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Investigation of Climate Change in Iran

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Abstract: The Islamic Republic of Iran lies in western Asia. In the north it is littoral to the Caspian Sea and borders Azerbaijan and Turkmenistan. It is contiguous with Turkey and Iraq to the West. In the South the country is littoral to the Persian Gulf and the Sea of Oman and abuts Pakistan and Afghanistan to the East. The principal and official language is Farsi (Persian). The population in 1994 (the base year) was about 57.7 million (now estimated at 72.0 million). The area coverage of different types of climate in Iran is 35.5% hyper-arid, 29.2% arid, 20.1% semi-arid, 5% Mediterranean and 10% wet (of the cold mountainous type). Thus more than 82% of Iran's territory is located in the arid and semi-arid zone of the world. The average rainfall in Iran is about 250 mm, which is less than 1/3 of the average rainfall in the world (860 mm). In addition, this sparse precipitation is also unfavorable with respect to time and location. Another important climatic element is extreme temperature changes that sometimes range from -20 to +50°C. Severe drought is also recognized as a feature of Iran's climate. In the last three years, the country has suffered severe desiccation and this lack of rainfall has resulted in extensive losses. Based on the research and assessment carried out during the Climate Change Enabling Activity Project under UNFCCC and using the scenarios proposed by IPCC, it is estimated that if the CO_2 concentration doubles by the year 2100, the average temperature in Iran will increases by 1.5-4.5°C which will cause significant changes in water resources, energy demand, agricultural products and coastal zones. The direct adverse impacts of climate change include changes in precipitation and temperature patterns, water resources, sea level rise and coastal zone, agriculture and food production, forestry, drought frequency and intensity and human health. The indirect adverse economic impacts result from the response measures taken by the developed countries.

Key words: Climate change, water resources, agricultural products

INTRODUCTION

Industrial Revolution in the early 19th century and the human social and economic development have changed people's lifestyle significantly. The need for energy and consumption of fossil fuels like coal, oil and natural gas have resulted in increased emission of carbon dioxide and other greenhouse gases into the atmosphere (Amiri and Eslamian, 2009). These emissions have changed the energy balance of the earth and its atmosphere. Global population growth has caused land use change, deforestation, increased agricultural and livestock activities and increased solid and liquid waste production, resulting in many environmental problems including climate change (Amiri and Eslamian, 2009). Atmospheric

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models predict that the earth temperature will increase from 1 to 3.5°C by the year 2100, which is more than temperature changes during the past 10,000 years. Emission of greenhouse gases, production of aerosols in the atmosphere, changes in the earth's reflection index and thermal pollution are the factors affecting climate change. Among these factors, the effect of greenhouse gases is well known and is the most important one. The earth absorbs most of solar radiations that reach the earth through its atmosphere and, after getting warm, reflects the thermal waves back to space. Portion of this infrared radiation passes through the atmosphere and a fraction of it is absorbed by greenhouse gases and reflected back to the earth surface which results in an energy balance between the earth and space. This so called greenhouse effect is a natural phenomenon, which has created the normal temperatures ranges in the atmosphere. Indeed, if the greenhouse effect did not exist, the earth's average temperature would have been about 15.5 degrees lower than the temperature that it has now and another ice age would occur (IPCC, 1996, 1998, 2007). However, the concentration of greenhouse gases in the atmosphere have exceeded the normal level by as much as 30%, resulting in global warming.

Iran has arid or semiarid climates mostly characterized by low rainfall and high potential evapotranspiration. The annual precipitation varies from about 1800 mm over the Western Caspian Sea coast and Western highlands to less than 50 mm over the uninhabitable Eastern deserts (Fig. 1). The average annual precipitation over the country was estimated to be around 250 mm, occurring mostly from October to March (Eslamian *et al*., 2009a). Annual precipitation is lower in the Eastern half of Iran compared with the Western half. In Northern Iran, the Caspian Sea shores have an annual precipitation of about 500 mm in the East to 1800 mm in the west. In contrast to other parts of the country, the amount of spring and Summer rainfalls are considerable in this region (Amiri and Eslamian, 2009).

