Water Scarcity Effect on Economic Growth in MENA Region during 1975-2017

أثر ندرة المياه على النمو الاقتصادي في منطقة الشرق الأوسط وشمال أفريقيا خلال الفترة 1975-2017

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Abstract:
The paper aimed at identifying the water scarcity effect on economic growth in MENA countries using a panel data analysis during 1975-2017. The findings showed that there is a negative effect of excess in water consumption on economic growth, which means that augmentation of water consumption rates decelerates economic growth for most MENA countries.
Key words: water scarcity; economic growth; panel data analysis; MENA countries
JEL Classification Codes : Q2, C23

ملخص:
تهدف الورقة إلى تحديد أثر ندرة المياه على النمو الاقتصادي لدول الشرق الأوسط وشمال أفريقيا (ش.أ.ش.أ) باستعمال دراسة البيانات المقطعية خلال 1975−2017. أظهرت النتائج أن هناك أثر سلبي للافراط في استهلاك المياه على النمو الاقتصادي، مما يعني أن زيادة معدلات استهلاك المياه تثبط النمو الاقتصادي لغالبية دول ش.أ.ش.أ.
كلمات مفتاحية: ندرة المياه؛ النمو الاقتصادي؛ دراسة البيانات المقطعية؛ دول ش.أ.ش.أ.
تصنيف JEL: C23, Q2

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Introduction:

The Intergovernmental Panel on Climate Change (IPCC) reported that the notable change in the pattern of natural phenomena, observed in many continents since the 1990s, is expected to evolve need for risk management and intergovernmental efforts[1]. Projection for the next 10 years, say experts from the World Economic Forum (WEF), shows that risks related to degradation in the state of nature are perceived as more likely and impactful than average, it also presumes that water-related crisis will be the 1st detrimental global risk on human being [2]. There are many reasons exacerbating the gap between demand and supply of water, but in fact empirical studies focused on the demand side management. Consistently the findings of the human development report (HDR) elaborated by the United Nation Development Program (UNDP) in 2006, advanced that the common challenge for water scarcity management is deficit of water supply, in most cases, generated by spatial scarcity (Middle East and North Africa, Sub-Saharan Africa and some Asian continents) or unsustainable use of this resource [3].

According to the Food and Agriculture Organization (FAO) estimations, "two-third of the world's population would experience difficult conditions to obtain fresh water, moreover 2.300 people die each day by disease related to unsafe potable water, and 769 million people lack access to clean water, almost all of them (99%) are living in developed countries"[4].

In an article published by the New York Times in 2014, Eduardo Porter criticized the abstraction of reality by getting water cheap i.e. free resource access and use, and assessed externalities on the environment e.g. excessive consumption, he considered the economic valuation of water by "Getting the water price right" as crucially important. After nearly a year, world development institutions start highlighting the water problem as a global concern, by sophisticate panel analyzes about administrative policies impact on water supply and uses e.g. water subsidies and stress[5].

It is presumed that two-thirds of world's population will suffer from water stress by 2025, and one-third will be living in territories with an absolute water scarcity, which means that most people will experience scarcity by the mid-21st century[6].

Among the important facts emphasized by the Food and Agriculture Organization (FAO):

- Water use has been growing at more than twice the rate of population increase in the last century;
- By 2025, 1,8 Billion people will be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be under stress conditions[7]. Therefore, the potential challenge is the increasing consumption growth rate (which is double of the population growth rate) rather than vulnerability, which is related to natural climate change or other geo-demographic conditions. As a result, many studies launched an urgent appeal for international collaboration to guarantee stability and maintain this valuable resource.

Unfortunately, shedding light on the global water stress masquerades the continental water scarcity, thus governments lack resources and integrated scheme to prevent extreme regional vulnerability to water scarcity. The MENA's population estimated about 5% of the total world population had access to merely 1% of the global water resources, and the number of water-scarce countries in MINA region has risen from 3 in 1955 to 11 by 1990 [8].Global estimates indicate that one-half of MENA's population lives under conditions of water stress[9], and that many people in rural and marginal areas have no access to water and sanitation services. In both Morocco and Yemen, less than 60% of population have access to improved water source and less than 50% have access to improved sanitation[10].

The Arab countries, instead of other countries from MENA region, are the most water scarce in the globe. The average water availability per person in the world is close to 7.000 m^3peryear, whereas in the MENA region, only around 1.200m^3peryear is available. Moreover, with the population expected to grow by 2025, per capita availability of water is expected to halve by 2050[11].

Problematic of the study:

Scarcity in MENA region is determined by dryness, lack of regional coordination strategies, and upstream countries control on water inflow, as it is the case with neighbouring countries of Israel concerning the Jordanian and Yarmouk River. Egyptian government also, disaccord on dams' projects elaborated in both Sudan and Ethiopia, which are considered as sources of breaks and ruptures in the Nile River flow, considered as the Egypt's lifeblood, which supplies more than 90% of Egyptians' water needs. Since 80% of the Nile water that reaches Egypt originates from the Ethiopian Highlands[12], constructing a dam on the Blue Nile will put control over 72% of Egypt water needs. Iraq is also facing a great challenge, because of the South-eastern Anatolia Project utilizing water sources of Tigris and Euphrates rivers.

In addition to climate conditions, which exacerbate water shrinkage, Arab continent beards with limited capabilities in mobilizing sufficient supply to meet the demand on water resources of their growing population. By 2050, expected shortage in MENA region is the result of a 50% growth in water demand and a 12% diminution in water supply.[13] Accordingly, it seems that water scarcity phenomenon in MENA region is being multifaceted, on the one hand, it is a natural problem i.e. related with climatic change and geographic characteristics of the MENA region; on the other hand, it is related with water demand. As a result, this study is a try to find out whether scarcity is related the growing demand, or it is a supply side phenomenon; resulted from water availability.

