

RESPONSE TO CLIMATE CHANGE IN THE KINGDOM OF SAUDI ARABIA

*A report prepared for FAO-RNE by
El Mostafa Darfaoui¹ and Abdu Al Assiri²*

1. FAO Senior Natural Resources Expert – 2. Director General of the Department of Natural Resources, MOA. KSA

INTRODUCTION

The Kingdom of Saudi Arabia (KSA) is a country of 200 million square kilometers representing about 80% of the Arabian Peninsula. It has 2410 kilometers of sea coasts, of which 1760 kilometers stretch along the Red Sea and 650 kilometers represent the eastern coast of the Arabian Gulf. Forest lands in Saudi Arabia cover 2.7 million hectares and rangelands extend over 171 million hectares. KSA also includes 35 sq. km of mangroves and 1480 sq. km of coral reefs. The country has an estimated population of 25,37 million inhabitants (MEP, 2009) and is a major oil and gas producer with a GDP/capita (total population) of SR 54,595.

Saudi Arabia has a semiarid, to hyper arid climate, characterized by very low rainfall (annual average of 70.5 mm) and extremely high evapotranspiration, resulting in water scarcity and reduced vegetal cover. Only 2% of the country's land area is considered arable, with the chief agricultural crops including dates and fruit.

The CO₂ emissions for the base year 1990 estimated in the first national communication (FNC) to the UNFCCC (2005) totaled 140,958 Gg and CO₂ sinks were 15,240 Gg. The energy sector contributed 90% of the total CO₂ emissions, followed by the industrial sector (8%) and agriculture (2%).

In terms of climate trends in KSA with regard to the scenarios adopted in the NFC (PME, 2005), there is a general warming all over KSA which varies from a minimum of 0.15°C to a maximum of 0.75°C, with an average of 0.40°C. The pattern exhibits a clear systematic distribution with stronger warming tendencies over the interior part of the country and an area of weaker warming along the western and eastern coasts. As for precipitation trends, there are vast areas of rainfall deficits covering all northern parts of the Kingdom (as low as -40%) and the eastern slopes of the Asir mountains (-14% in Abha).

Results obtained from running GCM models showed that an expected average warming in the Kingdom for the year 2041 to be higher than the global average, and it is expected to be highest (2.2-2.70C) during the summer in the north western region. The lowest warming (0.2-0.40C) is expected in the south and the southwest.

Annual total rainfall for the year 2041 from the model IAP_97 shows an increase in moisture ranging between 20 and 30% in the southwestern part of the country (Sarawat

Mountains) and a decrease (7-18%) in the rest of the country except for the Makkah and Madianah regions where the decrease is not expected to be more than 1%.

Based on a 1% increase in coastal development per year, and considering the projected sea level rise estimated by the IPCC scenarios areas ranging between 401 and 1726 hectares and between 1087 and 4674 hectares of sandy beaches are expected to be lost by the year 2100 along the Arabian Gulf and the red sea, respectively.

Saudi Arabia is particularly vulnerable to climate change as most of its ecosystems are sensitive, its renewable water resources are limited and its economy remains highly dependent on fossil fuel exports, while significant demographic pressures (2.3% increase), continue to affect the government's ability to provide for the needs of its population. The KSA Government is engaging in various mitigation and adaptation measures to cope with adverse impacts of climate change as well as with response measures especially by the Annex 1 parties of the UNFCCC, which are expected to have diverse economic and social impacts on the country. However, a great deal remains to be done to contribute in the mitigation programmes in order to face this global and national challenge.

I. Awareness on climate change

In a survey conducted in 2008 in 128 countries by the Gallup Poll, 49% of the surveyed individuals in Saudi Arabia were aware of climate change and 40% perceived it as a threat to their country, while 39% believed that it was caused by human activities (Gallup, 2009).

In a more recent pan-Arab survey conducted by the Arab Forum for Environment and Development (Saad, 2009) a majority of 98% surveyed individuals in the KSA believed that climate is changing, and 81% thought that climate change is a serious problem for the country, whereas 92% thought climate is changing due to human activities, including excessive use of energy and depletion of resources. 36% of respondents thought that the Saudi Government was not acting sufficiently to address the problem, while 44% thought the opposite, and a proportion of 20% of the sample did not have an opinion on this question. Asked to choose sectors where climate change will have major impact in their countries, it stood out that not a single respondent said there will be no effect at all. The majority, in the KSA and at the regional level, gave priority to health, drinking water and food, followed by safeguarding coastal areas. Those surveyed were also asked to choose the three most important measures necessary to mitigate the causes and adapt to the effects of climate change. Changing consumption patterns, mainly reducing the use of energy, was the main measure chosen, followed by education and awareness. Ratifying and implementing international treaties came third.

