For sustainable economic growth that seeks to improve environmental quality: an empirical analysis applied to morocco, algeria, tunisia, and egypt

El Alaoui, Aicha and Nekrache, Hassane

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Aïcha El Alaoui
Dr. Professor of Economics at the Faculty-Poly-disciplinary of BeniMellal. Member of Member of Economic and Social Sciences Laboratory. University of Sultan My Slimane. Mghila, B.P. 592, CP: 23000, BeniMellal, Morocco. Email. aicha_elalaoui@yahoo. fr, Tel. +212663506211

Hassane Nekrache
Dr. Statistician and demographer at High Commission for Planning, Morocco.
Email. n_hassane@yahoo. com, Tel. +212673342900

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Abstract:

This paper tries to examine the link between economic growth and environmental damage in **M**orocco, **A**lgeria, **T**unisia, and **E**gypt, denoted **MATE**. The main objective for these countries in the coming years is to improve economic growth, which is necessary in response to the increasing demand of their populations, the improvement of the life's quality of their citizens, and to meet the environmental challenges they face. For that, two steps are followed to investigate the relationship between economic growth and environmental damage. In the first step, a basic **E**nvironmental **K**uznets **C**urve (EKC) equation for each country over the period 1970-2010 is tested to measure the effect of economic growth on environmental quality and to determinate the possibility of the existence of an EKC. In the second step, a few variables are introduced in the basic EKC equation (model tested in the first step) such as economic openness indicator, enrollment rate, and urbanization rate. The purpose is to measure the possible influence of these variables (included economic growth) on the environmental damage, and to determinate also the possibility of the existence of an EKC. The results of both models show that the relationship between economic growth and environment is complex and ambiguous. It is not possible to find a unique form of this relationship and each variable introduced in the model can give some explanation where the application of EKC is unclear and uncertain. So, each country through policymakers, governmental and nongovernmental organizations must apply preventive and precautionary measures to reduce environmental damages. These measures must be appropriate to its economic and environmental conditions benefiting from the experiences of neighbors, especially those of developed countries, and to take lessons from their past mistakes related to pollution, regional development and resource management.

Key words: • Economic Growth • Environmental degradation • EKC.
Jet classification code: C13, N57, Q56

1.1.Introduction

The economic growth remains important for all countries, developing as well as developed countries. It affects people's well-being, i.e. health, education, employment, quality of life, etc. It affects also government's stability, from social and nutritional security to political stability. The recent example is the "*Jasmine*" revolution started in Tunisia. The principal reasons behind this revolution are the high rate of unemployment, the high index of corruption, the poor living conditions, the lack of democracy (free election), and the deficiency of freedoms (freedom of the expression and the press).

The economic growth requires the combination of different types of capitals in order to produce goods and services (World Bank, 2006). These include produced capital, human capital, institutional and social capital, and natural capital.

- 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 writing of **Becker** (1962, 1964), **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; 1988b), **Putnam** (1993), and **Portes** (1998);
- Natural capital, which is related to the natural resources such as air, water, minerals, the extracted raw materials (gas, phosphate, petroleum, . . .), and animals (fish, cow, pig, . .). This capital is vital for securing a sustainable economic growth and development, not only for the present but also for the future generation. Natural capital is defined by the **Global Development Research Center** 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 this of **Costanza and Daly** (1992).

The link between the economic growth and the four capitals mentioned above is complex and strong. This study focuses only on the relationship between the economic growth and the environment/the natural capital [1]. Indeed, the environment plays an important role in supporting all economic activities (agriculture, manufacturing and services). It contributes directly and indirectly in these activities. Directly by providing raw materials and minerals required as inputs for the production. Indirectly by providing ecosystems required as river, ocean, air . . . However, the economic growth has caused many changes to the environment, especially, since the industrial revolution. In its report, the **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, p.4). The 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, p.10). During the last years, the ozone layer became extremely fragile because of its low concentration of ozone (O_3). However, the pollution causes destruction of this layer notably via the reactions that take place between O_3 compounds and pollutants. It thus exposes humans to sunlight and therefore causes many health problems such as the skin cancer.