Object of the study:

This principal aim of the paper is to point out the main challenge facing most MENA countries in cope with the water scarcity problem, as well as:

- Determine the extent and compare characteristics of water scarcity between MENA countries;
- Analyse the main causes of water scarcity;
- Propose a solution to mitigate the outcomes of water scarcity on MENA region.

Importance of the study:

A specific objective of this study was to determine the effect of water scarcity on economic growth in MENA region, based on a push factor analysis, by showing the importance of water consumption management as a lever of economic growth in the MENA region.

Materials and methods:

This paper unpacks the over specified facet of water scarcity impact on the MENA countries, and stands on the fact that water management should start by endogenize scarcity. According to Stockholm International Water Institute (SIWI), many studies emphasize that agriculture and food production is the largest water consuming sector and the first employment generator, particularly in developing countries, and due to dependency on rainfall water with absence of a water management plan increases the risks of vulnerability to rainfall variability.[14]

The research main goal is to find out the link between water scarcity and economic growth in the MENA region via a cross-country analysis for a sample consisting of 20 MENA countries[15], using a panel regression model. Two variables were used to examine the relation between economic growth and water availability.

The principal assumption of the research is that there is an impact of water consumption on economic growth, the dependent variable Log (PGDP) -which is the decimal logarithm of percapita gross domestic (GDP) representing the share of individuals in aggregate revenue measured by the GDP for each country- is supposed correlated with the independent variable measured by the decimal logarithm of percapita municipal water withdrawal "Log(PMWW)". Water consumption in this study is represented by domestic water withdrawal. The main assumption is the existence of a positive correlation between economic growth and water consumption.[16] In fact, a pull operation exercised by economic agents during expansion conjunctures induces more water consumption, and additional demand in agricultural and industrial sector on water -estimated by withdrawn water- is explained by productive sector stretch on inputs including natural resources (water, air...etc.).

In order to investigate the effect of water consumption on economic growth, and in consideration of the positive correlation between the two variables[17], productive water consumption was excluded from water consumption to check the validity of the secondary assumption which stipulates that domestic water withdrawal negatively impacts the economic growth of MENA countries; because of water scarcity which characterizes this region.

The study covers the period between 1975 and 2017 and concerns the MENA countries. The dependent variable series "Log (PGDP)" were extracted from the World Bank (W.B.)

databases available on the W.B. website, while the independent variable series "Log (PMWW)" were extracted from the AQUASTAT database available on the Food and Agriculture Organization (FAO), this later provides restraint and/or discontinuous statistics for all countries, which imposed the use of unbalanced panel data analysis.

Descriptive statistics method is also used in this study in order to analyze the state of the water scarcity problem, and deduce the overriding challenge...

Literature review:

The reality of life dependence on water availability was already stated in the Quran[18], preserving water is both religious and humanitarian behaviour. Across the literature on the topic, scholars delineate one of three approaches to study water scarcity:

The competitive view:

In spite of the fact that many MENA countries were adapted with scarcity by their own strategy [19], many studies recommend public policies as population demand management on water, and risk management solution to establish a fair supply management.[20] From a realistic point of view, water scarcity is not expected to threaten future security in MENA region, as "water war" is an assumption based on the Malthusian theory, taking just human need and nature as factors inhibiting water availability in a static view. Although, debate on water security had a political dialect instead of being treated political economy perspective.

The quantitative view:

It is clear that water demand management is a key factor to guarantee water security in the MENA region, accordingly limiting water use is crucial in preserving from ulterior crisis[21], but it is not sufficient condition because demand is related with consumers' behaviour[22].

In fact, water management must accomplish supply systems needs first, by linking almost people with water and sanitation services, than move toward managing and balancing between needs and uses. It also needs to be founded on realistic estimations to foster a water plan and determine factors affecting water resources availability in order to forecast any possible extreme situation[23].

The protective view:

The sustainability concern, pushed by ecologist, sheds light on renewable resources to preserve environment for the coming generations, e.g. green energy for seawater desalination[24]. Other specialists in water integrity solutions point up corruption as the main cause of water dissipation, corruption in the water sector is supposed to spread up in subsidized activities. They advance privatization as a key factor to alleviate water dissipation in order to balance between present and future generations' rights to

access fresh water resources. Estimations show that water sector finances loss due to dishonest and corrupt practices between 20 to 40%.[25]

Diagnosis of water scarcity in the MENA region:

Water resource management affects almost all aspects of the economy, in particular, health, food production and security, domestic water supply and sanitation, energy, industry and environmental sustainability. Food and many industrial products use water abundantly; the share of water used in industry is increasing by time, because of complex technologies, diversification in products and multiplication of manufacturing tasks, in addition to the growing demand pushed by demographic factors (population and urbanization extension).

a. Source of water demand and supply in MENA countries:

Global water demand is largely influenced by population growth, urbanization, food and energy security policies, and macro-economic processes such as trade globalization and changing consumption patterns. While supply is mainly limited by climate change, pollution, speed and magnitude of water renewal[26].