Although no data were found on the level of awareness on climate change within the farmers in the KSA, the majority felt that the climate in the country is changing and that the trend is toward less moisture with an increase of drought severity and frequency.

Many farmers also recognized extreme events such as floods as a another indicator of climate change. During the 2010 season date producers noticed unusual early blooming of palm trees as further evidence of a change in the climate (Oihabi, 2010).

Concerned ministerial departments and institutions in the KSA are increasingly aware of the negative impact of climate change on the country's natural, economic and social environments and of the threat it constitutes to the country's water and food securities. The KSA Government is also very concerned about climate change as the efforts of mitigation adopted, especially by Annex I countries, are expected to have negative impact on the country's main resource, which is fossil fuel. This concern is expressed by the ratification of the UNFCCC and the Kyoto protocol and active participation of Saudi Government in all UNFCCC negotiations. The Saudi Government also took several initiatives, including allocating important financial support for environmental research and conservation projects and activities, counting climate change mitigation and adaptation.

II. National vision and policy strategies

The KSA Government ratified the UNFCCC in 1994. In 2005 the Country ratified the Kyoto Protocol and joined the Carbon Sequestration and Leadership Forum (CSLF). Since then the KSA has been participating actively in all UNFCCC's COPs and related protocols and bodies' activities and negotiations. During these recent years the Saudi Government took several carbone capture and storage (CCS) initiatives and hosted a number of CC and Clean Development Mechanism (CDM) workshops and meetings. The Government submitted its first national communication in 2005 and is currently in the process of preparing its second national communication (SNC), expected to be delivered by December 2010.

The impact of climate change is expected to affect all aspects of life in the KSA, including water resources, health, food and agricultural production, fisheries, biodiversity, forest and rangelands, etc. The measures taken by the Government and by many constituents of the Saudi society, including the private sector, science and technology institutions and to a lesser extent the civil society are many. Although more emphasis is placed on energy, water and agriculture, other sectors of concern are also considered.

Water resources

The KSA is a country under severe water scarcity (98 m³/inhabitant per year). Total water withdrawal in the KSA in 2006 was near 23.7 BCM, of which 98% is ground water of which 57% is non-renewable. Agriculture consumes approximately 88% of the total water withdrawals (FAO, 2008). (As a consequence of global warming the Kingdom's renewable water resources (both surface and underground), are expected to decrease significantly. The total water stress (decrease in groundwater recharge and surface runoff, the increase in irrigation requirements and domestic and industrial demands) at

1°C and 5°C increases in mean temperatures is expected to range between 1520 to 4,947 MCM, respectively (PME, 2005).

The KSA Government has taken various measures to ensure the sustainability of water resources, including assessments of water resources availability, construction of 302 dams with a total capacity of 1,354 million cubic meters, (MOA, 2009), building 30 desalination plants to supply about 50% of the domestic water supplies in the Kingdom, drafting of water conservation regulations, promotion of wastewater collection, treatment and re-use, and designing and eventual implementation of water saving policies in agriculture.. The major goals assigned to the KSA's 9th development plan (2010-2015) in terms of water policy are the following (MWE, 2010):

- Preserving non-renewable aquifers in sensitive areas through limiting their use to drinking, while prohibiting their use for agriculture purposes,
- Constructing more dams (74) to raise the total storage capacity in the country to 1349 MCB,
- promoting collection and reuse of wastewater (56 treatment plants in service in 2007, expected to attain 70 in the end of 2010),
- Reinforce water conservation measures in agriculture.

