intensity level of input use. The more straightforward policy is a ban on some pesticides, or restrictions of pesticide use for selected crop types only. This approach is difficult to implement in practice at the farmer level because of monitoring costs and of the very large number of commercial pesticide products (which would make the policy difficult to follow by individual farmers). Another instrument is an input tax on nitrogen fertilizers or on pesticides aiming at modifying the cropping practices of farmers through a change in the relative input prices. An important condition for such a policy to be successful is to ensure that alternative production modes are available; therefore, a policy of communication, training and adoption subsidy is often recommended jointly with the tax policy. Another condition is that the outlook of agricultural markets is favorable to farmers engaged in adopting alternative cropping practices. Recent economic analyses on the impact of pesticide tax policies or bans have shown that a reduction in pesticide use by farmers was in some cases neutral on their revenue, provided output prices were at a sufficient level and the price of other inputs was not modified (Jacquet et al. 2011). If farmers are also able to modify their cropping systems on top of their cropping practices, then more flexibility is given to farmers to adapt their production system following the increase in pesticide cost.

As in the case of pesticides, monitoring the use of nitrogen fertilizers on the field is very costly so that regulatory measures involving restrictions of use (quantity standard, application periods and methods) are likely to be successful only if enforcement measures are credible (and the cost of which can be supported by the regulator). A major problem with nonpoint source pollution is heterogeneity: cropping practices on the one hand and soil and climate on the other are fairly heterogeneous across farmers (and even land plot) even though production inputs used in agriculture may be relatively homogenous (especially in the case of nitrogen fertilizers). Consequently, even if the environmental pressure can be controlled at the farm level, the actual impact on the environment is more difficult to evaluate because of the complexity of biophysical transfer mechanisms (Bontems and Thomas 2000).

Because of transaction costs and informational asymmetries, top-down policies may perform poorly in practice. Alternative regulation schemes have been proposed in the literature, starting from the principle that nonpoint source pollution cannot be regulated using the same economic instruments as point source emissions. Regulation systems based on ambient pollution are applicable to a well-identified community of producers. The system proposed by Segerson (1988) among others consists of a collective penalty affecting the group of polluters if ambient pollution is above a predetermined level. The penalty can be applied directly to each polluter according to a predetermined rule within the group, or the latter can be left to decide on the distribution of payments among polluters. If the level of ambient pollution is lower than the threshold, then the penalty can be transformed into a subsidy (which could constitute a motivation for the payment of eco-systemic services). Segerson and Wu (2006) have shown that this scheme is optimal, because it leads each polluter within the group to select the required reduction in pollution so as not to “deviate” from the solution and thus avoiding the collective penalty. Millock and Salanié (2005) show, furthermore, that the possibility of cooperation among polluters can be accounted for by the regulator when designing the regulation scheme.

5.6.2 Voluntary approaches

The above mechanism based on ambient pollution relies on the notion that it could be relevant to let individual polluters organize their activities in order to reach a predetermined environmental objective. Private initiatives called voluntary approaches are based on the same idea, as well as the fact that in many cases a group of polluters may anticipate environmental regulation and organize a collective response to avoid future regulatory constraints. As an example, the Netherlands decided in 1991 to reduce the use of pesticide by 50% by the year 2000 through the imposition of a pesticide tax. Farmers and the pesticide industry negotiated with the government, and reached an agreement to suspend the tax policy, provided they could reach the objective by organizing themselves without public intervention (de Jong et al. 2001). The threat of imposing a tax in case of failure was certainly successful, as the objective of reducing pesticide use by half was eventually reached.

Other, well known solutions concern eco-labeling of agro-food products. International standards for agricultural producers are less present than for industries like the European Environmental Management Standard or ISO 14001 (Bataineh 2006, Ruzevicius 2009, and Grolleau and Thomas 2007), but a variety of labels are already in place for fresh products and meat (organic farming in particular). Producers choose to comply with technical specifications in production in order to increase or stabilize their market shares of differentiated products (environmentally-friendly food items compared to conventional ones). Their strategy implicitly requires that such markets for differentiated goods are developed, and that the proportion of consumers with a significant WTP for these products is sufficient (Grolleau et al. 2007).

CHAPTER 6

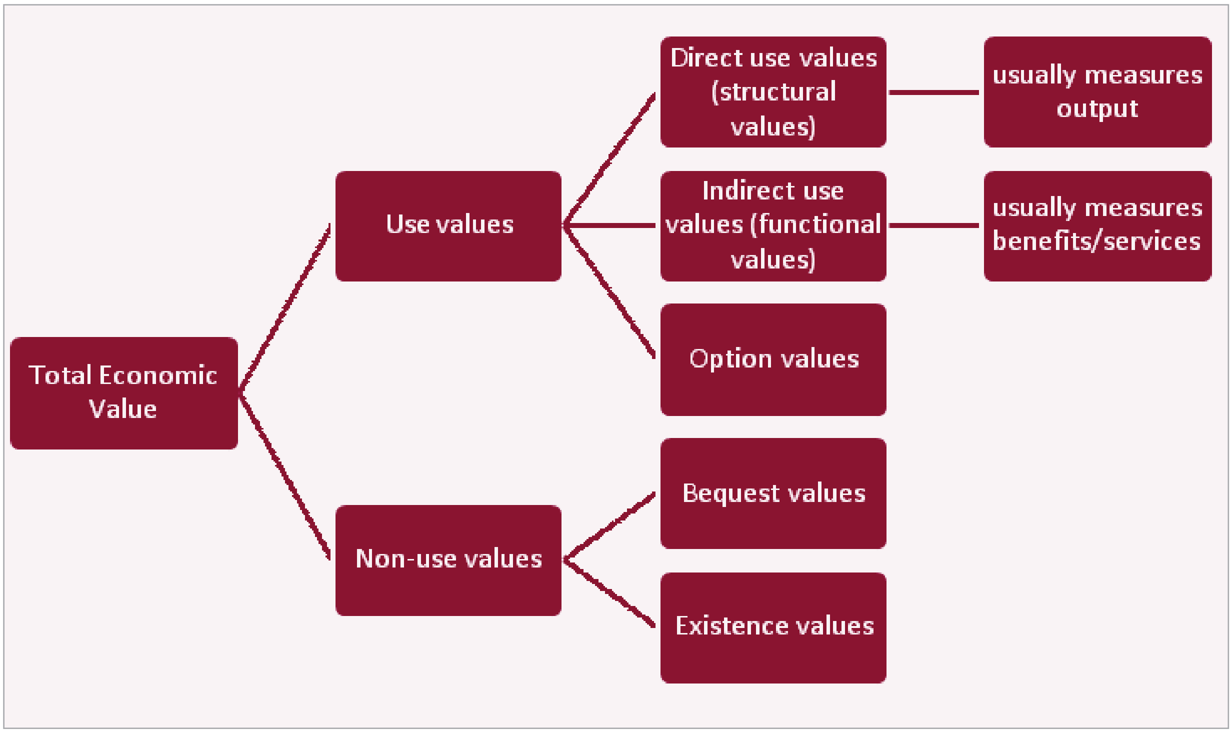
Environmental Valuation Methods

Environmental valuation is the process of putting monetary values on environmental goods and services, many of which have no easily observed market prices. Examples of environmental amenities include air and water quality improvements, scenic views, coral reefs, and biodiversity. It also includes many indirect processes associated with watersheds and water supply, agricultural practices and soil conservation, urbanization and air pollution, forests and carbon sequestration or erosion control, and ecosystem conservation.

In order to value these goods and services, economists have developed a "tool box" of valuation techniques. One general typology of these techniques consist of techniques based on changes in production or productivity, such as in the case of agricultural lands, forestry, fisheries or human health. Other techniques use survey-based information to estimate values; these are called "stated preference," while another set is referred to as "revealed preference". All of these techniques are well developed, commonly used, and quite robust. Numerous examples exist of their use, where for example Carson (2012) offers a comprehensive bibliography of the Contingent Valuation Method (CVM) where he indicates that there are over 7500 CVM studies and papers from over 130 countries. Another listing of environmental valuation studies developed by Environment Canada is the Environmental Valuation Reference Inventory (EVRI) which is a large online database of detailed information extracted from valuation studies that is assembled for policy-making purposes (www.evri.ec.gc.ca).

One can measure all or part of the value of different environmental resources by means of these methods. In this endeavor, a useful concept is that of Total Economic Value (TEV), which explicitly recognizes that the full economic value of a good or service is composed of different parts. Some are tangible and directly used, other are intangible or very remote. Figure 6.1 presents the TEV which is customarily divided between use values and non-use values. The former includes direct use values and indirect use values, whereby the environmental goods and services provide tangible products that the present generation uses. Concerning the latter, it is usually defined as bequest values; this is a form of altruism since it includes what we leave for the future generation. It further comprises existence values which is the value of knowing that something exists, even if we do not use it. Spanning the space between use and non-use values is the option value which represents the value, to a person, of having the option open for future use.

Figure 6.1
Total Economic Value



The remainder of this chapter summarizes the main differences between social and private valuation of the environment and highlights the valuation methods. It further tries to cover all applications concerning water, air, ecosystem and biodiversity, and irrigation that exist in the region. The applications encompass the following countries: Egypt, Kuwait, Lebanon, Morocco, Oman, and Tunisia.[5]

6.1 Social and Private Valuation of Environment

Environmental policy usually involves two fundamental questions. The first one deals with how economic agents can be induced to use the environment in a desirable manner. The second implies finding the right balance between environmental protection and use. The first question was covered in Chapter 5. The answer to the second necessitates dissociating between social and private valuation. From a welfare economics perspective, public intervention may be justified under the notion of a potential Pareto improvement: that is, if the overall benefits of public intervention exceed its costs. In this context, public intervention may guarantee greater efficiency in resource use. However, the sum of social benefits requires on the one hand estimating individual benefits and, on the other, aggregating these benefits to the relevant population.