As alternative, desalination by concentrating solar power is seen as a sustainable option against using fossil fuel. The cost of sea water desalination by means of concentrating solar power has been projected to decrease over time from currently 1,80 USD/m3 to 0,90 USD/m3 in 2050. [27]

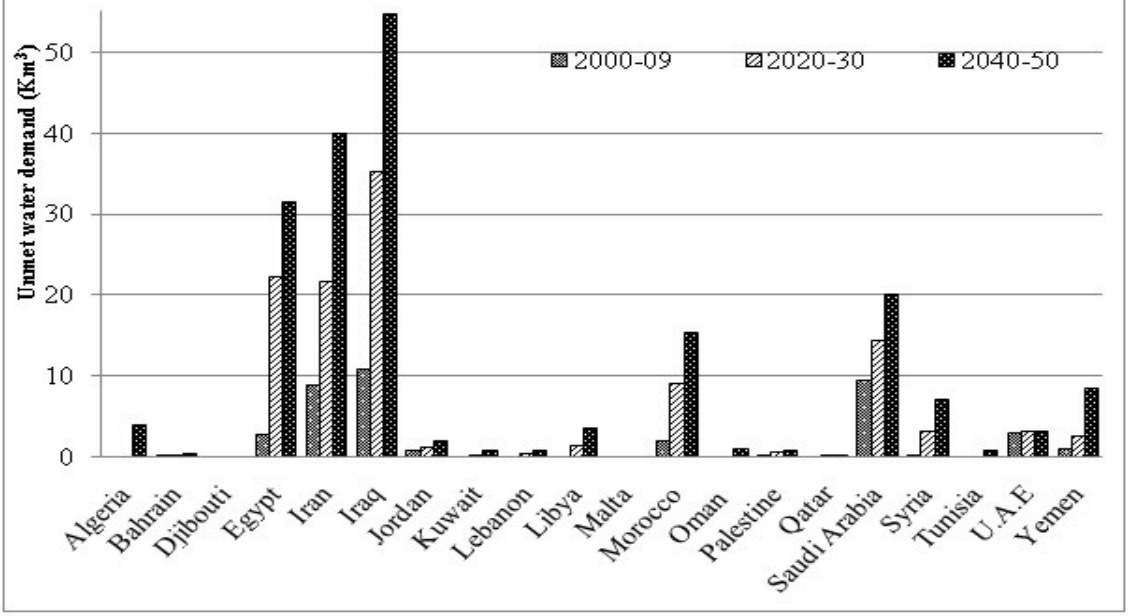
According to the W.B. estimates (Tab. 1), total unmet water demand will quintuple by 2050 under average climate change, three countries are likely to be the most water scarce countries, with more than 30 Km3unmet water demand (see Fig. 1).Water stress exposition could be explained by the highly dependence on external renewable sources for Iraq and Egypt, while for Iran demographic factors as population and urbanization growth coupled with high irrigation potential based on renewable water sources could explain the increasing dependence on groundwater consumption.

Table (01): MENA annual water demand and supply under average climate change scenario (Km^3)

	2000-09	***2020-30***	***2040-50***
Total demand	*258,57*	*315,74*	*388,87*
Irrigation	*213*	*237*	*265*
Urban	*28*	*50*	*88*
Industry	*20*	*32*	*40*
Total supply	*219*	*200*	*194*
Surface water	*171*	*153*	*153*
Ground water	*48*	*47*	*41*
Total unmet demand	***42***	***119***	***199***
Irrigation	*36*	*91*	*136*
Urban	*4*	*16*	*43*
Industry	*3*	*12*	*20*

Source: World Bank. (2012). Renewable Energy Desalination: An Emerging Solution to Close the Water Gap in the Middle East and North Africa. The World Bank, Washington.

Figure (1)
The presumed unmet water demand by 2050 in MENA region



Source: World Bank. (2012). Op. cit.

b. Water supply constraints:

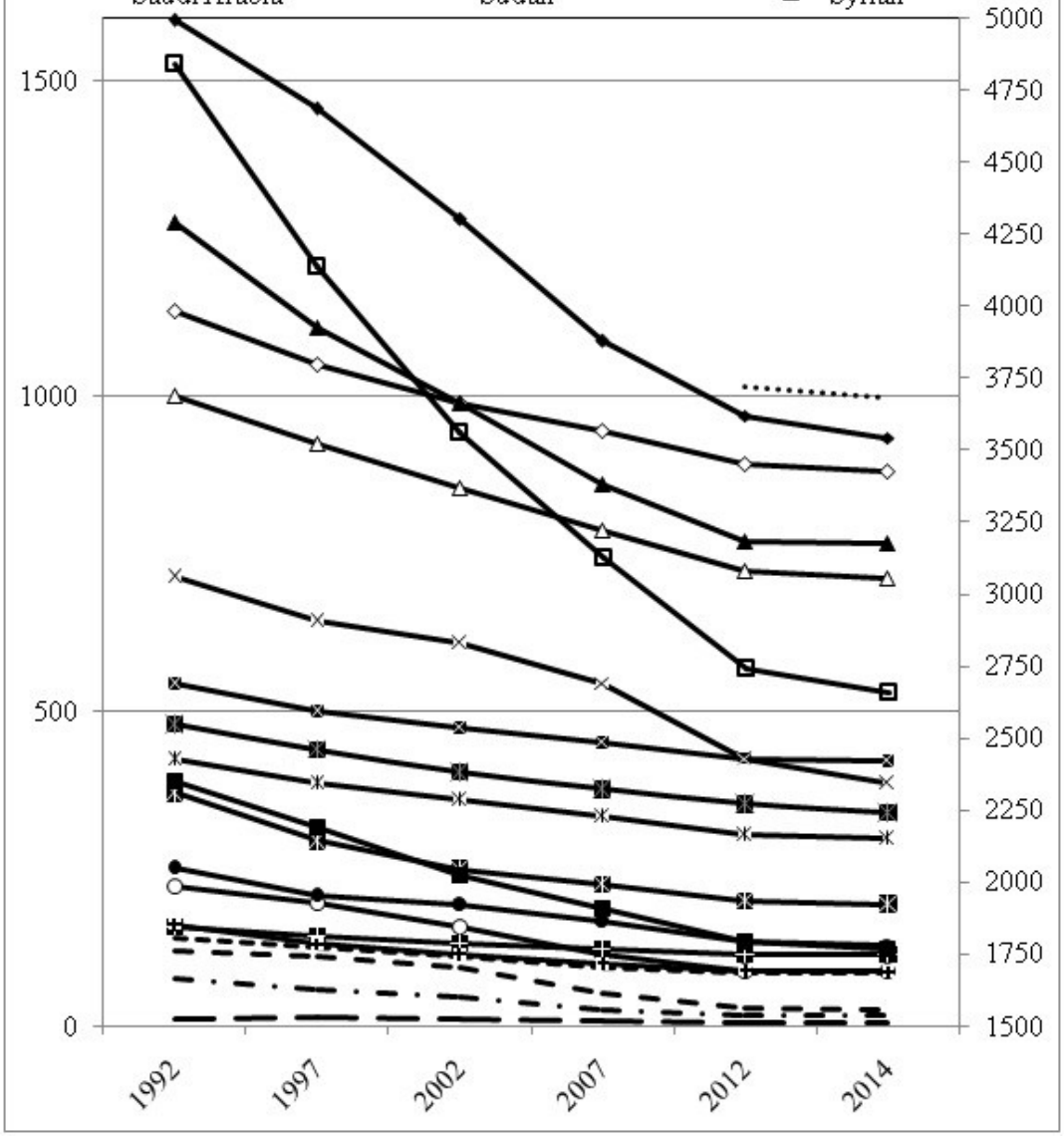
The main constraints of water supply in MENA countries could be classified under two main reasons, human related causes and natural causes.

