Chapter 18
Economic Growth and Environment: An Empirical Analysis Applied to Morocco, Algeria, Tunisia, and Egypt

Aïcha EL Alaoui and Hassane Nekrache

Abstract The main objective for many developing countries in the coming years is to improve the economic growth, which is perceived as necessary to meet the increasing demand of their populations, to improve their well-being, and to help manage existing environmental challenges. This work attempts to investigate the links between economic growth and environment in four countries from the MENA region (Morocco, Algeria, Tunisia, and Egypt, hereafter 'MATE'). To do so, two steps are followed: in the first one, a basic Environmental Kuznets Curve (EKC) equation for each country over the period 1970–2010 is tested to measure the effect of economic growth on environmental quality, and to determine the possibility of the existence of an EKC; in the second one, a few variables are introduced in the basic EKC equation (model tested in the first step) such as economic openness indicator and enrollment and urbanization rates. The purpose is to measure the possible influence of these variables (including economic growth) on environmental quality, and also to determine the possibility of the existence of an EKC. The results of both models show that the linkages between economic growth and environment are still uncertain, complex and ambiguous. It is not possible to find a unique form of this linkage and each variable introduced in the model can give some explanation where the application of EKC is unclear and uncertain. Therefore, these countries through policymaking, and the involvement of private actors (such as corporations and NGOs), must apply preventive and precautionary measures to reduce environmental damage. These measures must be adapted to specific economic and environmental conditions benefiting from the experiences and good practices developed in other regions and avoiding others' past mistakes related to pollution, regional development, and natural resource management.

Keywords Growth · Environmental degradation · EKC · OLS · CO_2 emissions

A. EL Alaoui (✉)
Sultan My Slimane University, Chief of Research group of "the social economy and social justice", Beni Mellal, Morocco

H. Nekrache
Statistician and Demographer Engineer, The High Commission for Planning, Rabat, Morocco

M. Behnassi et al. (eds.), *Human and Environmental Security in the Era of Global Risks*, https://doi.org/10.1007/978-3-319-92828-9_18

1 Introduction

Economic growth remains important for all countries, whether developing, less developed or developed. It may affect people's well-being, i.e. health, education, employment, quality of life, etc. It may also affect government's stability, from social and nutritional security to political stability, and population's welfare. The recent example is the 'Jasmine' revolution started in Tunisia. The principal reasons behind this revolution are, inter alia, high rate of unemployment, high index of corruption, poor living conditions, lack of democracy (free elections), and deficiency of freedoms (freedoms of expression and of the press).

Economic growth requires the combination of different types of capitals in order to produce goods and services (World Bank 2006). These include:

- *Produced capital*, which means machinery, buildings, roads and rail network.
- *Human capital*, which refers to education, health, knowledge and skills. In the early 60s, economists have accorded a large importance to this concept, especially, with the works of Becker (1962), Schultz (1961, 1962), Mincer (1958, 1962), Kiker (1966), and Blaug (1976).
- *Institutional and social capital*, which involves the quality of political institutions represented by the extent of their connections to the society and their respect to the norms, values and human rights. This concept was popularized, namely, by Bourdieu (1985), Coleman (1988a, b), Putnam (1993), and Portes (1998);
- *Natural capital*, which is related to the natural resources such as air, water, minerals, the extracted raw materials (such as gas, phosphate, and petroleum), and animals (such as fish, cow, and pig). This capital is vital for securing both sustainable economic growth and development, not only for the present but also for the future generations. Natural capital is defined by the Global Development Research Center[1] as "the environment stock or resources of Earth that provide goods, flows and ecological services required to support life". This concept is used in many studies, especially in the work of Costanza and Daly (1992).

The links between economic growth and the four capitals mentioned above is complex and strong. This study focuses only on the links between economic growth and the environment/the natural capital[2]. Indeed, the environment plays important direct and indirect roles in supporting and sustaining economic activities (agriculture, fisheries, tourism, manufacturing, and services): directly by providing raw materials and minerals required as inputs for production processes; and indirectly by providing the required ecosystems services (such as rivers, ocean, air, etc.).

However, the intensive and irrational economic growth has caused many changes to the environment, especially, since the industrial revolution. In its report, the

[1] http://www.gdrc.org

[2] This study uses the concept of the environment because it is general and includes different aspects of life and resources in the Earth.

IPCC's Fifth Assessment (AR5) showed that "since the beginning of the industrial era, oceanic uptake of CO2 has resulted in acidification of the ocean; the PH of ocean surface water has decreased by 0.1 (high confidence), corresponding to 26% increase in acidity, measured as hydrogen ion concentration" (IPCC 2014:4). The key environmental changes can be summarized in three aspects: the ozone layer; the temperature change; and the biodiversity loss.

- The first aspect of environmental damage is the ozone layer, which is a thin layer of stratospheric gas that protects life on Earth by absorbing the solar UV radiations and preventing them from reaching the Earth's surface (Daniel 1999:10). During the last years, the ozone layer became extremely fragile because of its low concentration of ozone (O3). However, the pollution causes destruction of this layer notably via the reactions that take place between O3 compounds and pollutants. It consequently exposes humans to sunlight, and therefore causes many health problems such as skin cancer.
- The second aspect of environmental damage is the change in the earth's temperature: the atmosphere and the oceans have warmed, the amounts of snow and ice have diminished, and the sea-level has risen. The IPCC's Fifth Assessment Report (AR5) documented that "the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale" (IPCC 2014:7). Moreover, this report confirms that "each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850", (IPCC 2014:2). Thus, the global average land and ocean surface temperature warming combined is estimated of 0.85 [0.65 to 1.06] °C2 over the period 1880 to 2012 (IPCC 2014:2). In addition, the glacier areas have continued to shrink almost worldwide in response to the increased surface temperature and the changing snow cover since the early 1980s.
- The third aspect of environmental damage is the biodiversity loss which refers to a substantial decrease of non-human species worldwide. Indeed, the anthropogenic activities and their impacts on the environment are now the main driver behind the extinction and scarcity of many species, whether insects, animals, or plants. The extinction's rate has currently reached a higher level of 100 to 1000 times the natural rate (Chivian and Bernstein 2010:5).

These three aspects of environmental change have caused direct and/or indirect problems such as increasing the risk of famine, contagious maladies (malaria, Ebola…), flooding, and water shortage (Khagram et al. 2003; Bass 2006; Martino and Zommers 2007). "The harmful effects of the degradation of ecosystem services are being borne disproportionately by the poor, are contributing to the growing inequities and disparities across groups of people, and are sometimes the principal factor causing poverty and social conflict" (Bass 2006:2). More precisely, the environmental damage will be experienced by developing countries and the poorest people, especially in Sub-Saharan Africa, South Asia, Southeast Asia, and Latin America regions. In urban area, the risks for peoples, assets, economies, and ecosystems have increased due to air pollution, drought, and water scarcity

(IPCC 2014:15). In rural area, the major impacts are on water availability and supply, food security, infrastructure, and agricultural incomes (IPCC, 2014:16).

