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Assessment of Climate Change Scenario in the Middle-East Region

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***Abstract*— One key issue in climate change impact studies is the need to make an in-depth study on the likely impacts facing each country. In this paper, an assessment of the climate change scenario has been carried out for the middle-east region. Particular emphasis has been laid on the climate change issues pertaining to the state of Kuwait – an important state in the Gulf region. A World Bank report presented alongside the Doha summit in Qatar in November 2012 revealed that the temperatures in the Gulf region have increased 50 percent faster than the global average. This is an alarming situation for the region that is already experiencing temperatures in excess of 50 °C in some regions. Most of the middle-east region including Kuwait has a high demand for electricity for air conditioning and desalination of water thus emitting huge amounts of greenhouse gases in the atmosphere. Kuwait being a prominent state of the middle-east region is vulnerable to the degrading effects and risks of climate change. Conserving energy and water, reducing carbon footprint and addressing climate change issues urgently is crucial for the sustainable development of the region. Therefore, the need of the hour is the pledge by middle-east countries including Kuwait to take proactive steps for addressing the issue of climate change. In this research, several solutions for mitigating the adverse impacts of climate change in Kuwait have been recommended. The research presented herein is likely to lend credibility to recent climate change modelling and assessment efforts being undertaken in the middle-east region**

***Keywords*— climate, change, middle-east, Kuwait, carbon**

I. INTRODUCTION

Climate change is perceived to be the biggest challenge facing the mankind today. Many aspects of the natural environment are likely to be impacted due to change in the climate. The United Nations Framework Convention on Climate Change (UNFCC) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and water temperatures, widespread melting of snow and ice, and rising global average sea level" (IPCC 2007a, Working Group I Summary for Policymakers, p. 5). During the past century, humans have substantially added huge amount of gases in the atmosphere by burning fossil fuels such as coal, natural gas, oil and gasoline to power cars, factories, utilities and appliances. These gases -primarily carbon dioxide, nitrous oxide, and methane -are known as green house gases.

Carbon dioxide (CO_2) is emitted naturally during respiration by plants and by all animals, fungi, and micro-organisms that depend either directly or indirectly on plants for food. It is also generated as a by-product of the combustion of fossil fuels or the burning of vegetable matter, among other chemical processes. Other sources of CO_2 include volcanoes, geothermal processes such as hot springs and geysers and dissolution of carbonates in crustal rocks. Methane (CH_4) is another major greenhouse gas and can lead to more rapid global warming than CO_2. It is emitted from burning of fuel in vehicles. Cattle ranching are another major source of methane emissions. Demand for dairy products has shown a rapid growth in recent years leading to huge increase in methane emissions. Flooded rice cultivation produces methane by the fermentation of the organic matter in the soil. It is released from submerged soils through the roots and stems of rice plants. The variation of concentration of carbon dioxide and methane in the atmosphere is shown in Figure 1 and Figure 2 respectively. It can be seen from Figure 1 and Figure 2 that the concentration of CO_2 and CH_4 began to increase in the atmosphere around 1760 – the time when the first industrial revolution began. Further increase in the concentration of greenhouses can be noticed during the Second Industrial Revolution, also known as the Technological Revolution - a phase of the larger industrial revolution corresponding to the latter half of the 19th century until World War I.

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During the 20th century the rate of increase of concentration of greenhouse gases in the atmosphere has been rapid.