- **The human-related causes of decreasing supply:**
- Water supply diminishing capacity could be explained by: (i) feeble or inappropriate water policies; (ii) pollution, environmental degradation and deforestation; (iii) absence of adaptive strategies of water use management and; (iv) detrimental of both individual and institutional behaviour in dealing with water services and sanitation investments. Causes of potential diminishing supply capacity could be natural and/or human related.
- **The natural causes of decreasing supply:**
- Many researches advanced that climate change has enormous effect on water availability. A recent study, in a water stressed region, identified an impact of water supply and water use on environment [28]. Because human activity is threatening the biosphere and affecting the earth system capacity of resource renewal, it's difficult to refine the nature's effect on supply, and any attempt to establish the link between environmental changes on water supply will be plausible, because humans are responsible of environment degradation.

In the meanwhile geo-climatic characteristics could explain the link between nature and water availability, e.g. most MENA (except Iraq and Iran) countries are experiencing water scarcity or extreme water scarcity using renewable water indicator

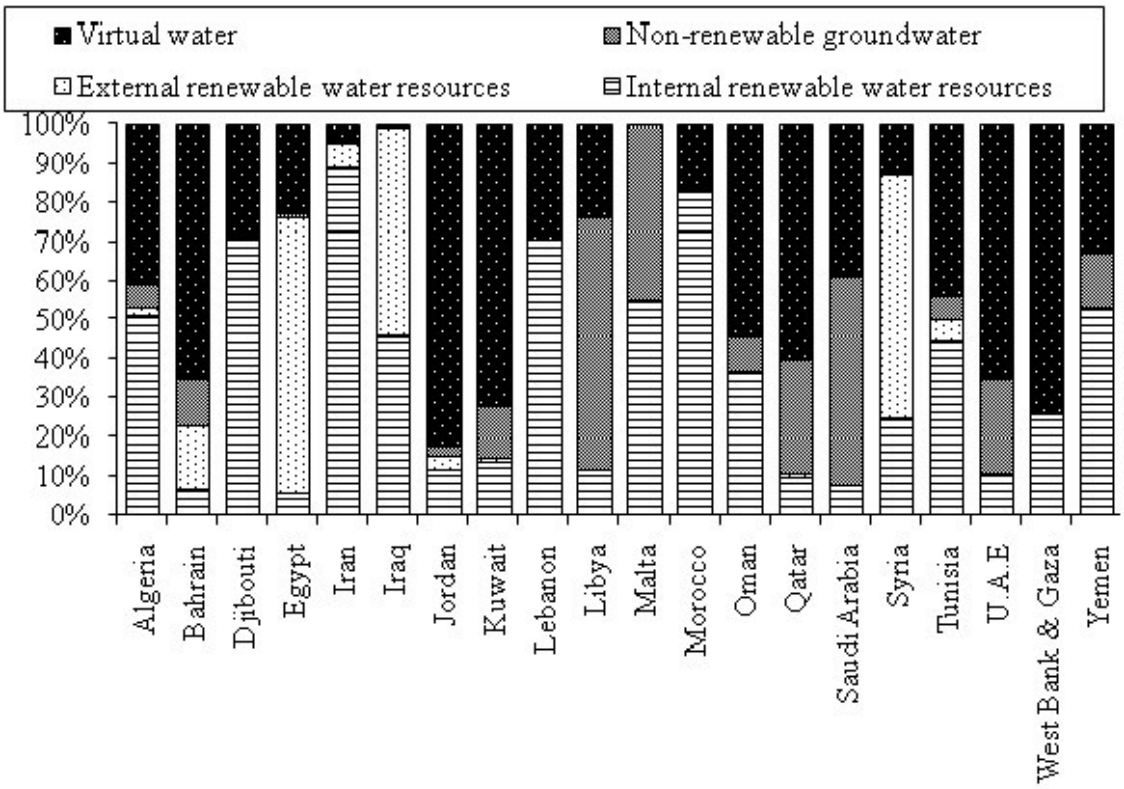
(see Fig. 2).Iran's soils which are salt affected could explain the low permeability[29], and consequently the high capacity of surface water supplying, while Euphrates and Tigris enhance water availability for Iraqi people (see Fig. 3).