There is a clear conscience about environmental challenges, from averting dangerous climate changes to halting biodiversity losses and protecting our ecosystems. However, developed economies have partially reduced the environmental damage through various measures (political, legal, economic, technological, educational, etc.), including the relocation of some production processes to developing countries, thus exporting their pollution to other regions. It is true that these foreign investments are important and vital for host countries since they contribute to their economic growth and help reduce poverty, migration and unemployment. However, these dynamics should be accompanied by the necessary measures (such as financial and tencnology transfer) to help reducing environmental impacts, especially an era of global change where the environment is increasingly perceived as a common concern for all countries.

The main objective for many developing countries in the coming years is to improve the economic growth, which is perceived as necessary to meet the increasing demand of their populations, to improve their well-being, and to help manage existing environmental challenges. Against this background, this paper attempts to investigate the links between economic growth and environmental damage in four countries from the MENA region (Morocco, Algeria, Tunisia, and Egypt, hereafter 'MATE'). The work is organized as follows: the second section reviews a sample of theoretical and empirical studies that focus on the linkages between economic growth and the environment; the third section presents the economic and environmental situation in Morocco, Algeria, Tunisia, and Egypt; the fourth section is dedicated to the presentation of both methodology and main results; finally the last section serves to sketch the main components of a strategy to induce environmental improvement in MATE with other relevant conclusions.

2 Theoretical and Empirical Discussions about the Links between Economic Growth and the Environment

Environmental issues received growing attention throughout the 60s via the publication of Rachel Carson's Silent Spring in 1962, which examined the impact of man's indiscriminate use of chemicals in the form of pesticides and insecticides, mentioned by Cole (1999). In the early 70s, Ehrlich and Holdren (1971, 1972), Commoner et al. (1971), and Commoner (1972a, b) identified three factors that created environmental impact (I): increasing human population (P); increasing economic growth or per capita affluence (A); and the application of resource depleting

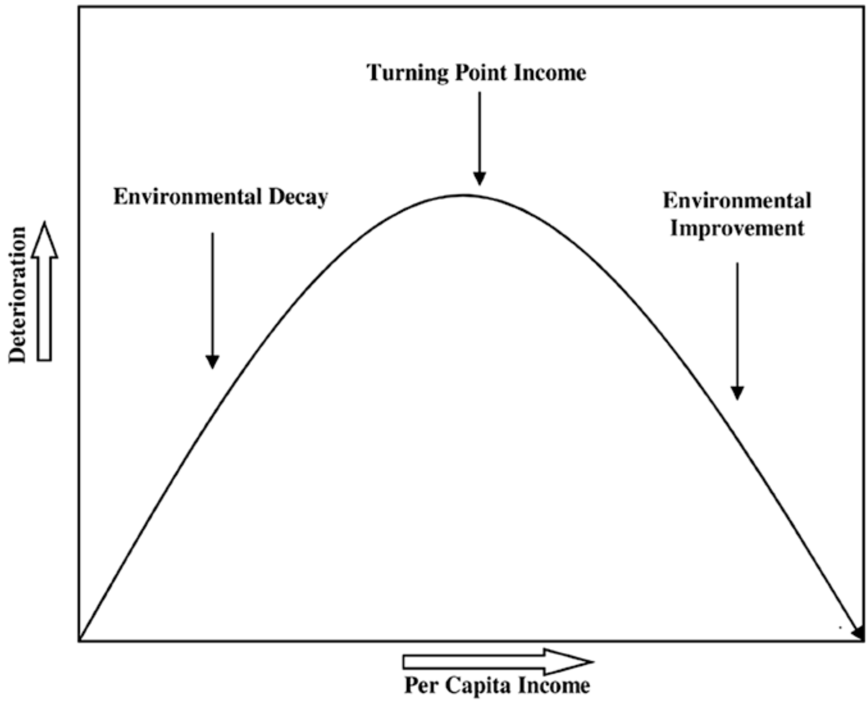

Fig. 18.1 Environmental Kuznets curve
Source: Yandle et al. (2002:3)

and polluting technology (T). These factors were considered as the worst for the planet and are linked by the following equation named IPAT[3]:

$$\text{Impact} = \text{Population} x \text{Affluence } x \text{Technology}$$

According to IPAT equation, the attention was growing to examine the links between economic growth and environmental quality. This relationship is represented by the Environmental Kuznets Curve (EKC), which refers to the hypothesis of an inverted U-shaped relationship between various indicators of environmental degradation and per capita income. In the early stages of economic growth, degradation and pollution increase, but beyond a certain level of per capita income, which will vary for different indicators, the trend reverses, so that a high income level of economic growth leads to environmental improvement. This implies that the environmental impact indicator is an inverted U-shaped function of per capita income. Typically, the logarithm of the indicator is modeled as a quadratic function of the logarithm of income. An example of an estimated EKC is shown in Fig. 18.1. The EKC takes the

[3] For more explication see Chertow (2001). The author tried to track the various forms the IPAT equation to examine which variables was worst for the planet.

name of Simon Kuznets (1955)[4] who hypothesized that income inequality first rises and then falls as the economic development proceeds from a certain threshold's economic growth.

The idea of this model is that population enrichment was accompanied by the demand for a cleaner environment. At the lowest income's level, the main preoccupations for a poor person are to afford the basic necessities for himself and his family such as food, shelter, water, and clothing, leaving a little place for other concerns as environmental issues. At the highest income's level, a rich person is more sensitive to environmental issues. What is true at the individual attitude is also valid at the national level. When an individual or a country becomes rich, it is easier to sacrify à part of the income to protect the environment. Many researchers have focused on the relationship between economic growth and environment such as Grossman and Krueger (1991, 1995); Beckerman (1992); Shafik and Bandyopadhyay (1992); Panayotou (1993; 1997; 2003); Shafik (1994); Selden and Song (1994); and Cropper and Griffiths (1994)[5]. Moreover, the empirical studies related to this subject have grown rapidly during last decades, especially in developed countries. This analysis represents a sample of these studies.

