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Adaptation and mitigation measures in Egypt and some Arab countries: Current state and future recommendations

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ABSTRACT

The current situation of vulnerabilities caused by accelerating impacts of climate change and the adaptation and mitigation measures taken by some Arab countries were investigated. The aim of this paper is twofold, the first is to define the current situation and future measures that Egypt is taking or has to take in order to face the accelerating impacts of climate change. The second is to define the differences or similarities of such impacts in the Arab region that has countries of different economical, social and political structures. If common, regional, climate change impacts exist, collaborative measures can be taken and a better adaptation capacity can be developed in the region. In this paper a comparative study for Egypt, Saudi Arabia, United Arab Emirate, UAE, and Sudan is provided. It was found that the most pressing issues in the four countries are sea level rise and water scarcity. This research paper claims the need for "researchers capacity building" in the area of climate change research to enable them carrying ambitious research projects.

Key words: Adaptation, mitigation, Arab countries, capacity building, water scarcity, sea level rise, climate change.

INTRODUCTION

Reducing human vulnerability should be a central purpose to achieve resource sustainability. As a result, there should be a collaborative effort between scientists in the region for assessing the vulnerable people and places to help alleviate human suffering, raise public awareness, guide decisions on where to allocate resources, and develop early warning systems to improve preparedness (Leisnham, 2011). The ongoing climate change (CC) has many economical, political, social and human consequences that should be addressed as soon as they are occurred or predicted. For example, CC is expected to make the poorest of the world communities poorer that put them in dual risk of physical consequences and violence or political instability. Around 2.7 billion people will be affected by the interaction of CC and economical, social and political problems (Smith and Vivekananda, 2007). Adaptation and Mitigation are the drivers to prevent or reduce many of these consequences. Mitigation has much concern in the globe than adaptation, although most severe mitigation efforts cannot suppress the impacts of past and current actions that caused climate change, in the next few decades. This makes adaptation inevitable as recommended by IPCC reports (Klein et al., 2007). Therefore, integration between strategies and policies of mitigation and adaptation are desirable, if not mandatory. However, before we can go any step towards integration, the current state should be investigated and analyzed. This analysis can work as a base for future plans of the integrated efforts of mitigation and adaptation.

In this study, the current critical problems of CC in four Arab countries, as a sample for the Arab region, are defined. The four countries are; Egypt that works as an example for north African Arab countries and one of the biggest countries in the region in term of politics and population; Saudi Arabia as the major producer of fossil fuels in the world that has tradeoff targets in this matter; Sudan is the southern extension of Egypt that have the same source of water (Nile River); and United Arab Emirate is a growing economy that suffers from water scarcity, together with Saudi and Gulf area. This research work is trying to answer the following questions: How do the four countries contribute to the environment? What are the CC problems exist and/or expected to occur in the four countries? What are the similarities and differences between those problems? What are the specific mitigation and adaptation measures taken now? What are the potential actions that should be considered? Can they be applied in regional level?

The following sections of the paper will try to provide an answer for these questions. Section 2 provides information about the current situation of energy consumption and emissions exerted by the four countries, aiming at assessing their contribution to the environment. The problems happened because of CC in the countries under study are presented in Section 3. In Section 4, adaptation and mitigation measures taken by the four countries are discussed. Discussion and conclusions are presented in Section 5 and Section 6 respectively.

1. ENERGY CONSUMPTION AND EMISSIONS

1.1. Energy consumptions

It seems that the energy consumption patterns in the four countries are related to their economical level. The energy production resources have been changed considerably in Egypt and UAE from 1990 to 2004. The natural gas share in energy production has exceeded the oil based energy production in the two countries. Saudi and Sudan have almost the same pattern in both cases. It is important to note that some oil producing countries use oil for electricity production although it is not the economical option. It is also obvious that only Egypt and Sudan have started Renewable Energy projects prior to 2006. Figure (1) shows the primary energy consumption development from 1990 to 2006. It is easy to recognize that Saudi is, by far, the major user of energy in the four countries and the Arab region as well. Furthermore, the trend of energy increase is higher than other countries. However, comparing the energy consumption per capita, the UAE showed the highest consumption rate increase between the four countries, may be because of current rapid economic development in the country.