The precise measure required in the process of estimating individual benefits is the net change in individual surplus (or income) that relates to a change in the quality or quantity of a non-market good. While revealed-preference methods are based on observed individual choices indirectly associated with a non-market good, the stated-preference approach relies on a survey method, directly eliciting individual preferences from reported WTP or willingness to accept (WTA). In the first case, the value of an environmental good is indirectly inferred from observed changes in expenditures or profit, and in the second case, the stated preference surveys provide information to trace the WTP distribution for a proposed change in an environmental good. In the stated-preference approach, environmental valuation combines economic theory associated with the structure of the utility function and econometric methods associated with the way unobserved disturbances enter the data-generating process. In fact, the structure of the utility function will be affected by the assumptions made about the distribution of the unobserved random utility. In the revealed-preference approach, a decision model for consumption or production is specified to predict changes in welfare or profit from changes in the quality or quantity of the environmental good. In this case, results will be conditioned upon specification assumptions needed to construct the individual model of decision.

It always helps to be concrete when discussing different ways of deciding about environmental protection. Take for example the matter of air pollution control in large urban areas (for instance the case of Cairo, Egypt). Cairo, like several urban areas around the Arab world, suffers from critical air pollution. This pollution originates from a variety of sources but particularly from old vehicles. The pollution can be cleaned up but only at significant cost. If pollution from micro-buses is to be reduced and micro-bus owners are to pay for the clean up, then the cost of transportation in the city will rise, affecting those who depend on collective transportation. The wealthy are less likely to use micro-buses and may be particularly concerned with pollution. Meanwhile, the poor may be less concerned about pollution, having other more important wellbeing concerns. Moreover, they are very likely to feel the impact of increased transportation costs. So what is to be done? If there is a vote, it is expected that the poor will obtain the majority of votes and only modest pollution control will result. On the other hand, if one looks at how much people would be willing to pay to reduce pollution, the rich will count much more since they have more resources. In this case the outcome may be quite different. Which approach should be used for making social decisions concerning pollution control? What makes the decision difficult in that case are the distributional issues. This in fact characterizes the public policy dilemma at the core of many pollution control problems in cities.

In such cases where markets do not exist or fail to generate economic efficiency, social and private valuations deviate. By focusing on individual preferences, environmental valuation takes account only of self-interest. But the issues where environmental valuation are used will often be those where public interest is the issue, that is, what is best for the society as a whole. Therefore, when a public good such as environmental protection is of concern, reaching a decision by simply adding up self-interest preferences may be wrong unless individuals act on the basis of public spirit. Pope and Perry (1989) demonstrate that individuals express different preferences with respect to intertemporal allocation of depletable natural resources. Those who obtain direct private control of these resources may be relatively less likely to conserve than society in general.

In the case of many environmental goods and services, there are no markets that can provide the data for WTP. Therefore, revealed and stated preference techniques are applied to provide the necessary data for WTP. After applying one of those techniques to calculate the individual preferences arising from the change due to an environmental project or policy, the calculation of total gain in wellbeing is crucial. This requires two forms of aggregation, an aggregation across all individuals and aggregation over time. The simplest procedure of aggregating gains and losses across individuals is to add up relevant WTP (or WTA) across all affected individuals. This requires choosing the sample carefully; it needs to be representative of the relevant population in order to justify aggregation. As this procedure weighs each individual's unit money equally, it tends to favor persons that are relatively well off. Thus, a policy which benefits a small number of wealthy individuals might be favored over an alternative policy which provides the same benefit to a larger number of poorer people. One way of testing for this effect of the program on the distribution of income is to recompute gains and losses using an adjustment factor (for more details consult Bateman et al. 2002). On the other hand, an aggregation across time is also required in case of social valuation. Time aggregation involves the choice of a time horizon and a discount rate. The former is usually determined by the life of the investment itself. The latter remains a subject of extensive debate in economics.

As an example, Saez and Calatrava Requena (2007) highlight that the incorporation of the intergenerational equity objective has rendered the traditional CBA approach obsolete for evaluating projects presenting an important number of environmental externalities and also projects whose impacts extend a long period of time. Based on the assumption that applying a discount rate rewards current consumption more than future consumption, it is only possible to introduce a limited intergenerational equity in a CBA. Saez and Calatrava Requena (2007) proposes an approach to discounting based on a different rationale for tangible and intangible effects. Two indicators are designed for environmental profitability: a) the Intergenerational Transfer Amount (ITA), which quantifies in monetary units what the current generation is willing to pass on to future generations when an environmental restoration project is carried out, and b) the Critical Environmental Rate (CER), which measures the implicit environmental profitability. These concepts were tested through an empirical case study pertaining to the assessment of an erosion control project in the southeast of Spain. The results yield standard profitability indicators that are higher and probably closer to the real values set by the contemporary society. The information provided by the proposed environmental profitability indicators is more transparent in quantifying the levels of intergenerational equity applied, thereby facilitating the difficult reconciliation of the CBA technique with the objective of sustainability.

6.2 Revealed and Stated Preference Techniques

As previously indicated, there are various typologies to group environmental valuation techniques. In this section we will adopt the one that splits them into two categories. The first category of environmental valuation concerns revealed preference (RP) techniques that use methods such as hedonic markets to estimate values; these include property value approaches and land value approaches. Additionally, the surrogate market approaches such as the travel cost method is another RP method. The second category is presented by the stated preference (SP) which encompasses a variety of methods such as CVM and choice experiment (CE).

6.2.1 Revealed preference techniques

Revealed preference methods draw statistical inference for values from actual choices individuals make within markets. Estimation of the values people place on environmental amenities or disamenities proceeds by specifying a theoretical framework and conducting data analyses from purchase decisions (prices paid and quantities purchased) according to this conceptual framework. There are four commonly used RP methods: hedonic pricing, travel cost, defensive behavior and damage costs. Hedonic models, generally property value models, are used to infer the premium that households pay to purchase a property near an environmental amenity or away from an environmental disamenity. Travel cost models are typically used to estimate use values for recreational activities and changes in these use values associated with changes in environmental quality. Models of defensive behavior focus on expenditures that people make to reduce exposure to disamenities such as water pollution or to offset adverse effects of exposure. Damage costs methods measure the resource costs caused by environmental contamination. Defensive behavior and damage cost methods are typically applied to value the health effects of pollution, in which case the damage cost method is known as the cost of illness.

Table 6.1 classifies RP methods according to the proposition made by Boyle (2003). This classification highlights key features and differences between methods used to estimate values for environmental amenities in terms of conceptual frameworks, data and applications that differ substantially. Travel cost, hedonics and defensive expenditure share a common feature that values are inferred from individual or household choices. Hedonic models are based on decisions to purchase a house from several choices that have different levels of attributes, including environmental amenities and disamenities such as the ambient air quality of the district, water and sanitation availability, and greenery of the neighborhood. Travel cost models are based on decisions to visit recreation sites that differ in travel cost and quality. Defensive behavior models are based on expenditures that households make to avoid exposure to an environmental disamenity. For example, installing a water filter to avoid illnesses that may be caused from the bad quality of municipal tap water. However, Individual or household decisions are not the basis for damage cost calculation. The cost of illness, for instance, is simply a summation of the direct (e.g. doctor visits and medication) and indirect (e.g. lost time of work) costs of treating an environmentally-induced illness. These costs result from a combination of individual and societal decisions.

Both travel cost and defensive behavior methods arise from a household production framework whereby people combine market goods that they purchase and their own time to produce a desired outcome. In a travel cost model, people combine the travel costs and other marginal costs of participating in a recreation activity with their travel time to produce a recreational experience—a fishing trip for example. The travel and time costs comprise the implicit price of participation. It is presumed that people will pay more for a higher quality recreational experience. With defensive behavior, people also combine purchased inputs with time, and the outcomes are improved health or wellbeing from reductions to exposure to a disamenity. The purchased inputs and time comprise the implicit price of improved health. Despite these similarities, the theoretical foundations of travel cost models and defensive behavior models are different. Travel cost is based on the premise of weak complementarity (Maler 1974).[6] As for the hedonic price models, they assume that a property is a heterogeneous

Table 6.1
Classification of Revealed Preference Valuation Methods

Method	Revealed Behavior	Conceptual Framework	Types of Application
Travel cost	Participating in recreation activity and site chosen	Household production, weak complementarity	Recreational demand
Hedonic pricing	Property purchased or choice of employment	Demand for differentiated goods	Property value and wage models
Defensive expenditure	Expenditures to avoid illness or death	Household production, perfect substitutes	Morbidity/mortality
Damage cost	Expenditure to treat illness	Treatment cost	Morbidity

Source: Boyle (2003).

good whose component attributes yield some level of utility (Rosen 1974). In this case, the price paid for a property is a function of the attributes which is commonly referred to as the hedonic price function. One or more of the attributes of the property may be an environmental amenity. On the contrary, damage cost does not include any estimate of consumer surplus or marginal prices. The cost of illness method simply attempts to measure the full cost of illness, including treatment costs. Treatment costs are based on individual and societal decisions of the level of care to be provided. The presumption is that if a certain level of care is provided, then it must be worth that much to society. No inference is made based on individual or household decisions. From an economic perspective, cost of illness is a less desirable benefit measure than the other three methods, which are firmly grounded in consumer choice and welfare theory.