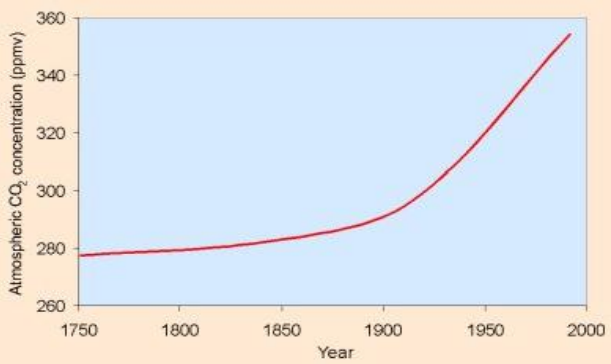

Figure 1 Variation of CO_2 concentration with time

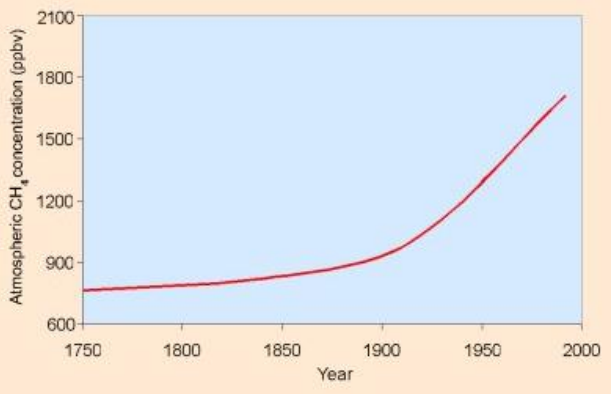

Figure 2 Variation of CH_4 concentration with time

Due to huge emissions, the concentration of greenhouse gases in the atmosphere is likely to double by 2050 (Jenkins and Derwint, 1990). In most developing countries, climate change represents an additional stress on ecological and socioeconomic systems that are already facing tremendous pressures due to rapid urbanization, industrialization and economic development. Results of several recent studies have confirmed that the Asian region is indeed warming, and the trend of warming is broadly consistent with the global warming trend (Singh et al. 2008). As a consequence, many aspects of the natural environment, including water resources, are anticipated to experience potentially serious climatic impacts in the South Asia region. India is considerably vulnerable to the impacts of climate change largely due to its huge and growing population, a 7500-km long densely populated and low-lying coastline, and an economy that is closely tied to its natural resource base.

Changing global climate and weather patterns are impacting snow cover in the Himalayas due to which the spatial distribution of rainfall has undergone significant irreversible change. In the event of shifting pattern of precipitation and runoff associated with climate change, the timings and magnitude of water availability at reservoir sites is likely to be impacted. Erratic monsoonal patterns are likely to be devastating for crop production.

The recent Intergovernmental Panel on Climate Change (IPCC) report (IPCC 2007a) clearly indicates the likelihood of considerable warming over sub-regions of South Asia, with greater warming in winter than in summer. Results of multi-model GCM (global climate model) runs under the Special Report on Emission Scenarios (SRES) B1 and A1F1 project an increase in average temperature over all of South Asia, with the greatest increase being projected for winter months. The projected rise in temperature for winter months exceeds the range of the global mean surface temperature rise (1.8 to 4°C) reported by the IPCC (2007b). The projected departure of global temperatures under various emission scenarios is shown in Figure 3. It can be seen from Figure 3 that departures as high as 6 °C from the base period 1961-1990 are projected under some scenarios. Such high departures can have devastating impacts on many aspects of ecosystems.

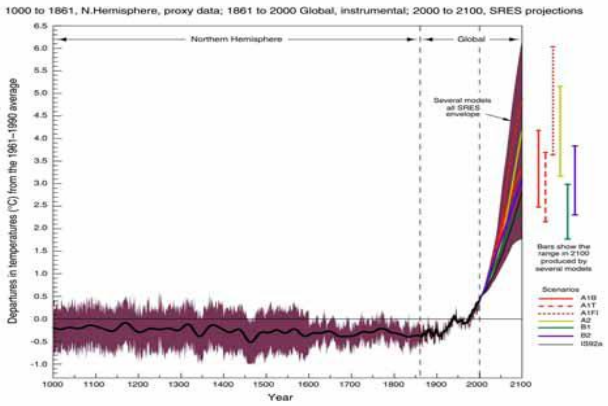

Figure 3 Departure of temperatures from 1961-1990 average under different scenarios

Global warming is responsible for the ongoing change in climate being experienced in almost all parts of the world including the middle-east. The problems caused by climate change are amplified for regions that are likely to be impacted economically. Most of the middle-east is economically strong and therefore highly vulnerable to the impacts of climate change.

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The phenomenon of climate change has a cascading effect which means a problem in one part of the world gets transported to other parts of the world in a slow but steady manner. In the middle-east which has a hot climate, the impact of global warming will be significant. Adaptation to changing climate is therefore crucial for the countries in the middle-east region. A significant impact of the ongoing climate change is likely also on the bio-diversity of the Middle East region. Many world organizations have established strategic plans for climate change such as the Global Strategy for Plant Conservation which was adopted in 2002 by the conference of the Parties of the convention on biological diversity. Most middle-east countries are under tremendous stress due to natural and anthropogenic factors. Kuwait being a prominent country of the middle-east region is vulnerable to the degrading effects and risks of climate change.