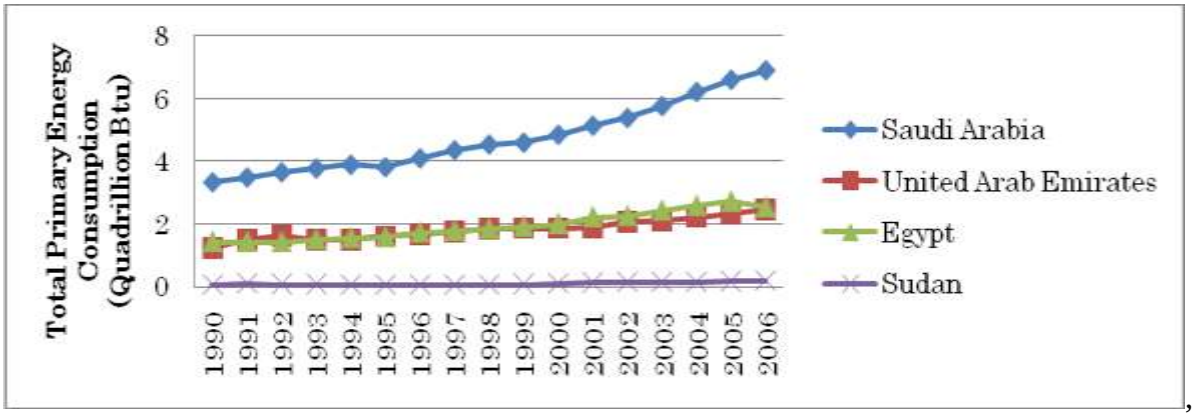

Fig. 1: Primary energy consumption in the four countries

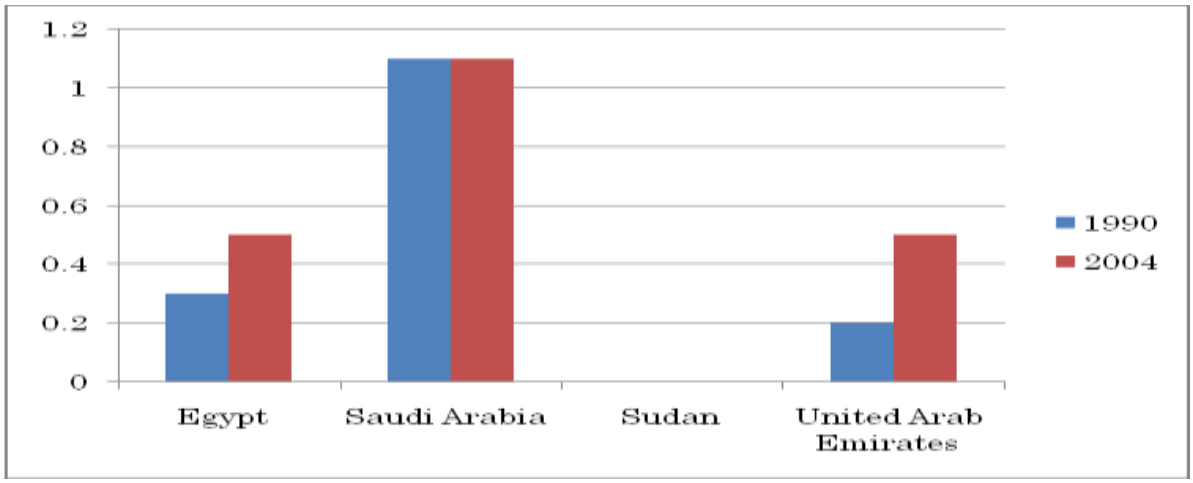

Fig. 2: The percentage of world share of CO_2 emissions

1.2. Current emissions

The total CO_2 emissions of the four developing countries are about 2 % from the world emissions (Fig. 2). It is also noticed that the emissions of the UAE is almost the same as Egypt in 2004 that show the huge amount of emissions due to the high energy consumption per capita from fossil fuels. In 2000 the UAE has ranked the second in the world for CO_2 emissions per capita, about ten times of world average, while Saudi Arabia was in the 11^{th} position in the world (Baumertet al., 2005), the trend of increase is shown in Figure (3). The emissions per capita for Egypt is almost half of the world average while for Sudan it is extremely small due to the reliance on the biomass as a main source of energy, though with low efficiency use.

