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Population and clean water: Evidence from Arab countries

Hala Abou-Ali *, Yasmine M. Abdelfattah

Department of Economics, Faculty of Economics and Political Science, Cairo University, Giza, Egypt

Abstract

The population-environment interactions are complex, because it works through different channels, such as preferences, technology, and economic activities. STIRPAT model is implemented, this model weights the impact of population size, income per capita and technology on environment. Lack of safe water access represents the indicator for environmental impact. This environmental stress measures reflect major concern for human health and productivity. The study will contribute to the existing literature by examining the interrelations between population, the environment and institution quality in the Arab countries, taking into account dynamics and the presence of heterogeneity between these countries. Exploring the population-development-environment dimensions is crucial to assess the current situation and provide policy makers with sustainable development policies. The variables adopted are lack of access to safe water, rule of law, population size and GDP per capita in addition to other demographic factors for the period of 1990-2014. Panel data techniques are adopted to estimate the STIRPAT model for all Arab countries. Our results support the importance of rule of law in decreasing water shortage in the Gulf Cooperation Council Arab countries (GCC). The impact of population pressure on Arab countries' water access is huge.

Keywords: Arab Countries; Population And Environment; STIRPAT Model; Safe Water; Panel Regression; Gulf Cooperation Council; Arab Countries

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* Corresponding author. *E-mail address:* habouali@feps.edu.eg

1. Introduction

Future climate change is predicted to affect safe water, arable land and coastal areas impacting agriculture production, population especially in densely populated coastal areas. Safe water access is a weakness in many parts of the Arab World which is likely to be further exacerbated by climate change. Lack of access to safe water arises from multiple influences. It is generally known that growing population and economic growth produce potential environmental and climate change pressures (Jorgenson and Clark, 2010). These pressures are revealed in higher demand for energy, food, land and water. Population dynamics and growing population, usually tops the list of major sources of growing environmental degradations (see Raupach, 2007). Population growth is also accompanied by the age structure and population distribution. The latter is particularly known for accelerating rural-urban migration, which is considered another cause of environmental degradation. If coupled with increased demand, this will contrarily affect livelihoods and worsen water-related problems. Such situation leaves some countries of the region most vulnerable to climate variability because of multiple stresses and low adaptive capacity. The frequent natural disasters such as floods and droughts, contribute to the extreme poverty of many of the Arab countries.

Water has also received the most attention since water scarcity is structural in most of the Arab countries (Dabour, 2002). Indeed, The Arab region is considered the most water distressed area in the world. According to Allan (2003), the region ran out of water in the 70’s and the area is currently surviving on non–renewable sources. Both West Bank and Gaza Strip have a water consumption below 100 liters per day (Joffé, 2016). Furthermore, the severe water stress facing the Colorado and Jordan rivers, was assessed as “water demand/supply gap” due to population increase and climate change (Jin et al., 2016). Likewise, Lebanon with an abundance of water relative to the region is predicted to face water shortages by 2025 because of demand increase only not taking into account climate change. Water scarcity is as well affecting the agriculture sector in the region which can cause threats of food security. Water shortages and the withdrawal of water from non-renewable resources increases land salinization and desertification. United Arab Emirates and Saudi Arabia, which are considered ones of the most arid areas of the region, have the highest annual per capita withdrawal of water and are highly dependent on food import (FAO, 2003; UN Water, 2012).

Arab countries include 22 countries. They widely differ in population size, level of development, per capita income, and degree of urbanization and level of environment preservation among other things. Some of them have a large number of inhabitants like Egypt others have population of less than one million such as Qatar and Djibouti. A subgroup suffers from high rates of poverty while other does not. Average per capita GDP during 1990 - 2014 ranged between a maximum of US$ 57.1 thousand for Qatar and US$ 621 for Comoros. They also widely differ in the degree of industrialization and environmental impact. Oil-rich countries such as Saudi Arabia have more access to profitable natural resources. This help them invest in projects to overcome water cuts compared to country as Jordan that is less fortunate in natural resources. In Saudi Arabia, desalination plants are constructed to provide additional water for cities, so water cuts are less common (Lautze et al., 2011). Thus, the paper will analyze the relationship between both size and growth of population, the environment, economic development and welfare of the people in the Arab world.

The paper applies Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model to study the impact of economic, technological and demographic factors on environment measured through lack of access to safe water in the Arab world. This model is used by several other studies such as Cole et al. (1997), Dietz and Rosa (1994, 1997), Engleman (1994), Fan et al. (2006), He et al. (2017), Liddle and Lung (2010), Meyerson (1998), Schmalensee et al. (1998), Shi (2003), Shuai et al. (2017), and York et al. (2003).

STIRPAT model was used by Poumanyvong and Kaneko (2010) to explore the effect of urbanization and energy use on CO_2 emissions. A balanced panel of 99 countries at different development stages covering the period 1975 to 2005 was used in estimating a range of panel regressions.

Sadorsky (2014) studied STIRPAT model using an unbalanced panel of 16 emerging countries over the period 1971–2009. One of these countries is Egypt which is one of the largest population in the Arab world. Their results demonstrated that the best way for emerging countries to minimize carbon emissions is to decrease income per capita, population size, and energy intensity. As these countries are facing a trajectory of increasing income per capita and population. Accordingly, there is a need to move to an energy efficient technology and switch to renewable energy.

Abou-Ali et al. (2016) studied the effect of population, income per capita and institution quality on the carbon emissions using STIRPAT model. Their paper was the first to investigate the population dynamics-environment nexus in the Arab world. Twenty-one Arab countries from year 1990 until year 2014 were studied. Empirical results of Arab countries support the existence for STIRPAT relationship using carbon emissions. Also, institution quality is badly needed to reduce carbon emissions this region.

Wang et al. (2017) investigated the determinants of energy related carbon emissions based on the STIRPAT model in Xinjiang, China during 1952–2012. This paper used time series analysis by dividing the whole period into three models to study the three development periods that Xinjiang, China has gone through. Their first conclusion is that the factors that affect the STIRPAT model differs in the three development stages. Second, Xinjiang's urbanization and industrialization has a minor positive impact on carbon emissions compared with the main contributors which are population size, income growth and investments.

This paper is organized as follows. A background on the demography and the environment in the Arab region is presented in Section 2. The applied method for examining population impact on environment in terms of access to safe water is sketched in Section 3. The sample description is depicted in Section 4 alongside the estimation results. Section 5 provides conclusions and policy implications.

2. Background

There are two opposing theories that summarize the relationship between population growth and environmental degradation. In the Malthusian tradition, humankind's activities exploit natural, mineral, and energy resources and the ability of the environment to absorb wastes is disproportionate to population growth. In the Boserupian tradition, the more population pressure will enhance the development of science and technology. Therefore, humankind can provide high-tech solutions to environmental problems (Shi, 2003). However, many empirical studies support the first theory by suggesting that overpopulation undermines efforts to improve environmental conditions, measured by greenhouse gas reductions (Bradshaw, 2016; Rosa and Dietz, 2012; O'Neil, 2010, 2015; Lancet, 2009) to air (Ram, 2016; Eyo and Ogo, 2013) and noise pollution (Basil and Agu, 2015).