It should be noted that there are complementary and substitute applications for each of the revealed preference methods. Consider the case where a river is polluted with toxic materials. Both travel cost and hedonic models may be appropriate, but for different affected groups. Travel cost could be used to estimate the benefits of cleaning up the river for people who travel to the river for recreation, while a hedonic model could be used to estimate the benefits to people who own property along the river. In this type of application, two RP methods are complementary in the estimation of benefits of a river clean up. The estimated benefits are additive in the calculation of the total benefit of cleaning up the river. Now consider a case where RP methods are substitutes, say the case of adverse health effects caused by air pollution. In this case, the hedonic model, defensive behavior, and cost of illness are all suitable approaches to estimate the same benefits of cleaning up air pollution. Here a choice must be made regarding which approach will provide the best benefit estimates for policy analysis. The key to using various RP methods is to identify first the change to be valued and then the affected groups. It is then possible to determine whether various approaches are complementary or substitutes, and if more than one approach should be used.

The key difference between these RP methods and the SP methods that are discussed in the next section is the type of data used to estimate values. SP methods rely on data from carefully worded survey questions asking individuals what choices they would make for alternative levels of an environmental amenity (intended behavior). On the other hand, RP methods rely on data that record people's actual choices (revealed behavior). From a conceptual perspective, SP methods can provide estimates of Hicksian surplus, whereas RP methods typically provide estimates of Marshallian surplus (Freeman 1993). Moreover, SP methods allow the estimation of use and non-use values while no one has yet developed a means of using RP methods to estimate non-use values. Another limitation of the RP methods is the inability to estimate values for levels of quality that have not been experienced. Therefore, there is a growing literature that combines both SP and RP methods. For instance the travel cost method has long been used to infer the economic value of nonmarket resources and public goods. More recently the CVM have gained popularity for eliciting these values. Cameron (1992) combines CVM survey responses with travel cost data on actual market behavior to estimate jointly both the parameters of the underlying utility function and its corresponding ordinary demand function. In her paper she offers a prototypical empirical example of a then new modeling strategy, variants of which have subsequently proved useful in many applications.

Adamowicz et al. (1994) examine and compare a stated preference model and a revealed preference model for recreational site choice. Both models are based on random utility theory and the data is obtained from the same individuals. The stated preference model is based on the respondents' choice from hypothetical choice sets. Attributes in the stated preference model are based on the ranges of the actual levels of attributes in the revealed preference choice set and are presented to respondents using a fractional factorial statistical design. Their results show that while independently estimated models appear to reflect different underlying preferences, joint estimation of the model parameters, including estimation of the relative scale parameter, provides evidence that the underlying preferences are in fact similar. Furthermore, combining the revealed and stated preference information yields additional benefits in estimation.

6.2.2 Stated preference techniques

As indicated in the previous section, there are several circumstances under which value measures cannot be derived from observing individuals' choices. There is a spectrum of methods that have in common their source of data, namely, individuals' response to questions about hypothetical situations. These questions may include: 'Would you be willing to pay xUSD for…?', 'What is the most that you would be willing to pay for..?' or 'Which of the following alternatives do you prefer…?'. Values of selected environmental goods and services are typically inferred from stated responses to such questions. Hence, these methods are normally referred to as stated preference methods. They usually encompass two broad types of methods: the CVM and the CE.

Under CVM, the valuation question may be asked in different forms. The most commonly used question simply asks people what is the maximum amount they would be willing to pay for a specific change in an environmental amenity. This is an open-ended case, in which the individual has to state a figure rather than respond to a predetermined figure proposed by the researcher. The major problem with this approach is that it confronts the respondents with an unfamiliar problem and asks them to offer a one-shot price. This is far from being a real market setting where individuals are faced with choices among sets of goods or services with listed prices. Another way to elicit this number is to use an iterative technique, which is called the bidding game. In the bidding game, individuals are first asked whether they would be willing to pay a specific sum (xUSD). If the individual answers yes, the question is repeated using a higher price. The procedure is repeated until the individual answers no. The highest price with a yes response is interpreted as the maximum WTP. The other common type of CVM question asks 'Would you be willing to pay xUSD for a specific change in environmental amenity?' and the responded cab only answer yes or no. These types of questions are known as dichotomous choice or close-ended questions. The third type of CVM questions which may be similar to the questions used in a CE method do not reveal monetary measures directly. The respondents are rather given a set of hypothetical alternatives each depicting a different bundle of environmental attributes. They are then asked to choose the most preferred alternative, to rank the alternatives in order of preference, or to rate them on some scale.

As previously mentioned, the CVM uses surveys of expressed preferences to evaluate WTP for (generally) non-market, environmental goods. This approach gives the method theoretical applicability to an extensive range of use and non-use values associated with such goods. However, recent years have seen the method come under sustained empirical and theoretical attack by critics who claim that the expressed preference statements given by respondents to CVM questions are subject to a variety of biases to the extent that "true" valuations cannot be inferred. This debate was reviewed and assessed in the recent report of the US's National Oceanographic and Atmospheric Administration (NOAA) "blue-ribbon" panel which gave cautious approval to the method subject to adherence to a rigorous testing protocol. Hence after, many studies were oriented to improve upon the method while giving some practical insights on an environmental amenity in a certain country. We try to give several examples of such applications. For instance, Wiser (2007) uses a split sample, dichotomous choice contingent valuation survey of 1574 U.S. residents to explore WTP for renewable energy under collective and voluntary payment vehicles, and under government and private provision of the good. They also evaluate the impact of "participation expectations" on stated WTP. They find some evidence that, when confronted with a collective payment mechanism, respondents state a somewhat higher WTP than when voluntary payment mechanisms are used. Similarly, private provision of the good elicits a somewhat higher WTP than does government provision. They also find that contingent valuation responses are strongly correlated with expectations for the WTP of others. Their results shed light on strategic response behavior and the incentive compatibility of different CVM designs, and offer practical insight into U.S. household preferences for how to support renewable energy.

The double bounded dichotomous choice (DBDC) contingent valuation is known to offer increased efficiency of WTP estimates compared with the single bounded format. However, evidence suggests that DBDC generates anomalous respondent behavior. Watson and Ryan (2007) provide the first investigation and explanation of these anomalies in health. Results suggest the incentives for truthful preference revelation are altered in the presence of a follow up question. This result is found using both regression techniques and analysis of raw responses. Although their findings suggest 'very certain respondents' exhibit less anomalous behavior, inconsistencies remain across bounds. The results of this study question the use of iterative valuation formats.

Bateman et al. (2008) report findings from the first UK CVM study to generally conform to the NOAA panel guidelines. The major objective of the research reported in their paper is the analysis of the effects of altering the method of eliciting WTP responses. They employed three WTP elicitation methods: open-ended questions (where the respondent is free to give any value); dichotomous choice questions (requiring a yes/no response regarding a set WTP bid level); and iterative bidding questions (where a respondent is free to move up or down from a given WTP starting point). Their results indicate that respondents experience significant uncertainty in answering open-ended questions and may exhibit free-riding or strategic overbidding tendencies (although this is less certain). When answering dichotomous choice questions, respondents seem to experience much less uncertainty although the suggestion that bid levels affect responses cannot be ruled out, and it is clear that respondents behave somewhat differently to dichotomous choice as opposed to open-ended formats. The iterative bidding approach appears to provide a halfway house with respondents exhibiting certain characteristics of both the other formats. They concluded that the level of uncertainty induced by open-ended formats is a major concern, and that further research into the microeconomic motivations of individuals responding to iterative bidding and dichotomous choice CVM surveys is high priority. A further aim of their analysis was to test for changes in estimated mean WTP induced by the application of different forms of truncation across all elicitation methods. Recommendations are made on appropriate truncation strategies for each elicitation method.

Zendehdel et al. (2008) introduce a qualitative valuation method to elicit stakeholders' intensities of preferences for a complex environmental issue and multiple social groups. Environmental valuation studies have shown that in any complex environment with a diversity of environmental services, stakeholders have difficulties using a monetary valuation to make trade-offs between different environmental services. Stated preference methods such as CVM have been criticized for their individualistic format and assumptions of commensurability between environmental criteria. To alleviate both of these criticisms, they propose a qualitative valuation method. The method contains a discursive step to allow stakeholders to discuss and construct a list of environmental criteria and alternative plans. The list of criteria and plans is subsequently used by a group of experts to formulate an Impact Matrix (IM), which is to be used in the succeeding individualistic steps of the methodology. The first individualistic step consists of asking the stakeholders to rank Alternative Impacts (AIs) in the IM for each single criterion. The stakeholders are then asked to express intensities of their preferences through pair wise comparisons between the AIs of the constructed rank order on each single criterion. These intensities are expressed on a qualitative scale. Subsequently, to provide social intensities of preferences, a social preference (social rank order) is first determined for each single criterion. They propose to use the median value among the intensities of preferences as the social intensity of preference by assuming interpersonal comparability and taking into account stochastic monotonocity. This is a pre-processing step, which allows them to reach social intensities of preferences in the Lar rangeland (Iran), where several social groups have conflicting interests on rangeland services, leading to conflicting preferences on environmental criteria.

Contingent valuation has been used extensively in estimating the value of environmental goods. One criticism for this approach, however, is that respondents in referendum-style contingent valuation surveys may express citizen assessments that take into account benefits to others rather than benefits that accrue purely to the respondent themselves. Within this context, Howley et al. (2010) aim to examine to what extent individuals express different preferences when adopting a personal or a social/citizen perspective. While their paper provides some support for the hypothesis that individuals express different preferences when adopting collective as opposed to personal choices, reported WTP was found to be insensitive to whether or not the respondents were asked the WTP question from a personal or social perspective.

Around twenty five years ago only a handful of very rudimentary contingent valuation studies had been conducted in developing countries; at that time the problems associated with posing hypothetical questions to low-income, perhaps illiterate respondents were assumed to be so overwhelming that one should not even try. Today it is assumed by many environmental and resource economists and policy analysts working in developing countries that contingent valuation surveys are straight forward and easy to conduct. Whittington (1998) examined some of the issues that have arisen and some of the lessons learned over the late 1980s and early 1990s about administering contingent valuation surveys in developing countries. In his paper he focuses on five issues in particular: (i) explaining to enumerators what a contingent valuation study is all about; (ii) interpreting responses to contingent valuation questions; (iii) setting referendum prices; (iv) constructing joint public-private CV scenarios; and (v) ethical problems in conducting such surveys. He argues that there are numerous issues that arise in contingent valuation work in developing countries that demand careful attention, but that in many respects it is easier to do high-quality contingent valuation surveys in developing countries than in industrialized countries.