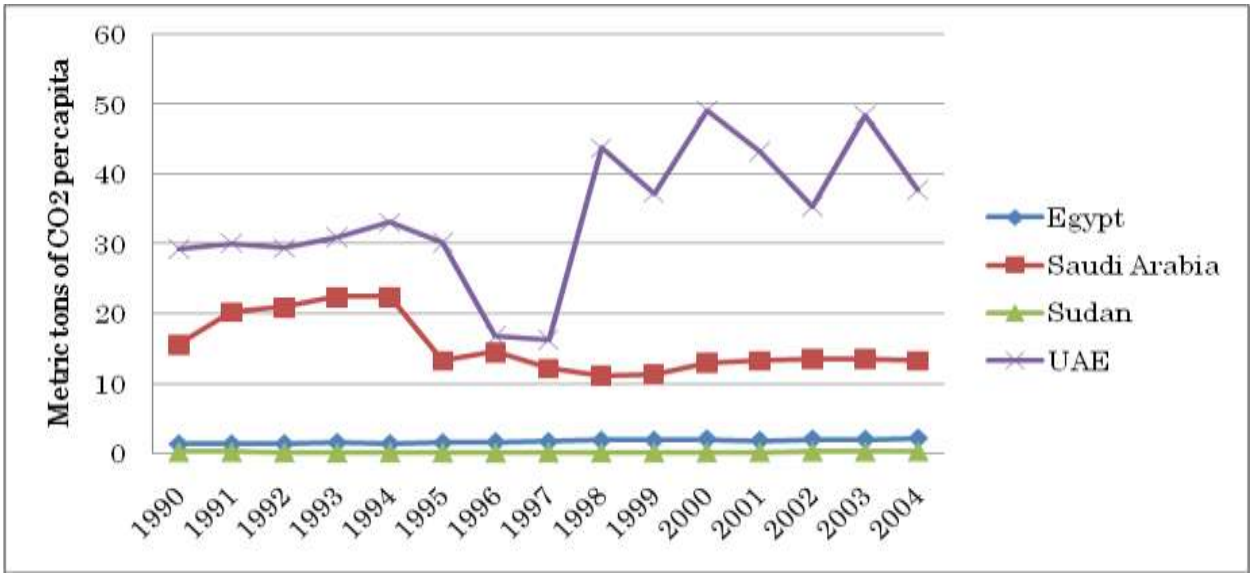

Fig. 3: The CO2 emission per capita

2. PROBLEMS OF CLIMATE CHANGE

Egypt and Sudan seem to be the most affected countries between the four countries from climate change, proving that who shares less in harming the environment suffers more. A large number of literatures addressing the vulnerabilities to climate change of Egypt and Sudan are exist. However, there is scarcity of literatures that consider its possible effects on Saudi Arabia and United Arab Emirate. In the following subsections the different threats that each of the four countries face, or may face in the future, are discussed.

a. Egypt

The vulnerability of Egypt to the impacts of climate change has been recognized and investigated thoroughly, especially water resources, agricultural resources and coastal zone resources (El-Raey, 1997; Sathaye et al., 1997). However, the most crucial problems, suggested by the research works exerted, are sea level rise, temperature increase and water scarcity (Onyeji and Fischer 1994; Frihy et al., 1996; Yates and Strzepek, 1996; El-Raey, 1997; El-Raey et al., 1997; El-Raey et al., 1999; El Raey, 2004; Hassan, 2007; IRIN CAIRO, 12 March 2008). In fact, these three problems are interrelated and are critical for social security of the country. For example, the food security is one issue that can be affected dramatically, as will be discussed in Section 5. The relation between water scarcity and population growth may complicate the problem as higher number of population may lead to the lofty rate of water consumption unless strict measures are taken. The Water Exploitation Index for Egypt and Sudan is 90% and 50% respectively (Boko et al., 2007).