In General, the most dominant measure for environmental impact studies is the carbon dioxide emission variable (Abou-Ali et al., 2016; Behera and Dash, 2017; Liu et al., 2017; Martínez-Zarzoso and Maruotti, 2011; Omri, 2013; Poumanyvong and Kaneko, 2010; Puliafito et al., 2008; Sadorsky, 2014; Zagheni, 2011; Zhang and Lin, 2012; Zhu and Peng, 2012). CO_2 is known to be a cause of higher temperature due to the higher greenhouse gas emissions. Hence, it is considered as a measure of global warming (Shi, 2003). Most of the studies attempting to explain the environmental impact, study it from the perspective of the size of the population and the level of economic growth. However, other factors are also important. The technological, the social and political aspects also play an important role on the environmental impact. The STIRPAT Framework allows in studying the environmental relationship more inclusively. Furthermore, within the literature on environmental measured by carbon emission, the STIRPAT model was extensively investigated, particularly for Asian countries (Li and Sun, 2016; Ma et al., 2017; Shahbaza et al., 2016; Zhang and Lin, 2012; Zhu and Peng, 2012).

However, water has rarely been used as a measure of environmental impact within the STIRPAT framework in the Arab region. Vörösmarty et al. (2000) linked possible global precipitation changes induced by climate change and water demands controlling for population growth. Their results showed that the impact of increasing water demand originating from population growth is more considerable than the effect of climate change; the latter includes both an increase of aridity in some areas and an increase of rainfall in others. Shafik (1994) was the first to use the lack of access to safe water to study environmental degradation. Again, studies on the environmental impact concentrating on water stress within this model were mostly studied in Asian countries using water footprint (Zhang, 2016; Zhao et al., 2014), while the Arab region was neglected. This is despite the fact that using water as a determinant of environmental impact can further investigate the aridity in the region. Furthermore, most of the empirical investigations concerning the environment in the MENA region, have not treated water solely. It was always combined with other variables. For instance, Al-Mulali and Ozturk (2015), used ecological footprint to test for the environmental impact of urbanization, trade openness, industrial output and political stability. Charfeddine and Mrabet (2017) extended on Maluli and Ozturk's (2015) work on panel data analysis for 15 MENA countries. Likewise, Al Ayouty et al. (2017), discussed the relationship between the quality of the environment and the clean manufacturing industries in Egypt from 1990-2013. Among the determinants of environmental quality, the lack of access to improved sources of water was used. Also, more recently, Landis et al. (2017), used water to study the effect of economic, geographic and social means of connectivity on water insecurity in the Niger River Basin, which passes through Algeria. Henceforth, the STIRPAT model using water determinant in the Arab region was almost never investigated. A literature gap that this paper attempts to fill.

2.1. Population characteristics of Arab countries

2.1.1. Population size

Total population of the Arab countries included in this study is estimated to be around 377 million inhabitants in 2014. With 752 thousand inhabitants, Comoros has the smallest population size while Egypt has the largest population with 83 inhabitants. Figure (1) shows a possible grouping of these countries.

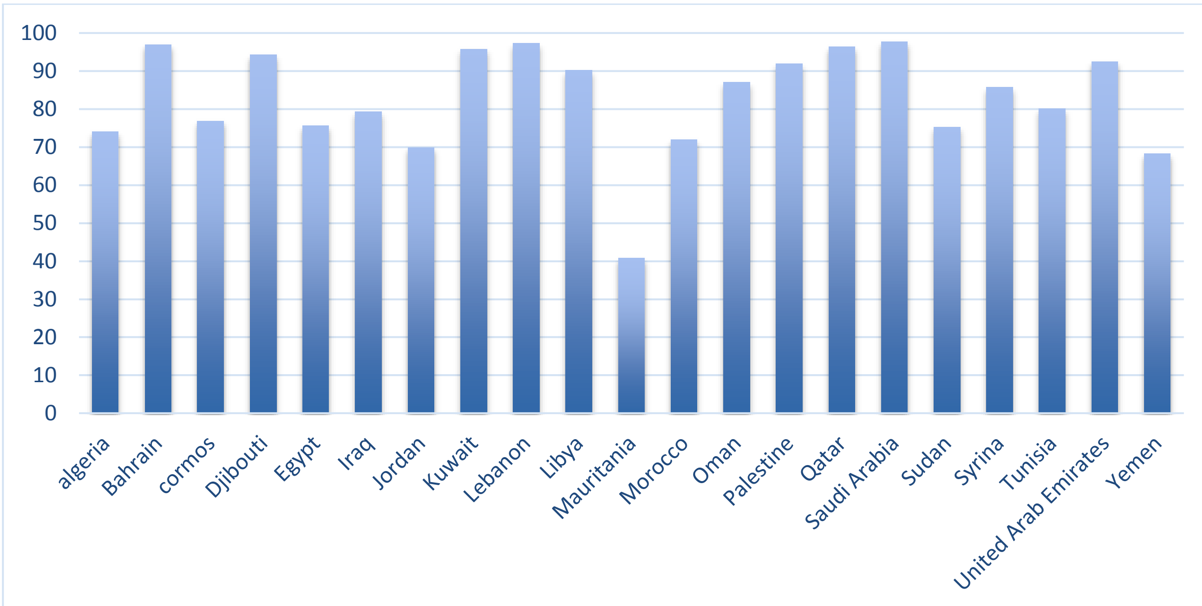


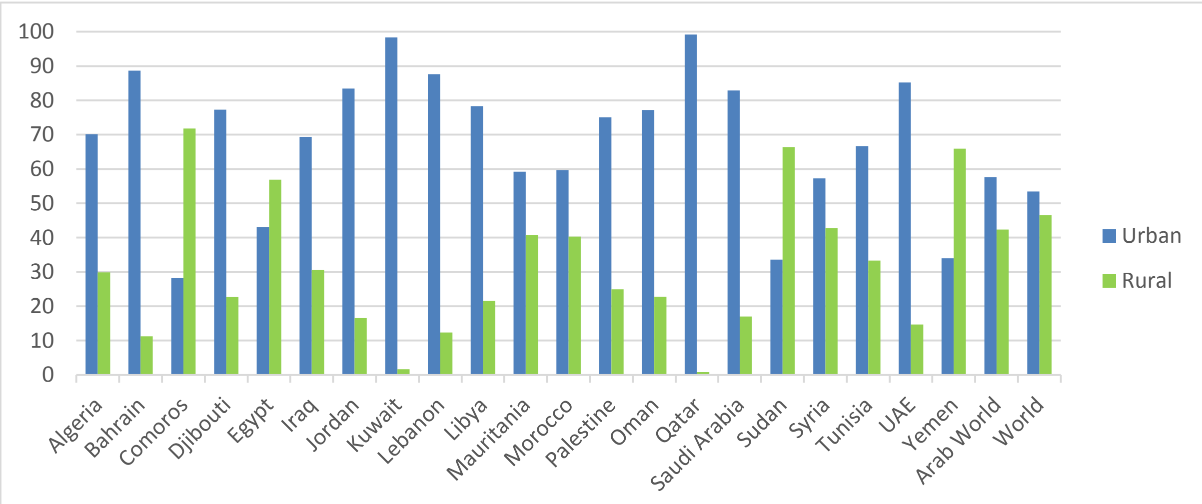
Figure 1. Grouping population size of Arab countries in year 2014 (Source: Authors' graph using WDI)

2.1.2. Degree of urbanization

More than 50% of the total population of about 16 countries live in urban areas. See Figure (2). In both Kuwait and Qatar more than 90% of the population live in urban areas. Urbanization uptakes only 28% in Comoros and 30% in Yemen. Egypt, with 36 million metropolitan dwellers, has the highest share of urban population of the region. It forms, on its own, 17% of the Arab population living in urban area. This is due to its large population which represents more than 23 % of total Arab countries population.