Carbon dioxide emissions from countries such as Qatar and the United Arab Emirates (UAE) are high compared with Europe. In Qatar and UAE it is 59.56 and 29.2 metric tonne per capita respectively. By comparison the figures for the European Union (EU) and the United States of America (USA) are 8.09 and 17.82 respectively. Temperatures in the Gulf region have increased 50 percent faster than the global average. This was revealed in a World Bank report presented alongside the Doha summit in Qatar in November 2012. Kuwait, for example, measured temperatures in excess of 52 °C. Kuwait has been blessed with oil and gas but unfortunately does not have adequate fresh water, and also have a hot climate. The ability to grow food is limited as well. Many climate change issues are exclusive to Kuwait. Due to hot and humid climate, the demand for electricity is very high. A significant amount of electricity consumption is for desalination of water. Both the air-conditioning and desalination are highly energy intensive processes. Burning fossil fuels (primarily gas) to produce electricity and water releases greenhouse gases, mainly Carbon di oxide. In fact, approximately 90% of the CO_2 that Kuwait emits is caused by the process of burning fossil fuels to provide energy. As a result, large amount of CO_2 emissions are released in the atmosphere. Undoubtedly climate change will impact Kuwait as well as other middle-east countries significantly in the future.

II. Research Objectives

Research related to evaluation of climate change impacts in the middle-east region, including Kuwait is presently in a nascent stage. A limited number of studies have been carried out in the Kuwait region.

The temperature rise in Kuwait since 1957 is between 1.5° C and 2° C, which is higher than the global average, as per the Meteorological Department for Civil Aviation at Kuwait International Airport. The corresponding average rise reported from around the world has been around 0.9° C. An alarming fact is that the rise is not due to urbanization as most of the climate stations are located outside the city limits. Kuwait is dependent on desalination plants for its fresh water, and at temperatures over 37-38° C the turbines generating the electricity driving these plants have to be turned off.

The major objective of the present research is to assess the scenario of anthropogenic climate change in the middle-east region. Particular emphasis will be laid on the assessment and evaluation of climate change scenario in Kuwait. Some adaptation and mitigation strategies, particularly for Kuwait are discussed in this paper. A literature review of trend studies in south-Asia has also been presented in order to put the work presented in this paper in context. Studies related to impacts of climate change on hydrological systems have also been reviewed.

III. Literature Review

A major impact of climate change around the world is anticipated to be on the hydrological systems including reservoir operations. One of the most important aspects that would be impacted is the availability of water resources on a regional scale with the modification of the hydrological cycle (Xu and Singh, 2004). The changes in the timings of precipitation are likely to impact runoff generation processes both in terms of magnitude as well as timings. Operational decisions for water resources infrastructure such as reservoirs are dependent on both the timings and magnitude of flows, and therefore climate change impact assessment must consider both these characteristics. The operation of reservoir systems is, therefore, likely to be more reliable if the impacts of potential climate change on inflow sequences are considered. The hydrological systems are potentially very sensitive to change in climate as the changes in precipitation affect the magnitude and timing of runoff and the frequency and intensity of floods and droughts (IPCC, 2007a).

Reservoir operations have been extensively studied (Oliveira and Loucks 1997; Sharif and Wardlaw 2000; Tu et al. 2000). Several studies have been conducted to evaluate hydrological impacts of climate change on watersheds in different parts of the world (Burn et al. 2010; Khattak et al. 2011). Applications describing the impacts of climate change on reservoir operations are, however, limited.

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Klemes (1985) performed an assessment of the anticipated sensitivity of water resource systems to climatic variations, and found that (a) decrease in reliability might occur much faster than any decrease in precipitation or increase in evaporation losses; (b) the impact of drier climate would be more severe where the present level of development is high than where it is low; and (c) the relative effect of the precipitation change would probably be greater than that of the evapo-transpiration change. Burn and Simonovic (1996) investigated the potential impacts of changing climatic conditions on the operational performance of water resource systems. Reservoir operation was carried out for two potential monthly flow sequences reflecting two different sets of climatic conditions. Reliability (the probability of success) and resilience (a measure of how quickly the reservoir will recover from a failure) criteria were used to show that, despite moderate changes in inflow characteristics, the values of the performance criteria are substantially impacted. It was concluded that the reservoir performance was sensitive to the inflow data.