The delta area is the most fertile land in the country and about 300 km of coast on the Mediterranean Sea and Red Sea that host a number of highly populated cities with a considerable part of its areas lies under the sea level. A recent study on the city of Alexandria, the second biggest city in Egypt, which includes around 40 % of Egyptian industry, showed that for a SLR of 0.5m about 30% of the city area will be lost due to inundation, over 1.5 million people will have to be relocated, 195,000 job losses as well as land, properties and revenues in the range of $30 billion (El-Raey, 1997; El-Raey et al., 1999). The studies claimed that the most harshly affected employment sector will be industry, followed by tourism and agriculture.

According to the third report of IPCC, a relationship between ambient temperature rise and heat-related mortalities in Cairo was found.

b. Saudi Arabia

In fact Saudi complains from other type of vulnerabilities which is losing oil revenue if world agrees to the global cap on emissions and therefore they ask America and other countries for compensation (Friedman April, 2009). This may explain why there is almost no research work that is directed to studying the country vulnerability from the environmental impacts of climate change. However, Saudi lies in arid region with low quality soil that may be affected by water scarcity. The coastal areas of Red sea and Arabian Gulf are fringed low land and any increase in sea level rise may lead to many problems in the cities that lay on the coast. Precipitation decrease and temperature increase are also expected (Vincent , 2008)**.**

c. Sudan

Sudan has a wide range of climates, fertile land and landscapes, however it is one of the countries that is suffering, and will mostly suffer in the future, from the climate change problems (Adger, Agrawala et al., 2007; Omer, 2007; Reuveny, 2007). Some of the reported problems because of climate change are drought, desertification, interstate conflicts, famine, and erosion. For example, North Darfur was the most vulnerable region of Sudan, as during the years of drought between 1983 to 1985 a great demographic and socio-economic conditions have been affected due to migration of great numbers of population who left their homes due to famine and the environmental impacts of desertification and drought (Osman-Elasha et al., 2006). Furthermore these problems have lead to a major migration problem for about 4 to 4.5 Millions early 1990 (Reuveny, 2007).

d. Emirate

The growing economy of UAE makes it important to think about the possible impacts of climate change on their development. The UAE lies in arid region that seems to suffer from many climate change problems such as: increasing average rain fall pattern change and sea level rise that cause a significant risks for the UAE's investment-intensive coastal zones (Ministry-of-Energy, 2006). Under the climate change, the vulnerability of water, soil quality, coastal erosion and threat to biodiversity in the UAE will be worse (Pachauri 2008). With the future possibility of lower rainfall levels, surface runoff could decrease drastically and lead to further reducing both surface and groundwater availability. Moreover, accelerated sea level rise associated with climate change would exacerbate increasing soil and water salinity in some coastal areas. Salinization of soil and water used for irrigation would threat agriculture and food production in the UAE (Ministry-of-Energy, 2006).

3. ADAPTATION AND MITIGATION MEASURES

The mitigation measures seem to be the most appreciated in the studied countries. All the four countries made ambitious, yet small, plans to reduce their CO_2 emissions as well as energy efficiency projects. The adaptation measures are very few and in almost all countries and limited to the activity planning and management level. Egypt seems to be a head in taking mitigation and

adaptation measures. In the following section the different measures in the countries considered are discussed.

a. Adaptation Measures

The above discussion highlighted some of possible vulnerabilities that the four countries may face under climate change. With a limited adaptive capacity for people of these countries (citizens and governments) the situation becomes worse and needs more attention. It was also noticed that the nature of the vulnerabilities is different in type and timing. The adaptation measures taken by countries are different and depend on the capacity of the country to anticipate potential risks and the ability to react as a result of unexpected risks. To the best of author's knowledge no adaptation measure research are published for three countries (Saudi, UAE, and Sudan), except some related but not directed work for Sudan by United Nations Development program (United-Nations-Development-Programme-in-Sudan, 2006). Therefore, only the adaptation measures taken in Egypt are discussed here.