Among the Arab countries, the higher rate of urbanization is typically associated with greater affluence of the people that allow them to move from rural areas to urban areas. Henceforth, the higher rates of urbanization will be found in the wealthier countries, but also in the ones with weak agriculture sectors which are mostly oil producing countries.

The life style associated with urbanization can further explain the reasons behind water stress in the region. The higher education rate and the growing urbanization in the region has led to a decrease in the average size of Arab families. However, the culture of individualism associated with the greater urbanization has led to an expansion in the number of family units. As more spaces are added, new families have access, legally or illegally, to the principle water systems. These more affluent family units increase the ownership of water-intensive-user machines such as dishwashers and washing machines.



gure 2. Rural and Urban differences in the Arab World Year 2014 (% of population) (Source: Authors' graph using WDI)

Along with this, the rapid unplanned urbanization in the region makes water management relatively hard. This makes the poorest people the least fortunate from this situation as adequate sewerage systems are not build to cope with the high stress of growing urban population (Ramadan, 2015).

2.1.3. The rule of law and environmental regulations

There is a difference between having an environmental regulation and implementing it. The relationship between the rule of law and the environmental regulations is mainly affected by corruption. Corruption can undermine the effectiveness of the government and hence render the control policies for pollution less effective (Goel et al., 2013). The most known explanation given for the failure of the application of law and regulations equitably is the "connections". These connections of informal ties with public bureaucrats allow advantaged individuals to be protected from the penalty of not fully applying the laws and regulations. Political corruption is indeed significant in the Arab region. Not only are that briberies dominant. In fact, the directions of economic policies themselves are inefficient (CPI, 2016). Figure 3 gives a picture on the distribution of rule of law in the Arab world in year 2014. Rule of law is obtained from Worldwide Governance indicators. Its values range from -2.5 to 2.5. The higher the value of the rule of law, the better governance (Kaufmann et al., 1999). Bahrain, Jordon, Kuwait, Oman, Palestine, Qatar, Saudi Arabia and United Arab Emirates are experiencing positive value for the rule of law. However, all their values are less than one, which means also that they enjoy strong governance. For oil-producing countries, corruption could be associate with the size of the governmental activities. Natural resources in these countries are controlled by the government. This creates opportunities for rent seeking and give rise to corruption (Asghari, 2014).

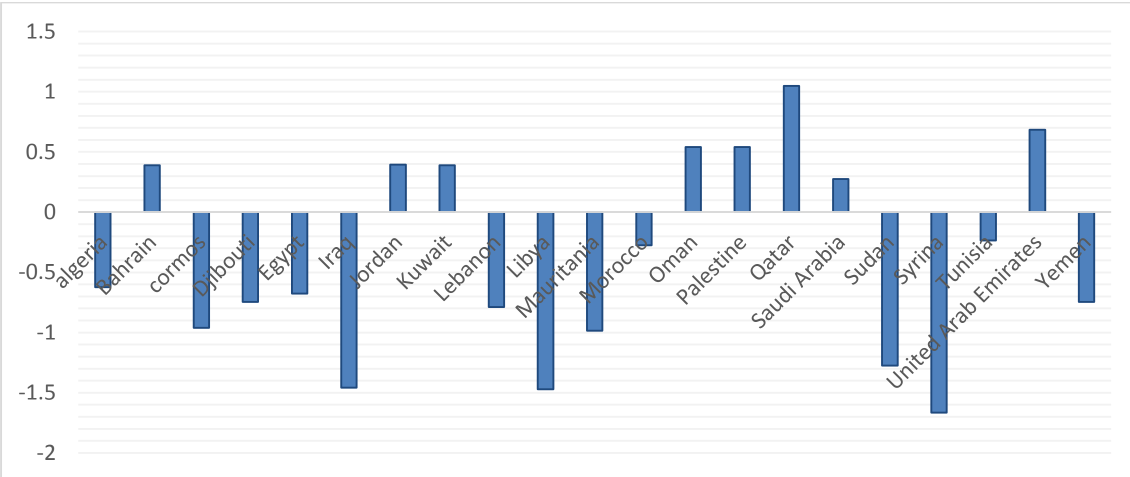


Figure 3. Rule of Law in the Arab countries for the year 2014 (Source: Authors' graph using WDI)

2.1.4. Unemployment

Oil producing countries are least likely to have unemployment with Qatar experiencing the lowest rate at 0.5% and the highest rates are revealed in Iraq at 18% and Libya at 20% (see Figure 4). The average rate of unemployment in the non-oil countries is relatively higher than oil producing countries with the highest in Djibouti at 50%.

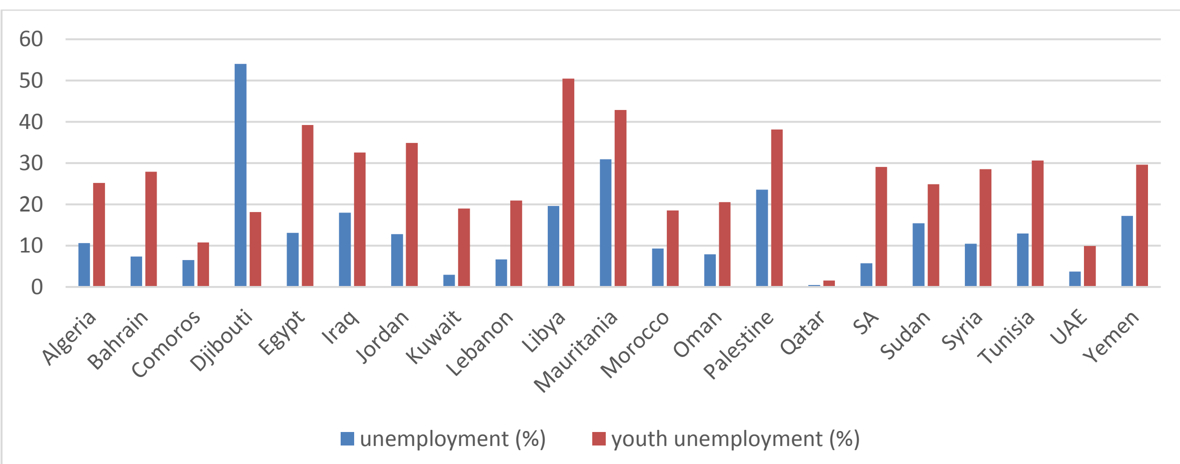


Figure 4. Unemployment along youth unemployment in the Arab Region in 2014 (Source: Authors' graph using WDI)

Unemployment rate in these countries is not responsive to cyclical output. The presence of the monopolies and oligopolies is one important reason for the inability of the creation of small and medium enterprises (Hamia, 2016). Unemployment is also due to the capital intensive industries dominating in these economies due to the high energy subsidies (Plante, 2014). Accordingly, and due to the age structure of these population, youth unemployment can be threatening to the quality of governance. Indeed, a high rate of youth unemployment is normally associated with political instability (Sumpf et al., 2016).

