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Biodiversity and climate change in Kuwait

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Abstract

Purpose – The purpose of this paper is to demonstrate the various consequences of climate change on the biodiversity of Kuwait. Many world organizations have established strategic plans for climate change, such as The Global Strategy for Plant Conservation, which is adopted in 2002 by the Conference of the Parties of the Convention on Biological Diversity.

Design/methodology/approach – The paper utlizes a wide range of research projects completed at the Kuwait Institute for Scientific Research (KISR), which provide information leading to the degradding effects and risks of climate change on the biodiversity and ecosystem services of Kuwait.

Findings – The biodiversity of Kuwait is under severe stress due to natural and anthropogenic factors. The region is also threatened physically and biologically by the global warming phenomena. More severe and harsh climatic conditions will cause increase in formation of sand dunes, sand encroachment, and extreme dust storms. In 2008, Kuwait has the worst ever reported summer since 1991 with increase in intensity and frequency of dust storms. Drought will cause more water demand for local consumption and irrigation. The seawater temperature increase would affect the spawning period of fish and shrimp and would cause migration of fish to other more suitable areas. This would cause severe impact on the fish industry in Kuwait and the region. Losses in plant cover will be due to sand encroachment or erratic rainfall periods causing runoff and flooding.

Research limitations/implications – The work is based on various projects at the KISR and by some journal publications that relate to climate change impact on biodivesity. More research work is needed to test the long-term impact of climate change on bidivesity of Kuwait.

Originality/value – There is a need to develop a strategic plan for climate change mitigation and adaptation in Kuwait. Specific elements of the plan would include: research for identification of vulnerable species, collecting field population data, conducting modeling research to inform conservation programs; monitoring key species; *ex situ* conservation using living collection and ensuring representation in conservation collection; *in situ* conservation and increase in protected areas; education and public awareness programs; networking; and sharing knowledge.

Keywords Plants, Deserts, Biodata, Land, Kuwait, Global warming

Paper type Research paper

Introduction

The United Nations defined biodiversity as "the variability within and among living organisms and the systems they inhabit" Convention on Biological Diversity (CBD). Biodiversity provides products; such as food, medicines, materials; and services as well as it supports the ecosystem functions that are essential for life on earth; such as fresh water, soil conservation, and climate stability (UNEP, 2001).

The rate of biodiversity loss has been reported by many scientists to be increasing at an unprecedented rate due to many human and natural factors. The CBD stressed the need of maintenance of biodiversity and the immediate and long-term changes that are required to address threats to biodiversity. Natural phenomena and climate change are among the threats that face biodiversity.

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Long-term climate change is caused by alteration in the Earth's orbit around the sun (Milankovitch Cycles) and by the collective effect of changes to the composition of the Earth's atmosphere (the greenhouse effect and global warming). Climate change constitutes three main variables; elevated carbon dioxide (CO_2), altered rainfall patterns, and temperature ranges. Results of temperature rise predicted dramatic alterations in ecosystems, seawater rise; drought in arid and semi-arid regions as well as extreme weather events, such as heat waves, wildfires, storms, and flash floods. Other implications of climate change are species losses, economic losses, and spread of disease such as malaria. Climate change will have greater effect in higher latitudes and elevations and areas that have lower diversity and higher isolation such as Mediterranean and grassland ecosystems (Sala and Chapin, 2000). Climate change may also indirectly affect species and ecosystems by altering important factors such as: water flows in rivers and wetlands; level of groundwater; the degree of dry land salinity; and the frequency of extreme climate events (floods, hail tropical cyclones, drought, and ocean acidity).

As per UN records, biodiversity is threatened by climate change and large number of species over 50 to 100 years will either need to migrate rapidly to keep up with changing conditions, to adapt locally to such changes or to face extinction. Forecasts predict that between 17 and 35 percent of species on earth will become extinct in the next 100 years. Climate change is also having impacts at ecosystem scales. It will affect all ecosystem processes but at different rates, magnitude, and directions (BGCI, 2008). By 2000, 27 percent of the world's coral reefs had been degraded in part by increased water temperatures, with the largest single cause being the climate-related coral bleaching event of 1998 (Sala and Chapin, 2000).