The first estimation of the EKC was established by Grossman and Krueger (1991), which analyzed the environmental impact of the North American Free Trade Agreement (NAFTA)[6]. The authors distinguished three separate mechanisms that can affect the level of pollution and the rate of depletion of scare environmental resources. These effects are the scale, the composition and the technique effects[7]. The authors used a cubic function to estimate the concentration of pollutants in the air (sulfur oxides (SO2), suspended particles, and dark matter (thin smoke)) in urban areas using the Global Environmental Monitoring System (GEMS) dataset as part of a study on the potential environmental impacts of NAFTA. The authors suggested that trade liberalization generates some benefits, such as increased income growth which tends to alleviate pollution problems, and increased specialization in sectors that cause less than average amounts of environmental damage. They suggested, also, that "the environmental impacts of trade liberalization in any country will depend not only upon the effect of policy change on the overall scale of the economic activity, but also upon the induced changes in the intersectoral composition of economic activity and in the technologies that are used to produce goods and services", (Grossman and Krueger 1991:36). Similar findings had been reported by Shafik (1994), he concluded that "some environmental indicators improve with

[4] Simon Kuznets (1901–1985) was an American economist, demographer and statistician of Ukrainian origin. He won the Nobel Prize in 1971.

[5] For a chronological presentation of the EKC, see Stern (2004). This author confirmed that the EKC concept was popularized through World Bank Development Report (1992).

[6] The NAFTA came into effect on January 1, 1994, creating the largest free trade region in the world. It is an agreement signed by Canada, Mexico, and the United States, creating a trilateral trade bloc in North America. For more detail see www.international.gc.ca/trade-agreements-accords-commerciaux (Global Affairs Canada).

[7] For more details, see Grossman and Krueger 1991, pp.3–4.

rising incomes (like water and sanitation), others worsen and then improve (particulates and Sulfur oxides), and others worsen steadily (dissolved oxygen in rivers, municipal solid wastes, and Carbon emissions)" (Ibid:769–770).

"Has past economic growth been associated with the accumulation of natural capital or the drawing down of natural resource stocks? Is the accumulation of physical and human capital from complement to or a substitute for the accumulation of natural capital? How do these relationships vary across different environmental resources? And how have macroeconomic policies affected the evolution of environmental quality?" (Shafik and Bandyopadhyay 1992:1). The authors tried to respond to these questions exploring the links between economic growth and environmental quality by analyzing the patterns of the environmental transformation of several countries at different income levels. The authors tested three models (log-linear, log-quadratic and log-cubic) to explore the shape of the links between income and each environmental indicator[8], which was used as the dependent variable in a panel regression using data from up to 149 countries over the period 1960–1990. Excluding deforestation and dissolved oxygen, they found that income has the most consistently significant effect on eight of environmental indicators than that of policy variables, i.e. the variables related to trade policy and political and civil liberties. Lack of clean water and urban sanitation decline uniformly over time with increasing income. River's quality tended to worsen with increasing income. The two indicators of air pollutants – Suspended Particulate Matter (SPM) and SO2 – confirmed the EKC hypothesis. Both per capita municipal waste and carbon dioxide emissions increased with rising income: "access to clean water and sanitation have elasticities of -0.48 and -0.57 respectively, implying that a 1 percent increase in income results in about 0.5 percent more people in the population are served by improved facilities" (Shafik and Bandyopadhyay 1992:22).

In another background paper in World Development Report, Beckerman tried to analyze the link between economic growth and environmental quality, namely local air quality and access to drinkable water and sanitation. The author has clearly described this link arguing that "there is a clear evidence that, although the economic growth usually leads to environmental deterioration in the early stages of the process, in the end the best way to attain a decent environment in most countries is to become rich" (Beckerman 1992:482). The author found that there is a strong positive relationship between income level and environmental quality. Although the environment in developing countries may get worse, he confirmed that "in the longer run they will be able to reverse the trends in more common forms of air pollution, and attain levels of water supply and sanitation essential to an acceptable, decent and healthy standard of living" (Ibid:21).

Examining the effect of population pressures on forest ecosystems in 64 developing countries over the period 1961–1988, Cropper and Griffiths documented that if

[8] They estimated for 10 environmental indicators which are "the lack of clean water, lack of urban sanitation, ambient levels of SPM, ambient SO2, change in forest area between 1961–1986, the annual rate of deforestation, dissolved oxygen in rivers, fecal coliforms in rivers, municipal waste per capita, and carbone missions per capita", (Shafik and Bandyopadhyay 1992, p.5).

there are "two countries with rapid population growth and significant forest resources but with different levels of per capita income, the country with the highest income is likely to be deforesting less rapidly. As income grows, people will switch to energy sources other than firewood and will use modern agricultural techniques that reduce the demand for agricultural land", (Cropper and Griffiths 1994:250). The authors showed that the Kuznets curve for deforestation was verified. Thus, an increase of the growth rate of per capita income by eight percentage points reduces the rate of deforestation by one-tenth of a percentage point.

Several studies have focused on the links between international trade and environmental quality, and have confirmed that the international trade can improve the environmental quality. Accordingly, the international trade would accelerate income; so it can allow a quick passage to the ascending part of the curve. Grossman and Krueger (1991:21) showed that trade liberalization generates an increase in income levels and then it can strengthen the incentives for 'environmental dumping'. Hence, they proposed that free trade can protect the environment. Lopez (1994:163) showed that "economic growth and trade liberalization decrease the degradation of natural resources if and only if producers internalize their stock feedback effects on production". He concluded that the effect of trade liberalization depends on three assumptions: (i) the manufacturing sector is protected vis-à-vis to the primary sector; (ii) the productive stock effects of the resource occur entirely in the primary sector; and (iii) the productive sector is characterized by constant returns to scale technology (Ibid:183). Antweiler et al. (2001) investigated how the openness to trading opportunities affects pollution concentrations by developing a theoretical model to divide trade's impact on pollution into scale, technique, and composition effects. The authors concluded that "free trade is good for the environment" (Ibid: 878).

The turning points[9] come somewhere between $4000 and $5000 per capita GDP, measured in 1985 US dollar (Grossman and Krueger 1991:5). 'Similar' results are found by Cropper and Griffiths (1994) which the turning points are $4760 per capita income for Africa and $5420 per capita income for Latin America. However, these points vary substantially across environmental indicators[10]. Shafik and Bandyopadhyay (1992) found that the turning points are $3280, $1375, and $1375 (per capita income in 1985 US dollar) for sulfur dioxides, SPM, and fecal coliform, respectively.

Other studies[11] have estimated the turning point to be generally higher. The turning points vary for the different pollutants[12], but almost in every case they occurred at an income of less than $8000 U.S dollars in 1985, (Grossman and Krueger 1995,

[9] Stern (2004:1425) presented in Table 1 a summary of turning points for sulfur emissions and concentrations assigned at the several studies. See also Table 1 of Cole (1999:92).

[10] For more details, see Shafik (1994).

[11] See for example Selden and Song (1994), Grossman and Krueger (1995), and Cole et al. (1997).