Agriculture

The agriculture sector is known to be most vulnerable to climate change but also to participate in GHE by producing methane and NO₂, through livestock rumination, decomposition of manure and biomass burning, but can have a major role in mitigation by storing Carbon in the soil, and vegetation cover. Climate change is expected to impact heavily on agriculture and food production in the KSA, especially through reducing water availability, but also through direct effects on crop yields. The KSA is seeking to achieve food security by implementing its newly prepared water and environment friendly Agriculture Strategy (2010-2030) and meeting the food deficit from the global market, while reducing market risks through building strategic reserves and developing social security network programmes for low income inhabitants (MOA, 2010). The Agriculture Strategy (AS) also includes promoting Saudi agricultural investments in collaboration with countries with a high agricultural potential. This policy primarily aims at producing food, but also aims at saving 8.5 billion cubic meters of irrigation water by 2030. The key targets are to:

- Reduce hectareage under wheat by 94% from 523,000 ha in 2004 to 33,700 ha in 2030.
- Stop alfalfa and other high water consuming fodder crop productions except where they utilize treated waste water. Also promote the development of feed industries using agricultural waste products,

- Improve irrigation efficiency from 45% in 2010 to 65% in 2030, by improving agricultural and irrigation practices and using new irrigation water saving technologies and low water requirement crops,
- Double fish production and raise individual share to 18.5 kg in 2030 in addition to improving quality to reach international standards, ,
- Increase fishing areas in the international waters, promote investment in aquaculture and use genetic engineering to improve fish resources.
- Control costs erosion by increasing protected coral reefs and mangrove areas.

The AS includes developing a national agricultural meteorology network and early warning system to improve water management and to predict droughts, pests and extreme events. It also aims at strengthening research, extension, capacity building, rural development and infrastructure and at developing regulations, technology transfer, information and marketing systems and strengthening public, professional and civil society institutions.

Forests, rangelands, biodiversity and desertification

Both forest and rangelands are facing serious challenges in the KSA, as a result of severe natural conditions (dry climate, poor soil) and human activities , (excess utilization of fuel wood, overgrazing, expansion of uncontrolled urbanization and intensive recreation). Natural ecosystems identified as being at risk in relation to climate change in Saudi Arabia include mountain forests and woodlands, wadis, rawdas, wetlands, coastal areas, etc. Anticipated negative impact of climate change on range and forest lands over the next 50-100 years in Saudi Arabia include: increase in the frequency and changes in the patterns of natural disturbances, such as drought, sand storms, fire, floods, leading to increased die- back and die-off in forests and woodlands, spread of diseases, change in species composition and richness, drop in productivity a decrease in biodiversity.

Coral Reefs represent the most significant habitat found along the Saudi shores (both Red Sea and Arabian Gulf). These reefs as well as the mangrove forests form important habitats and provide shelter and food for a wide array of marine life. These resources are likely to be negatively impacted by global warming and by sea-level rise especially through acceleration of coastal erosion as well as inundation and coral reef bleaching. Large scale changes in species composition and zoning in mangrove forests are expected due to changes in sedimentation and organic accumulation. Future studies are needed to investigate the impact of climate change on coral reefs and mangrove ecosystems, biodiversity and health.

As natural forest and rangelands fodder and meat production will drop sharply as the climate becomes drier, the economic and social sustainability in rural areas will be severely stressed and rural exodus is expected to increase dramatically. Furthermore,

the desertification phenomenon is expected to gain in severity in affected area. To face this situation the KSA adopted in 2005 a National Forest Strategy and Action Plan , National Action Programme to combat desertification and to mitigate the effect of drought in the framework of the UNCCD, It is also currently preparing a range, livestock and feed strategies . In terms of forest and rangeland ecosystems rehabilitation, much has been done since 2006. The Ministry of Agriculture has been implementing a Juniper ecosystem rehabilitation project aimed at combating juniper die back as well as executing afforestation projects in Al Gonfoda, Wadi Dawassir, Najrane, Al Hasa and other areas for sand stabilization and as CC mitigation. Several mangrove rehabilitation projects have also been implemented by the MOA, Saudi Commission for Wildlife, PME, and the private sector (ARAMCO). The KSA is also implementing limited range rehabilitation and management activities hindered by the common land tenure. The MOA also established a range research center in Al Jouf where studies and research activities are conducted and where approximately 30 metric tons of about 40 range plant species' seeds are produced annually in addition to useful shrub seedlings. Efforts to develop new techniques and improved plant material in this center will certainly contribute to mitigating and adapting to climate change impacts in the KSA and in the region as a whole.

To protect biodiversity and endangered plants and wildlife, the SCW conducted assessment surveys of the status of the flora and fauna and compiled management plans to ensure their sustainable survival. The SCW also established 15 protected areas covering about 5% of the land area and conserving about 43% of the country's flora and established National Wildlife Research Centers in Taif and Thumamah. The PME also established a regional drought monitoring and early warning centre. ,

Unfortunately, the involvement of conservation organizations within civil society remains insignificant and the coordination among stakeholders leaves much to be desired, which is having strong negative impact on the outcome. Adopting a participative approach involving the private sector, professional organizations and the civil society at large, and allocating more funds to foster their activities, in addition to building capacity, are all essential prerequisites to boost land sustainable management, which is necessary to insure efficient, adaptation to climate change, desertification control and conservation of biodiversity in the country.