Given that, developing countries applications using another stated preference method of non-market valuation started to emerge. This method is the CE that originally developed in the marketing and transportation literature (see, for example Louviere and Hensher 1983).For the last three decades, it is increasingly being applied in other fields such as environment, health and agriculture. The CE is a hypothetical approach to elicit preferences, which allows obtaining rich information about people's preferences, although this at the same time means a more complex choice situation for the respondents. It also requires a careful design of the survey in terms of attributes proposed to respondents. For an overview of CEs see e.g. Alpizar et al. (2003), Birol and Koundouri (2008) and Louviere et al. (2000). There are an increasing number of studies using the CE technique in developing countries. Bennett and Birol (2010) survey a variety of applications of CE in developing countries to illustrate the flexibility of the CE method and the ability to apply it to a range of goods from food items, to recreation demand, to protection of unique ecosystems and choices over local public goods. The CE exercise typically requires the presentation of information to the respondent about the terms and conditions of the program offered. This is quite a complex task per se. In a developing country where illiteracy is quite prevalent, the task is even more challenging. It is therefore of particular interest to study how CEs can be applied in this context.

Compared to the CVM, the CE includes several advantages and disadvantages such as:

1. Using only CVM would restrict the respondent's choice to merely one quality where the quality of the environmental good may differ from one location to another. One could argue for the use of a repeated CVM approach with many scenarios, but this could be rather costly.
2. The NOAA panel has issued guidelines on the design of CVM studies in environmental damage suits (Arrow et al. 1993). For instance, they suggest that CVM results should be calibrated against experimental or actual market findings.
3. The CE may avoid some of the response difficulties with CVM. For example, dichotomous choice designs in CVM may still be subject to yea saying despite improvements in design standards (Blamey et al. 1999). On the other hand, CE does not explicitly ask about money values so it is argued that CE is easier for the respondent to understand than CVM.
4. Carson et al. (1999) argue that, given a consequential survey, a CVM with a binary discrete choice is incentive compatible while any other elicitation format is not.[7]
5. The use of CE in the context of environmental and health issues is more recent than that of CVM. Therefore, Bateman et al. (2002) argue that more studies using CE approaches and further evidence on their results are required before one could be confident about implementing CE approaches.

For an extensive discussion on the advantages and disadvantages of CE relative to CVM, see Bateman et al. (2002).

6.3 Water

As previously argued, contrary to most other goods or resources, water is essential for many consumption or production activities. In economic terms, perfect substitutes for water are rare for most uses (irrigation, residential use), which implies some significant economic value for water. Additionally, water degradation can affect total economic value (TEV) of a water ecosystem, including (i) direct uses, such as irrigated agriculture, fisheries, health and tourism; (ii) indirect uses, such as the decline in prices of urban land close to a polluted site; and (iii) non-uses, such as biodiversity. Moreover, water resources in the Arab world are scarce, which can induce groundwater overexploitation that may lower the groundwater level, affecting all water uses. Therefore, water efficiency is a crucial factor.

Beaumont (2000) estimates how much wealth a cubic meter of water generates in different parts of a country's economy in a selection of Arab countries. He calculates figures of water value using revealed preferences technique by combining the FAO data on water use by sector (agriculture, domestic, industry) and information on GDP generated by the major sectors of the economy (agriculture, industry, services). For agriculture and industry the calculations are straightforward as it is merely a case of dividing the wealth created in monetary terms by the volume of water used by that sector. However, for the service sector it is extremely difficult to assess just how much water is used. For the most part, water use in the service sector is confined to what might be defined as domestic uses. These include personal hygiene, food preparation, cleaning and toilet flushing. The amount of water used tends to be small when compared with industrial usage. Very little water is actually used as part of an individual service with the obvious exception of the cleaning of clothes and similar items. Any estimate of water used in the service sector is bound to be arbitrary, but it seems reasonable to conclude that per capita use will not exceed 60% of the national per capita domestic consumption. Beaumont (2000) however notes that people who work in the service sector will still consume considerable quantities of water at home when they are not working. He uses an average domestic use of 60% to estimate the amount of water used by the service industries where the number of workers in the sector is also known. His results show that the wealth created by a cubic meter of water in the three sectors of the economy varies considerably. It is particularly low in agriculture, where for the region as a whole it averages US$1.86/cubic meter. The highest value of US$9.89 is found in the West Bank and the lowest value of US$0.40 in Afghanistan. The vast majority of the figures are below US$2.00/cubic meter. In the industrial sector the regional average for wealth creation is US$532.77/cubic meter of water. However, there is a very large range from a low of US$18.58 in Egypt to a high of US$1887.69 in Kuwait. It is difficult to distinguish any overall pattern, though the oil rich countries tend to record high figures. Throughout the Middle East, the average wealth created by the service sector is US$649.37/cubic meter of water. The maximum value is US$2,036.3 in Morocco and the minimum is US$154.88 in Lebanon. Overall the data indicate that the wealth creation/cubic meter of water in the industrial and service sectors is basically similar, with the service sector tending to record the higher values in most individual countries. What the results of Beaumont (2000) clearly show is that if water availability is a limiting factor then it makes economic sense to transfer water from agriculture to the industrial or service sectors. However, the position is not

Table 6.2
Wealth Generated by the Use of Water in Each Sector of the Economy – US Dollars/Cubic Meter

Country	Agriculture	Industry	Service
Afghanistan	0.40	268.62	
Algeria	5.35	88.53	385.30
Bahrain	0.61	315.15	
Egypt	0.96	18.58	685.53
Iran	1.22	92.55	511.57
Jordan	1.68-1.91	138-207	360.10
Kuwait		1887.69	237.37
Lebanon	0.69	69.92	154.88
Libya	0.48	209.00	516.30
Morocco	1.47	109.66	2036.30
Oman	0.45	389.47	
Qatar	0.53	653.57	
Saudi Arabia	0.81	492.18	411.07
Syria	2.18	53.04	1512.00
Sudan	0.52	22.60	707.07
Tunisia	2.90	183.74	1158.36
UAE	1.16	149.05	211.01
West Bank	9.89		
Yemen	1.77	400.00	
Average	1.86	532.77	649.37
Maximum	9.89	1887.69	2036.30
Minimum	0.40	18.58	154.88

Source: Beaumont (2000).

usually that straightforward as in a number of poorer countries, a significant number of people still earn their living through agriculture.

6.3.1 Water and sanitation services

A household's decision on whether or not to connect to the piped water system has rarely been examined in the context of Arab countries. McPhail (1994) conducted a study on 82 households in urban areas of Tunis, Tunisia. His study reveals that the most important obstacle in connecting to the piped water system is the cash down payment required by the utility (corresponding to the fixed cost of access). Furthermore, the results of the contingent valuation questions showed that the respondents could easily afford the anticipated monthly charges for piped water and sewer service, and their bids for this service were very close to those for households already receiving them.

Thereafter, several country studies that evaluated water and sanitation services or health effects around the Arab countries were conducted. Tunisia, for example is already a water-stressed country. The limited water supply is unevenly distributed across the country. High demand for water resources has intensified their use creating serious challenges such as increasing degradation and risk of depletion. Using travel cost, replacement cost, damage cost and changes in productivity Croitoru et al. (2010) estimates the annual cost of water degradation in Tunisia by addressing the effects of water salinity, contamination, water logging, dam sedimentation and overexploitation of groundwater on the major economic sectors. The study estimated the overall cost of water degradation and groundwater overexploitation in Tunisia at US$165.8 million, or 0.6% of GDP in 2004.

In her work, Ahmed (2000) relies on both SP and RP methods to report that households in Cairo, Egypt are willing to pay to avoid unreliable water service, while those who are hurt the most are willing to pay the highest amount. She finds that total benefits are underestimated when the conserved water is allocated equally among households suffering from unreliable service, but is maximized when the limited conserved water is allocated starting with those having the least unreliability problem. She also finds that when water service is unreliable, Cairo households invest in water-improving technologies (WIT) such as storage tanks and electrical pressure boosting pumps. Households' WTP for water improvement programs is higher, the higher the ongoing costs of defensive technologies and lower the higher the technologies' ability to mitigate the risk of inadequate water service. Households with both a pump and a tank are willing to pay LE 5.05 ($1.53) while those using only a pump are willing to pay LE 3.18 ($0.96) per week for a water reliability improvement program. These amounts are 2.4 and 1.5% of average household monthly income. Her work further shows that females are willing to pay less than males for residential water connections. This is despite the fact that improved water connections provide females with substantial benefits in the form of time and effort savings as well as improved health status. However, she did not find support for the hypothesis that females' lower WTP results from the fact that females have limited control over household income.

Nonmarket valuation methods have proved useful in planning and evaluating investments in water and wastewater infrastructure in developing countries. Therefore, Hoehn and Krieger (2000) used contingent referendum methods to estimate household WTP for each of four types of service improvements stemming from water and wastewater investments in Cairo, Egypt. An analysis of the net economic benefits of the investments concluded that benefits exceeded costs for all projects. Cost recovery was not assured with a fixed tariff. WTP for some households was less than the per-household cost necessary for cost recovery. Cost recovery was also sensitive to whether tariffs were set for individual services or charged for a combined package of services. Hoehn and Krieger (2000b) argued that donor agencies invested millions of dollars in the 1980s and 1990s to improve water and wastewater services in Cairo, Egypt. An economic analysis of these investments raised several issues relevant to planning and financing similar projects. First, some service improvements are more valuable to households than others (i.e., a water connection was worth more than improved reliability of water service). The choice of how to allocate scarce project resources among different possible service improvements may substantially affect the measured benefits of the project. Second, recovering project costs through the fixed tariff charged for water and wastewater services in Egypt may charge a substantial portion of households more than they are willing to pay for the services. Quantity-based pricing that allows households to adjust their water use to their budget would allocate program costs among households in a manner more consistent with the value of the services.