The second aspect of environmental damage is the extreme change in the earth's temperature: the atmosphere and the oceans have warmed, the amounts of snow and ice have diminished, and the level of the sea 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

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

days and nights has increased on the global scale", (IPCC, 2014, p.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, p.2). Thus, the global average land and ocean surface temperature warming combined is estimated of 0.85 [0.65 to 1.06] °C[2] over the period 1880 to 2012, (IPCC, 2014, p.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 measure of ice core shows that the "atmospheric concentrations of CO2 have increased from 280ppmv[2] in pre-industrial times to 365ppmv today", (Daniel, 1999, p.93).

The third aspect of environmental damage is the biodiversity loss or the "biological diversity" loss. It refers to all species living in the world. However, human actions on the environment and the air pollution highlight the disappearance and scarcity of certain species, whether insects, animals, or plants. So, human activities have increased the species extinction's rate to a higher level of 100 to 1,000 times the natural rate, (**Chivian and Bernstein**, 2010, p.5).

These three aspects of the environmental damages have caused direct and/or indirect problems such as the increase risk of the famine, the contagious maladies (malaria, Ebola…), flooding, and the risk of water shortage (**Khagram, Clark and Raad**, (2003), **Bass** (2006), **Martino and Zommers** (2007), among others). "The harmful effects of the degradation of the 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, p.2). While, the environmental damage will be experienced by developing countries and the poorest people, especially in Sub-Saharian Africa, South Asia, Southeast Asia, and Latin America regions. In urban area, the risks for peoples, assets, economies and ecosystems have increased such as air pollution, drought and water scarcity (IPCC, 2014, p.15). In rural area, the major impacts are on water availability and supply, food security, infrastructure and agricultural incomes (IPCC, 2014, p.16).

Everybody has a clear conscience about environmental challenges, from averting dangerous climate changes to halting biodiversity losses and protecting our ecosystems. However, the developed economies have partially reduced the environmental damage by, especially, installing/relocating/transferring a part of their production as investments in developing countries, thus exporting their pollution to these countries. But, these investments are important and vital for developing countries; it ensures continued economic growth and helps to reduce poverty, migration and unemployment. For that, the solution is in reducing environmental impacts, namely by highlighting the importance of technological innovations in developing countries.

This paper tries to examine the link between the economic growth and the environment in **M**orocco, **A**lgeria, **T**unisia, and **E**gypt, denoted **MATE,** where the main objective for these countries in the coming years is to improve economic growth, which is necessary in response to the increasing demand of their populations, the improvement of the life's quality of their citizens, and to meet the environmental challenges they face.

The article is organized as follows: The second section reviews a sample of theoretical and empirical studies that focus on the relationships between economic growth and the environment. The third section presents economic and environmental situation in Morocco,

[2] This expression means "parts per million by volume".

Algeria, Tunisia and Egypt. The fourth section is allotted for the presentation of the methodology and of the main results. The fifth section serves to sketch the main components of a strategy to induce environmental improvement in MATE and to conclude.

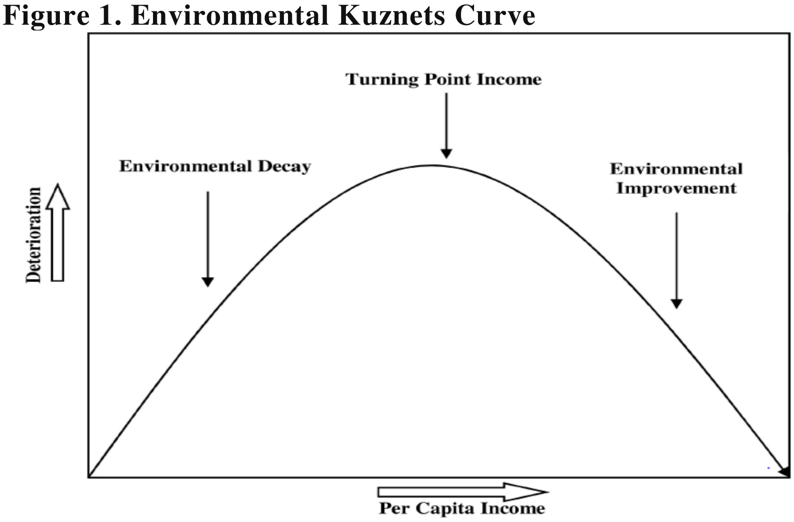
1.2. Theoretical and empirical discussions about the relationship between economic growth and environment

The 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) and **Commoner** (1971, 1972a, 1972b) 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 and polluting technology (***T***). These three factors were considered as the worst for the planet and are linked by the following equation named **IPAT**[3]:

Impact = **P**opulation *x***A**ffluence *x***T**echnology.