Recognizing the critical concern of global warming in south Asia, various studies have been conducted in the region to analyze trends in hydro-meteorological variables at regional and basin level (Hingane et al., 1985; Sinha et al., 1997; Arora et al. 2005; Singh et al., 2008). Hingane et al. (1985) analyzed long-term mean annual temperature records from 1901 to 1982 over India and detected an increasing trend in mean surface air temperatures. It was observed that about 0.4°C warming has taken place over India during the last eight decades mainly due to rise in maximum temperatures. Sinha et al. (1997), however, showed that the changes in mean annual temperatures are partly due to the rise in the minimum temperature caused by rapid urbanization. Pant and Kumar (1997) have reported an increase in mean annual temperatures in India at the rate of 0.57 °C per 100 years. Arora et al. (2005) investigated temperature trend all over India using Mann-Kendall non parametric technique and linear regression method. The results showed that mean temperature has increased by 0.94°C per 100 years for the post monsoon season and 1.1°C per 100 years for the winter season. Warming trend has also been found for Bangladesh. Ahmad and Warrick (1996) reported that the broad region encompassing Bangladesh has warmed at the rate of 0.5°C per 100 years. Shrestha et al. (1999) reported increases of 0.61°C, 0.90°C and 1.24°C per decade in winter maximum temperatures for Nepal, Himalayan and trans-Himalayan climate stations respectively.

CICERO (2000) estimated a temperature rise of 0.9°C for Pakistan by 2020 and predicted that the temperature rise could double by 2050.

Marco et al. (2003) analyzed the temperature data of 160 climate stations in China using Mann-Kendall and inverse distance methods. An increasing temperature trend was detected all over the country; however negative trend was detected in high latitude regions during summer. Winter period showed a warming trend with 95% significance level in southwest of Xinjiang and southwest of Tibet region. Fowler and Archer (2005) examined temperature data of seven climate stations in the Karakoram and Hindu Kush mountains of the upper region of UIRB for seasonal and annual trends using regression techniques. Mean and maximum winter temperatures showed significant increase while mean and minimum summer temperatures showed consistent decline. Zhang et al. (2005) analyzed monthly temperature and precipitation data for 51 climate stations and three hydrometric stations in the Yangtze basin, China. Significant positive and negative trends at 90, 95 and 99% significant level were detected using Mann-Kendall test. The middle and lower regions of the Yangtze basin showed downward temperature trend and an upward precipitation trend. The authors concluded that the middle and lower regions of the basin are likely to face more serious flood disasters in the future.

IV. Climate Change Scenario In Kuwait

Kuwait lies on the Arabian Gulf; its geography is made up of mostly flat desert on the mainland, and nine islands off the coast, some marshy and uninhabited. The climate of Kuwait can be extreme, with temperatures ranging from very cold to very hot, although the average annual temperature is 33 °C. The long and dry summer extends May through October. The August is the the hottest month with an average temperature of 44 °C. The winters are mild, with January the coolest month, with an average temperature of 7 °C. Rain storms may occur, and the wind may cause dust storms. The contribution of water to the carbon footprint of the region is something peculiar to the Gulf states including Kuwait because most of their drinking water comes from desalinated seawater. Kuwait experienced the effects of human-induced climate change following the Gulf War; Iraqis set oil wells on fire while retreating. The fires burned an average of 5 million barrels of oil, and 70 million cubic meters of gas per day, producing emissions of carbon dioxide (500,000 tons per day) and sulfur dioxide (40,000 tons per day).

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In addition to emissions, the regional climate impact from smoke caused the surrounding areas to cool (between 10 and 20 C) and damage to the land allowed the wind to blow away eroded soil.

As far as rainfall is concerned, Kuwait has been experiencing a sharp drop in rainfall during the last two decades. The long-term average rainfall in Kuwait is of the order of 125 mm. However, the distribution has shown erratic patterns during the recent years. Conventionally, Kuwait gets rain during late fall or early winter. But since the 80's, it has been experiencing some rain in November and then a spell of dryness followed by some showers in late March. The spatial and temporal distribution of rainfall in Kuwait has thus shown a marked change with the present rainfall patterns being characterized by sudden spells and long periods of dryness. Globally, sea levels could rise by up to 59 cm within the next century. In the UAE, studies show that a rise in sea level by 1 meter would affect 1,155 square kilometer of land. Even if the actual rise is lower than these estimates, it would still result in disastrous impacts on infrastructure, marine life and wildlife, health and, of course, businesses and economy. Clearly, no business can survive without energy and water. But genuine efforts must be made to use less, and make that effort a priority.