Figure (2)
Per capita part of water in MENA countries



Source: FAO. (2016). AQUASTAT database - Food and Agriculture Organization of the United Nations. [Retrieved on 14-03-2016].

Figure (3)
The role of renewable water in MENA countries in 2005



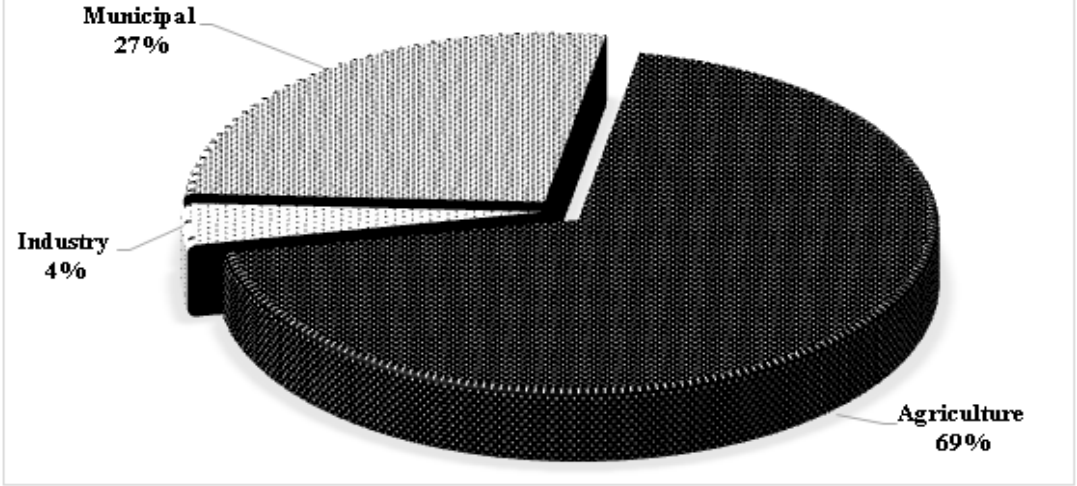
Source: World Bank. (2007). Making the Most of Scarcity: Accountability for Better Water Management in the Middle East and North Africa, Washington, DC.
Notes:
Malta's non-renewable groundwater was calculated using "TPPI" The Today Public Policy Institute report.

c. Water demand expansion:

There are many determinants of water use, scholars consider that population is the key factor affecting water consumption, but according to the FAO dataset, water withdrawal was 1,7 times as fast as population in growth over the last century[30], which means that there are other factors inducing water demand instead of population growth. Across-country study, using correlation analysis between GDP per Capita and domestic water withdrawals for MENA countries, shows that there is a positive correlation between the two variables[31]. In fact, economic growth affects water withdrawal in a composite mean: first by growth rate of economic sector (agriculture, industry or services), and second by the sectoral share in total withdrawn water, the simple strategic rule consists of shifting toward sectors with less withdrawal share (see fig. 4).

In MENA region, the economic structure represents an indirect stimulus of water consumption, by the mean of increasing the effective use of withdrawn water; since most industrial and service activities eventually, destruct the total quantity and/or quality of withdrawn water (see Fig. 5).

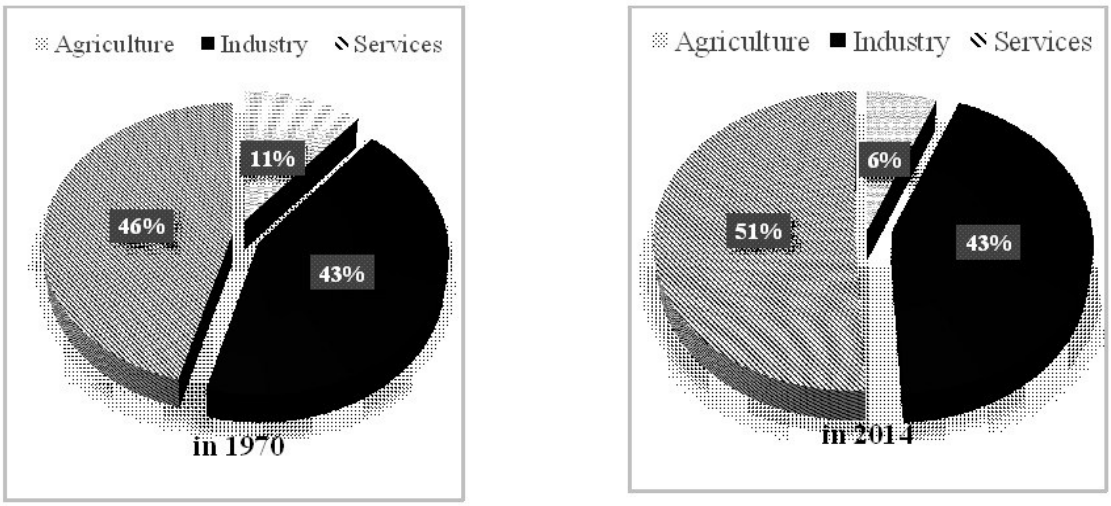
Figure (4)
Water withdrawawals by sector in MENA countries 2010



Source: FAO. (2016). AQUASTAT Database. Accessed on [09/04/2016 0:49].

Figure (5)

Percentage contribution to GDP by sector, MENA region



Source: World Development Indicators database. Accessed on [09/04/2016 0:49].