According to IPAT equation and Rachel Carson (1962), the attention was growing to examine the relationship between the economic growth and the environmental quality. This relationship is represented by the **E**nvironmental **K**uznets **C**urve, noted **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 **Figure1**. The EKC takes the 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.

Figure 1. Environmental Kuznets Curve



Source: Yandle, Vijayaraghavan and Bhattarai (2002), p.3.

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

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

The idea of this model is that population enrichment was accompanied by the demand for a cleaner environment. At the lowest income 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 scarify à part of its income to protect the environment. Many researchers have focused on the relationship between the 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 the last decades, especially in developed countries. This paper 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). 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[6]. The authors used a cubic function to estimate the concentration of pollutants in the air (SO_2, suspended particles and dark matter (thin smoke)) in urban areas using the Global Environmental Monitoring System (GEMS) dataset as part of a study of 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", p.36. Similar findings are reported by Shafik (1994), he concluded that "some environmental indicators improve with 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)", pp.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) tried to respond to these questions exploring the relationship 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 relationship between income and each environmental indicator[7], which was used as the dependent variable in a

[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] For more explication see Grossman and Krueger, 1991, pp.3-4
[7] They estimated for 10 environmental indicators which are "the lack of clean water, lack of urban sanitation, ambient levels of suspended particulate matter (SPM), ambient sulfur oxides (SO_2), 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).

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, political and civil liberties. Lack of clean water and lack of urban sanitation decline uniformly over time with increasing income. River's quality tended to worsen with increasing income. The two indicators of air pollutants (SPM and SO_2) 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, p.22).

In another background paper in World Development Report 1992, Beckerman tried to analyze the relationship between economic growth and environmental quality, namely local air quality and access to drinkable water and sanitation. The author has clearly described this relationship 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", p.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", p.21.

Examining the effect of population pressures on deforestation in 64 developing countries over the period 1961-1988, Cropper and Griffiths (1994) documented that if 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", p.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 relationship 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) showed that trade liberalization generates an increase in income levels, then it can strengthen the incentives for 'environmental dumping', p.21. So they proposed that free trade can protect the environment. **Lopez** (1994) 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", p.163. 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, (Lopez, 1994, p.183). **Antweiler, Copeland and Taylor** (2001) investigated how the openness to trading opportunities affect 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", p.878.

The turning points[8] come somewhere between $4,000 and $5,000 per capita GDP, measured in 1985 U.S. dollars, (Grossman and Krueger, 1991, p.5). 'Similar' results are found by Cropper and Griffiths (1992) which the turning points are $4,760 per capita income in Africa and $5,420per capita income in Latin America. However, these points vary substantially across environmental indicators[9]. Shafik and Bandyopadhyay (1992) found that the turning points are $3,280, $1,375 and $1,375 (per capita income in 1985 U.S. dollars) for sulfur dioxides, SPM and fecal coliform, respectively.

Other studies[10]have estimated the turning point to be generally higher. The turning points vary for the different pollutants[11], but almost in every case they occurred at an income of less than $8,000 U.S dollars in 1985, (Grossman and Krueger, 1995, p.369). Selden and Song's estimates are under $10,000 per-head (1985 U. S dollars). These authors tested four indicators of air pollution (SPM, SO_2, NOx and CO) in their model using the GEMS aggregate emissions data obtained from the World Resources Institute. But, **Cole, Rayner, and Bates** (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 $5,700 to a high $34,700 in 1985 U.S dollars).

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), and **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 an economic growth and a higher income, but there are several other factors can play an important role in improving our biodiversity and ecological systems such as education, quality of institution, and civil society[12]. However, many critics have argued that the EKC suffers from severe methodological problems that cast doubt on the reliability of EKC results (**Cole and Neumayer**, 2005, p.298). The authors documented that the rich countries have become clean up, at least partly, by exporting the dirty production of products 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", p.521.