It is clear from the literature that climate change is happening now and has a direct effect on biodiversity. How the climate change and conditions will impact the most vulnerable species that will be affected, need to be assessed and monitored for future management actions that can help in the conservation of species. The implication of climate change on biodiversity is still in need of more analysis and interpretation studies. In other words, there is a need for accessible information on the likely impacts of climate change on biodiversity as well as to analyze the possible benefits and risks of the measures that address climate change and their effects on biodiversity and ecosystem services.

In this paper, climate change is addressed with special focus on its impact on biodiversity in the arid regions and the State of Kuwait. The factors that influence biodiversity conservation, climate change implications, and strategic thinking for long-term conservation are presented as well as recommendations for future action to mitigate biological losses.

Factors reducing biodiversity

Many anthropogenic and natural factors affect on the conservation of biodiversity. Some of these factors are outlined in Table I. These factors have been influencing biodiversity at national and global levels. The climate change through increase in atmospheric CO_2 concentration, warming, precipitation changes and alteration of the frequency, and severity of extreme events; is adding more pressure on the resources by influencing changes on ecosystems, habitats and plant, and animal species. The interaction of climate change with pre-existing threats to the biota potentially is the most serious and pressing problem.

Table I.
Impacts on biodiversity of major pressures and associated effects on ecosystem services and human well-being

Potential implications for ecosystem services and human well-being	Impacts on biodiversity	Pressures
Increased agricultural production	Decrease in natural habitat	Habitat conversion
Loss of water regulation potential	Homogenization of species composition	
Reliance on fewer species	Fragmentation of landscapes	
Decreased fisheries	Soil degradation	
Decreased coastal protection		
Loss of traditional knowledge		
Loss of traditionally available resources	Competition with and predation on native species	Invasive alien species
Loss of potentially useful species	Changes in ecosystem function	
Losses in food production	Extinctions	
Increased costs for agriculture, forestry, fisheries, water management, and human health	Homogenization	
Disruption of water transport	Genetic contamination	
Decreased availabilitv of resources	Extinctions and decreased populations	Overexploitation
Decreased income earning potential	Alien species introduced after resource depletion	
Increased environmental risk (decreased resilience)		
Spread of diseases from animals to people	Homogenization and changes in ecosystem functioning	
Changes in resource availability	Extinctions	Climate change
Spread of diseases to new ranges	Expansion or contraction of species ranges	
Changes in the characteristics of protected areas		
Changes in resilience of ecosystems	Changes in species compositions and interactions	
Decreased resilience of service	Higher mortality rates	Pollution
Decrease in productivity of service	Nutrient loading	
Loss of coastal protection, with the degradation of reefs and mangroves	Acidification	
Eutrophication, anoxic water bodies leading to loss of fisheries		

Source: UNEP (2007)

Implications of climate change to biodiversity

The concentration of CO_2 in the atmosphere has increased from its pre-industrial level of 280 to 379 ppm CO_2 equivalent Intergovernmental Panel on Climate Change (IPCC, 2002). At the same time, the climate in most parts of the world are warming. Global temperatures have increased by 0.79°C on pre-industrial levels (Natura 2000, 2007). The IPCC report predicts and estimated increase in global temperatures of between 2.5 and 4.8°C on pre-industrial levels by the year 2100. Such changes in physical system have an impact on natural systems (e.g. timing in seasons, flora, and fauna). The implications of climate change on biodiversity is at species and ecosystem levels.

Flooding, sea level rise, and changes in temperature will impact ecosystem boundaries causing some ecosystems to expand while others will become smaller. Habitats will change as rainfall and temperatures change and some species will not be able to keep up leading to a sharp increase in extinction rates (Reid and Swiderska, 2008).