Abd Rabbou (2000) uses CVMs to evaluate, with the help of a survey, whether the citizens in the Agami district are willing to contribute to the cost of providing a municipal sewage collection network. Abou-Ali (2003) analyzes the impact of better water quality on health improvements using two stated preference methods: CE and the CVM. These methods were administered to a random sample of 1500 households in metropolitan Cairo, Egypt. The results show that both methods give about the same welfare measures. Moreover, households in metropolitan Cairo do have a positive WTP for reducing health risks related to water quality amounting to roughly double their current water bills.

Belloumi and Matoussi (2002) focuses on the Oued Kheirate water table, the main fresh water reservoir of one of the most disadvantaged regions in Central Eastern Tunisia. In their paper, they estimate, by the CVM, the water quality value and determine the explanatory variables of users' WTP. This value represents the WTP to protect groundwater from salination. This can be integrated in the cost-benefit analysis to decide whether it is possible to preserve groundwater quality.

Water scarcity in the Gaza Strip is a real crisis for people in this area. Ground water is the main source for domestic use in the Gaza Strip and it suffers from rapid decline in both quality and quantity. The crisis should be managed carefully to secure the water demand at an appropriate price. The water sector cannot be managed successfully without a suitable water pricing system because any improvement process for the water supply service will increase the cost of this service. Water pricing must be integrated with other measures to ensure that environmental, economic and social objectives are met cost effectively. Globally, evaluation of water pricing systems continues to be a very essential issue. Subsequently, Al-Ghuraiz and Enshassi (2005) reports on a research that studied the ability and willingness of customers to pay for improved water supply service in the Gaza Strip. This factor is an important factor, which strongly affects water pricing systems. Seven hundred and sixty questionnaires were distributed among the subscribed households in the governorates of the Gaza Strip. Only 609 of them were used in the analysis. Their results revealed that the WTP for improved water supply service, which matches the WHO standard, was about 3.0 NIS/m^3. This price was also affordable by all income groups. Their study concentrated on socioeconomic factors that have not been given sufficient attention by previous studies. In other words, their paper has investigated the affordability and WTP for improved water supply service in the Gaza Strip. It was recommended in this study to build the water tariff structure, for the improved service that matches the WHO standards, on the average price 3 NIS/m^3. The use of cross subsidy technique also was recommended to help poorer households that cannot afford the average price.

Becker et al. (2012) deals with a cost effective analysis of two options to increase the water supply in Israel. The first policy is to divert 300 million cubic meters (MCM) of water from the Sea of Galilee (SOG) to the central part of Israel. This policy is the existing one. The second policy is to replace this diversion with desalinated water plants that would be built on the Mediterranean Coast (MC). These two options carry both market and non-market consequences. The first policy has a negative effect on the SOG itself due to the lower lake level. It also carries some negative consequences on the Jordan River (JR) and the Dead Sea (DS) which are located downstream. The second policy involves water production at a higher cost and has negative external effects of scarce coastal land usage and high energy consumption. A payment card (PC) contingent valuation (CV) survey was carried out at the four sites (the SOG, the DS, the JR and the MS). We show that when one takes these non-use values into account, the preferred solution will shift from the usage of the SOG to the desalination policy.

6.3.2 Irrigation water

Population growth will contribute to a decrease in water availability by 50% by 2050, and climate change is predicted to bring more frequent and severe droughts and floods (World Bank 2007). In many areas, water overuse and misuse are further degrading water supplies and threatening the population's welfare. Inappropriate irrigation practices may increase water salinity and reduce agricultural productivity. Inadequate access to clean water and sanitation results in waterborne diseases, particularly among children. Dam sedimentation and groundwater overexploitation threaten future water availability for drinking and irrigation.

Therefore, irrigation water management is crucial for agricultural production and livelihood in the Arab world, as in many other parts of the world. To implement effective water management, knowledge of farmers' demand for irrigation water is crucial to assess reactions to water pricing policies, to establish a cost-benefit analysis of water supply investments, or to determine the optimal water allocation between different users. Storm et al. (2011) emphasizes that previously used econometric methods providing this information often have prohibitive data requirements. In their paper, the CVM is adjusted to derive a demand function for irrigation water along farmers' WTP for one additional unit of surface water or groundwater. An application in the Middle Drâa valley in Morocco shows that the method provides reasonable results in an environment with limited data availability. For analyzing the censored survey data, the Least Absolute Deviation estimator was found to be a more suitable alternative to the Tobit model, as errors are heteroskedastic and non-normally distributed. They conclude that the adjusted CVM to derive demand functions is especially attractive for water scarce countries with limited data availability.

Challenges facing the water sector in Egypt call for the adoption of an integrated water resources management (IWRM) approach, which integrates all available resources to meet escalating water demand of different water use sectors. Kandil et al. (2003) provides a review of the irrigation water sector drivers in Egypt in terms of challenges, policies and their characteristics. The paper also introduces a proposal for a vision for institutional reform in the irrigation sector to provide the proper enabling environment for wide application of the IWRM concept and a greater role for the private sector in the irrigation sector. Some key steps to realize the institutional reform vision in the irrigation sector are also presented.

6.4 Air

Transport, power generation, and industry account for the bulk of air pollutant emissions in several Arab countries. Air pollution is a growing problem, particularly in heavily populated cities such as Cairo in the Arab

Republic of Egypt and Tehran in the Islamic Republic of Iran. Long-term exposure to combustion-related fine particulate air pollution is an important environmental risk factor for lung cancer and cardiopulmonary mortality (Pope et al. 2002). In addition to causing health problems, air pollution also damages the environment by reducing visibility and the landscape's aesthetic value. Croitoru et al. (2010) addresses these issues in detail for Jordan, where the cost of air pollution was estimated at 1.2% of GDP in 2006. In their study they assume that air pollution affects selected road-traffic and industrial hot spots without affecting tourism poles or overall air quality at the national level. The cost may be a good deal higher in other countries such as Egypt (2.1% of GDP) and the Islamic Republic of Iran (1.6% of GDP) because of the impact of air pollution on deaths and illnesses in those countries' most populated cities (World Bank 2002/2005).

Larsen (2012) expands this analysis across 16 countries of the Arab League. Ambient concentrations of air PM are high by international comparison with many cities in the region (e.g., Cairo and many cities in Syria). The urban population has increased by 30 million from 2000 to 2008 in the 16 countries. About 52% of the population in these countries lived in urban areas in 2008. An estimated one-third of the total population (>100 million people) lived in cities with populations over 100 thousand inhabitants in 2010, ranging from 0% in Comoros to 70% in Djibouti (Table 6.3). The proportion of the population living in cities with over 1 million inhabitants reached over 40% in Lebanon and over 30% in Iraq. PM is the outdoor air pollutant that is globally associated with the largest health effects. The WHO has recently reduced its guideline limits to an annual average ambient concentration of 10 μg/m^3 of PM2.5 and 20 μg/m^3 of PM10 in response to increased evidence of health effects at very low concentrations of PM. The populations in cities with more than 100 thousand inhabitants in the 16 countries assessed in this study are undoubtedly exposed to higher concentrations of PM than the WHO guideline limits. Data on actual PM concentrations in these cities are, however, scarce and in many cases non-existent. Available estimates suggest that population weighted annual PM10 ambient concentrations in these cities range from about 40 μg/m^3 in Morocco to over 160 μg/m^3 in Sudan. Converting these figures to PM2.5 at a rate of 0.4, indicates that PM2.5 ambient concentrations range from around 16 – 66 μg/m^3 in these countries (Table 6.3). A conversion factor of 0.4 was applied due to their arid climate with higher shares of larger size particulates than in most non-arid climates. PM concentrations in Comoros are not presented as Comoros has no cities with population > 100 thousand inhabitants. The study by Pope et al. (2002) is also used here to estimate mortality from exposure to PM2.5 in the 16 countries.

Estimated annual cost of health effects from PM pollution in cities > 100 thousand inhabitants was US $10.9 billion in 2008 in the 16 countries (Table 6.3). This cost reflects both mortality and morbidity. Cost of mortality is calculated by multiplying the estimated annual cases of mortality from PM2.5 by a value of statistical life (VSL). The cost of PM pollution ranges from an equivalent of nearly 0.5% of national GDP in Somalia to 2.9% in Iraq. The three counties with the lowest cost have low population shares living in large cities, and low to moderate PM concentrations and cardiopulmonary and lung cancer mortality rates. The five countries with the highest cost have high population shares living in large cities and/or high PM concentrations, and moderate to high cardiopulmonary and lung cancer mortality rates. The estimated cost in Jordan of 1.3% of GDP is similar to the mean estimate in Croitoru et al. (2010).