[12] They focused on four types of indicators: concentrations of urban air pollution; measures of the state of the oxygen regime in river basins; concentrations of fecal contaminants in river basins; and concentrations of heavy metals in river basins.

p.369). Selden and Song's (1994) estimates are under $10,000 per-head (1985 US dollar). These authors tested four indicators of air pollution (SPM, SO_2, NOx, and CO_2) in their model using the GEMS aggregate emissions data obtained from the World Resources Institute[13]. But, Cole et al. (1997) used carbon dioxide, carbonated fluorocarbons (CFC) and halons, methane, nitrogen dioxide, sulfur dioxide, suspended particulates, carbon monoxide, nitrates, municipal waste, energy consumption and traffic volumes to examine the EKC. They have estimated the turning points for different pollutants (from a low $5700 to a high $34,700 in 1985 US dollar).

The EKC has been the subject of growing criticism (Arrow et al. 1995; Ekins 1997; Torras and Boyce 1998; Perman and Stern 1999; Stern and Common 2001); Cole and Neumayer 2005). Some authors have confirmed that the EKC is just a utopia because the solution of environmental degradation is not related only to economic growth and higher income, but there are several other factors that can play an important role in improving the state of ecological systems such as education, quality of institution, and civil society[14]. Some critics have argued that the EKC suffers from severe methodological problems that cast doubt on the reliability of its results (Cole and Neumayer 2005:298). The authors documented that the rich countries have become clean up, at least partly, by exporting the dirty production processes to poorer countries. This fact may therefore explain the reductions in local air pollution experienced in most developed countries found in many studies.

Arrow et al. (1995) highlighted that the inverted-U relation is evident in some cases but not evident in all cases implying that economic growth is not sufficient to induce environmental improvement in general. They concluded that "economic growth is not a panacea for environmental quality" (Ibid:521).

Stern and Common (2001) and Perman and Stern (1999) declared that the studies which used only OECD data will have to estimate an optimistic turning points with variables that are likely to be no-stationary. Consequently, the standard estimation will probably generate spurious results. Ekins (1997) argued, also, that estimated turning points are highly dependent on the choice of functional form, the data set, and the estimation method. The EKC literature is overly optimistic in suggesting the existence of a systematic inverted-U relationship between income and pollution (Ibid:805).

[13] http://www.wri.org

[14] For example, Panayotou (1993:2) proposed that "the state of natural resources and the environment in a country depends on five main factors" ignoring/neglecting other factors that impact economic growth. These factors are: "a) the level of economic activity or size of the economy; b) the sectoral structure of the economy; c) the vintage of technology; d) the demand for environmental amenities; and e) the conservation and environmental expenditures and their effectiveness".

3 Description of Economic and Environmental Situation in MATE

In MATE, economic growth differs significantly from a country to another and within the same country. The best growth rates of real GDP and of real GDP per capita were recorded during the period 1970–1989, and the highest rates were recorded by Egypt. However, Morocco grew speedily by 3.9% during the period 2010–2013 against 3.1%, 2.8% and 2.6% respectively in Algeria, Egypt, and Tunisia. These rates are lower than those recorded in Africa (all countries combined), South Asia, Sub-Saharan Africa (SSA), East Asia and Pacific (EAP), and China. These growths were accompanied by a rapid urbanization in all regions of the World, but it is more important in developed countries than that in developing countries. Roughly 80% of China and OECD populations live in urban area against only 41.5% in Africa (all countries combined) and 36% in Sub-Saharan Africa. In MATE, the majority of Algerian, Moroccan, and Tunisian populations live in cities, while Egyptian populations live in rural area. Table 18.1 gives an idea about economic growth and rapid urbanization known in majority regions of the world.

Consequently, living in urban areas has an important impact on both citizens' life-style and economic activities such as boosting demand for transport, telecommunication technology, manufactured goods, drainage, sanitation, and other demands linked to the urban consumption culture. Thus, these changes in the population's behavior will increase the environmental damage, especially for air and water. Table 18.2 provides an idea about the evolution of environmental damage measured by CO_2 emissions in MATE and in other regions of the World.

Table 18.2 shows that: (i) Africa's emissions are lower compared to those of the World; (ii) the highest CO_2 emissions per GDP are recorded in China and EAP-developing countries; (iii) CO_2 emissions per capita are recorded in OECD members followed by South Africa; (iv) Egypt's emissions per GDP are more important than those recorded in Algeria, Morocco, Tunisia, and those recorded in MENA; (v) Algeria's emissions per capita are higher than those recorded in Egypt, Morocco, and Tunisia, but lower than those recorded in MENA; (vi) MATE's emissions per GDP are higher than those recorded in Africa and the World, but MATE's emissions per capita are lower than those recorded in the World, and more important than those recorded in Africa.

Figure 18.2 shows that there is a relationship between CO_2 emissions per capita and real GDP per capita, but this relationship has not a unique form.

In Sub-Saharan Africa (SSA), combustible renewable and waste constitute more than 50 percent of energy use during the period 2000–2009 (Fig. 18.3). In Tunisia, combustible renewable and waste is important than that recorded in China. The lowest rates are recorded in Algeria, Morocco, Egypt, and MENA.

The highest energy use per capita is recorded in OECD members followed by South Africa and MENA-all income levels (Fig. 18.4). Algeria, Tunisia and Egypt have an average of energy use per capita more important than that in Africa (all countries combined). The lowest energy use per capita is recorded in Morocco; it is just more than 400 kg of oil equivalent per capita.

Table 18.1 Real GDP (g)[a], Real GDP per capita (gy)[b], urban and rural population, during 1970–2013

	g (%)			gy (%)			Urban population[c], %			Rural population[d], %		
	Average of period:			Average of period:			Average of period:			Average of period:		
Countries/Region of the world	70-89	90-09	2010–13	70-89	90-09	2010–13	70-89	90-09	2000–13	70-89	90-09	2010–13
Algeria	5.0	2.7	3.1	2.0	0.9	1.2	44.0	59.5	68.5	56.0	40.5	31.5
Egypt	6.1	4.6	2.8	3.8	2.9	1.1	43.4	43.0	43.0	56.6	57.0	57.0
Morocco	4.6	3.8	3.9	2.3	2.4	2.5	40.9	53.1	58.4	59.1	46.9	41.6
Tunisia	5.4	4.8	2.6	3.0	3.4	1.5	50.3	62.9	66.2	49.7	37.1	33.8
China	9.2	9.9	8.8	7.4	9.0	8.2	20.0	36.2	51.2	80.0	63.8	48.8
EAP- all income levels[e]	4.9	3.6	4.8	3.1	2.6	4.1	27.9	41.5	53.3	72.1	58.5	46.7
EAP-developing only	7.8	8.4	8.1	5.8	7.2	7.4	21.9	36.7	49.3	78.1	63.3	50.7
LAC-all income levels[f]	4.0	2.9	3.8	1.8	1.4	2.6	63.7	74.7	78.8	36.3	25.3	21.2
LAC-developing only	4.1	2.9	3.9	1.8	1.3	2.7	63.1	74.3	78.5	36.9	25.7	21.5
MENA-all income levels[g]	5.2	4.6	4.0	2.2	2.4	2.1	49.0	58.5	63.2	51.0	41.5	36.8
MENA-developing only	4.1	4.3	2.3	1.3	2.2	0.6	46.5	55.3	59.6	53.5	44.7	40.4
OECD members[h]	3.3	2.2	1.8	2.4	1.4	1.2	70.3	75.9	79.4	29.7	24.1	20.6
South Africa	2.7	2.5	2.8	0.4	0.6	1.4	48.8	56.8	63.0	51.2	43.2	37.0
South Asia	4.3	6.0	6.4	1.9	4.1	5.0	21.9	27.5	31.6	78.1	72.5	68.4
SSA-all income levels[i]	2.9	3.5	4.2	0.1	0.8	1.5	22.1	30.7	35.9	77.9	69.3	64.1
SSA-developing only	2.9	3.4	4.3	0.1	0.7	1.5	22.1	30.7	35.9	77.9	69.3	64.1
Africa	3.9	4.1	4.7	1.1	1.7	2.3	27.2	36.9	41.5	72.8	63.1	58.5
World	3.5	2.6	2.9	1.7	1.3	1.7	39.3	46.7	52.3	60.7	53.3	47.7