The literatures about Egypt have not agreed upon how the adaptation measures are considered. In a recent study it was pointed out that there is no agreement between scientists and government officials about specific climate change adaptation activities and therefore, adaptation activities in Egypt have been limited to studies and planning (Agrawala et al., 2004; IRIN CAIRO, 12 March 2008). Another study has argued that Egypt has taken proactive measures to face these challenges to protect its future generations from serious threats that will increase in the absence of actions taken today (El Raey, 2004). In earlier study, some of hard, anticipatory, adaptation measures were taken to protect the coast in different areas (El-Raey et al., 1999). However, those adaptation measures seem to be random as no planning or adaptation management schemes were discussed. In the same study some another hard adaptation measures, such as beach nourishment and breakwaters were investigated for the socio-economic point of views. As signatory to the 1995 United Nations Framework Convention on Climate Change (UNFCCC), Egypt has prepared a National Action Plan on Climate Change to coordinate its efforts to face this serious and important challenge, to maintain its sustainability economic development, and to provide a safe environment for its future generations (Egyptian-Environmental-Affairs-Agency, 2009).

To overcome water scarcity due to climate change, if freshwater supply has to be replaced by desalinated water, then the cost of desalination seems to be unaffordable (Bates et al., 2008). The average treatment costs for water desalination and chlorination are shown in Table (1). In Egypt, if the difference between water resources and water consumption are to be desalinated, i.e., 25km^3 it will cost around 1 billion US$ with huge amount of CO_2 emissions that interfere with mitigation efforts. Therefore research in new desalination technology is required to reduce the costs as well as greenhouse gas emissions (Bates et al., 2008).

Table.1: Average costs of water treatment

Water type	Average treatment cost (US$/m3)	Treatment method
Sea water	1.00	Desalination
Brackish water	$0.60	Desalination
Fresh water	0.02	Chlorination

Source: (Bates et al., 2008)

b. Mitigation Measures

Many mitigation projects have been initiated and built in Egypt, which are listed here based on Agrawala (Agrawala et al., 2004):

- Cooperation Agreement Pilot Project (TCAPP) in cooperation with the U.S. Country Studies Program. The TCAPP is chartered to develop consensus among key Egyptian organizations on a set of high priority, climate-friendly, technology issues aimed at;
  - Successful commercialization.
  - The Promotion of wind energy for electricity generation
  - An active program within the Ministry of Electricity and Energy through the New and Renewable Energy Authority
- Fuel cell bus demonstration project
- Hybrid electric bus technology
- Natural gas motorcycle
- Methane recovery from landfills
- Integrated solar thermal/natural gas programs
- Energy efficiency improvement and emissions reduction project
- Fuel switching from liquid oil to natural gas.

Recent research study in Egypt has considered three GHG mitigation scenarios, based on a technology assessment, including Fuel Substitution, Renewable Energy and Energy Efficiency. These scenarios aim at producing about 208 peta joules (PJ) by 2016/17 with 18.4 million tons CO_2 emissions reduction (Agrawala et al., 2004).

Saudi Arabia, as the major producer of oil, has some worries from the climate change talks by the United Nations. Saudi Arabia thinks that they can be between vulnerable countries, of climate change policies, economically by penalizing carbon emissions rather than energy taxes (Brewer, 2003; The Economic Times April, 2009). On the other hand, Saudi Arabia wants support, for example, to develop alternative energy sources such as solar energy (The Economic Times April, 2009). Solar energy is the most promising renewable energy resource in the Middle East region. Egypt, Saudi Arabia and recently UAE are developing this resource extensively in terms of solar water heaters, photovoltaic systems and concentrated solar plants (Alawaji, 2001; El-Fadel et al., 2003). In contrary with adaptation researches much work has been done by many researchers in Saudi Arabia that ranges from real case studies to scenarios development (Al-Dayel, 1988; Alnatheer, 2006; Shaahid and El-Amin, 2009; Shaahid and Elhadidy, 1994). Although Saudi Arabia had signed the Kyoto Protocol it seems to be less convinced to take serious measures towards mitigation as well as adaptation (The Economic Times April, 2009).

The UAE is more interested in sharing the efforts towards minimizing the effects of climate change. In the 14th UN conference on climate change held in Poznan, Poland, from 1-12 December, the UAE Minister of Environment and Water said "the UAE has directed a lot of attention towards this vital issue, where the related social, economic and environment aspects of climate change represent a basic part of the country's policy in this respect". And that UAE adopts and takes part in developing techniques and modern systems in the oil industrial sector (UAEInteract December, 2008). The high economic growth, low cost of energy and urbanization in UAE led to quadruple the primary energy consumption from oil and natural gas in the past two decades. Therefore, the energy consumption per capita was the highest in the world (Kazim, 2007; Radhi, 2009). There are trials to assess the environmental impacts aiming at reducing the CO_2 emissions in many sectors (Agashichev and El-Dahshan, 2003; Al-Iriani, 2005; Radhi, 2009).