Stern and Common (2001) and Perman and Stern (1999) declared that the several studies used only OECD data will have to estimate an optimistic tuning point 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

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

[9]For more explication see Shafik (1994).

[10]See for example Selden and Song (1994), Grossman and Krueger (1995), and **Cole, Rayner and Bates** (1997).

[11] 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.

[12] For example, Panayotou (1993) 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", p.2.

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, p.805.

1.3. 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, majority of Algerian and Tunisian populations live in cities, while Moroccan and Egyptian populations live in rural area. **Table 1** gives an idea about economic growth and rapid urbanization known in majority regions of the world.

Table 1. Real GDP (g) (1), Real GDP per capita (g_y) (2), urban and rural population

	g (%)			g_y (%)			Urban population (3), %			Rural population (4), %		
	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 (5)	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 (6)	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 (7)	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(8)	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 (9)	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 World Development Indicators (WDI), 2015. ***(1) g*** is growth rate of the real GDP (2005 US$); ***(2)*** g_y is growth rate of the real GDP per capita [real GDP per capita =GDP (constant 2005 US$)/total population]; ***(3) Urban population (%)*** represents share of urban population in total population; ***(4) Rural population (%)*** represents share of the rural population in the total population; ***(5) EAP*** is the East Asia and Pacific; ***(6) LAC*** is Latin America and Caribbean; ***(7) MENA*** is the Middle East and North Africa; ***(8)OECD*** is the Organization for Economic Co-operation and Development; **(9)** ***SSA*** is Sub-Saharan Africa.

Consequently, live in cities have an important impact on life-style of citizens and economic activities such as boost demand of transport, telecommunication technology, manufactured goods, drainage, sanitation, and other demand linked to consumption style in the cities. Thus, these changes in the population's behavior will increase the environmental damage especially in air and water. **Table 2** gives an idea about the evolution of environmental damage measured by CO2 emissions in MATE and in other regions of the World.