Source: Calculated using WDI (2015)

[a]g is growth rate of the real GDP (2005 US$); [b]gy is growth rate of the real GDP per capita [real GDP per capita = GDP (constant 2005 US$)/total population]; [c]Urban population (%) represents share of urban population in total population; [d]Rural population (%) represents share of the rural population in the total population; [e]EAP is the East Asia and Pacific; [f]LAC is Latin America and Caribbean; [g]MENA is the Middle East and North Africa; [h]OECD is the Organization for Economic Co-operation and Development; [i]SSA is Sub-Saharan Africa

Table 18.2 CO_2 emissions in MATE and other regions of the World (1970–2009)

Countries/Region of the world	G-CO_2 (1)				P-CO_2 (2)			
	70–79	80–89	90–99	2000–09	70–79	80–89	90–99	2000–09
Algeria	0.9	1.1	1.3	1.0	2.1	3.0	3.1	3.0
Egypt	1.6	1.7	1.6	1.8	0.8	1.3	1.6	2.3
Morocco	0.6	0.6	0.7	0.7	0.6	0.8	1.1	1.4
Tunisia	0.7	0.8	0.8	0.7	1.0	1.6	1.8	2.3
China	7.2	5.7	3.7	2.4	1.2	1.8	2.5	4.1
EAP- all income levels (3)	0.9	0.9	0.8	0.9	1.9	2.3	3.1	4.2
EAP- developing only	4.3	3.8	2.8	2.1	1.1	1.6	2.3	3.4
LAC-all income levels (4)	0.6	0.6	0.5	0.5	2.1	2.3	2.4	2.7
LAC -developing only	0.6	0.6	0.5	0.5	2.0	2.3	2.3	2.5
MENA-all income levels (5)	1.0	1.1	1.2	1.2	3.0	3.5	4.1	5.2
MENA-developing only	1.2	1.4	1.6	1.6	2.0	2.3	2.8	3.5
OECD members (6)	0.7	0.5	0.4	0.4	11.0	10.4	10.8	10.9
South Africa	1.5	1.9	2.0	1.7	7.5	9.8	9.1	8.7
South Asia	1.3	1.6	1.8	1.6	0.4	0.5	0.8	1.1
SSA-all income levels (7)	1.0	1.2	1.1	1.0	0.9	1.0	0.9	0.8
SSA-developing only	1.0	1.2	1.1	1.0	0.9	1.0	0.9	0.8
Africa	0.6	0.6	0.6	0.5	0.9	1.0	0.9	1.2
World	0.9	0.8	0.7	0.6	4.2	4.1	4.1	4.5

Source: Calculated using WDI (2015)
[a]G-CO_2 refers to CO_2 emissions (kg per 2005 US$ of GDP) = CO_2 emissions/ Real GDP (constant 2005 US$); [b]P-$CO_2$ is CO_2 emissions (metric tons per capita) = CO_2 emission/total population; [c]EAP is the East Asia and Pacific; [d]LAC is Latin America and Caribbean; [e]MENA is Middle East and North Africa; [f]OECD is the Organization for Economic Co-operation and Development; [g]SSA is Sub-Saharan Africa

4 Methodology and Results

Estimating and quantifying the effect of economic growth on environmental quality vary according to the conditions of each country such as the economic growth rate, the degree of openness, the population density, and education and public policies. For this reason, two steps have been followed to investigate the links between economic growth and environmental degradation using a basic EKC equation used in many studies.