Impacts of Annex 1 Response Measures on Saudi Arabian Economy

Saudi Arabia remains highly dependent on fossil fuel exports. Actions by Annex I countries to reduce greenhouse gas emissions are expected to have adverse impacts on the country's revenues. The Intergovernmental Panel on Climate Change (IPCC) in its Third Assessment Report projected lower oil demand and revenues for developing countries that are highly dependent on the export of fossil fuels. Saudi Arabia and other oil exporters have been negotiating for effective use of flexibility mechanisms, e.g. emissions trading and certain emission credits and large CDM projects, and the inclusion

as a means by which developed countries can offset their emissions instead of targeting oil substitution. Until now the Subsidiary Body for Scientific and Technological Advances is not seriously considering this proposal due to concerns about “the long-term liability for the storage site, including liability for any seepage”. Economic diversification is considered the main adaptive key to offset climate change impact and spillover effects of Annex I countries mitigation measures. Saudi Arabia has taken steps towards diversifying its economy by opening its market, allowing foreign investments, privatization of certain industries; and becoming a member of the World Trade Organization. However, the KSA considers that significant assistance to its economy by developed countries is essential for achieving the necessary diversification, especially through investments and technology transfer.

III. Institutional arrangements

The focal point of the UNFCCC in the KSA is based at the Ministry of Petroleum and Mineral Resources (MPMR). This choice is justified due to the importance of petroleum in the country's economy and as a source of GHE and in view of the expected severe impact of climate change mitigation measures on fossil fuel markets, and consequently on the country's revenue.

In 2009, the KSA funded the National Committee for the Clean Development Mechanism, which is the Designated National Authority (DNA) for CDM in the KSA. The National Committee is chaired by a representative of the MPMR and includes members from twelve relevant Ministries and entities (Appendix 1). The National Committee is supported by a Secretariat based at the Ministry of Petroleum and Mineral Resources and which reports to the Chairmen of the Committee.

Considering its duties and competency, the General Presidency of Meteorology and Environmental Protection (PME) is also a Government Agency dealing with climate change. The PME coordinates certain activities related to climate change, especially the reporting processes to the UNFCCC and Kyoto Protocol.

The PME is also chairing the Environment Council created in 2009 by a Royal Decree to replace the Ministerial Committee for the Environment, which assured the coordination at the national level of environmental activities. The Environmental Council is composed of 11 ministries in addition to the King Saud City for Science and Technology, SWC and the Saudi Commission for Tourism and Antiquities. The Environment Council functions consist on proposing environmental policies, strategies and regulations and performing the assessment and coordination of the Government and private sector activities aimed at environmental protection. Climate change mitigation and adaptation are among the subjects of concern of this new Council.

A Center of Excellence for Climate Change Research (CECCR) was launched in 2009 within the King Abdelaziz University in Jeddah (KAU), with the mission of studying

climate change and its possible impacts on the society and providing consultations for the decision makers in the Kingdom of Saudi Arabia. The CECCR was established at the Department of Meteorology, Environment & Arid Land Agriculture of KAU to keep up with the accelerated pace of scientific developments in the field of climate change and climate modeling. It is also aimed at nurturing a group of capable researchers to face the future challenges imposed by the increasing aridity of the climate in the KSA and the region as a whole.

The Ministry of Agriculture is among the government institutions involved in policy making and design and implementation of activities related directly or indirectly to climate change, especially in relation to its impact on water resources, and crop production and protection. The Ministry of Water and Electricity is also involved by dealing with the incorporation of the CC dimension in its planning and actions related to water. Among the other institutions involved are the Ministry of Health, which organizes meetings, workshops and awareness raising actions on the impact of CC on nutrition, human well being and diseases; the Ministry of Education; the SCW and the Prince Sultan Research Centre for the Environment, Water and Desert are all and to various degrees involved with CC mitigation and adaptation research and development actions.