As one of the promising energy sources for the next few decades, nuclear energy is receiving more attention than before as environmental issues become more important and

Table 6.3
Estimated PM Exposure, Mortality from PM and Cost of Health Effects, 2008

	Percent of total population living in cities 100K+	Number of people in cities 100K+ (Millions)	Estimated annual PM2.5 (μg/m³)	Attributable fraction of cardiopulmonary and lung cancer mortality due to PM2.5	Annual cases of mortality due to PM2.5	Cost of PM air pollution (million US$)	Cost of PM air pollution (% of GDP)
Algeria	28%	9.6	32	0.20	3,846	1615	0.97
Djibouti	70%	0.6	22	0.15	185	17	1.89
Egypt	34%	27.4	48	0.24	18,956	3270	2.02
Iraq	52%	16	46	0.24	10,148	1214	2.86
Jordan	50%	2.9	25	0.16	898	280	1.32
Lebanon	49%	2.1	18	0.12	951	575	1.97
Libya	34%	2.1	35	0.21	866	1111	1.19
Mauritania	12%	0.4	35	0.20	197	15	0.53
Morocco	39%	12.2	16	0.11	3,615	867	0.99
Somalia	20%	1.8	18	0.12	479	12	0.46
Sudan	29%	12.1	66	0.28	8,207	962	1.72
Syria	32%	6.5	40	0.22	2,215	515	0.93
Tunisia	20%	2	19	0.13	803	272	0.67
WBG	37%	1.4	22	0.15	346	45	0.76
Yemen	20%	4.7	34	0.20	1,515	152	0.57

Source: Larsen (2012).

the supply of fossil fuels becomes unstable. One reason is based on the rapid innovation of nuclear technology which solves many of its technological constraints and safety issues. However, regardless of these rapid innovations, social acceptance for nuclear energy has been relatively low and unchanged. Consequently, the social perception has often been an obstacle to the development and execution of nuclear policy requiring enormous subsidies which are not based on the social value of nuclear energy. Therefore, this study, Jun et al. (2010), estimates the social value of nuclear energy-consumers' WTP for nuclear energy—using CVM—and suggests that the social value of nuclear energy increases approximately 68.5% with the provision of adequate information on nuclear energy to the public. Consequently, they suggest that the social acceptance management in nuclear policy development is important along with nuclear technology innovation.

Abd Rabbou (1998) attempts to value environmental damages caused by a cement factory in Alexandria, Egypt. The case study utilizes the contingent valuation approach to value the environmental damage caused by the Alexandria Cement Company in Egypt. The study also deals with the shortcomings of using this method under local conditions.

Belhaj (2003) deals with the estimation of the WTP for a 50% reduction in air pollution caused by road traffic in Rabat-Salé, Morocco using contingent valuation and hedonic price methods. In the CVM, two techniques are employed: iterative bidding and dichotomous choice, with both empirical analyses based on the same set of individuals. This strategy enables comparison between the two estimation techniques; Probit and generalized Tobit models. Moreover, parametric and nonparametric approaches are used to calculate the mean and median WTP. Subsequently, Abou-Ali and Belhaj (2005) analyze the welfare effects of the same reduction, namely 50% reduction in air pollution caused by road traffic, in both Cairo, Egypt and Rabat-Salé, Morocco using a CVM with identical elicitation questions. Despite the fact that both the numbers of inhabitants and vehicles are higher in Cairo, the WTP to reduce the impacts of vehicle emissions is higher in Rabat-Salé, although incomes are rather similar in both cities. They show that the relatively often-used benefit transfer leads to biases where damage costs are sometimes under- or overestimated.

6.5 Solid Waste, Incineration and Landfills

The Middle East and North Africa region is also, unfortunately, affected by conflicts that have caused enormous losses in terms of deaths and injuries. Such violent conflicts also damage the environment in ways that are often expensive to restore, if not irreversible. Sarraf et al. (2010) provides a comprehensive valuation of the environmental damages caused by the 34-day conflict in Lebanon in July and August 2006. The hostilities killed almost 1,200 people, injured more than 4,400 and severely damaged the country's infrastructure. Moreover, the bombing of a power plant in Jiyeh (north of Beirut) caused the spill of about 12,000 to 15,000 tons of oil into the Mediterranean Sea. The conflict left enormous amounts of demolition and military waste, including debris, rubble, and unexploded ordnances (UXOs). The valuation of damages caused by the oil spill is based on the users' forgone benefits: the difference between the expected and actual benefits derived from activities on the coast. Expected benefits refer to the level of environmental benefits that would have been enjoyed had the oil spill not occurred. Actual benefits are those provided after the outbreak of the hostilities. This study estimates the cost of environmental damage associated with the oil spill and waste at 2.4% of GDP in 2006. The impacts of demolition and military waste account for 1.4% of GDP, primarily because of the high costs of disposing of demolition waste, of casualties, and of agricultural losses caused by UXOs in South Lebanon. The damage due to the oil spill represents 1% of GDP, mainly because of the high costs of cleaning up the waste, the cost of oil burned and spilled, and the income losses from coastal services (for example, hotels and restaurants).

Another study on solid waste in the region (Bartelings 1996) was conducted as her Master's thesis. The study is a contingent valuation survey in Morocco and Sweden on solid waste disposal. Belhaj (2003) has also conducted a study that calculates the WTP for better household waste collection in Rabat-Sale, Morocco.

6.6 Ecosystems, Biodiversity and Cultural Heritage

Many studies have been conducted around the world on ecosystem services and double counting is a frequent problem that causes uncertainty and poor reliability in estimating the value of ecosystem services. By referring to previous studies of ecosystem service valuation, Fu et al. (2011) identifies the basic causes of double counting. These include ambiguous definitions and inconsistent classifications of ecosystem services, poor understanding of ecosystem complexity, inadequate recognition of exclusiveness and complementarities of individual ecosystem services, spatiotemporal scale dependence of ecosystem services, and overlap and lack of cross-referencing between ecosystem service valuation methods. In their study, measures for reducing double counting in ecosystem service valuation are proposed as follows: (1) identifying the spatiotemporal scales of ecosystem services; (2) valuing the final benefits obtained from ecosystem services; (3) establishing consistent classification systems for ecosystem services; and (4) selecting appropriate valuation methods for the study context.

Forest ecosystems provide a variety of valuable goods and services. Forests in the Middle East and North Africa cover about 20.6 million hectares, or just 0.5% of the world's forests (World Bank 2009). Despite their scarcity in the region compared with other regions, these forests provide a wealth of valuable goods and services, such as watershed protection, biodiversity, and other non-wood forest products. Forests are threatened by deforestation, however, which often induces a complete or partial loss of the goods and services on which forest communities highly depend. Barrio and Loureiro (2010) present a meta-analysis of forest studies using the CVM to value the provision of forest values around the world. In their meta-analysis, the marginal value of different management programs that provide a variety of forest goods and services is estimated. Their results show that WTP estimates for forest management programs are sensitive to the program's objectives, particularly when linked to the provision of recreational services. Other variables such as the type of forest, location, survey mode, or the type of respondent were also found to significantly affect the WTP estimates.

The potential of non-timber forest products (NTFPs) in the Mediterranean region as a source of livelihood and sustainable development has been widely recognized. Yet, surprisingly few efforts have been made to value them comprehensively. Valuation efforts usually focused on selected NTFPs traded on formal markets, at local level. Croitoru (2007) aims to provide comprehensive estimates of NTFPs benefits at national and regional level in the Mediterranean region. Six major groups of NTFPs are identified: firewood, cork, fodder, mushrooms, honey and other NTFPs (Table 6.4). Valuation is based on a wide variety of techniques, drawing on official statistics, and supplemented by results of local surveys. It shows that at Mediterranean level, NTFPs provide annual benefits of about €39/ha of forests, accounting for about a fourth of the total economic value of forests estimated by this study. The average estimate for southern countries (Euro 54/ha) is considerably higher than for northern (Euro 41/ha) and eastern countries (Euro 20/ha). Croitoru's paper reveals the degree of importance of the main NTFPs benefits for the country groups and

Table 6.4
The Value of Non-Timber Forest Products by Country Group, Euro/ha, 2005 Prices

Country	Firewood	Grazing	Cork	Mushrooms	Honey	Other NTFPs	Total NTFPs
Morocco	17	31	1	1	4	1	54
Algeria	0	36	1	ND	0	0	38
Tunisia	3	81	11	0	2	12	109
Egypt	7	ND	NA	ND	97	ND	104
Palestine	4	24	NA	ND	ND	27	55
Lebanon	31	8	NA	ND	98	5a	142
Syria	0	ND	NA	ND	0	7	8

Notes: ND = no data available; NA = not applicable; NC = not calculated due to insufficient relevant information.
Source: Croitoru (2007).

the region as a whole. It also discusses some reasons for concern when drawing policy tools for improving rural income and forest conservation in the Mediterranean.

Another example is the cedar forests in Lebanon that give shelter to a rich biodiversity and constitute important mountainous relic habitats harboring a wide range of endemic, rare and threatened species, and species with economic potential. These forests, once covering the eastern and western mountain chains, have been the providers of quality timber for the region in historical times. The ancient practices have left the country with only 12 forest relics distributed on the Mount Lebanon chain. Even though they are recognized worldwide as flagship species and sites of cultural, religious and historical values, these forests have attracted limited international funds for their conservation. These funds proved to be unsustainable for long-term conservation plans; therefore a system for securing local funds for the protection of cedar forest is needed. In this context, Sattout et al. (2007) designed a study with three main objectives. Firstly, to illustrate the differences in the value of cedar forests between citizens and villagers and users and non-users. Secondly, to identify the best ways to collect local funds and design other tools (involving for example public participation) needed in setting out a sound strategy for the conservation of the cedar forests. Thirdly, to use the findings of their study as a tool to develop further studies and to inform and influence decision makers with regards to the importance of a long-term conservation and sustainable use programs as well as to consider a strategic approach for its sustainable use. Using an open-ended questionnaire, CVM is applied to highlight the importance of well-informed population, to obtain the WTP for a scenario to conserve cedar forests in Lebanon; to increase their surface areas; to promote sustainable activities and to explore the degree of importance of their attributes and of the option, bequest and existence values as perceived by the Lebanese population. The WTP is tested by using a regression model relating WTP to all socio-demographic variables. The questionnaires (416) were run in three main cities in Lebanon and in villages surrounding two nature reserves. The difference in the individual WTP value for users and non-users was approximately US$20 per household for both villagers and city dwellers. The frequency of the zero WTP value was higher for nonusers. The results obtained encouraged a national initiative to create a national trust fund and to integrate symbolic fees on the amenity services associated with cedar forests.