As shown above Sudan is the most environmental friendly country, in the sense of energy use, with almost 80% of its energy production from biomass. Furthermore, some research work mentioned that Sudan has a clear obligation to continue research, development, and implementation of new technologies for renewable energies such as bio-gas production, wind energy, solar energy, biomass energy (Omer, 2001a; Omer, 2001b; Omer, 2005; Omer, 2007; Omer, 2008; Omer and Fadalla, 2003). An interesting study explained the role of women in promoting the appropriate energy technologies rural population over the past 15 years and showed various potentials of possible resources in Sudan (Omer , 2007).

In year 2008 the governments of Egypt and Sudan have held a talk about cooperation in the field of bio-ethanol production from rice straw, with investments of $ 150 million, through establishing a joint company with Sudan MISRODAN for cultivating and producing ethanol (Gulf-Oil-and-Gas, 2008).

4. DISCUSSIONS

Water scarcity is the major similarity between the four countries, and in principle with all Arab nations that may require more cooperation and experience sharing in that field. Many research works have been carried out to study the economical efficiency of seawater desalination as one solution to overcome the problem (Al-Sahlawi, 1999; Hafez and El-Manharawy, 2003; Lamei et al., 2008; Wichelns, 2001).

To overcome any future vulnerability for water scarcity the four countries need to implement a water demand management strategies which require: capacity building programs, awareness raising across institutions and society. Salih and Ibrahim have recommended the International Hydrological Program (IHP) of UNESCO as a regional framework for assisting the Arab region in establishing a sustainable management approach to the scarce of water resources . However, any management program relies on its targeted people and their level of understanding for the risk they may face. For example, people need to be convinced that there may be a problem of drought, to accept learning about how they can respond if they face it. Nowadays, it is the easiest time to set soft adaptation plans that can be understood and accepted by the society because, as shown in Figure (4), the illiteracy rates are decreasing in the four countries, and may be all Arab countries. This development of literacy level makes educational programs and capacity building programs more effective.