Many other universities and research centers in the country are tackling climate change issues, however, a great deal is still to be accomplished to provide the Country with the means and appropriate measures to deal properly with CC mitigation and adaptation at the national and global levels. The private sector is also involved in climate change mitigation and adaptation, but mainly in the energy and petrochemical industries. The involvement of civil society is still lagging behind. The main associations involved are the Saudi Environment Association, the National Biology Society and the Agricultural Sciences Association. Other institutions with large budgets and strong capacity can make substantial and quality inputs with more involvement in CC research such as the KACST and all universities and research centers, including agricultural centers. Several UN and international, regional and sub-regional agencies and organizations (UNEP, FAO, UNDP, WB, UNDESA, IMF, GEF, ESCWA, CDM, GTZ, LAS, ACSAD, AOAD, GCC, PERSGA, ROPME etc..) contribute and support the KSA in its efforts to mitigate and adapt to climate change.

Although some coordination among several stakeholders involved in CC occurs within the framework of the National Committee for the Clean Development Mechanism, which counts among its members the national focal points of the UNCCD and CBD, however, better coordination among all parties involved in CC matters is required to create synergies and design and implement integrated and sizeable programs.

IV. Technical knowledge

Various activities, directly or indirectly related to climate change mitigation and adaptation, are undertaken by the KSA government agencies and the private sector, in

collaboration with developed countries and sub-regional, regional and international agencies and organizations. Such activities are focused on the country's main concerns, specifically the energy sector and water resources. Nevertheless, various activities are also undertaken in fields related to food security, such as agriculture, forests and rangelands, fisheries and aquaculture, animal production and health, plant production and protection, rural development, etc...

Mitigation activities in the energy sector

A number of studies and mitigation projects have been implemented or are under implementation in KSA in the petroleum and energy sector. As mentioned earlier the KSA government and the private sector are actively engaging at a global level on many issues regarding CCS activities based on new advanced technologies as means of reducing GHGE instead of reducing the use of fossil fuels. The KSA is making efforts to reduce emissions by upgrading refineries to produce cleaner fuels. The kingdom is also supporting moves to reduce climate change by developing and exporting solar energy starting from the year 2020 (Heba Hashem, 2010). In collaboration with KACST and International Companies (IBM), the KSA launched a research programme on solar-powered water desalination based on using advanced material membranes. The targeted solar concentrator system will capture energy equivalent to 1,500 suns, according to IBM, powering a plant that will produce 30,000 cubic meters of fresh water per day for a city of 100,000 people (IBM, 2010).

The KSA is also in the process of initiating a project consisting of injecting a total of 40 million standard cubic feet per day (cfd) of CO₂ into the world's biggest Ghawar. The project, fully financed by ARAMCO, is to be implemented by 2012. The project technology is developed in collaboration with partners from developed countries and international companies and organizations.

Only one CDM project is in the pipeline in the KSA up to the end of 2010, and it entails the Madinah Landfill Gas Capture Project implemented with the technical assistance of the Swiss company Vitol. A daily input of 900 tons of municipal waste is deposited on the new landfill. Closure is expected in 2025. The project aims at promoting good waste management practices, contributing to technology transfer and reducing the emissions of greenhouse gases.

Irrigation water and agriculture

The MWE, in collaboration with several international agencies, such as the International Monetary Fund, is preparing a National Water Strategy. The MWE is also currently in the process of updating the assessment of underground water status in collaboration with King Faysal University, Abdullah Abo Nayan and BRGm companies and the GTZ. In cooperating with the UNDP, MWE is also in the process of conducting a study on water consumption in the different sectors in the KSA, especially in agriculture.

Modern irrigation (localized and sprinkler irrigation), covers about 66% of the total irrigated area in KSA, while the remaining proportion (34%) is under surface irrigation. The MOA adopted a programme to encourage farmers to modernize their irrigation systems and to promote the use of treated wastewater in the irrigation of authorized crops and greenhouses, but also to adopt measures related to good agricultural practices, such as farm management, choice of low water demanding crops, IPM, organic agriculture, etc... A large technical cooperation programme (UTF) between the MOA and FAO includes several projects and activities related to improving irrigation efficiency, plant and animal production and protection, fisheries, forestry and range management. All these projects contribute directly or indirectly towards adaptation to the effects climate change.

Furthermore, in 2006, and in collaboration with FAO, the Ministry of Agriculture implemented a successful Juniper ecosystem rehabilitation project based on runoff water harvesting, removal of dead trees and branches and planting local juniper saplings in an effort aiming to combat the juniper die back in the Sarawat Mountains. The project has been sustained in Assir area, where about 10.000 juniper trees have been planted. With the technical assistance of FAO, the KSA developed also good technology in range seed and seedlings production. The seed is used to produce highly drought resistant fodder on private farms and rangelands. However, their use at large scale is facing land tenure difficulties and lack of livestock producers' awareness and participation.