Some implications of climate change on biodiversity shown in Table I are listed as follows (UNEP, 2007): species extinctions; expansion or contraction of species ranges (migration); changes in species compositions and interactions (adaptation); changes in resource availability; spread of diseases to new ranges; changes in the characteristics of protected areas; and changes in resilience of ecosystems.

Climate change affects biodiversity in both terrestrial and marine ecosystems. Species in both ecosystems are vulnerable to climate changes they often die out in their present areas and colonize new areas. It is expected thus that as the climate changes in the future, there will be disruption of natural communities and extinction of populations and species (Chambers, 2002). High-diversity ecosystems, for example Melanesia Islands, which has most of the diversity terrestrial ecosystems on the plant and over half of the world's species of coral can be found, have been vulnerable to degradation and habitat losses. The climate change in Melanesia was evident in coral bleaching due to increase in temperature; rising sea level (predicted to rise 1-1.5 m by 2100; and ocean acidification due to absorption of CO_2 predicted to reach levels of acidity by 2100. Acidity of ocean waters reduces the availability of calcium carbonate required by organisms such as corals, sea urchins, calms, and zooplankton. Acidification also interferes with respiratory processes in fishes, and may impact their food supply. Scientific projection show that calcium carbonate levels in the world's equatorial regions will become marginal for corals and phytoplankton by 2070, which will cause major disruption to marine food webs (Museum, 2008).

Human actions to address the impacts of climate change can sometime be both beneficial and harmful to biodiversity. For example, some carbon sequestration programs, designed to mitigate impacts of greenhouse gases, can lead to adverse impacts on biodiversity through the establishment of monoculture forestry on areas of otherwise high-biodiversity value (Reid and Swiderska, 2008). Avoiding deforestation, primarily through forest conservation projects, is an adaptation strategy that may be beneficial, with multiple benefits for climate change mitigation, forest biodiversity conservation, reducing desertification, and enhancing livelihoods. It must be recognized that some "leakage" in the form of emissions resulting from those conservation efforts can occur. Climate change will also affect current biodiversity conservation strategies. For example, shifts from one climate zone to another could occur in about half of the world's protected areas, with the effects more pronounced in those at higher latitudes and altitudes. Some protected area boundaries will need to be flexible, if they are to continue to achieve their conservation goals. An important consequence of restoring biodiversity would be the sequestration of atmospheric CO_2 in terrestrial and marine (coral) ecosystems.

Consequences of climate change to biodiversity in the arid regions

Dryland ecosystems cover a variety of terrestrial biomes (i.e. arid steppe, grassland, tropical and subtropical savannahs, dry forest ecosystems, and coastal areas), which are extremely heterogeneous (Bonkoungou, 2001). The biodiversity of arid regions is not well documented and the number of named species in dry lands and those under extinction are not known. Nevertheless, biodiversity in aridlands represents a vital biological capital. They provide *in situ* genetic storehouses for major agricultural crop plants that are key for long-term food security for most people in the world. Its components include raw materials, the wild progenitors of the most important agricultural crops and the active ingredients for the pharmaceutical and cosmetic industries.

The driving force in biodiversification in drylands is: water, soil nutrients, drought, salinity, herbivore, pressure, and fires. Species in aridlands have adapted themselves to drought and rainfall seasonal fluctuation patterns. Some organisms are able to develop rapidly and complete their life cycle in a very short period of time. Some plant species, for example, develop large-below ground tissues to store water and nutrient or corky bark to insulate living cells from desiccation and fire burning. Another driving force is human population that develops complex pastoral and cropping system. The importance of this biological capital deserves better recognition by the international community, as aridlands biodiversity is under increased threat from the combined effects of anthropogenic and climatic factors.