Table 2. CO2 emissions in MATE and other regions of the World, 1970-2009

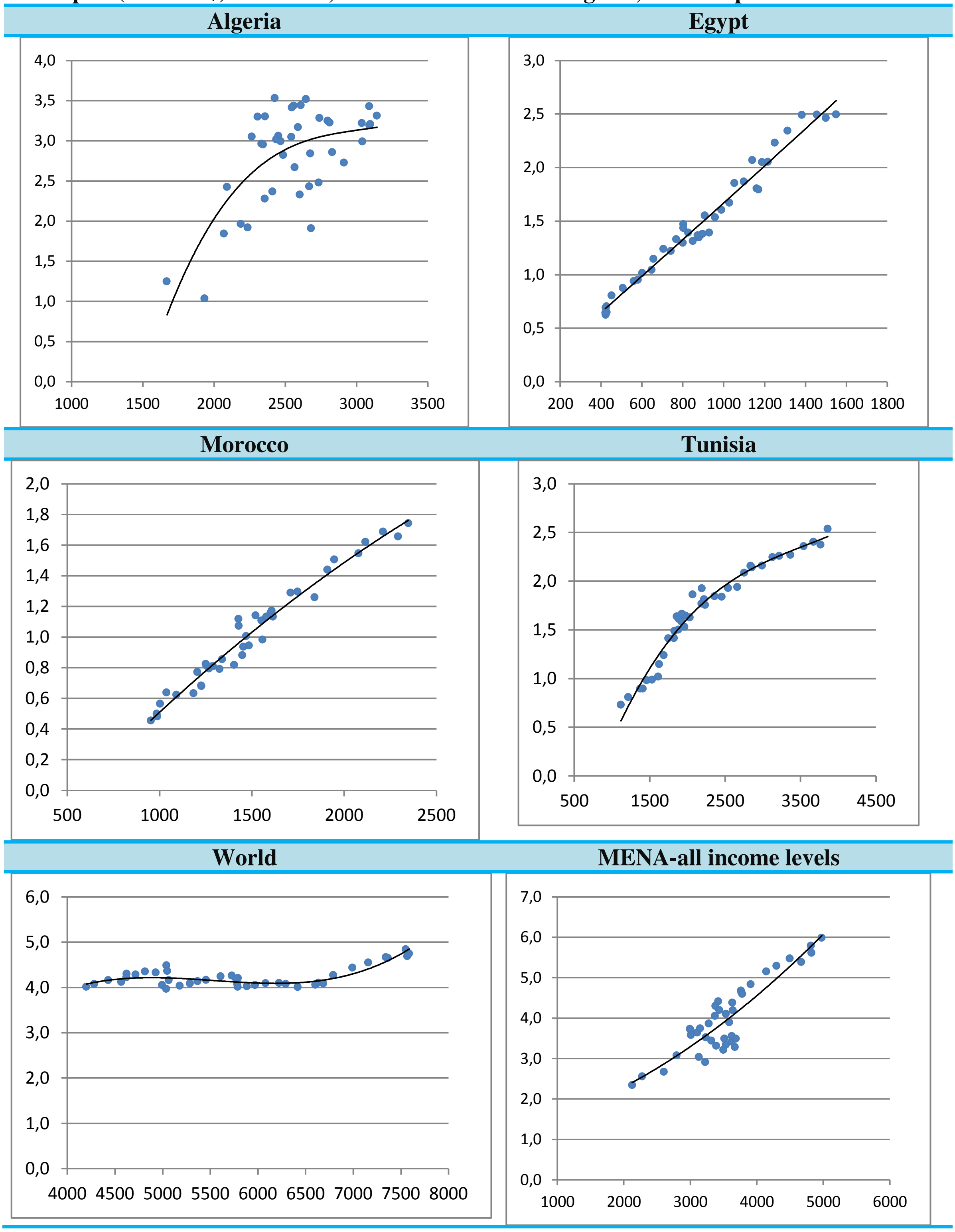
	G-CO2 (1)				**P-CO2 (2)**			
Countries/Region of the World	**70-79**	**80-89**	**90-99**	**2000-09**	**70-79**	**80-89**	**90-99**	**2000-09**
Algeria	0.9	1.1	1.3	1.0	2.1	3.0	3.1	3.0
Egypt	1.6	1.7	1.6	1.8	0.8	1.3	1.6	2.3
Morocco	0.6	0.6	0.7	0.7	0.6	0.8	1.1	1.4
Tunisia	0.7	0.8	0.8	0.7	1.0	1.6	1.8	2.3
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 World Development Indicators (WDI), 2015. ***(1) G-CO2*** refers to CO2 emissions (kg per 2005 US$ of GDP) =CO2 emissions/ Real GDP (constant 2005 US$); ***(2) P-CO2*** is CO2 emissions (metric tons per capita)=CO2 emission/total population; ***(3) EAP*** is the East Asia and Pacific. ***(4) LAC*** is Latin America and Caribbean. ***(5) MENA*** is Middle East and North Africa. ***(6)OECD*** is the Organization for Economic Co-operation and Development. ***(7) SSA*** is Sub-Saharan Africa.

Table 2 shows that ***(i)*** Africa's emissions are lower compared to those of the World; ***(ii)*** the highest CO2 emissions per GDP are recorded in China and EAP-developing countries; ***(iii)*** CO2 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 and 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.

The following figure (**Figure2**) shows that there is a relationship between CO2 emissions per capita and real GDP per capita, but this relationship has not a unique form.