Competition in both local and international markets for the food business requires the development of differentiated products in order to meet the demand of more quality-stringent, health-conscious, and attribute-oriented consumers. Boughanmi et al. (2007) attempts to evaluate consumers' preferences for value-added fish products in Oman and identifies the most important attributes that are preferred by consumers. Such information is of value to the fish processing companies that are looking for profitable business opportunities in local or international niche markets. The study uses a conjoint analysis method to estimate consumer total utility for value-added fish products on the basis of four attributes: form of product, package size, method of cooking and price. A sample of 200 consumers is selected in four major supermarkets in the Muscat region to conduct the conjoint experiment. Results of the conjoint analysis show that the most important attribute in the purchasing decision of the average consumer is the cooking method, which contributes 79.21% to the average overall preference, whereas the least important attribute is the price, contributing only 0.34% to overall preference. The most preferred product is a finger or nugget fish form formulated for frying and packed in a small package, whereas the least preferred products consist of the burger form formulated for microwaving and packed in large or medium packages. Segmentation of the fish value-added market according to nationality showed that there is no significant difference between Omani and non-Omani preference structure.

On a more global level, participation in ecosystem-based marine recreational activities (MRAs) has increased around the world, adding a new dimension to human use of the marine ecosystem and providing another good reason for strengthening effective management measures. In this context, Cisneros-Montemayor and Sumaila (2010) takes the first step in studying the effects of MRAs on a global scale by estimating their socioeconomic benefits, which are captured in the study by three indicators: the amount of participation, employment and direct expenditure by users. A database of reported expenditure on MRAs was compiled for 144 coastal countries. A meta-analysis was then performed to calculate the yearly global benefits of MRAs in terms of expenditure, participation and employment. It is estimated that 121 million people a year participate in MRAs, generating US$47 billion in expenditures in 2003 and supporting one million jobs. The results of this study have several implications for resource managers and for the tourism industry. Aside from offering the first estimation of the global socioeconomic benefits of MRAs, this work provides insights on the drivers of participation and possible ecological impacts of these activities. Their results could also help direct efforts to promote adequate implementation of MRAs. Furthermore, they hope that their work will provide a template for data collection on MRAs worldwide.

Other interesting ecosystems specific to costal zones are wetlands which often cut across national borders. Wetland conservation is far from being a major concern in view of the intense pressure that is being excreted everywhere in favor of a frantic economic competition, especially in view of the economic services and benefits that wetlands provide. Benessaiah (1998) considers demographic, economic, biodiversity and development aspects of Mediterranean wetlands. Five locations are presented: the Kune-Vain lagoons in Albania, Béni Belaid in Algeria, Delta of the Neretva River in Croatia, Merja Zerga in Morocco and Sebkha el Kelbia in Tunisia. A series of theoretical tools on wetland economic evaluation are implemented while also presenting readers with insights into their limitations such as lack of data. The volume explores governance and institutional issues that face decision makers and stakeholders in the development and use of wetland resources, and concludes with practical recommendations on integrating socio-economic evaluation into sustainable management of wetland resources.

Cultural heritage, natural heritage and intangible cultural heritage as defined by the United Nations Educational, Scientific and Cultural Organization (UNESCO) have multidimensional characters. Interest in the multidimensional character of culture from the economic perspective is a rather modern trend. Only recently cultural economists have started to work on developing a methodology for valuating cultural assets, and hence the literature is rather limited. Moreover, the discussions and available studies on valuation of damages and losses of such assets are even less common. The contingent valuation study conducted in Morocco to assess the value of Fes Medina to foreign visitors was conducted by the World Bank in 1998. It is one of the best examples of valuation studies in the cultural sector. Although the study focuses on the foreign visitors and non-visitors to Morocco and Fes Medina rather than the local residents and other Moroccans, it clearly details the applicability of the CVM when valuing cultural assets. Like the rest of Morocco's 30 Medinas, Fes Medina has been largely overlooked for much of the 20thcentury as investment concentrated on areas outside traditional urban centers. As a result, by 1990, many of the city's cultural assets (e.g. oldest mosque in the northern Africa, Islamic university founded in 859 A.D., Royal Palace, traditional houses and other important cultural assets) were in serious disrepair and jeopardy, threatened by a crumbling infrastructure, devastating pollution and poverty. The decline was further reinforced by increasing population growth resulting in high population density consisting mostly of residents with income levels below the national average. In 1980 UNESCO launched an international safeguarding campaign, which raised awareness about the site's importance, but did not succeed in generating the necessary financial support to carry out any significant rehabilitation works. Subsequently, a CV study funded by the World Bank was carried out in 1997 to estimate the use and non-use values of cultural assets in Fes Medina. The aim of the study was to provide rational arguments for attracting financial support for conservation and rehabilitation of Fes Medina.CV was carried out in Fes, Casablanca and Tangier. For the CV component, a sample of 600 adults was surveyed representing both tourists and those visiting Morocco for business or other purposes during June – July 1997. Four hundred out of the 600 interviews were conducted in Fes, 120 in Casablanca and 80 in Tangier. The results of the study showed that the estimated economic benefits derived from the project were very high once the use and non-use values of the cultural heritage were considered. It is important to mention that benefits of Fes Medina's rehabilitation project were divided into five categories depending upon the beneficiary. In category 1 were benefits accruing directly to residents of Fes; in category 2 were those accruing to Moroccans who are not residents of Fes; in category 3 were those accruing to foreign visitors to Fes; in category 4 were those accruing to foreign visitors to Morocco who do not visit Fes; and in category 5 were those accruing to non-Moroccans who do not visit Morocco. However, the study did not consider any of the potential benefits to Moroccans (category 1 and 2) and concentrated on quantifying as far as possible the potential benefits likely to accrue to non-Moroccans, if the project was undertaken. Moreover, Carson et al. (2002) further describes this World Bank study and summarizes that the Turnbull lower bound on the sample mean for Fes visitors was US$69.59. The related aggregate estimate for the 161,149 estimated adult visitors to Fes who stayed overnight in a Fes hotel was US$11.23 million. Similarly the Turnbull lower bound on the sample mean for visitors to Morocco who did not visit Fes was US$30.92. Finally, the related aggregate estimate for the estimated 1.5 million adult visitors who stayed overnight in a Moroccan hotel but did not visit Fes was around US$46.9 million.

6.7 Agriculture

Most MENA countries import at least 50% of the calories they consume.[8] Growing populations and increased demand for agricultural products such as cereals may trigger even more reliance on imports in the future. Although many countries in the region stress the importance of maintaining or increasing agricultural productivity, inappropriate cropping or irrigation practices and overgrazing of rangeland contribute to degradation of agricultural land and reduce productivity over time.

During the campaigns of the fifties through the nineties, spraying desert locust (DL) was considered to be the only effective instrument in the sense of reducing agricultural damage. Nevertheless, this strategy has been criticized by FAO, donors and affected countries partly because this strategy is connected with considerable resources and partly because spraying may lead to harmful effects to farmers and their environment. However, because of the lack and scarcity of reliable data both on the effects of spraying as well as on their costs, it is not easy to unambiguously change control strategies and concentrate on alternative methods to deal with DL plagues. To close this gap, Abou-Ali and Belhaj (2008) sheds light on this problem, to study whether the Moroccan, the Sudanese and the Eritrean agricultural sectors have suffered from DL invasions of the eighties and nineties, and to compare the benefits and costs of DL control campaigns. The CVM is used in their study to estimate total benefits of not using insecticides and to compensate farmers in the case of DL invasion. The results of the CVM show that instead of using insecticides farmers are willing to pay an amount per year to a fund that can compensate them for the losses caused by DL.

In Morocco, desert and arid land represent 78% of total land, semiarid land covers 15%, and 7% is sub-humid and humid. Soil is fragile because of its organic-matter content of less than 2%, even in humid zones (World Bank 2003). These soils suffer from water and wind erosion. Under these conditions, overexploitation and unsustainable management of the already vulnerable soils lead to land degradation. Sarraf and Jorio (2010) estimates the costs of annual land degradation in terms of the lost productivity of croplands and rangelands. The degradation of cropland and rangeland in Morocco has an estimated annual cost of US$91 million to US$178 million, or an average ofUS$134 million—0.4% of GDP in 2000. Cropland degradation accounts for 88% of this cost, and rangeland degradation for only 12%, the latter is almost equally divided between areas with forest and steppe dominance. These results do not capture several problems, such as the impact of salinity on irrigated soil. Therefore, the above estimate most likely underestimates the total impact of land degradation. If one considers a total population of 30.4 million in Morocco the damage corresponds to about US$4 per capita in 2000—a conservative figure relative to other countries in the region. For example, land degradation in Africa, which loses 75 billion tons of soil per year, costs approximatelyUS$70 per capita, or US$400 billion per year (Lal 1998). In addition, the estimate for Morocco corresponds to about 1.6% of agricultural GDP—which is at the lower end of the estimates for Africa. For example, in Sub-Saharan Africa, annual onsite losses from land degradation range from 1% of agricultural GDP in Madagascar, Mali, and South Africa to 8% in Zimbabwe (Bojo 1996). Three different studies from Ethiopia, however, have estimated annual losses of less than 1% (FAO 1986), 4% (Bojo and Cassells 1995), and 5% of agricultural GDP (Sutcliffe 1993). The varying results attest to the weakness of the data and the dependence on the assumptions made (Pagiola 2002). The total cost of environmental degradation (COED) in Morocco is estimated at US$12 billion, or 3.7% of GDP in 2000 (World Bank 2003). In sum, cropland and rangeland degradation account for about 11% of the total COED—considerably more than the share attributed to deforestation. In contrast, the costs of air and water degradation are much greater than those related to cropland and rangeland degradation, primarily because of the substantial health impacts of air and water pollution.