Environmental characteristics of aridlands include low and unpredictable rainfall, low-relative humidity, high-summer temperatures, strong desiccating winds, frequent dust storms, and mobile sand encroachment. Desertification is a major problem in aridlands. It is also related to climate in many ways. Degradation of vegetation cover decreases carbon sequestration capacity of drylands thus increasing emissions of CO_2 into the atmosphere. But carbon storage capacity of drylands is poorly documented and most of the biomass of trees is higher below ground. Land degradation and loss of vegetative cover in the aridlands increase suspended dust in the atmosphere. Recent studies have provided first substantiated evidence that atmospheric dust can affect both regional and global climates. Climate change affects drylands biodiversity by influencing species distribution range, water supplies, heat extremes, the humidity, and temperature of soils and thus the albedo (Bonkoungou, 2001).

The effect of desert environmental constraints on plants in the aridlands has been well documented. However, the links of these constraints to climate change has been poorly studied. Prediction models of climate change on biodiversity on short-term (500 years) and long-term basis ($>$100,000 years) received little attention from scientists in the aridlands. Some recent research shows that an increase in temperature by 3°C will increase the evapotranspiration rate due to warmer conditions, which would result in a drier soil. Warming would lead to a decrease in plant productivity of both above-ground plant parts and roots in grassland communities (de Boeck *et al.*, 2007). Community compositions are expected to shift with changes in climatic variables in desert areas such as Sonoran desert, where there have been increases in woody shrubs due to regional climatic changes (Chambers, 2002). Climate change is influencing the "phenology" (climate-related natural timing of events such as migration or breeding), reproductive success, changes in abundance, range size and range position shift of plant and animal species (Natura2000, 2007). Changes in the climate most clearly affects, the distribution of species that are highly mobile such as birds and butterflies. Period of bird migration, abundance, and composition are among the variables that are expected to be influenced by climate change in the aridlands.

Many of the countries that will be at risks from climate change lie in the arid regions (such as drought-prone and sub-Saharan Africa). The people in these areas depend heavily on climate-sensitive sectors and natural resources. These include agriculture, fishing, water provision, grazing, timber, and non-timber forest products such as food, medicine, tools, fuel, fodder, and construction material (Reid and Swiderska, 2008). The dependence on these resources means the impact of climate and their environmental changes on biodiversity and ecosystem services poses a real threat to the livelihoods food security and health of the poor. Bonkoungou (2001) stated that simulation models predict that:

> [. . .] dryland biomes such as savannahs, grasslands and Mediterranean ecosystems will be among the biomes experiencing the largest biodiversity change, and will be affected significantly by the combination of land use change and climate change.

Short-term climate change impact on biodiversity in Kuwait

Kuwait is an aridland with a total surface area of 17,818 square kilometers. Rainfall varies annually and seasonally with an average of 114 millimeter (1958-2008) (Figure 1). Dusty days in Kuwait are the highest in the region compared to other Gulf countries (Figure 2). It prevails mainly during summer. Numerous studies in Kuwait have been

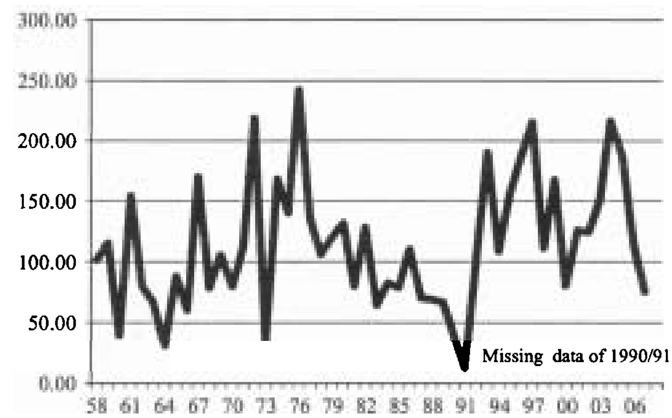
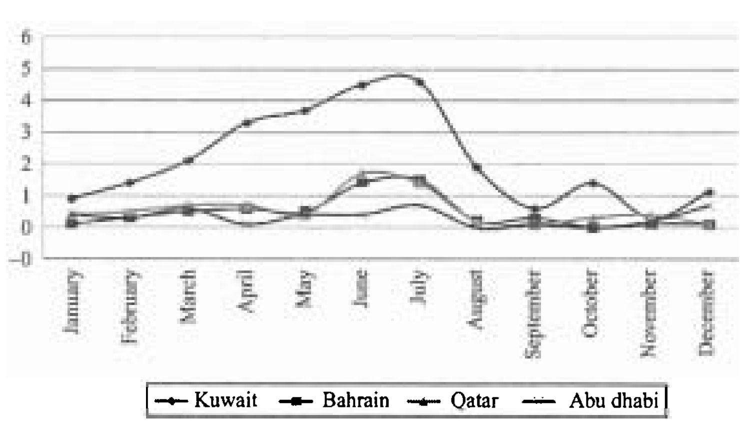