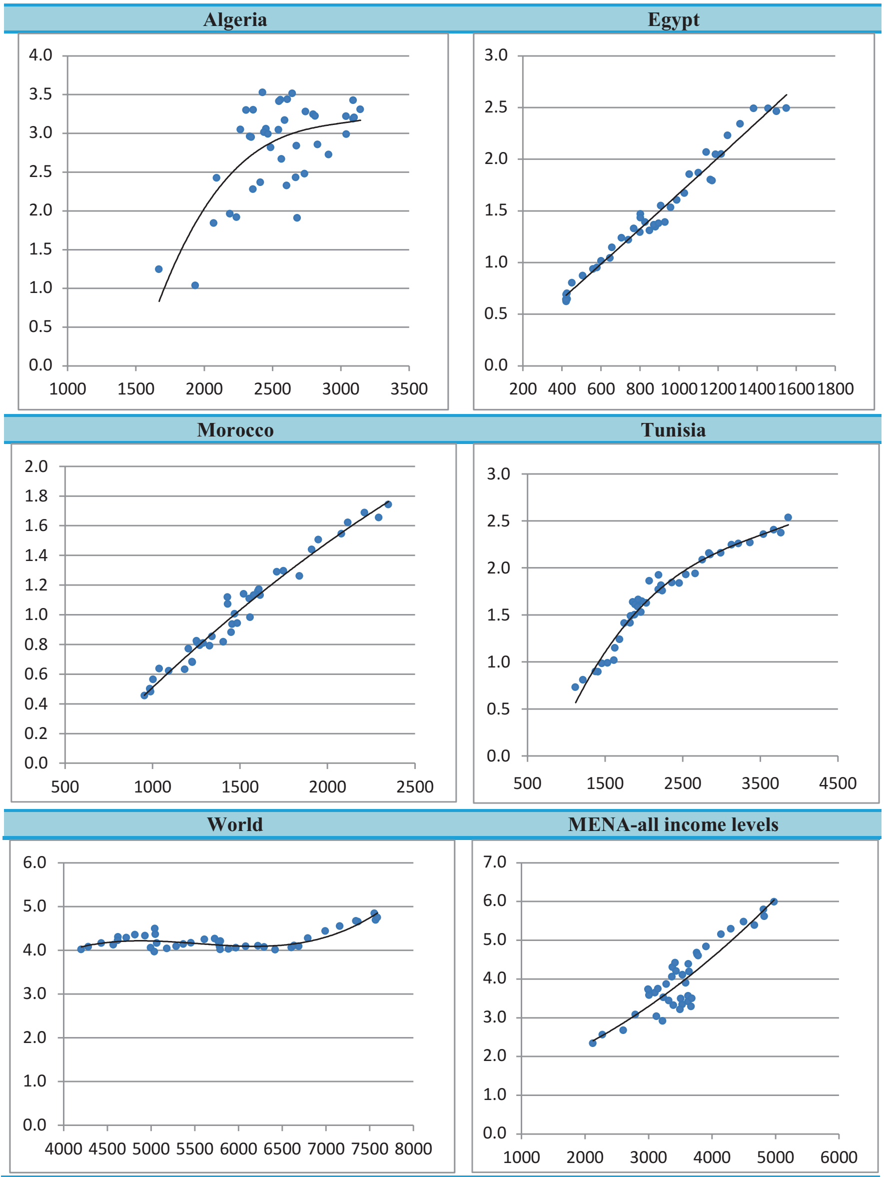

Fig. 18.2 Statistical relationships between CO_2 emissions (metric tons per capita) and real GDP per capita (2005 US$) of MATE, the world, and MENA regions (period 1970–2010)
Source: Elaborated using WDI (2015). E refers to CO_2 emissions per capita in level. Y refers to the real GDP per capita 2005 US dollars in level

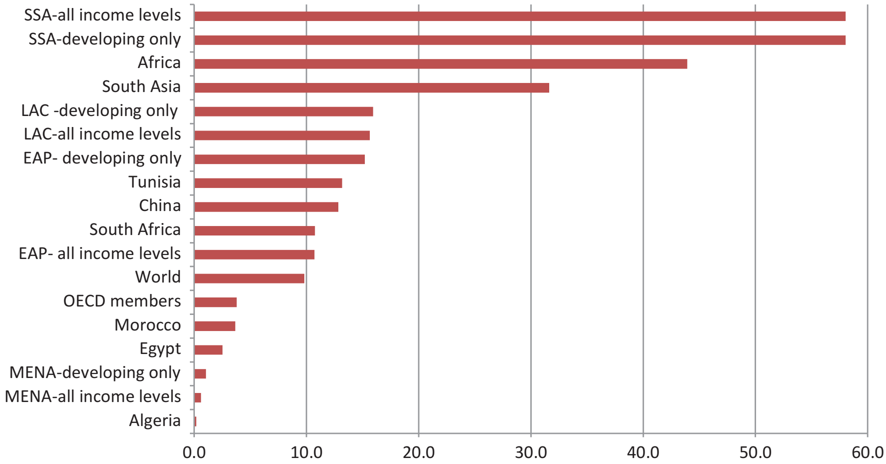

Fig. 18.3 Ranking of regions of the world by combustibles renewable and waste (% of total energy use) (period 2000–2009)
Source: Elaborated using WDI (2015)

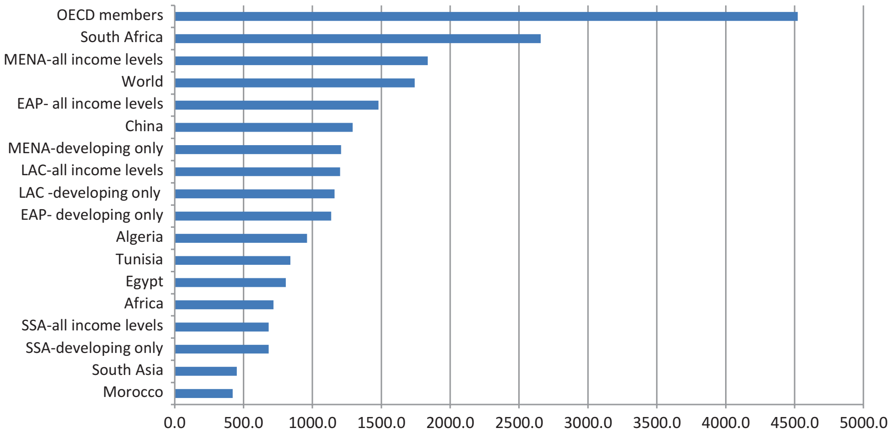

Fig. 18.4 Ranking of regions of the world according to energy use per capita (kg of oil equivalent per capita) (2000–2009)
Source: Elaborated using WDI (2015)

4.1 First Step

A basic EKC equation for each country over the period 1970–2010[15] is used to measure the effect of economic growth on environmental quality and to determine the possibility of the existence of an EKC, i.e. the determination of the environmental curve in the form of an inverted U, which is estimated by the following form:

$$LE_{it} = a_0 + a_1 LY_{it} + a_2 \left(LY_{it}\right)^2 + \varepsilon_{it} \qquad \textbf{model 1}$$
$$For\ each\ i = Algeria, Egypt, Morocco\ or\ Tunisia.$$

Here, *LE* is the logarithm of the environmental degradation, *LY* is the logarithm of the per capita income, *εt* refers to the error term, and *t*= '1970, 1981 … 2010' year. The existence of an EKC implies that the coefficients a1 and a2 will be positive and negative, respectively, ($a_1 > 0$ and $a_2 < 0$). In that case, there is a level of real GDP per capita beyond which the environmental indicator begins to improve, the turning point (noted Ytp), therefore, is determined by: $\mathbf{Y_{tp}} = -\dfrac{\mathbf{a_1}}{\mathbf{2a_2}}$.

4.2 Cond Step

This step consists of introducing other variables[16] in the basic EKC model because this might have some impact on the level of environmental damage by decreasing or increasing it. These variables are:

- Urbanization: the increase of people living in urban areas often involves more waste production and energy consumption;
- Enrollment rates: because they have a direct and indirect impact on income and it may modify peoples' life style;
- Economic openness indicator measured by (X + M)/GDP, where X and M represent, respectively, exportation and importation.

$$LE_{it} = a_0 + a_1 LY_{it} + a_2 \left(LY_{it}\right)^2 + B.X_{it} + \varepsilon_{it} \qquad \textbf{model 2}$$
$$For\ each\ i = Algeria, Egypt, Morocco\ or\ Tunisia.$$

Where *B* is a parameter vector and *X* is an independent variables vector.

This work uses annual data taken from World Bank. Table 18.3 summarizes the descriptive statistics of all variables used in this work.

---

[15] The data of CO2 emission per capita is not available over the period 2011–2015.

[16] There are several factors that affect economic growth or environmental damage, but we cannot use all these variables, so we make some selection according to the availability of data regarding MATE and it importance.