Several projects are also implemented to survey and assess mangrove and coral reef resources and to assure their protection and rehabilitation. A number of projects and activities are also undertaken by the KSA government agencies and the private sector to protect fisheries and develop and diversify aquaculture.

No survey data on the level of technical knowledge on CC issues among technicians in the different sectors, especially those related to food production and security, is available. Although the level of awareness of the climate change at the local as well as the national level is relatively high, the technical know-how related to the adaptation measures, seems very low among all government agencies and the private sector 's staff as well as the farmers, fishermen, and herders. Great efforts need to be made to strengthen the capacity of all stakeholders to increase awareness about the options available and the ways of incorporating CC adaptive measures in their programmes, projects and activities.

V. Funding opportunities

The total budget allocated for the ninth development plan (2010-2014) of the Kingdom amounts 1444 billion SR (385 billion US\$), of which 26.5 is allocated to the Ministry of Agriculture (6.6%). Climate change mitigation and adaptive activities are not included in the institutions' budgets as such, but are funded as separate development projects and activities.

In 2007 King Abdullah announced that a US\$300 million fund will be invested in the KSA to support cleaner and more efficient petroleum technologies for the protection of the local, regional and global environment, and to promote the development of technologies such as carbon capture and storage (CCS). It will also promote the transfer of environmentally friendly technologies from advanced countries to the KSA and some OPEC member countries, as well as other developing nations.

The private sector in the KSA, such as ARAMCO, the country's giant energy company, invests significant funds to upgrade some of its factories to reduce GHGE and to promote CCS activities. Public agencies and private companies in the water and agricultural sectors also invest important resources in water resource assessment, development and management. The country also encourages the development of in-farm water-saving irrigation systems and practices. Other institutions such as the PME and the CECCR invest in the establishment and management of early warning systems and climate modeling.

Up to now the CDM is not much promoted in all the Gulf Cooperation Council Countries (GCC) for four main reasons: (i) CDM's complexity, (ii) low awareness of the mechanism within the region, (iii) its potential impact on institutional policy and legal frameworks and, (iv) relatively low rate of CDM projects (Kilani 2006).

The KSA is considered a rich country, and therefore is not eligible to many financial support opportunities made available for developing countries by UN and other international, regional and sub regional agencies and funding institutions. However, almost no efforts are made to benefit the country from the available opportunities such as the CDM, the various carbon funds managed by the World Bank or mechanisms, such as the Reducing Emissions from Deforestation and Forest Degradation (REDD) and REDD+.

At a global scale and as a response to the challenge of national food security which is expected to worsen with climate change, King Abdullah bin Abdulaziz proclaimed a "food security initiative," in 2009, backed by an investment fund of 3 billion Saudi Riyals (about \$800 million), to support investment by private sector Saudi companies in agricultural projects abroad (Lippman, 2010). In February 2009, the Hail Agricultural Development Company, a private company, signed a lease with the government of Sudan for large areas of land for wheat, vegetables, and animal feed production. Saudi officials also held talks with the Tanzanian government for a 500,000-hectare lease arrangement. But political concerns were quick to emerge, suggesting that Saudi Arabia and other emerging countries were embarking on a neocolonial investment strategy (Sven Behrendt , 2009). In response, the Saudi government has become more engaged in the broader discourse regarding food security. In 2008, Saudi Arabia donated more than \$500 million to the World Food Programme, to help the least developed countries cope with high food and fuel prices. The Saudis also financed the World Summit on Food Security at the UN Food and Agriculture Organization headquarters in Rome in November 2009.

VI. Conclusions and Recommendations

Climate change is a serious challenge to the Kingdom of Saudi Arabia, which is under tremendous pressure as a result of the hyper aridity of the climate, severe shortage in water resources, rapidly growing population and reliance on fossil fuels, the latter of which is viewed globally as major source of GHGE.