2.1.5. Literacy rate

The majority of the Arab countries scores a literacy rate of 80% or more. Mauritania has the lowest literacy rate at only 40% as in Figure 5 shows. The quality of institutions depends heavily on the literacy rate of the population. A low literacy rate is accompanied by the adverse selection problems in the recruitments of bad politicians. More educated citizens are more likely to understand the issues upon which they vote and recognize corrupted officials (Fortunato and Panizza, 2015). Nevertheless, the link between the rule of law and the education system is the democratization of the political system. In most of these Arab countries, democratic systems are weak and hence, the degree of literacy of the population might not have a significant impact on the quality of institution (Diwan, 2016).

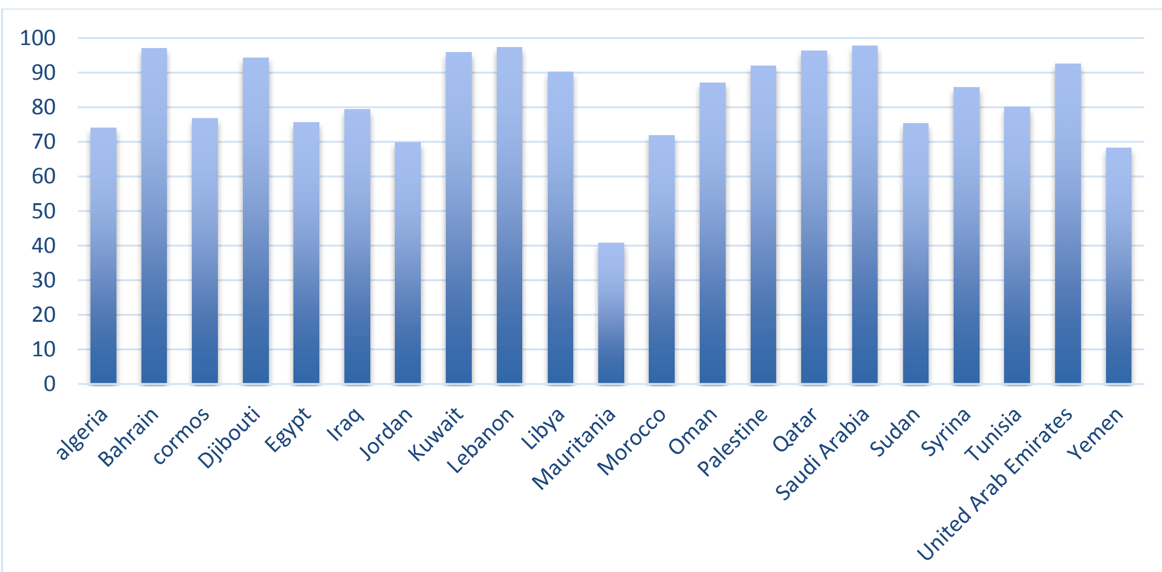
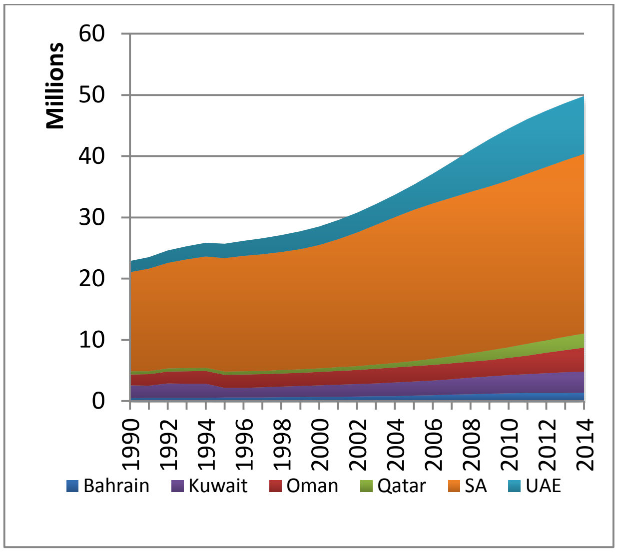


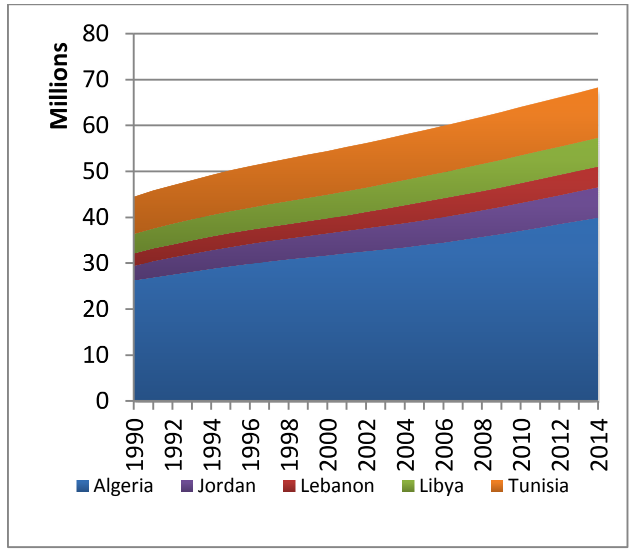
Figure 5. Literacy rate in the Arab Region in 2014 (Source: Authors' graph using WDI)

2.1.6. Population dynamics

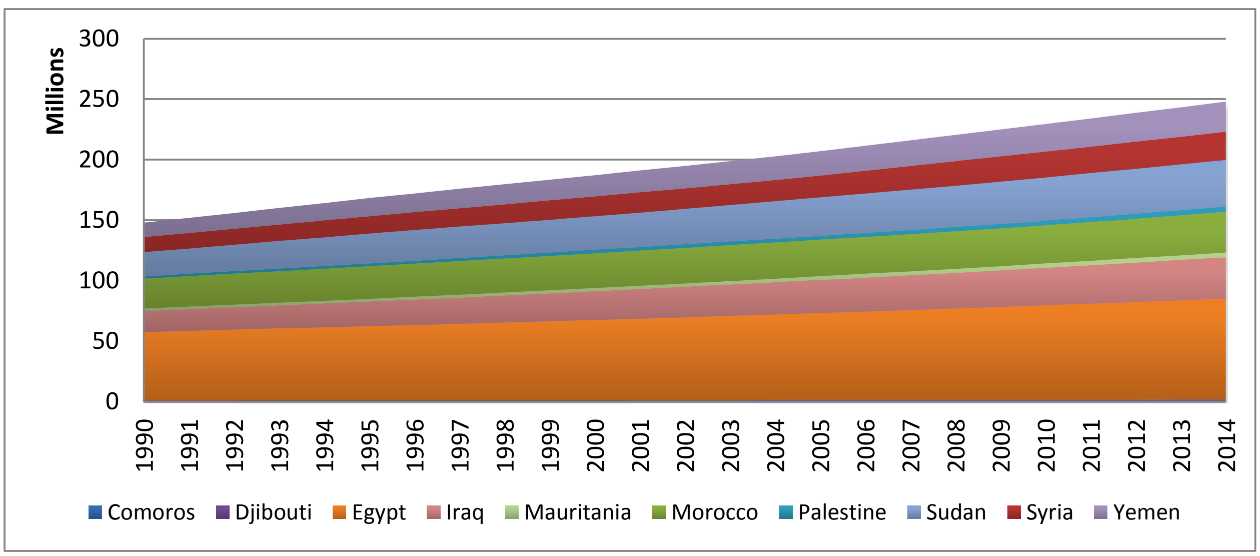
The Arab region is home to approximately 377 million people in 2014, a number that is projected to grow to 472 million by 2025, and to 2.25 billion by 2050 (UNPD, 2011). The average growth rate is above 2 percent for most countries in 2012. The fertility rate is extremely high in Arab non-oil countries compared to most similar developing economies who adopted a family planning policy and export-oriented industries.