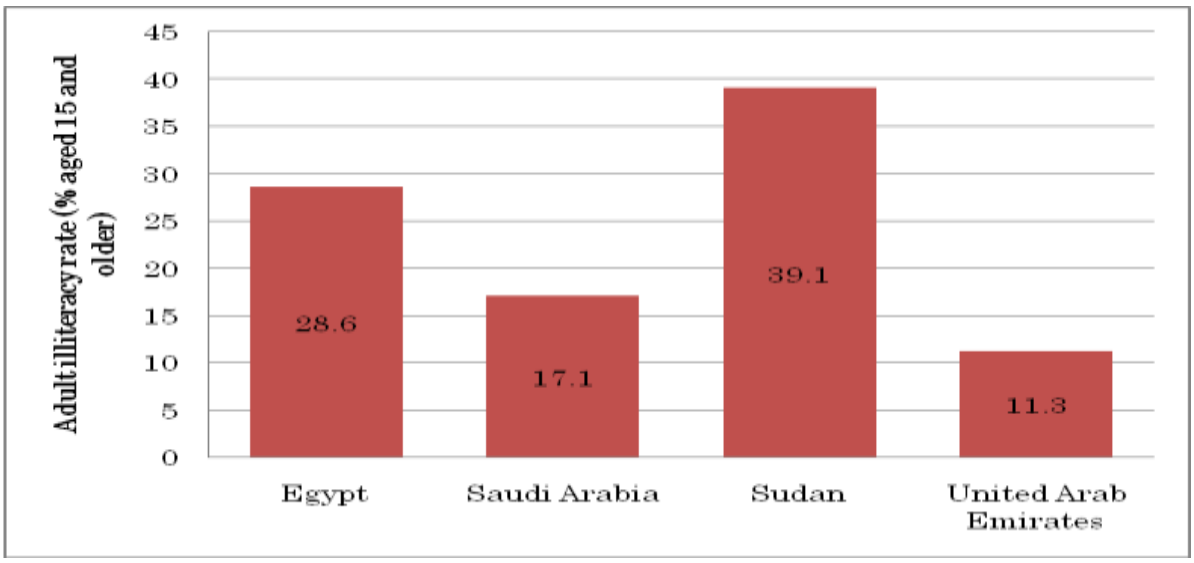

Fig. 4: Adult illiteracy rates for people aged more than 15 years

Another advantage for the four countries is, as shown in Figure (5), the continuous increase in the number of internet users which, makes information sharing and transfer, through discussion groups or any online conferencing services possible and effective. As discussed above Sudan has suffered, and still suffering, from drought and desertification, and to some extent, has accumulated local knowledge of how to adapt to those circumstances. This experience can be an add value for the other three countries who are expected to practice the same type of vulnerability. In this case, the Sudanese expertise can be called and adjusted to other countries and can be a useful base for them to build their adaptive capacities. The same can be applied for Egypt in case of sea level rise. One may argue that adaptation measures are local and it is difficult to be transferred. However, from the author point of view, if impact is local, the expertises are universal and can be adjusted. Therefore, one measure cannot be applied 100% but it cannot, by any means, go to 0%, as at least certain level of know-how can be acquired. Joining the UN programs such as IHP or other UNDP programs can help in building the capacities of the researchers and experts of those countries and lead to higher level of cooperation and risk management.

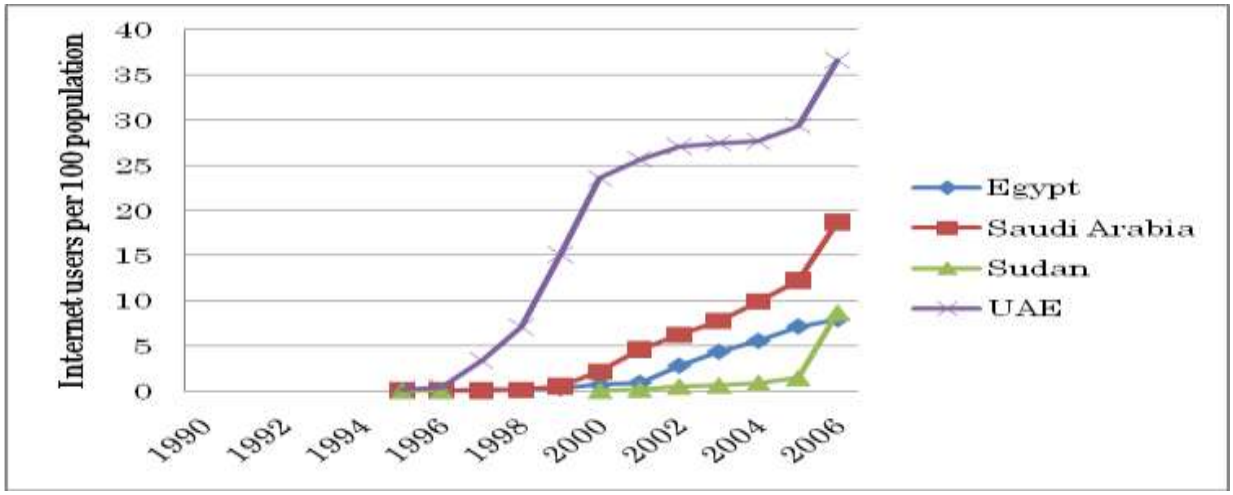

Fig. 5 : The number of internet users for every 100 of population

Egypt was among the first Arab countries to join the cooperative global efforts to confront climate change. Its First National report to the United UNFCCC was issued in 1999 and played extensive attention to the risks facing the country due to climate change and sea-level rise, mainly in relation to agriculture, water resources, human health, and the coastal zone (particularly the Nile Delta). The report has estimated the economic loss for sea level rise in several coastal cities and identified large range of adaptation options. Nevertheless, the implementation arrangements for the adaptation options were not considered well (Agrawala et al., 2004).