The KSA is concentrating its efforts on searching solutions to limit adverse impacts of mitigation measures taken by Annex 1 countries on its economy, and on advocating the use of CCS and CDM instead of replacing the use of fossil fuels with renewable and less polluting sources of energy. The Kingdom is also carrying out efforts towards upgrading its petroleum industry and adopting cleaner technologies as a contribution in CC mitigation. KSA's strategy to mitigate water shortages is based on developing new and alternative water sources and improving water use efficiency, mainly through using improved localized irrigation systems and low water requirement crops. Efforts are also made to develop better CC models, early-warning and storm-forecasting systems. Finally, assuring the country's food and water requirements is a chief objective which guides a number of actions and activities of the KSA Government. However, a great deal remains to be accomplished in terms of CC mitigation and adaptation by the KSA Government as well as by the private sector to cope with the threat. The civil society's contribution in efforts related to CC needs to be organized and strengthened.

The KSA could develop its unlimited potential of solar and wind energy and reduce industrial and transport GHE by using appropriate technologies and management practices. Although significant efforts have been made in terms of policy making to overcome the distortions in water management, a great deal remains to be accomplished towards better water resources management and the optimization of the use of the available unconventional water resources, including treated waste water, brackish and sea water. Dry-land farming and more efficient water harvesting techniques are recommended in the southwestern part of the Country on the abandoned terraces of the Sarawat Mountains and along the coasts of the red sea which benefit from annual runoff water born in the neighboring and relatively humid mountains. Developing these options will save water and improve the livelihood of small farmers in these areas. Scientific research which include selecting better drought tolerant crops and including the development and use of new tolerant varieties are essential tools to cope with the expected adverse climatic conditions from CC. The availability of generous funding sources and the excellent research capacities at the local universities and other research institutions must be harnessed to achieve these goals.

Although reforestation of degraded lands as well as afforestation, agroforestry and improvement of rangelands are limited by adverse climate and aridity, they could, nevertheless, contribute greatly to improve the country's environment and to sequester

carbon. These activities will need the necessary political backing and human resources. Such projects stand a good chance to succeed because of available moisture from the Sarawat mountains, whereas in the drier areas treated waste water can be used to irrigate these plantings. Mixed afforestation can reduce the pressure on natural forests and rangelands by providing much needed fodder and fuel wood. Very little research is done on measures to improve forest and rangeland rehabilitation techniques affected by climate change. To achieve this goal additional capacity, financial resources and infrastructure will be needed.

More research is also needed on the effects of sea level rises and on measures to protect and develop threatened resources. The fishing and aquaculture sectors are contributing substantially to food security and hence the concern of the effects of sea level rises on such resources is high, therefore, mitigation measures must be put in place to safeguard these resources. The Jeddah fish farming center run by the MOA-FAO technical cooperation programme is conducting some research on aquaculture which needs to be extended to include the potential impacts of CC, and the methods to counteract the negative effects.

The shortage in skilled human resources in the agricultural sector is impacting negatively on the sustainable use of natural resources, on food production and on the development of appropriate technologies to face the challenges related to global warming and its implications. National and provincial universities and education institutions need to adapt their curricula to address the country's new needs and to build the necessary capacity to deal with these issues. International and regional organizations can also assist the public sector and education systems to accelerate the process of capacity building on matters related to CC.

Many other measures also need to be considered at the country level to reduce and to mitigate the impact of CC. These include improving fertilizer use efficiency, management of livestock waste, restoration of degraded lands, improving crop residue management, development and distribution of crop varieties and livestock breeds resistant to drought, storms and floods, higher temperatures and saline conditions, promotion of agroforestry to increase ecosystem resilience and biodiversity maintenance, reduction of rural and urban poverty, improvement of transport and communications in areas vulnerable to disasters, development of early-warning and storm-forecasting systems, contingency relief plans and rehabilitation, introduction of land use systems to stabilize slopes and to reduce the risk of soil erosion and mudslides. Important funding opportunities exist at the national, sub-regional and regional levels and these need to be exploited to allow for well designed and relevant research programmes and activities.