Table 18.3 Statistic descriptive of the variables (sample: 1970–2010)

Variables	Notation: variables_code of country	Mean	St. Dev	Max	Min	Obs.
Real GDP per capita at 2005US$	Y_alg	2558.05	331.10	3143.63	1669.43	41
	Y_egy	886.72	320.90	1550.24	421.35	41
	Y_mor	1494.88	365.59	2348.59	953.93	41
	Y_tun	2263.14	724.89	3861.51	1119.71	41
Environment's Indicator: CO2 emissions per capita	E_alg	2.82	0.61	3.53	1.04	41
	E_egy	1.47	0.56	2.50	0.62	41
	E_mor	1.01	0.35	1.74	0.45	41
	E_tun	1.69	0.48	2.54	0.73	41
Enrollment rate measured by rate of primary completion	Pcr_alg	74.31	13.73	93.40	40.52	39
	Pcr_egy	77.81	20.29	105.91	34.64	39
	Pcr_mor	52.22	16.13	83.90	26.08	39
	Pcr_tun	79.18	13.98	101.72	55.02	39
Urbanization rate is the share of urban population in total population	u_alg	52.15	9.17	67.53	39.50	41
	u_egy	43.18	0.59	43.95	41.48	41
	u_mor	47.26	7.13	57.68	34.48	41
	u_tun	56.80	7.22	65.93	43.48	41
Economic openness indicator = (X + M)/GDP	open_alg	57.74	11.48	76.68	32.68	41
	open_egy	52.87	12.66	82.18	32.48	41
	open_mor	56.69	10.76	88.35	36.68	41
	open_tun	80.63	15.24	115.40	46.74	41

Source: Calculated using WDI (2015)
Code of country refers to alg = Algeria, egy = Egypt, mor = Morocco, and tun = Tunisia

Table 18.4 summarizes the regression results for each country based on the two models mentioned above (model 1 and model 2), differ with some specific additional independent variables (u, pcr and open).

Model 1 In MATE, real GDP per capita and its square are statistically significant and the coefficients attached to these variables are respectively, positive and negative. Therefore, these results prove the existence of an EKC and the levels of real GDP per capita beyond which the environmental indicator begins to improve, noted Ytp, are around $8000 per capita (2005 US dollar), except in case of Egypt whose turning point is higher (more than $26,000 per capita according to 2005 US dollar). This result can be partially explained by the feeble level of real GDP per capita in Egypt against those recorded in Algeria, Morocco, and Tunisia.

Model 2 In case of Egypt, real GDP per capita and its square have not expected signs. Therefore, the results cannot prove the existence of an EKC in this country. However, real GDP per capita and its square have expected signs in cases of Algeria, Morocco, and Tunisia; hence the results prove the existence of an EKC. But, the turning points of Morocco and Tunisia are estimated more than $8000 per capita (2005 US dollar); for the case of Tunisia, the turning point is estimated higher (more than $10,000 per capita according to 2005 US dollar).

Table 18.4 Results of models 1 and 2 from OLS estimation method, sample 1970:2010

			Algeria		Egypt		Morocco	Tunisia		
			Model 1	Model 2	Model 1	Mode 2	Model 1	Model 2	Model 1	Model 2
	Constant	a0	−218.00	−2.38	−7.80	−4.28	−39.53	−10.29	−51.23	−47,63
		Std. dev	62.29	131.91	2.76	2.87	8.79	9.21	5.40	7,78
		t-stat	−3.50	−0.02	−2.83	−1.49	−4.50	−1.12	−9.49	−6,12
Independent variables	LY	a1	54. 87	0.64	1.38	−0.38	6.36	1.86	12.49	11,55
		Std. dev	15.99	33.47	0.83	1.03	2.41	2.48	1.40	1,99
		t-stat	3.43	0.02	1.67	−0.37	3.89	0.75	8.89	5,81
	LY2	a2	−3.43	−0.03	−0.027	0.10	−0.54	−0.09	−0.75	−0,70
		Std. dev	1.06	2.12	0.06	0.08	0.16	0.17	0.09	0,12
		t-stat	−3.35	−0.01	−0.42	1.33	−3.28	−0.54	−8.19	−5,63
	Pcr	b1		0.01		0.001		0.0003		−0,004
		Std. dev		0.01		0.002		0.0016		0,002
		t-stat		1.40		0.56		0.1777		−2,10
	Open	b2		−0.01		0.0003		0.004		0,002
		Std. dev		0.01		0.001		0.002		0,001
		t-stat		−0.11		0.28		2.60		2,19
	u	b3		−0.001		0.06		0.03		0,01
		Std. dev		0.01		0.03		0.00		0,01
		t-stat		−0.11		1.93		5.37		1,76
Turning point at 2005US$		Ytp	7987,28	10531.12	26254.02	—	8662.42	10461.87	8347.83	8305.85
		R2	0.57	0.57	0.98	0.98	0.96	0.98	0.96	0.97
		F-stat-value	25.122	8.62	925.88	380.78	523.62	364.15	482.12	233.95
		Probability of F-stat	0.0033	0.0000	0.0000	0.0017	0.0000	0.0000	0.0000	0.0000

Source: Estimated using the available data

In Egypt, Morocco and Tunisia, the economic openness (open) is linked positively to CO2 emissions per capita. These results mean that the openness increases the environmental damage. But, this variable is a negative sign in case of Algeria. This result can be explained by that Algeria is an exporter country of Oil and gas which represent more than 97% of total exports. However, urbanization rate (u) is linked positively to CO2 emissions per capita in MATE. Rate of primary completion has no stable sign in model 2. This indicator is negative and significant in case of Tunisia and it is positive and not significant in other cases.

5 Environmental Strategies and Concluding Remarks

There are conflicts between economic growth and environment. Improving the quality of citizens' life cannot be realized, even if it is not sufficient, without boosting economic growth whether in developed or developing countries. But, this growth often generates negative environmental externalities which affect ecosystems' balance and reduce biodiversity, sometimes irreversibly. The links between these variables are still uncertain, complex, and ambiguous. Therefore, it is not possible to find a unique form of this links, and each variable introduced in model can give some explanation, as it is shown in this work, where the application of EKC is often unclear and uncertain.

These results mean that each country through policymaking and the involvement of other actors such corporations and non-governmental organizations must apply preventive and precautionary measures to reduce environmental damage. Such measures must be adapted with the specific economic and environmental conditions while benefiting from the experiences and good practices developed in other regions and avoiding others' past mistakes related to pollution, regional development, and natural resource management.

In parallel, it is necessary to establish a global political strategy to protect ecosystems and biodiversity in all countries because solidarity and participation of all people of the planet are important steps to reduce environmental damage. These steps mean that the present generations must not only think about future generations while using resources, but it must involve all people in improving and protecting the environment through solidarity actions, recreational activities and volunteering.