Figure 1. Annual precipitation of Kuwait in 50 years (1958-2008)



Source: Kuwalib (1990)

Figure 2. Average number of dusty days in the Arabian Gulf

carried out dealing with vegetation dynamics and soil. Vegetation dynamic shows correlation to seasonal precipitation (Omar, 1991) and drought has shown a direct influence on plant cover, composition and abundance (Omar, 1991). The rangelands in Kuwait have been subjected to severe pressure from anthropogenic factors such as overgrazing, off-road use of vehicles, desert camping, and expansion in urban areas. The invasion of Kuwait in 1990 and the subsequent wars caused more pressure on the desert ecosystem and resulted in further degradation of the groundcover and losses in flora and fauna. The primary plant communities have been altered due to these pressures and the vegetation map of Kuwait showed a significant difference in their distribution from 1974 to 2000 (Omar *et al.*, 2001). Some studies show severe losses in plant community types particularly the *Rhanterium epapposum* (Arfaj) (Omar and Bhat, 2008). Among the factors that are responsible for the alteration in this community are: overgrazing; off-road traffic, spring camping and recreation, Gulf war effect on native vegetation and gravel quarrying (Omar and Bhat, 2008).

Climate change impacts on biodiversity have not been fully studied in the region nor in Kuwait. Some provisional changes that may occur are presented in this paper based on previous related research studies and the author's experience in the field. These are shown as follows.

Impact on vegetation and soil

Perennial shrubs constitute about 27 percent of Kuwait surface area while perennial grass and sedge constitute 67.9 percent. The current status of vegetation show intensive land degradation (Omar *et al.*, 2001). Impact of drought on natural vegetation was discussed in (Omar, 1991). The study showed the impact of drought period from 1979 to 1989 on vegetation dynamics after protection from grazing. During extreme low-rainfall periods such as 1983/1984 and 1988/1989, with rainfall in seasons less than 40 millimeter (Figure 3), shrubs dominated the study areas and annuals were significantly less in species composition. However, some species increased during drought while others decreased. This shows the ability of some annual plants to tolerate drought. However, it is clear that if