Abou-Ali (2012) analyzes the welfare effects of improved land and water quality conditions on agricultural production in Damietta, Egypt, using a choice experiment. The survey was administered to a random sample of farmers in Damietta governorate, Egypt. In the analysis various econometric models are estimated in order to help in identifying farmers' preferences toward interventions aimed at mitigating poor agricultural soil and irrigation water conditions which have traditionally reduced farmer incomes in rural Damietta. A significant WTP for improving agricultural productivity through improved irrigation and especially availability of certified seeds is found. However, relative WTP indicated that the maximum amount farmers are willing to pay for improvements is less to them than the cost of the program.

CHAPTER 7

Directions and Priorities of Research

The objective of this policy research report was to prioritize research actions for a better management of natural resources and the environment in Arab countries. Criteria considered the most important for this objective were policy relevance, impacts on social welfare, and areas of research not covered elsewhere. Academic research is often a prerequisite for sound recommendations presented to policymakers. Nevertheless, we have tried to identify directions and priorities of research needed in this field with the intention to go beyond academic research on environmental topics in Arab countries, and to include data and policy implementation considerations.

The first point of conclusion is that priority should be given to an effort for achieving a sustainable data management system on the environment in Arab countries. Existing data is mostly available at the aggregate level and include country-specific indicators from various sources, both national and international. This data must be checked for consistency with local statistical experts and harmonized across countries when necessary. This is particularly important for agricultural data in their relationship with environmental issues, as far as data collected by national statistical offices are concerned.

Moreover, many analyses cannot be conducted with existing data at the aggregate (country) level alone, and require additional effort to collect more data at the individual level of producers and households. This includes environmental assessments combining ecological and economic models and the evaluation of environmental tax reforms, which implies that surveys need to be conducted for a better understanding of industrialists, farmers and consumer behavior towards the environment. Coupling economic models of production with ecological data can be achieved by combining air, soil and water quality data at the local level, with spatial information on production practices. Since such an effort involves significant data collection costs, priority should be given to the most harmful externalities of economic activities, in regions where environmental impacts are known to be particularly important. Data at the individual level would enable economists to explore margins of action on the consumption and production sides, for a better understanding of the limits to behavioral changes. Such limits can be useful to design environmental policies suited to the actual conditions of farmers, industries and households in Arab countries, so as to achieve minimal acceptability of policies. This is particularly important regarding environmental tax reforms, which need to be carefully designed in regions where economic agents are not accustomed to contributing to the provision of public goods through direct taxation. With data at the individual level, spatial and temporal aspects should be favored, bearing in mind the important role of land-use changes on the environment. Localization of population (the urban-rural fringe) and economic activities are major determinants of environmental degradation, and the economic and statistical methods for analyzing spatial data are developing rapidly.

Second, while it is true that more economic analyses are needed to characterize the behavior of economic agents in relation to the environment and natural resources, an important gap remains regarding social preferences towards the environment. This issue of preference elicitation can only be partially addressed by revealed-preference methods based on actual market decisions, and stated-preference experiments have to be considered at a more ambitious scale. Indeed, little evidence is available on preferences towards the environment in Arab countries, and this has two consequences. First, economic values for environmental components are not available to calibrate cost-benefit analyses and other models for helping decision making. Second, the potential for significant changes in production technology, through adoption of innovations in industry and agriculture, is very difficult to evaluate. In other words, specific surveys are needed for estimating WTP for environmental goods and services on the one hand, and willingness to receive for producers considering adoption of alternative production modes. Again, such an effort will need to be planned by taking into consideration the most harmful impacts on the environment first. Since data is not available to produce the prioritized list of externalities, the method of transfer can be used by mobilizing empirical results from the economic literature on similar settings. At the same time, behavioral and experimental economics can be considered for complementing the set of values to be obtained by stated-preference methods. These techniques have proved very useful when environmental goods and services poorly interact with market goods.

The third point concerns specific environmental scenarios for Arab countries. Apart from the IPCC projections on climate change and some prospective exercises for predicting future water availability in Arab countries, very few scenarios combining climate, economic development and land use changes are available. To identify sustainable paths for Arab economies, it is necessary to build scenarios including also consumption patterns, technological change, and expected trends in international trade. Scenario building is a difficult exercise as it involves modeling efforts at various scales including world markets. However, alternative methods for producing scenarios of future conditions in Arab countries can be employed instead, based on expert consultation and partial analyses available on some sectors. The first one could be the energy sector, as many Arab countries are major contributors to the world oil supply. There exist equilibrium models managed by international organizations which could be extended to better account for the participation of Arab countries to international trade, and to model changes in land, production and consumption patterns of these countries. In constructing economic and climate scenarios for Arab countries, a typology of countries should be considered. A relevant distinction could be made between agricultural countries and the others (where services are more important), because emission patterns and processes of depletion of natural resources are heterogeneous across countries.

Fourth, environmental policies are difficult to evaluate in Arab countries, as the legislation has evolved only recently in favor of the conservation of natural resources and the protection of the environment. Nevertheless, there exist some tentative assessment exercises regarding air pollution and water use in Egypt and Jordan, which could be pursued and extended to other existing policies. We insist at this stage on the preliminary requirement of having adequate data to identify preferences and processes of decision making of economic agents faced with such policies. When public policies are expected to be poorly effective, private initiatives can be considered, as discussed in this report. The potential of voluntary agreements and standard adoption in Arab countries in an important one, as is the challenge of securing public-private partnerships in activities associated with the management of natural resources. The water industry is an interesting candidate for assessing the possible benefits of private-public partnerships, because such partnerships are used in many countries (see Abaza 2008; Abderrahman and Husain 2004) and there exists a growing literature on the determinants and the way to assess the performance in private participation and delegation of public services to private operators. Of particular importance regarding the converging signals concerning climate change, is the need to explore mitigation and adaptation strategies of economic sectors in Arab countries. Irrigated agriculture and the management of water resources have been examined more than other activities because they are expected to be the first to be impacted by climate change. Collective systems of natural resource management are an alternative to centralized or privately-operated systems in particular local settings, and the potential of such systems for resource management needs to be explored as well.

Finally, sustainability should be an entry point for all research efforts as well as for recommendations which could be made from them. Greening of the economy and mainstreaming the environment into all projects, public or private, are recommended strategies by international institutions. The way to achieve a sustainable development path for Arab countries through these strategies is a key challenge for environmental economists. This report has suggested ways of improving the current state of research to progress towards more operational definitions of such strategies in the future.

Notes

1. The "resource curse," a concept which emerged in the late 1980s alleging that natural resource abundance leads to a host of negative economic, political, and social outcomes, e.g., the Dutch Disease.
2. China is attempting to introduce a 'green GDP' accounting scheme as a way of ranking local governments' success in achieving economic growth that does not cost the environment. But the scheme is faltering at the pilot stage due to political infighting (Qiu 2007).
3. For more details on ESI see :http://sedac.ciesin.columbia.edu/es/esi/
4. OECD includes Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, and the United States. Central European countries (CE6) include Bulgaria, the Czech Republic, Hungary, Poland, Romania and the Slovak Republic. Latin American countries (LA6) include Argentina, Brazil, Chile, Mexico, Venezuela and Uruguay. East Asian countries (EA6) include Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam.MENA15 includes Algeria, the Arab Republic of Egypt, Bahrain, the Islamic Republic of Iran, Jordan, Kuwait, Lebanon, Morocco, Oman, Qatar, the Republic of Yemen, Saudi Arabia, the Syrian Arab Republic, Tunisia and the United Arab Emirates.
5. The only study conducted in Kuwait which applies stated preference techniques is Hammitt (2004) who attempts to value the public health impact of the 1990 Iraq invasion through valuing mortality and post traumatic stress disorder among civilians who remained in Kuwait during occupation.
6. Weak complementarity restricts the consumption of an environmental amenity to zero when consumption of a related market good is zero.
7. A consequential survey is defined as one that is perceived by the respondents as something that may potentially influence agency action. Furthermore, the respondent is required to care about the outcome of that action.
8. Food consumption statistics are from the FAOSTAT database of the Food and Agricultural Organization of the United Nations (FAO). http://faostat.fao.org.

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About the Authors

Hala Abou-Ali is an Associate Professor at the Faculty of Economics and Political Science, Cairo University, Egypt, with a B.Sc. (with first honors) in Statistics from Cairo University and a Ph.D. in Economics from Gothenburg University, Sweden. She joined The Economic Research Forum in 2008 on a part time basis to take the lead on the work carried out on environmental economics in the MENA region. Her fields of specialization are in the areas of environmental and development economics. She has accumulated experience in the economic value of environmental resources in developing countries, with a particular focus on water and air pollution and agricultural land degradation. She has also worked on issues such as impact evaluation of investments, poverty assessment and the Millennium Development Goals for the World Bank and the UNDP.

Alban Thomas is a Senior Researcher in economics and the deputy-head of the Social Science Division at INRA (French Institute for Agricultural Research). He has a micro-econometric background and is a natural resource and agricultural economist. His research topics include the empirical analysis of environmental impacts from agriculture and the evaluation of environmental policies in agriculture and industry, the behaviour of water users and social water-pricing systems. He now works on the adoption of innovative agricultural practices and cropping systems, the demand-side management of water resources, water utility management and tariffs. He has co-edited a national scientific expertise on French agriculture and drought (2006) and has co-ordinated several research projects for the French ministries of agriculture and the environment, as well as in Brazil and the Middle East for international institutions (World Bank, Inter-American Development Bank, Economic Research Forum).