(a) High Income



(b) Upper Middle Income



(c) Low and Lower Middle Income

Figure 6. Population size by Income Groups in the Arab region 1990-2014 (Source: Authors' graph using WDI)

The rapid increase in oil-prices during the 1970s was accompanied by an increase in per capita incomes in the Arab region with a sharp decline in death rates. Therefore, The Arab non-oil countries didn't gain a significant economic benefit during the 1970s oil boom (Winckler, 2013). Furthermore, the natural increase rates continue to grow which is the main cause of high population growth rate. The Arab region is characterized by being one of the fast-growing populations in the world. Although the population growth rate of the Arab countries has declined in 2010 to 2.13% compared to 3.52% in 1990. Despite that the population growth rate in the region is double of the world's growth rate.

The fertility rate is approximately 3.21 children per women. The region further exhibits young age structures, characterized by high proportions of youth. The median age of the population in the Arab world is around 20 years old. Such young age structures mean that the populations will continue to grow for some time.

Having a quick look through the past, by examining Figure (6), upward trends in population size is apparent for the period 1990 to 2014. It should be noted that most countries have been increasing with a decreasing rate except for SA and UAE which experienced a substantial increase in growth rates for the years 2000 and 2006, respectively. It is also clear that income category doesn't play a substantial role in the variation of population growth. However, it should be noted that Egypt is in a category of its own. It is home to about quarter of the inhabitants of the region.

2.2. Economic indicator

This section summarizes the GDP indicators of the Arab countries. It will present GDP level, per capita share, rates of growth and its sectorial source of income.

2.2.1. GDP level

On average for 1990-2014, the Arab counties are estimated to have US $ 1,096 billion of total GDP. Saudi Arabia had the largest share of US$ 523 billion in 2014. The OPEC in general has the highest GDP of US $1192 billion in 2014. This amount represents 68% of the total GDP of the countries included in the study. Cormos has the lowest GDP at US$ 464 million due to its low level of development and its small population size. Alternatively, Egypt's GDP is estimated at US$131 billion due to its large population size. The wide variation between GDP levels in Arab countries is reflected in the high value of the standard deviation which is estimated to be US$350 billion.

2.2.2. GDP per capita

The Arab countries classification by income groups is performed following the World Bank's definition. High-income countries are those with a GNI per capita of $12,276 or more in 2010. Upper-middle income countries are defined with a GNI per capita between $3,976 and $12,275. Followed by lower-middle income countries with a GNI per capita between $1,006 and $3,975 and low-income countries are those in which 2010 GNI per capita was $1,005 or less (World Bank, 2012). According to World Bank data for GDP per capita, some Arab countries are included in the high-income group. These are Bahrain, Qatar, Kuwait, Oman, SA and UAE (see Figure 7) which is around 29% of the Arab countries. Notice that the GCC countries are all high-income countries. Those in turn are the GCC countries as shown in Figure 7. Others are in upper middle-income group. They are five namely, Lebanon, Jordan, Libya, Tunisia and Algeria. The rest are classified as lower middle and low-income countries forming 47.6% of the region. The highest GDP per capita is in Qatar at a level of US$61 thousand followed by UAE at US$26 thousand. The mean GDP per capita is approximately US$3.6 thousand with a standard deviation of US$0.575 thousand. Comoros is the only Arab country classified as low-income therefore it was added to the group of lower-middle income countries.

2.2.3. GDP growth rate

The overall average GDP growth rates per annum in the Arab countries was 4.49% with standard deviation 1.95% for the period 1990-2014. The Arab Countries that are undergoing civil war after the Arab spring revolutions are suffering from very low or negative growth rates. It is 0.04% for Syria, -6.43% for Iraq and -24.03% for Libya.

2.2.4. GDP Sectoral sources

The structure of the GDP may be divided into three main sectors agriculture, industry and services. The share of industry to GDP and Service to GDP are almost similar around the region ranging from 8 to 82% and 10% to 82%, respectively. The agriculture sector has a lower contribution to GDP around the sampled countries. It ranges from 0.3% to 51%. In fact, the main source of GDP for the vast majority of the population of Arab countries is the industrial sector. Industry contribute to GDP by 47% in Iraq, 78% in Libya and 40% in Egypt. 48% of the GDP for the whole group is generate by the service sector and a standard deviation of 16%. Agriculture dominates in Sudan and Cormos with 37% and 44%, respectively. However, it adds below 5% of GDP in Oman, Djibouti, Libya, Kwait, UAE and Bahrain.

Agriculture is known to be the sector that consumes the highest share of water in an economy. Above the fact that agriculture is dominant in many of the Arab countries, Water usage is also inefficient. According to (FAO, 2003) the water use efficiency is about 40%. Hence, given the low recharge of water and the over withdrawals due to the usage inefficiency, the ground water resources are also threatened. This leaves the region's agriculture land at risk and leads to saltwater intrusion in aquafers close to the sea (Park, 2016).

2.3. Environmental impact

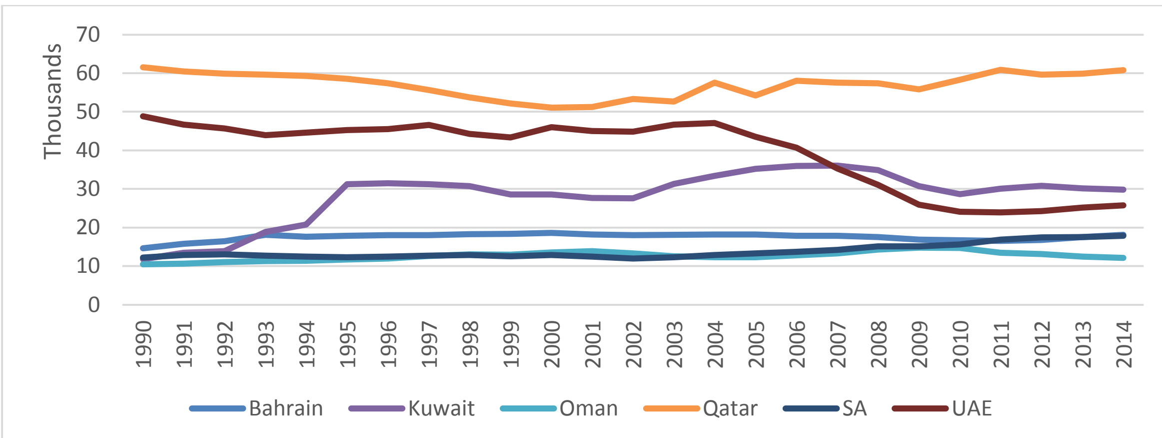
Trends in environmental variables as well as inter-country differences are analyzed in this section. The main indicators used availability of potable water and sanitation. These two indicators measure the quality of environmental health.