Results and discussion:

Using unbalanced panel data analysis to investigate the relation between the logarithmic values of both variables in MENA countries, results show that there is a negative correlation between growth rate of both municipal water withdrawals and per capita GDP, this could be explained by the fact that excessive water consumption hinders economic growth in the MENA region (see Tab. 02).Recently, the growing agricultural needs of freshwater induced a great depletion of groundwater in some MENA countries. The concern is that depletion rate is higher than recharge rate for most cases; moreover most groundwater is effectively a non-renewable resource, which means that it needs a very long timeframe to be replenished. Generally, non-renewable resources have a negligible rate of recharge on the human scale (less than 1%). In practice, non-renewable groundwater refers to aquifers with large stocking capacity in relation to the average annual volume discharged, it could refers also to fossil groundwater reserves in cases when the pumping exceeds the natural recharge[32]. A recent study found that less than 6% of groundwater is replenished within 50 years[33].

Table (2): The effect of water consumption on GDP per capita Panel analysis of MENA region during 1975-2017

Dependent Variable: LOG(PGDP)
Method: Panel EGLS (Period SUR)
Date: 30/12/17 Time: 12:17
Sample: 1 194
Periods included: 15
Cross-sections included: 20
Total panel (unbalanced) observations: 55
Linear estimation after one-step weighting matrix

Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	*-7.1765*	*1.094614*	*-6.55619*	*0.00000*
LOG(PMWW)	*-1.00925*	*0.120436*	*-8.37996*	*0.00000*
PGDP	*1.17E-10*	*2.45E-11*	*4.764973*	*0.00000*
Weighted Statistics				
R-squared	*0.906486*	*Mean dependent var*		*-5.75198*
Adjusted R-squared	*0.902889*	*S.D. dependent var*		*7.152142*
S.E. of regression	*0.9038*	*Sum squared resid*		*42.47644*
F-statistic	*252.0324*	*Durbin-Watson stat*		*1.789179*
Prob(F-statistic)	*0.00000*			
Unweighted Statistics				
R-squared	*0.861552*	*Mean dependent var*		*-12.3065*
Sum squared resid	*1284.756*	*Durbin-Watson stat*		*2.174925*

Source: authors' calculation using Eviews 7

There is no consensus about how to estimate the water demand; national authority could proclaim the unmet demand, while international organizations focus on the idea

that water deficit is likely to happen just under a worst-case scenario in the future[34], water demand is underestimated if supposed equal to water withdrawal or water use.

Water supply account excludes total withdrawn water, knowing that a certain proportion of withdrawn water goes to a literally consumptive use and the rest returns to rivers or ground water. In irrigation, for example, a certain proportion of withdrawn water is consumed by the crops and turns into green water flow as total evaporation, while a significant proportion infiltrates into the soil and percolates below the root zone, recharging ground water. Both the consumptive water flow and the return flow of drainage water are included in the water withdrawn but only the consumptive part can be considered as true water use. Water recharging ground water can be reused further downstream. Alternatively, it may be involved in supporting an aquatic habitat in a river or wetland, but it partially returns with poor quality because of soil pollution[35]. Moreover, the concept of used water, in statistical surveys, omits the indirect and virtual water consumed individually or collectively.

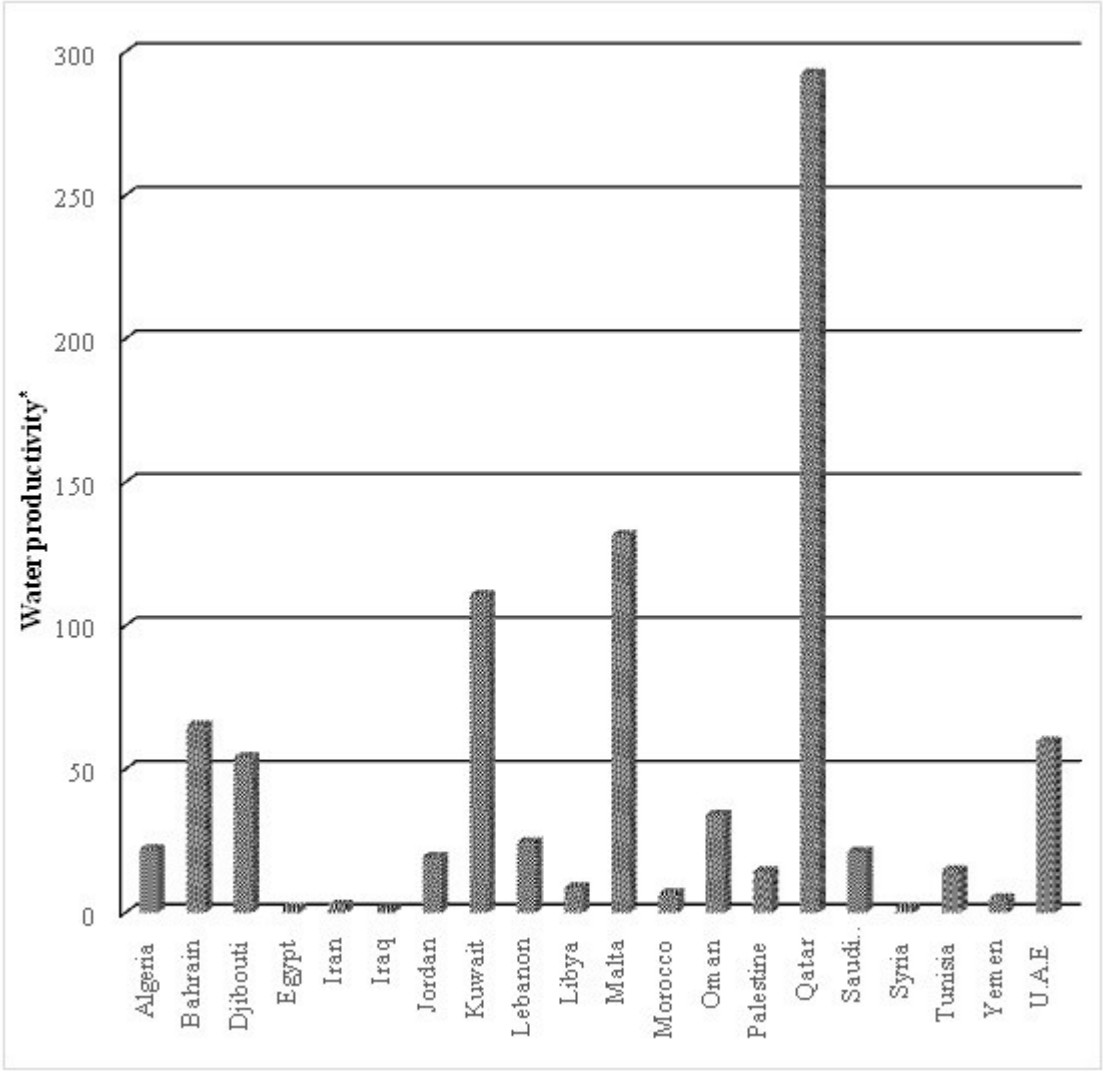
1. Causes of scarcity in MENA countries:

Most of MENA countries' weather is characterized by dryness; therefore, water use is relying highly on renewable underground water resources, which reduces the capacity of providing cultivators with sufficient volume of water for irrigation.

Based on data collected from some MENA countries surveys, experts consider that "most irrigated surface does not utilize techniques as much as spate irrigation through mobilizing stream and rivers' water for plants irrigation in water scarce countries" [36] which means agriculture is dependent on rain-fed systems.

Nevertheless, available statistics on water pricing indicate that subsidizing is widely adopted especially for irrigation water prices[37]. Subsidizing policy, in most MENA countries, aims to maintain the national capacity of agricultural sector and enhance individual purchasing power, by reducing effective price of water; consumers respond with an excessive use since they thought that cheap goods are always largely available, this behaviour harms long-term productivity (see Fig.6).

Figure (6): Water productivity in MENA countries during 2013

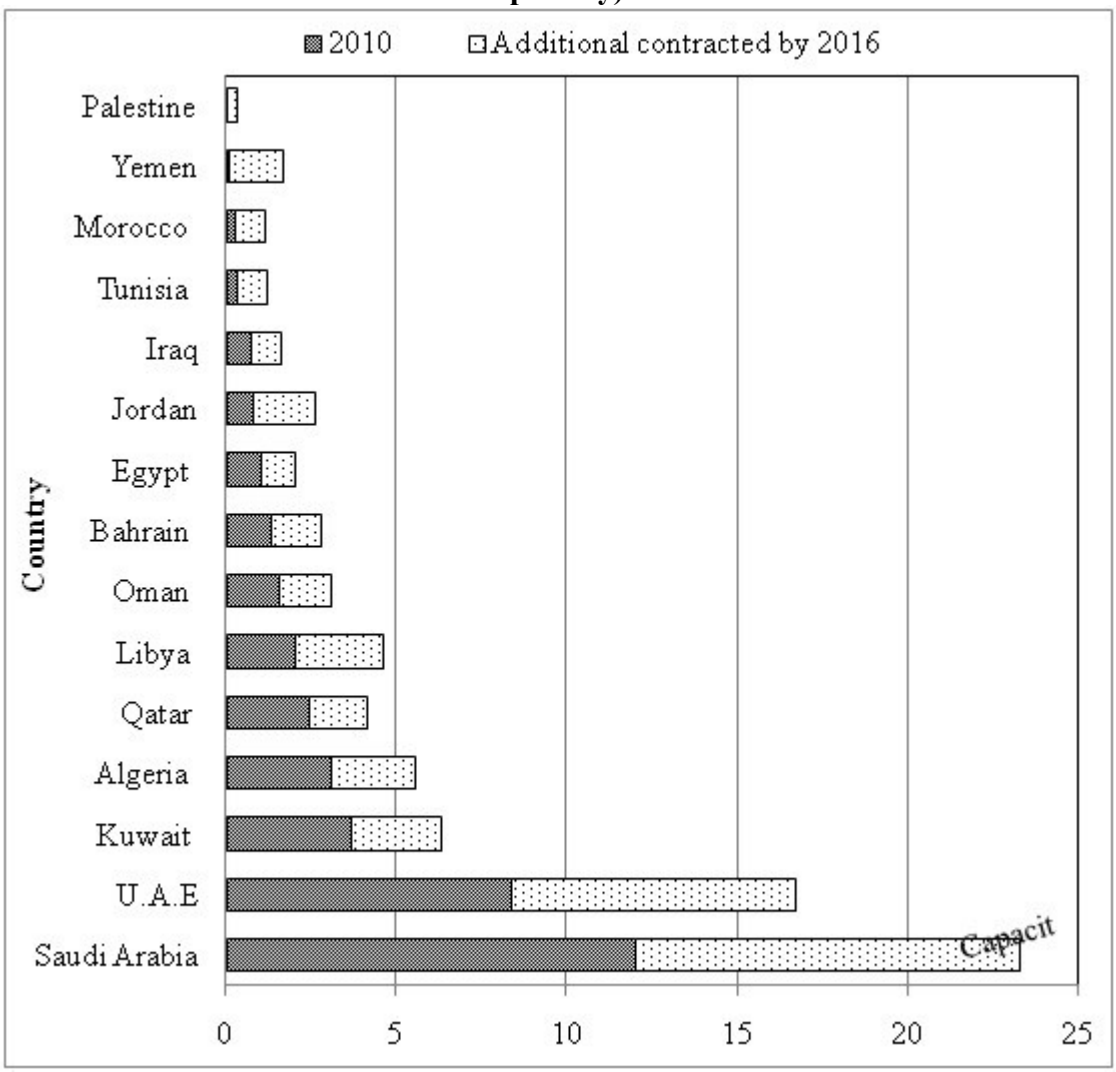


Source: World Bank, (2016).
Note:
(*)constant 2005 US$ GDP per cubic meter of total freshwater withdrawal.