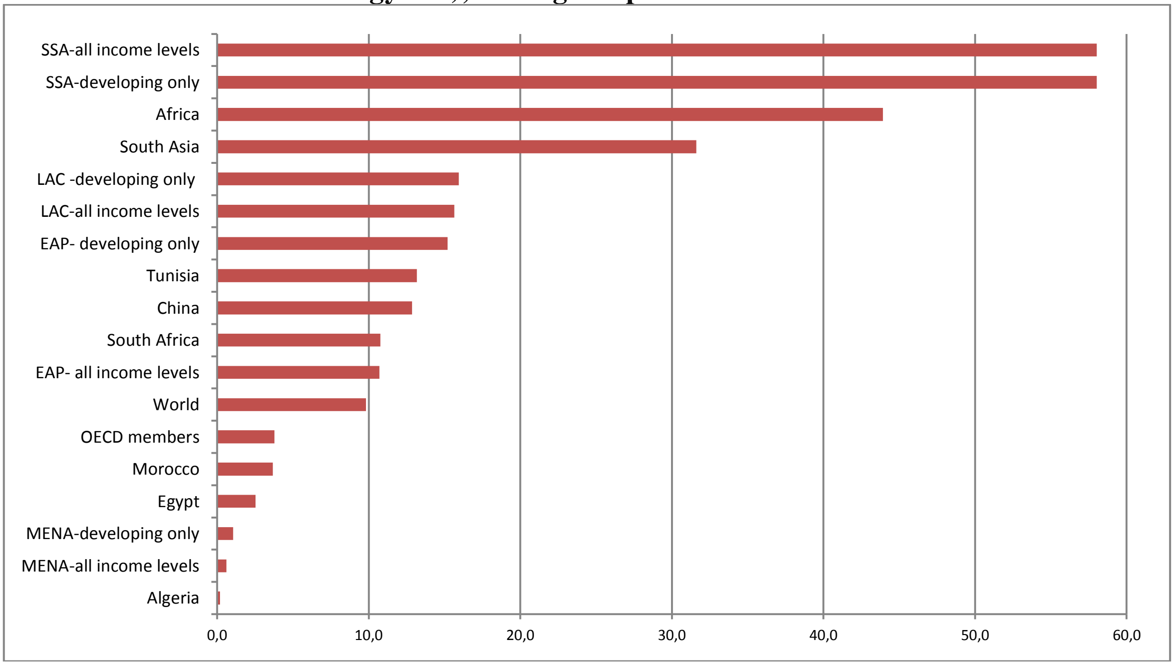
Figure No2. Statistical relationships between CO2 emissions (metric tons per capita) and real GDP per capita (2005 US$) of MATE, the world and MENA regions, over the period 1970-2010



<u>Source</u>: Elaborated using World Development Indicators (WDI), 2015. ***E*** refers to CO2 emissions per capita in level. ***Y*** refers to the real GDP per capita 2005 US dollars in level.

In Sub-Saharan Africa (SSA), combustible renewable and waste constitute more than 50 percent of energy use during the period 2000-2009, **Figure 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.

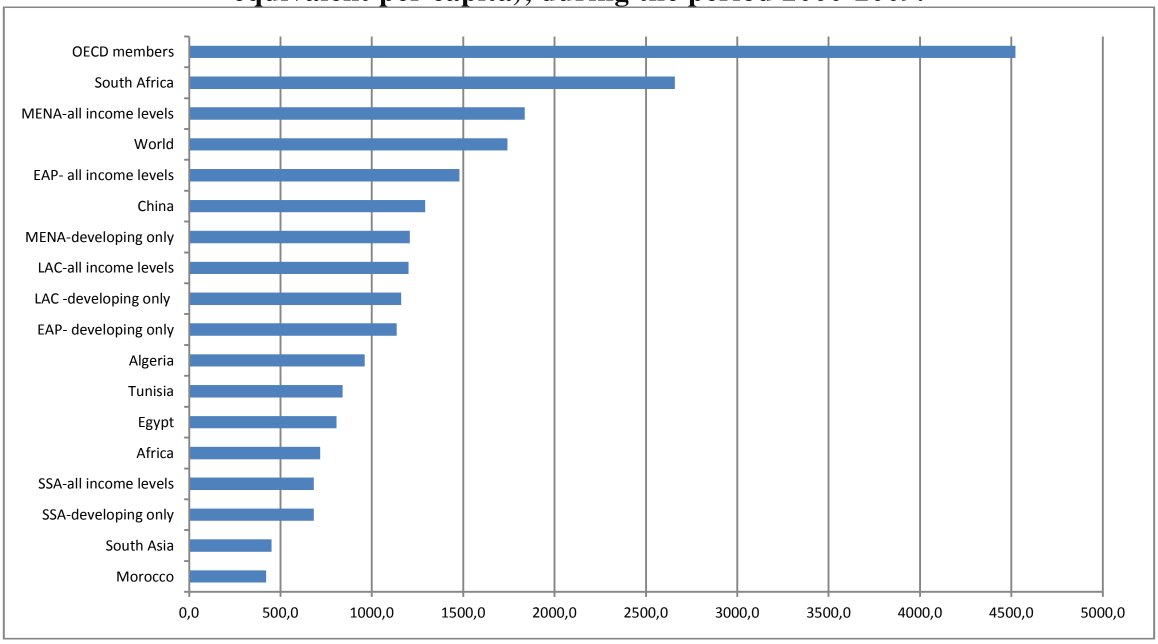
Figure 3. Ranking of regions of the World by combustibles renewable and waste (% of total energy use), during the period 2000-2009.