2.3.1. Potable water and sanitation availability

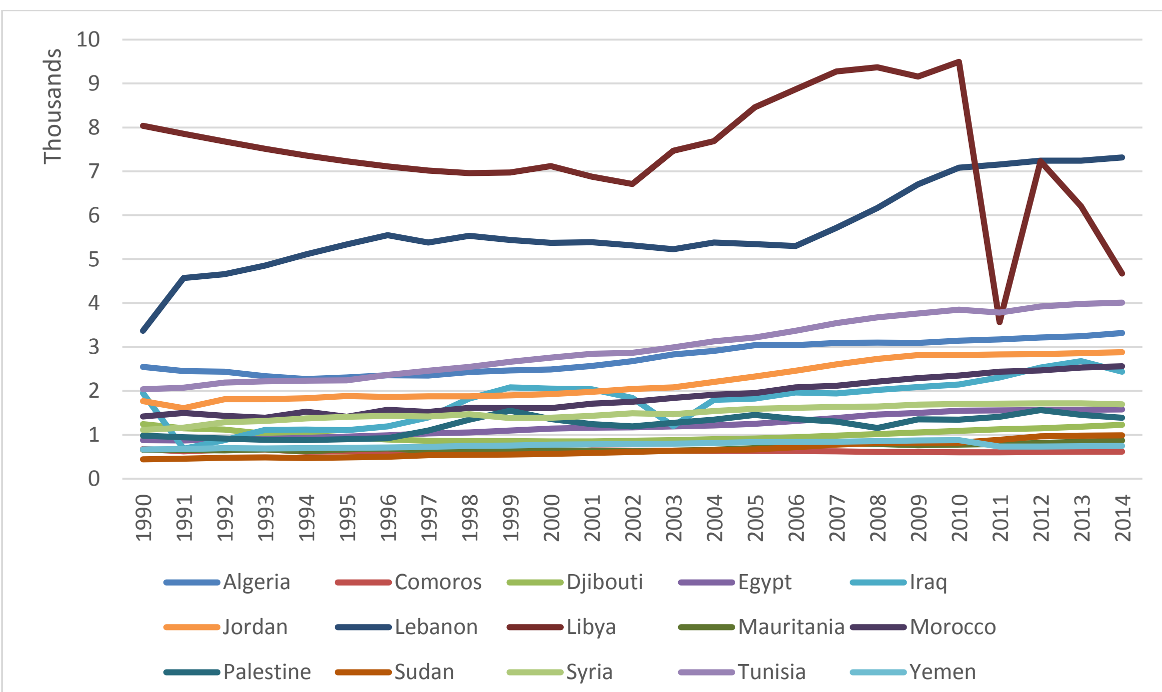
Gueye et al. (2005) points that Water Exploitation Index is high in several countries in the North African subregion: it is more than 50% for Tunisia, Algeria, Morocco and Sudan, and more than 90% for Egypt and Libya.[1] The Arab world is the water-scarcest region (Roudi-Fahimi et al., 2002). The millennium development

[1] Water Exploitation Index: total water abstraction per year as percentage of long-term freshwater resources

goal of 2000 engaged governments' policy in achieving increased efficiency of water utilities and attention to sanitation programs. When comparing the state of the Arab world with world coverage in terms of the percentage of population with access to improved water source and sanitation facilities. Figure (8) depicts that on average the Arab countries are above world average. However, when zooming into the Arab countries the story is quite heterogeneous. In the case of GCC countries, there is a high percentage of improved water source and sanitation facilities (Figure 9a and 10a). Except for Oman which has done some improvement in term of access to water moving from 80 percent to 93.4 percent and in term of access to sanitation shifting from 82 percent to 96.7 percent between 1990 and 2014.

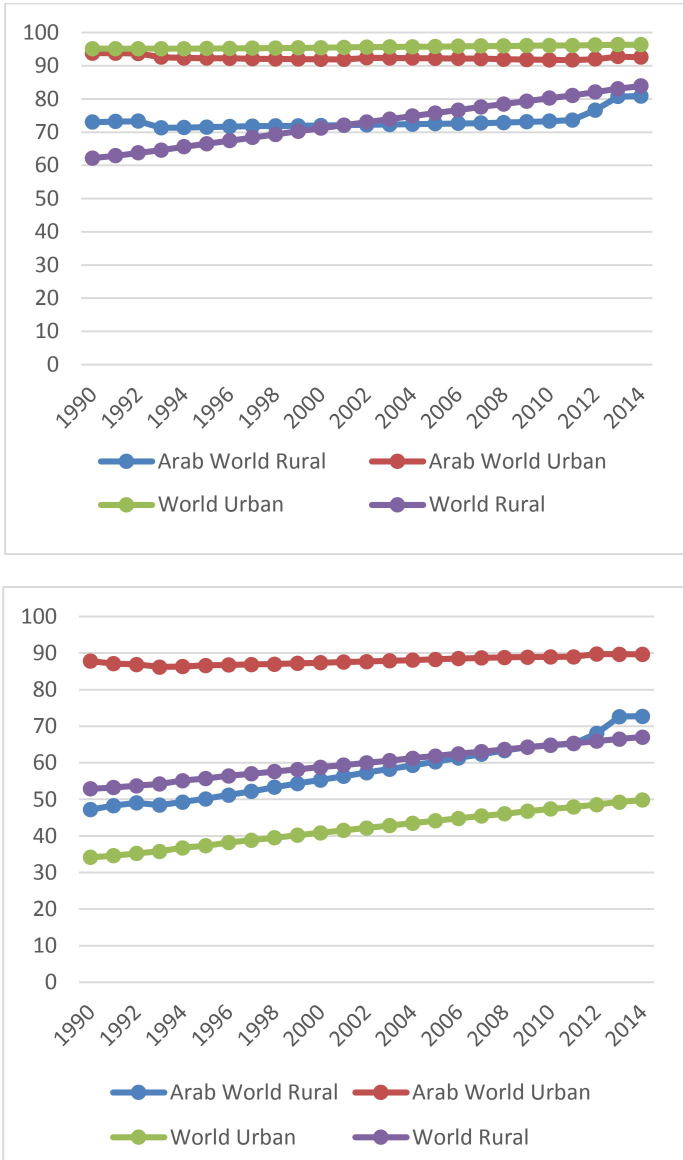


(a) GCC Arab Countries



(b) Non-GCC Arab Countries

Figure7. GDP Per Capita, PPP by Affiliation to GCC Countries 1990-2014 (Source: Authors' graph using WDI)