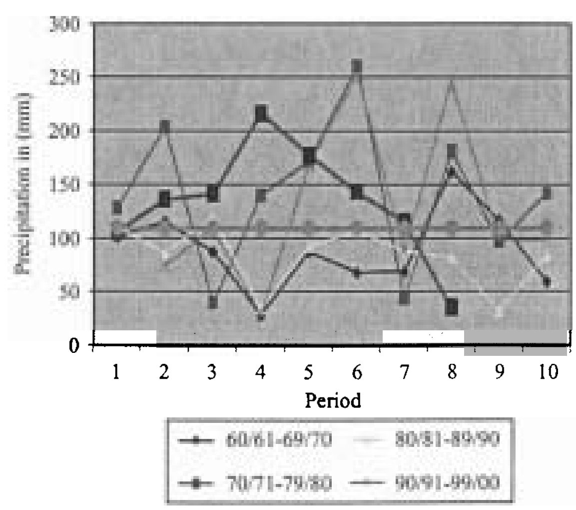


Figure 3.
Seasonal precipitation in four decades for the State of Kuwait

drought prevails in the region and for a long time, due to climate change or natural phenomena, it is expected that the plant cover will be severely affected in time. Annuals and shrubby plants are important for sequestering CO_2 "greenhouse gas" and play important role in the hydrological and nutrient cycles. If they disappear during drought the soil surface will be vulnerable to wind erosion and sand encroachment. It is provisioned that mobile sand will increase with the increase in temperature and drought. Vegetation stabilizes and protects the soil surface from wind erosion and recycles nutrients. Protecting plant cover from anthropogenic factors will improve soil condition and reduce erosion however, when drought prevails the vegetation will deteriorate regardless of the extent of protection (Omar, 1991).

The season of 2007/2008 showed lowest rainfall records averaging less than 40 millimeter. The number of dusty days was extreme in comparison to the past 17 years data (Figure 4). This is an important observation that needs to be studied and its link to the climate change needs to be assessed. Annual species under low rainfall, high temperature and wind erosion will find unfavorable conditions to germinate and grow. Plant succession will regress to lower productivity lands with complete barren soil.

Primary plant communities such as *R. epapposum* (Arfaj), *Cyperus conglomerates* (Thandah), *Haloxylon salicornicum* (Al Rimth) and *Zygophyllum qatarense* (Harm) showed recent alteration in distribution in comparison to the vegetation map of 1974. The comparison showed that some plant communities retreated in distribution whereas others expanded (Figures 5 and 6). For example, *C. conglomeratus* (Thandah) community in the 1974 vegetation map covered 10.1 percent of the total area compared to 26.9 percent in the 2000 map indicating its potential to expand in time (Omar *et al.*, 2001). This map unit extended over areas that were previously dominated by *R. epapposum* (Arfaj), *H. salicornicum* (Al Rimth) and *Z. qatarense* (Harm) communities by 9.9, 7.8 and 1.0 percent of areas, respectively, 7.8 percent of the area remained unchanged. On the other hand, the percentage distribution of the *R. epapposum* (Arfaj) community was considerably altered from 30.6 percent in the previous vegetation

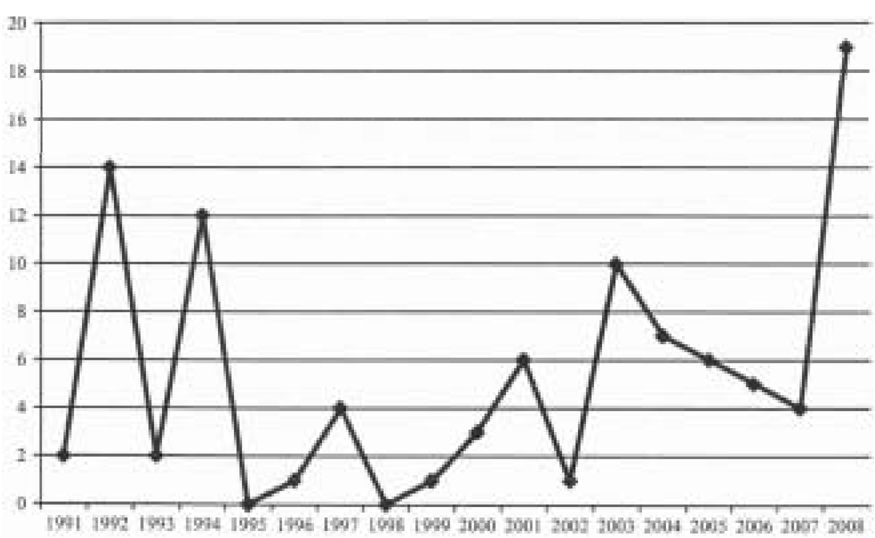


Figure 4.
Number of dusty days in Kuwait (1991-2009) international airport data