Source: Elaborated using World Development Indicators (WDI), 2015.

The highest energy use per capita is recorded in OECD members followed by South Africa and MENA- all income levels, **Figure 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.

Figure 4. Ranking of regions of the World according to energy use per capita (kg of oil equivalent per capita), during the period 2000-2009.



Source: Elaborated using World Development Indicators (WDI), 2015.

1.4.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, the degree of openness, the population density, the education and public policies. For that, two steps are followed to investigate the relationship between environmental degradation and economic growth using a basic EKC equation used in many studies.

- ***First step***: a basic EKC equation for each country over the period 1970-2010[13] is utilized to measure the effect of economic growth on environmental quality and to determinate 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.

$$LE_{it} = a_0 + a_1 LY_{it} + a_2 (LY_{it})^2 + \varepsilon_{it} \qquad \textbf{model. 1}$$

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

- ***Second step***: introducing other variables[14] in the basic EKC model because that might have some impact on the level of environmental damage by decreasing or increasing it. These variables are:
  - ***(i)*** The urbanization because more people in cities involve more wastes and consumption of carburant and combustible;
  - ***(ii)*** The enrollment rate because they have a direct and indirect impact on income and it may modify peoples' life style;
  - ***(iii)*** The economic openness indicator measured by (X+M)/GDP, where X and M represent, respectively, exportation and importation.

Model1 will as follow:

$$LE_{it} = a_0 + a_1 LY_{it} + a_2 (LY_{it})^2 + B.\ X_{it} + \varepsilon_{it} \qquad \textbf{model. 2}$$

For each i= Algeria, Egypt, Morocco or Tunisia.

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

This study uses annual data taken from World Bank. **Table 3** summarizes the descriptive statistics of all variables used in this study.

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

[14] 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 data availability of MATE and it importance.

Table 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 5 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*)

Table 5: Results of models 1 and 2 from OLS estimation method, sample 1970:2010

			Algeria		Egypt		Morocco		Tunisia	
			Model 1	Model 2	Model 1	Model 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
	LY^2	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$		Y_{tp}	7987,28	10531.12	26254.02	---	8662.42	10461.87	8347.83	8305.85
		R^2	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.

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 Y_{tp}, are around \$8000 per capita (2005 US dollars) except in case of Egypt, its turning point is very higher. It is more than \$26000 per capita (2005 US dollars). 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, these results cannot prove existence of an EKC in Egypt. However, real GDP per capita and its square have expected signs in cases of Algeria, Morocco and Tunisia. These results prove existence of an EKC. But, the turning points of Morocco and Tunisia are estimated more than \$8000 per capita (2005 US dollars) and of Tunisia, this point is estimated very higher; it is more than \$10000 per capita (2005 US dollars).

In Egypt, Morocco and Tunisia, 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. 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 no significant in other cases.

1.5. Environmental strategies and concluding remarks

There are conflicts between economic growth and the environment. Improving quality of citizens' life cannot be realized, even if it is not sufficient, without the economic growth whether in developed or developing countries. But, this growth conducts destruction of the ecosystems and biodiversities in the Globe with irreversible impact in future. The relationship between these variables is complex and ambiguous. Therefore, it is not possible to find a unique form of this relationship and each variable introduced in the model can give some explanation, as it is shown in this study, where the application of EKC is unclear and uncertain. These results mean that each country through policymakers, governmental and nongovernmental organizations must apply preventive and precautionary measures to reduce environmental damages. These measures must be appropriate to its economic and environmental conditions benefiting from the experiences of neighbors, especially those of developed countries, and to take lessons from their past mistakes related to pollution, regional development and resource management.

In parallel, it is necessary to establish a global political strategy to protect the ecosystems and biodiversities 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 generation must not only think about future generations while using resources, but also it must be some kind of involvement of all people in improving and protecting the environment through solidarity actions, recreational activities and volunteering as in case of the epidemic or the natural disasters or the wars.

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