Kuwait experienced floods in 1993 and 1997. In 2011, the weather conditions in Kuwait reached tornado levels with wind speeds exceeding 160 km/h and touching 180 km/h. These changes are indications of change in climate in Kuwait. Moreover, dust storms have shown a marked increase in the state. The conditions of drought created in the neighboring regions due to climate change are creating dry beds, which become the source of dust storms blowing into Kuwait. Specifically the region between Syria, Jordan and Iraq known as the dust triangle is considered responsible for most of the dust storms in Kuwait. Despite the harsh environment, Kuwait supports more than 2 million people. With 10% of the world oil reserves aggregating to 99 billion barrels, Kuwait has a vibrant economy. Major industries including refining, marketing, and distribution revolve around oil economy of Kuwait. The poor and dry soil means less than 1 percent can be used for farmland. Kuwait is one of at least 11 countries consuming more than 100 percent of their renewable water resources, though the water is reportedly free of water-borne pathogens. Limited fresh water means desalination plants are needed to supply fresh water. These plants require energy to heat the salt water to boiling and energy to provide cooling to condense the steam into fresh water droplets.

Kuwait contributes to large scale carbon dioxide emissions mainly because oil exploration, production and refining are energy intensive process.

V. Adaptation And Mitigation Strategies

Several countries in the middle-east region have already taken steps towards combating adverse impacts of climate change. For example, Kingdom of Saudi Arabia (KSA) has taken major steps towards sustainability through raising awareness, forming partnerships with innovators and sharing information. The government of KSA is also introducing initiatives such as Estidama Pearl Rating System and developing new ideas like high efficiency district cooling systems, solar and wind parks for energy generation, rooftop solar systems, standards for efficient air conditioners and lighting, solar powered desalinisation plants and increasing public transportation.

The UAE is the fifth highest consumer of energy per capita in the world. The UAE is now putting more effort into reducing its footprint. In February, Abu Dhabi announced Masdar, which is being labelled as the world's greenest city. Once ready it will be a carbon neutral place to live where cars will not be allowed. Additionally, new laws are in discussion in Dubai to improve the environmental standards of buildings in the emirate. This would look at reducing water usage and improving power consumption required for cooling properties in the hot summers.

The State of Kuwait ratified the UNFCCC on 28 March 1995 and ratified the Kyoto Protocol on 11 March 2005. As a participant in the United Nations Framework Convention on Climate Change, Kuwait is responsible for providing national communication, including assessment of potential impacts of climate change. To meet this challenge, the Environment Public Authority (EPA), with an administrator appointed by the Council of Ministers, oversees environmental testing and education for voluntary programs. In addition, the EPA acts in a resource capacity. It advises federal and governmental policy makers on developing regulations and has authority to enforce the regulations provided within Kuwait's environmental laws through monitoring and compliance enforcement.

VI. Conclusions

The onus to aggressively tackle the problem of climate change is with the developed countries that are historically responsible for high levels of emissions rather than countries such as the Kuwait, which may have high per-capita emissions, but is responsible for only a fraction of global emissions.

Kuwait is not responsible for global warming on a large scale but it must be a part of the solution of the problem of climate change. There are several steps that could be taken by the government of Kuwait to mitigate the impacts of climate change. Some solutions for mitigating the adverse impacts of climate change in Kuwait are recommended here.

- Development of solar and wind parks for energy generation
- Development of solar powered de-salination plants
- Measures to reduce electricity and water consumption
- Development and enforcement of legally binding emission standards for vehicles
- Development and enforcement of legally binding standard for green buildings
- Research for development of innovative products with the aim to reduce footprints
- Greater emphasis on research towards development of cleaner technologies
- Better Public transportation system
- Greater emphasis on water reuse and recycling practices

Human impact on the planet has accelerated over the last hundred years, with the composition of the Earth's atmosphere being radically altered by burning fossil fuels. Understanding climate change impacts and agreeing to take steps forward are critical imperative for the future. In Kuwait, future impacts from climate change may include: changes in the coastline, a decline in the water supply that is already poor, and an increase in temperatures causing higher incidence of heat stress. It may also impair air quality, primarily through increases in ground-level ozone pollution in heavily populated urban areas. Therefore, the need of the hour is the pledge by middle-east countries including Kuwait that could help in closing the ambition gap between the actions that countries have committed to and the actions required to save the planet from catastrophic climate change impact.

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