a. Food and water security

All simulations of climate scenarios indicated that Sudan and many African countries would lose cereal-production potential by the 2080s, except the NCAR model (Fischer et al., 2005). Egypt as a food importing country is also at risk of the problems of CC due to the changes in world markets with changes in local and regional systems and changes in the national agricultural economy (McCarthy et al., 2001). Egypt and Sudan rely mainly on water that originates out of their border as they cover 97% and 77% of their needs from the Nile River that originates in Ethiopia. Therefore, the two countries lie under water stress that will increase as any water related climate change occurs unless water management schemes are set and put into action. Saudi Arabia and United Arab Emirate mainly rely on the desalination of sea water that is considered acceptable in the current economic conditions, however with any economical problem, for example oil export shrinking and temperature increase with less diversified economy, they may suffer from an increase in water stress and political instabilities. Reducing human vulnerability should be a central purpose to achieving resource sustainability. Saudi Arabia and other Gulf countries are in lead of using desalinating brackish and salt water as an advanced water management techniques. Egypt is also managing complex irrigation and drainage networks. Some countries in the region have also begun making policy and institutional changes, including policies to promote end-use efficiency. Egypt spent about US$ 29 billion on water projects including potable water and sanitation services in 1982-2004; and irrigation infrastructure during 2000-2004 (Kharraz, El-Sadek et al., 2012). Those efforts give pushes towards the challenge of building a collaborative effort between scientists in the region for

assessing the vulnerable people and places and help alleviate human suffering, raise public awareness, and guide decisions on where to allocate resources as suggested by Leisnham (Leisnham, 2011).

5. CONCLUSIONS AND FUTURE CHALLENGES

Due to limitations of time as well as data availability and reliability, this study covers only 4 countries from the Arab region. The main common vulnerabilities from CC in the adaptation measures taken by the four countries have been identified and analyzed. The analysis of the mitigation and adaptation measures in the four countries showed a lack of considering adaptation by governments as well as researchers. It was noticed that not so many researchers are involved in mitigation and adaptation research for the four countries and many of research works were carried out by foreign researchers. This may be, in most cases, because of two reasons. The first is the lack of experienced researchers who are working, or interested in, the field. The second reason is that most research projects for adaptation are supported technically, and sometimes financially, by foreign countries where their citizens carry out the main part of the research that made. This should draw our attention to the importance of the capacity building for CC researchers' community. This study recommends building collaborative framework between countries in the Arab region. Development of new collaboration framework between the vulnerable countries in the area for water scarcity and sea level rise risk management is a new challenge ahead. This framework has to consider the analysis of areas of expertise or knowledge acquired by the experts of each country and synthesis them to provide useful information. The new framework will rely on building the information infrastructure for available knowledge and presenting this knowledge in its spatial context through the use of the Geographical Information System.

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Adaptation and mitigation measures in Egypt and some Arab countries: Current state and future recommendations

اجراءات التكيف وتخفيف آثار تغير المناخ في مصر وبعض الدول العربية - الوضع الحالى والتوصيات المستقبلية

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المسالمتخلص

يناقش هذا البحث محورين, الأول هو تحديد الوضع الحالي والمستقبلى والتدابير التي تتخذها مصر أو التى يجب اتخاذها من أجل مواجهة اثار تغير المناخ المتسارع. والمحور الثاني يهدف الى تحديد أوجه التشابه أو الاختلاف من هذه الآثار في منطقة واحدة ولكن مع اختلاف الهياكل الاقتصادية والاجتماعية والسياسية. إذا كان هناك صفات مشتركة بتغير المناخ والآثار البيئية المترتبة علية فإنه يمكن اتخاذ تدابير تعاونية فى المنطقة ككل مما قد يزيد من القدرة على التكيف في المنطقة. في هذه الورقة نقدم دراسة مقارنة لمصرمع المملكة العربية السعودية، دولة الإمارات العربية المتحدة، والسودان. تعتبر مشكلتى ارتفاع مستوى سطح البحر وندرة المياه من أكثر القضايا إلحاحا في البلدان الأربعة. نتيجة آخرى لهذه الورقة البحثية هي الاحتياجات لبناء القدرات للباحثين في مجال تغير المناخ في المناطق المعرضة للخطر لتمكينهم من تحمل مشاريع بحثية طموحة.