The figure number 6 shows that productivity, in most of the MENA region, is less than 20 units, while just a fourth had 60 units of productivity or more (very dry continent including: Qatar, Malta, Kuwait, Bahrain and U.A.E), which could explain that the more dry is the continent the more economic water is used.

Because of the climate nature, which is dry most of the year, in many Arab countries from MENA region, governments were engaged in water desalination project. The table number 05 represents expectation of desalination capacity within 2026.There are disparate strategies between Gulf continent and the rest of MENA countries, economic and technologic factors are the main reasons behind the feeble capacity of seawater treatment in many Arab countries (see Fig.7).Measuring water desalination capacity for individuals (per person a day unit) is more suitable for valuation of efforts to meet water needs, e.g. governments of Kuwait and U.A.E are more relying on desalination to satisfy municipal needs.

Figure (7)
Accumulated desalinated water in selected Arab countries, 2010 and 2016 (10^6 m^3 per day)



Source: UNDP, (2013). Water Governance in the Arab Region: Managing Scarcity and Securing the Future. UNDP-RBAS, New York.

For some countries, seawater treatment represents a short term solution to fulfil the water gap, instead of engaging in mobilization projects, e.g. Multipurpose Dams, in order to enhance irrigation capacity of large surfaces which necessitates mobilizing sufficient financial support for a multi-year strategic plan implementation.

The W.B. spent enormous efforts, in order to encourage cooperation with private operators in managing water[38]. Even public water services were obvious, many conditions are abstaining this engagement, such as: (a) an absence of financial incentives for investors, (b) a miss understanding of legal reforms introduced by government in order to promote cooperation with the private investors, this is also the case when co-operators are unspecialized or less experienced (c) unmotivated behaviour amongst entrepreneurs.

In an essay to accommodate water price with market requirements, many governments shift from fees to administered dues, as example, Algeria's progressive pricing scale of water consumption (see Tab. 03). This policy has a triple objectives, economic (consist in high returns along with high ranges of consumptions), social (involving big consumers in subsidizing the poor's consumption) and environmental (conserving natural resource by inciting people to preserve it from excessive use).

Table (3)
The urban water tariff grid (for a given district)

Brackets	Tranche m^3/trimester (1)	Multiplier coefficient(2)	Ex.: Town Basic tariff: B monetary units(3)
1st bracket	[0-a]	x	x× Base = x×B
2nd bracket	]a-b]	y	y × Base = y×B
3rd bracket	]b-c]	z	z × Base = z×B
4th bracket	More than c	w	w× Base = w×B

Source: authors.
(1) a, b, c: are tranche limits measured by m^3/trimester;
(2) x, y, z, w: are multiplier values;
(3) B: is the basic tariff.

The 3rdbracket is also the uniform tariff applied for administrations, artisans and services of the tertiary sector. The 4th bracket is also the applied tariff for industrial and touristic plants.

2. Water policies in MENA region:

The common challenge of water scarcity creates a rapprochement between MENA countries, agreements are joining upstream with downstream countries as a corollary of water security, many desalination plants were established and other projects are on the way of realization in order to enhance the water balance[39]. There are also advances in promoting water services and sanitation, likewise practices are consistent with the beneficial effect of virtual water, as a result, pressures are being relieved on interior water resources (see Fig. 3). Even the economic solution seems to be financially more effective than restructuring credits on water uses, supply management in water sector still be advised, at least for most MENA countries. Since necessary conditions to apply real water prices are not met in present, required policies are supposed to deal with people's unmet needs by supplying sufficient water in quantity and quality at first, then seek to preserve water by getting the water price right.

Conclusion:

Studies about water resources in MENA region show a growing capacity of mobilization pushed by construction of many water refineries, but requirements include the method of protecting this resource more than mobilizing it which eventually presses on the scarcity problem.

The water strategy must focus on supplying water with sufficient quantities and in respect of health standards concerning municipal water, instead of preservation which

necessitates an integrated management system based on collaboration between consumers and local administration, with introduction of economic and financial means in dealing, consuming and using water. Preservation could be initiated by programs of maintenance and promotion for water treatment plans to enhance reuse of water, with desalination plants using renewable energy sources. The important finding of this study is that the main challenge of water scarcity management is that excessive consumption induces unsustainable economic growth. As a result water policies must focus on:

- Planning strategies to protect water resources.
- Maintaining structures.
- Working on empowering the production capacity of water through new techniques of desalination.
- Engage in establishing a long term territorial programs for collaboration to maintain water security.
- Modernization of linkage and gridding techniques with water system and avoiding waste and loss of this precious resource.
- Decentralize potable water pricing and call citizens for collaboration to preserve water resources, to overcome the future strategic challenge which is conservation of resource that has often been considered as a free resource.

Recommendations:

The study points out some major recommendations for policy orientation of MENA countries, mentioned as followed:

- There is a need of collaborative plan for an equitable water use in the middle east countries, because groundwater and external water sources represent an important share of water consumption for those countries;
- Water scarcity management should focus on water demand in MENA region, to enhance economic growth rates;
- The shift in economic model for most MENA countries –from manufacturing to agriculture; and from subsides to water pricing- could represent a booster for economic growth;
- Strategies of water preservation represent a lever for economic growth; which means that more mobilization of different water sources will boost the production throw the reduction of water use cost.

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