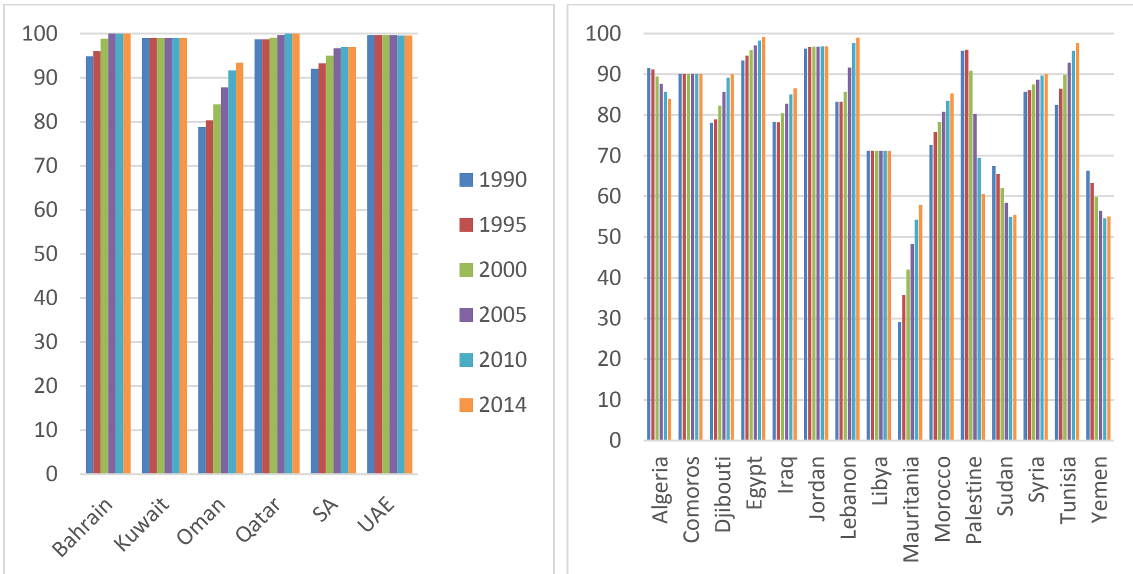


(a) Water

(b) Sanitation

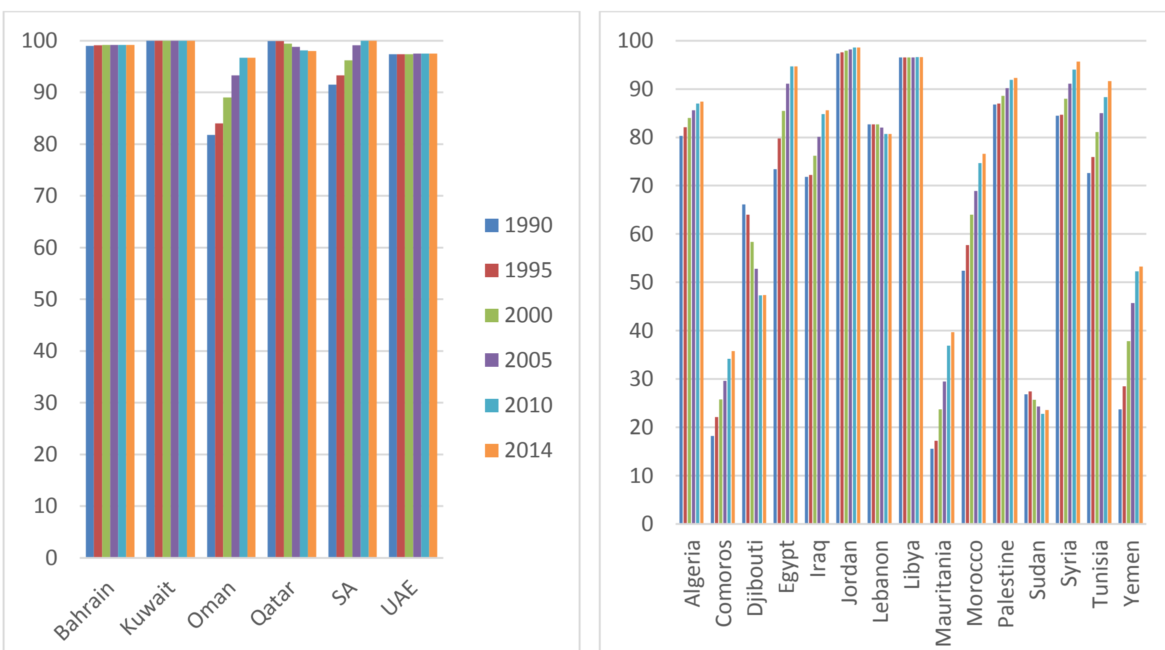
Figure 8. Percentage of population with access to improved water source and sanitation facilities (Source: Authors' graph using WDI)

Turning to panels (a) and (b) of Figure (9) the access to improved water source in GCC and non GCC population is illustrated, respectively. The figures reveal disparities that exist between countries. It could be observed that the only non-GCC country with sustained full coverage is Lebanon. Despite of continuous efforts to extend water services, the water service in Algeria, Palestine, Sudan and Yemen does not seem to catch up with rapid population growth, hence service coverage is worsened. As to the status of water in the remaining countries, the proportion of population with sustainable access to an improved water source has increased over the years for most countries.



(a) GCC (b) Non-GCC

Figure 9. Percentage of population with access to improved water source by GCC affiliation (Source: Authors' graph using WDI)



(a) GCC (b) non GCC

Figure 10. Percentage of population with access to sanitation facilities by GCC affiliation (Source: Authors' graph using WDI)

As for panels (a) and (b) of Figure (10) the access to sanitation facilities in GCC and non GCC population is illustrated, respectively. It could be observed that none of non-GCC country has a sustained full coverage. Non-GCC countries are divided into two groups. First group has sanitation coverage of less than 50 percent and those are Comoros, Mauritania, Sudan and Yemen. The second group, the proportion of population with sustainable access to sanitation varies but has a better coverage.

3. Methodology

STIRPAT is the model used in this study. Ehrlish and Holdren (1971) were the first to identify this model. It is an extension of the IPAT model. This model is commonly used to analyze the environmental damage caused by human activity. This accounting model is derived from three components as expressed in the following equation:

$$I = PAT$$

where I represent for environmental impact and P refers to population. The level of per capita consumption or affluence is coined to by A, measured in GDP per capita. T characterizes technology.

An important limitation to the IPAT model is the inadmissibility of hypothesis testing: the IPAT has a mathematical identity. The proportionality assumed between the variables in the function does not manifest the factor impacting the environment in the model (York et al., 2003). The STIRPAT model was thus proposed to overcome the limitation of the IPAT model. Dietz and Rosa (1994, 1997) were the first to propose a stochastic identity into the IPAT model:

$$I = aP^bA^cT^d\varepsilon$$

where I, P, A, and T are defined as in the IPAT equation; a, b, c, and d are the model parameters; and ε represents a residual term. This equation allows the use of statistical regression method to estimate a, b, c and d from the data on I, P, A and T. The IPAT accounting model can thus be converted from an accounting to a general linear model. Hence, hypothesis testing and the influence of each variable can be assessed, as the importance of each is now non-proportionate. A logarithmic form was also added by York et al. (2003) to facilitate hypothesis testing and estimation. The amended STIRPAT model was articulated as follows:

$$\ln I_{it} = \ln a_i + b \ln P_{it} + c \ln A_{it} + d \ln T_{it} + \varepsilon_{it}$$

where i denotes Arab countries and t denotes time. $\ln a_i$ are the Arab countries specific effects and ε_{it} is the random error. A one percentage citrus paribus change in population is reflected in the change of environmental impact by the change in c. It is customary in such models to measure T as the share of industry in GDP or is encompassed in the error term (York et al., 2003; Shi, 2003).

4. Empirical results

The data used in this study is compiled from World Development Indicator (2015) and World Governance Indicator covering the years 1990 to 2014 with the intention of analyzing the historical characteristics of the relations between the environment and the impact factors during that period. The STIRPAT model is estimated using Water (Ln (100- Improved water source (% of population with access)) as dependent variable and Population (Ln of the total population), Affluence (Ln of GDP per capita, PPP (constant international $)), Institution (Ln of rule of law index), urban (Ln of the share of population in urban areas) as independent variables. Institution quality is added to the model based on the work of Abou-Ali and Abdelfattah (2013) and Abou-Ali et al. (2016) as rule of law is found to be of a great influence on enforcing environmental regulations and environmental protection. The analysis includes twenty-one Arab countries namely, Algeria, Bahrain, Comoros, Djibouti, Egypt, Arab Rep., Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Occupied Palestine, Oman, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates and Yemen. However, Somalia is dropped due to lack of data. A summary statistics for the variables of the empirical study while accounting for the differentiation between the Arab countries (GCC and non-GCC) in Table 1 and according to their income level are shown in Table 2.