References

Antweiler W, Copeland BR, Taylor MS (2001) Is free trade good for the environment? Am Econ Rev 91:877–908

Arrow K, Bolin B, Costanza R, Dasgupta P, Folke C, Holling CS, Jansson BO, Levin S, Mäler K, Perrings C, Pimentel D (1995) Economic growth, carrying capacity and the environment. Science 268:520–521

Bass S (2006) Making poverty reduction irreversible: development implications of the millennium ecosystem assessment. IIED Environment for the MDGs' briefing paper. International institute on environment and development, London

Becker GS (1962) Investment in human capital: a theoretical analysis. J Polit Econ 70(5):9–19

Beckerman W (1992) "Economic development and the environment: conflict or complementarity", background paper for the world development report 1992. The World Bank, Washington, DC

Blaug M (1976) The empirical status of human capital theory: a slightly jaundiced survey. J Econ Lit 14(3):827–855

Bourdieu P (1985) The forms of capital. In: Richardson JG (ed) Handbook of theory and research for the sociology of education. Greenwood, NewYork, pp 241–258

Chertow MR (2001) The IPAT equation and its variants. Changing views of technology and environmental impact. J Ind Ecol 4(4):13–29

Chivian E, Bernstein A (2010) How our health depends on biodiversity. Center of Health and the Global Environment, Harvard Medical School, Boston

Cole MA (1999) Limits to growth, sustainable development and environmental Kuznets curves: an examination of the environmental impact of economic development. Sustain Dev 7:87–97

Cole MA, Neumayer E (2005) Environmental policy and the environmental kuznets curve: can developing countries escape the detrimental consequences of economic growth? In: Dauvergne P (ed) Handbook of global environmental politics. Elgar original reference. Edward Elgar, Cheltenham, pp 298–318 ISBN 9781843764663

Cole MA, Rayner AJ, Bates JM (1997) The environmental Kuznets curve: an empirical analysis. Environ Dev Econ 2:401–416

Coleman JS (1988a) Social capital in the creation of human capital. Am J Social 94:95–121

Coleman JS (1988b) The creation and destruction of social capital: implications for the law. Notre Dame J Law Ethics Publ Policy 3:375–404

Commoner B (1972a) A bulletin dialogue on 'The Closing Circle': response. Bull At Sci 28(5.):17):42–56

Commoner B (1972b) The environmental cost of economic growth. In: Ridker RG (ed) Population, resources and the environment. Government Printing Office, Washington, pp 339–363

Commoner B, Corr M, Stamler PJ (1971) The causes of pollution. Environment 13:2–19

Costanza R, Daly HE (1992) Natural capital and sustainable development. Conserv Biol 6:37–46

Cropper M, Griffiths C (1994) The interaction of population growth and environmental quality. The American Economic Review. vol 84, No. 2, papers and proceedings of the hundred and sixth annual meeting of the American economic association (May, 1994), pp 250–254

Daniel JJ (1999) Introduction to atmospheric chemistry. Princeton University Press, Princeton

Ehrlich PR, Holdren JP (1971) Impact of population growth. Science 171:1212–1217

Ehrlich PR, Holdren JP (1972) A bulletin dialogue on 'The Closing Circle': critique. Bull At Sci 28(5.):16):18–27

Ekins P (1997) The Kuznets curve for the environment and economic growth: examining the evidence. Environ Plan A 29:805–830

Grossman GM, Krueger AB (1991) Environmental impacts of a North American free trade agreement. National bureau of economic research. Working paper No 3914, NBER, Cambridge, MA

Grossman GM, Krueger AB (1995) Economic growth and the environment. Q J Econ 112:353–378

Intergovernmental Panel on Climate Change (IPCC) (2014) Climate change 2014: synthesis report. Contribution of working groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change [Core writing team, RK Pachauri and LA Meyer (eds)]. IPCC, Geneva, 151 pp

Khagram S, Clark WC, Raad DF (2003) From the environment and human security to sustainable security and development. J Hum Dev 4(2):289–313

Kiker BF (1966) The historical roots of the concept of human capital. J Polit Econ 74(5):481–499

Kuznets S (1955) Economic growth and income inequality. Am Econ Rev 49:1–28

Lopez R (1994) The environment as a Factor of production: the effects of economic growth and trade liberalization. J Environ Econ Manag 27(2):185–204

Martino D, Zommers Z (2007) Environment for development, Chapter 1 of report of Global environment outlook, GEO4, United Nations Environment Programme (UNEP)
Mincer J (1958) Investment in human capital and personal income distribution. J Polit Econ 66(4):281–302
Mincer J (1962) On-the-job training: Costs, returns, and some implications. J Polit Econ 70:50–79
Panayotou T (1993) Empirical tests and policy analysis of environmental degradation at different stages of economic development. Working paper WP238, technology and employment programme, International labour office, Geneva
Panayotou T (1997) Demystifying the environmental Kuznets curve. Turning a black box into a policy tool. Environ Dev Econ 2(04):465–484
Panayotou T (2003) Economic growth and the environment. Harvard University and Cyprus International Institute of Management, Harvard. https://www.unece.org/fileadmin/DAM/ead/sem/sem2003/papers/panayotou.pdf
Perman R, Stern DI (1999) The environmental Kuznets curve: implications of non-stationarity, working papers in ecological economics 9901, Centre for resource and environmental studies, Australian National University, Canberra
Portes A (1998) Social capital: its origins and applications in modern sociology. Annu Rev Sociol 24:1–24
Putnam RD (1993) The prosperous community: social capital and public life. Am Prospect 4(13):35–42
Schultz TW (1961) Investment in human capital. Am Econ Rev 51(1):1–17
Schultz TW (1962) Reflexions on investment in man. J Polit Econ 70(5):1–8
Selden TM, Song D (1994) Environmental quality and development: is there a Kuznets curve for air pollution emissions? J Environ Econ Manag 27:147–162
Shafik N (1994) Economic development and environmental quality: an econometric analysis. Oxf Econ Pap 46:757–777
Shafik N, Bandyopadhyay S (1992) Economic growth and environmental quality: time series and crosscountry evidence. Background paper for the world development report 1992, the World Bank, Washington, DC
Stern DI (2004) The rise and fall of the environmental Kuznets curve. World Dev 32(8):1419–1439
Stern DI, Common MS (2001) Is there an environmental Kuznets curve for sulfur? J Environ Econ Manag 41:162–178
Torras M, Boyce JK (1998) Income, inequality, and pollution: a reassessment of the environmental Kuznets curve. Ecol Econ 25(2):147–160
World Bank (2006) Where is the wealth of nations? measuring capital for the 21st century. The World Bank, Washington, DC
Yandle B, Vijayaraghavan M, Bhattarai M (2002) The environmental Kuznets curve: a primer. Research study 02–1. Montana, USA. Political Economy Research Center (PERC)