References

- Alkolibi M. Fahad. 2002. Possible effects of global warming on agriculture and water resources in Saudi Arabia: impacts and responses. *Climatic Change* 54: 225–245, 2002
- Al Zawad F. Macci. 2008. Impacts of Climate Change on Water Resources in Saudi Arabia. Proceedings of the Third International Conference on Water Resources and Arid Environments and the 1st Arab Water Forum. Presidency of Meteorology and Environment, Dammam, Saudi Arabia
- Carnegy endowment for international peace. <http://carnegieendowment.org/publications/index.cfm?fa=view&id=23859>
- FAO. 2008. Water and agriculture in Saudi Arabia. AQUASTAT - FAO's Information System on Water and Agriculture. FAO. http://www.fao.org/nr/water/aquastat/countries/saudi_arabia/index.stm
- Gallup. 2009. Awareness of Climate Change and Threat Vary by Region. www.gallup.com/poll/124652/awareness-climate-change-threat-vary-region.aspx
- Heba Hashem, 2010. Industry Insight: Saudi Arabian CSP vies for a place in the sun. *CSP Today* (5/8/2010). <http://social.csptoday.com/industry-insight/saudi-arabian-csp-vies-place-sun>
- IBM. 2010. IBM and KACST unveil research initiative to create solar powered water desalination plant. www.ibm.com/news/sa/en/2010/03/31/z337573t40642u34.html
- Johm Kilani 2006. Summary of the CDM conference in Saudi Arabia. Arab Environment Watch.
- Lippman Thomas W. 2010. Saudi Arabia's quest for food security. Council on Foreign Relations. Middle East Policy Spring 2010 Pg. 90 Vol. 17 No. 1 I
- MOA (Ministry of Agriculture of the Kingdom of Saudi Arabia). 2009. Agricultural Statistics Year Book, Vol 23. MOA. Riyadh, KSA.
- MWE (Ministry of Water and Electricity of the Kingdom of Saudi Arabia). 2010. Water planning and development. www.mowe.gov.sa/English/mowedevelopment.aspx
- Oihabi A. 2010. Personal communication. FAO-KSA Programme Coordination Unit. Riyadh, KSA.
- PME (Presidency of Meteorology and Environment). 2005. First National Communication of the Kingdom of Saudi Arabia, submitted to the UNFCCC. PME, Riyadh, KSA.
- Saad, Najib. 2009. Arab Public Opinion and Climate Change. In Arab Environment climate change. Impact of climate change on Arab Countries. Edited by Tolba, K. M. and Saad, W. N. Report of the Arab Forum for Environment and Development. ISBN: 9953-437-28-9.

Sven Behrendt , 2009. The G20 and Saudi Arabia's Changing Foreign Policy Agenda.
Carnegie Endowment For International Peace.
www.carnegieendowment.org/publications/index.cfm?fa=view&id=23859

November, 2010

Appendix 1: List of recent activities and projects on climate change

- Preparation of a national water strategy, this project is implemented in collaboration with the International Monetary Fund.
- Updating the study of underground water resources in KSA, A project of the Ministry of Water and Electricity implemented by contracts with Abdullah Abo Nayan and BRGM companies and with GTZ - Dornya Union.
- A study on water use in agriculture in being undertaken by the MWE in co-operation with UNDP.
- A project CCS project consisting of injecting 40 million standard cubic feet per day (cfd) of CO₂ into the world's biggest Ghawar oilfield. The project, fully financed by Aramco.
- Saudi SNC is under preparation by the Presidency of Meteorology and Environment (PME), in collaboration with UNDP and with GEF funding.
- CDM project "The Madinah Landfill Gas Capture Project", implemented in Madinah region.
- Delineation and protection of forests and woodlands in KSA, funded and implemented by the MOA.
- The Juniper ecosystem rehabilitation project in Sarawat Mountains funded and implemented by the MOA.
- Al Gonfoda, Wadi Dawassir, Al Hassa and Najrane afforestation projects for environmental protection and sand advance control funded and implemented by the MOA.
- Protection and rehabilitation of the mangrove areas project funded and implemented by the MOA.
- MOA-FAO Cooperation Programme (UTF) consists of several projects and activities related to improving irrigation efficiency, plant and animal production an protection, fisheries, forestry and range management all contributing directly or indirectly in the efforts towards adaptation to climate change.
- King Abdullah bin Abdulaziz "food security initiative," , backed by an investment fund of about US\$800 million, to support investment by private sector Saudi companies in agricultural projects abroad.
- Climate change modeling by the CECCR.
- Afforestation projects using treated waste water in certain cities in KSA, such as Jaddah.

Appendix 2: Members of the National Committee for the Clean Development Mechanism (DNA)

- Ministry of Municipal and Rural Affairs
- Ministry of Commerce and Industry

- Ministry of Health
- Ministry of Water and Electricity
- Ministry of Agriculture
- Meteorology and Environmental Protection Presidency
- Royal Commission for Jubail and Yanbu'
- Saline Water Conversation Corporation
- Saudi Aramco
- Saudi Arabian Basic Industries Corporation (SABIC)
- Saudi Electricity Company
- King Abdulaziz City for Science and Technology.