Table 1. Summary statistics by GCC affiliation

	GCC countries [a]				Non-GCC countries			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Water	4	5	0	21	20	15	1	71
Population (thousands)	5,612	7,941	477	29,400	16,800	18,200	413	83,400
Affluence	28,087	16,693	10,473	61,536	2,158	1,964	439	9,494
Urban	86	10	66	99	58	19	21	88
Institution	2.46	0.26	1.57	3.05	1.35	0.59	0.08	2.46

Source: Authors' calculations using WDI. [a] GCC countries are Gulf Cooperation Council which are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates.

From Table 1, the GCC countries on average are performing better than non-GCC countries in terms of fine access to safe water, fewer population size, greater income per capita and better rule of law. While, proportion of population living in urban areas in the GCC countries on average is greater than non-GCC. In Table 2, summary statistics of the three income groups endorses that the higher the income the better the performance of these countries in term of the safe water access and law of law enforcement. This is accompanied by an inverse relationship between income level and population size.

After calculating the summary statistics, the STIRPAT model is estimated using a fixed-effects (within) regression. Groupwise heteroskedasticity and cross-sectional dependence is checked owing to the great variability graphically observed across countries in the different variables adopted. The modified Wald test for groupwise heteroskedasticity (Baum, 2001) and Friedman's test of cross-sectional independence in fixed effect regression (Hoyos and Sarafidis, 2006) are exploited. The no heteroskedasticity hypothesis is rejected while the other hypothesis of the cross-sectional independence is not rejected. Therefore, robust variance covariance matrix is applied in the estimation to overcome the heteroscedasticity problem. Suggesting that both fixed effects and random effects estimators are consistent. Hausman test to check the efficiency of the random-effects model is used. The null hypothesis of Hausman is rejected which supports the non-efficiency of random-effects. Therefore, the fixed-effects regression is adopted.

Table 2. Summary statistics by income group

	High income [a]				Upper-middle income				Low-middle income			
Variable	Mean	Std. Dev.	Min	Max	Mean	S.D.	Min	Max	Mean	Std. Dev.	Min	Max
Water	3.79	5.46	0.01	21.21	12.63	9.33	1.01	28.81	23.29	16.58	0.81	70.91
Population	5,612	7,941	476	29,400	11,300	11,200	2,703	39,900	19,600	20,300	413	83,400
Affluence	28,087	16,693	10,473	61,536	4,214	2,177	1,609	9,494	1,131	504	439	2674
Urban	86.06	9.52	66.10	99.16	73.78	9.79	52.09	87.67	49.59	17.43	20.93	77.26
Institution	2.46	0.26	1.57	3.05	1.58	0.54	0.53	2.46	1.23	0.58	0.08	2.24

Source: Authors' calculations using WDI. [a] The high income countries are the GCC countries.

Based on the fixed effects model results, the overall STIRPAT model of the lack of access to water exhibits a quadratic function of population size. This function provides a U shape relationship. Population size has a diminishing effect on lack of access of safe water. Therefore, the lack of access to water is small when population is small and when population increase the water shortage increases. The turning point of population in which the lack of access to safe water starts to increase is about 16.2046 million inhabitants. This should be an incentive to countries with smaller population size not to grow in such a water stressed area. As for income per capita, a one % increase in income per capita leads to approximately 1.037 % decrease in lack of access to water, with other factors remaining constant. This means that access to clean water improves with higher per capita incomes. Urbanization rate have a positive significant relationship with lack of access to safe water.

By looking at the difference between the GCC countries and non-GCC ones, the overall STIRPAT model's result is not valid any more. The STIRPAT model for GCC countries also have a U shape quadratic function with population size. In the GCC countries, Institution has a negative statistically significant relationship (see Table 3). This endorses that rule of law are an important variable to impose regulations in the GCC countries. On the other hand, the U shape relationship doesn't exist in the non-GCC countries STIRPAT model. Affluence is the only significant variable in non-GCC countries model. In the non-GCC countries, Affluence has a negative statistically significant relationship.

Table 3. STIRPAT model of lack of water for Arab Countries.

	GEE	Within	Random	GCC	Non-GCC
Population	-21.707***	-21.617***	-19.148***	-21.261*	0.058
	(7.585)	(1.707)	(1.452)	(9.090)	(0.785)
Population squared	0.674***	0.667***	0.601***	0.658*	
	(0.243)	(0.058)	(0.048)	(0.313)	
Affluence	-1.072**	-1.037***	-1.035***	-1.029	-0.772*
	(0.460)	(0.172)	(0.140)	(0.990)	(0.393)
Urban	0.893	1.236*	0.614	3.196	0.707
	(0.928)	(0.715)	(0.515)	(12.063)	(0.982)
Institution	-0.041	-0.034	-0.119	-5.292**	0.362
	(0.260)	(0.143)	(0.149)	(2.042)	(0.210)
Constant	180.072***	178.811***	159.063***	170.504*	4.512
	(60.935)	(14.132)	(11.240)	(75.019)	(9.179)
Observations	525	525	525	150	375
R^2	0.4522	0.4522	0.4464	0.739	0.131
Hausman testa p-value			108.75 0.0000		

*Source: Authors' estimation. Note: t-statistics are in parenthesis, *** p<0.01, ** p<0.05, * p<0.1. [a] Random is more efficient than within under null hypothesis.*

5. Conclusion and policy implications

Comparison of the state of the Arab world with world coverage in terms of the percentage of population with access to improved water source, on average the World average is above Arab countries average. However, when zooming into the Arab countries, disparities between countries exist. The only non-GCC country with sustained full coverage of improved water source is Lebanon. The withdrawal of water from non-renewable resources has to be stopped in countries such as United Arab Emirates and Saudi Arabia, where they have the highest annual per capita withdrawal of water. Countries with high income such as GCC countries need to invest more in the construction of desalination plants to provide additional water for their cities. The estimated STIRPAT models offer adequate explanation of the relationship between population dynamics and environmental stress. The investigation reveals a sort of a vicious circle in the relationship between institution quality, population, economic development and the environment. Lower income per capita, higher population size and weak rule of law leads to less access to safe water. The lack of access to safe water starts to continue increasing after about 16.2046 million inhabitants in the Arab World. This circle would require a comprehensive policy package to be broken. Therefore, the regional and local responses to the environmental problems must take into account the vulnerability and composition of the population they target. It is important to monitor programs to continuously evaluate socio-economic performance and demographic performance in the region. Therefore, Governments in oil-producing countries for example, must reduce corruption as their natural resources are controlled by the government. So, governance is one of the most important factor that influence the managing of natural resources and the environment. Age structure of non-GCC population and youth unemployment can threaten the quality of governance. This has been seen in Egypt, where a high rate of youth unemployment was associated with political instability in January 2011. Efforts should be directed to extend water services, as some countries are unable to catch-up with the increasing population growth, which causes worsened coverage. Finally, better measures for environmental degradation is needed especially for water access, as the measures already available are not consistent and doesn't show the variability between countries.

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