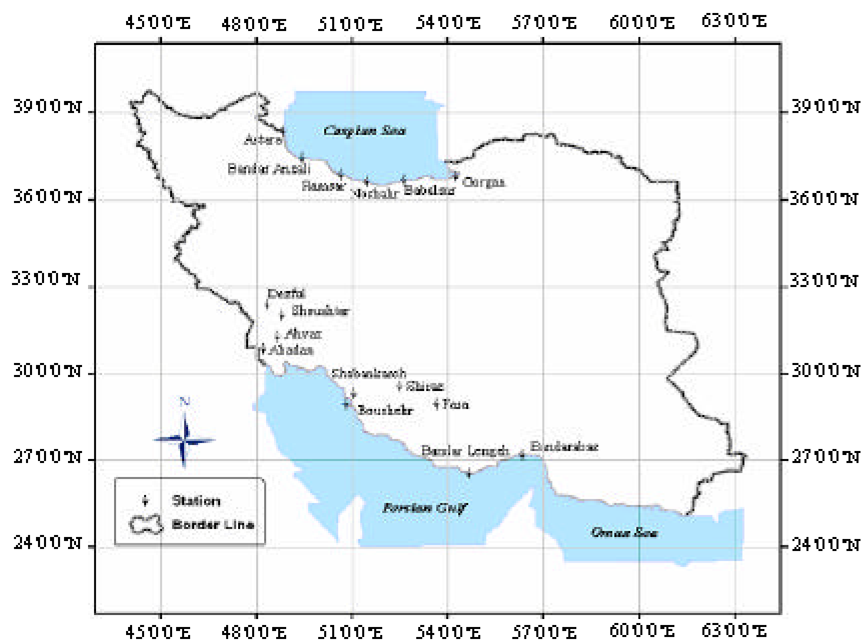


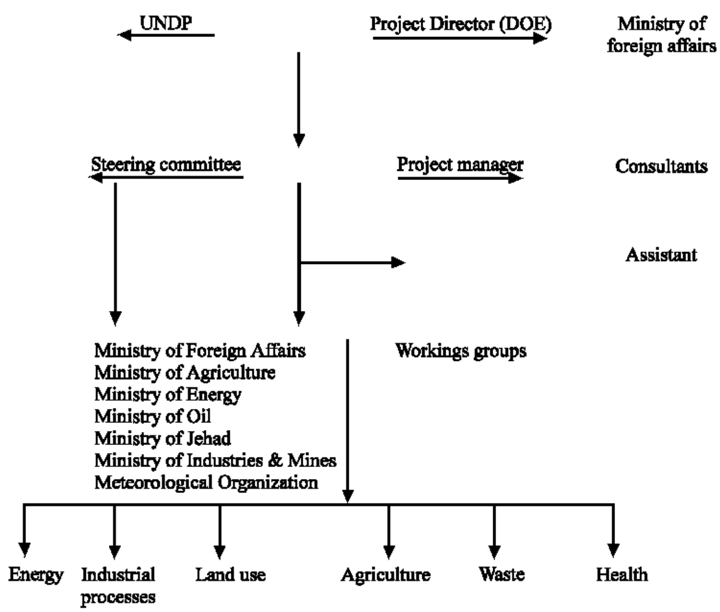
Fig. 1: Geographical location of the precipitation stations in Southwestern and Northern parts of Iran

Temperature variations are commonly used to detect and quantify possible changes in climate. Another means is to analyze trends and variability in precipitation data. Some investigators have reported that there is an enhanced hydrologic cycle over the last two decades, especially for some parts of the Northern Hemisphere (Chen *et al*., 1996; Henson, 2006). Although, much emphasis has recently been placed to quantify climate change over different parts of the globe (Bebbington, 1999; Karl *et al*., 1996), the authors are unaware of any comprehensive studies dealing with the detection of climate change in Iran.

General Information on Climate Change Enabling Activity in Iran

- National Focal Point : Ministry of Foreign Affairs/Department of Environment
- Fund provided by: GEF/UNDP
- Project starting date: January 1998
- Submission of Initial National Communication to UNFCCC: March 2003 (www.climate-change.ir)

General Information Project Organization (www.climate-change.ir)



Summary of Results

- Establishment and initiation of the Climate Change Activities in Iran
- Acquisition and compilation of the Activity Data
- Identification of problems and gaps
- Preparation of the national greenhouse gas inventory
- Proposing policies and measures for GHG abatement
- Assessment of the vulnerability of the country and adaptation to climate change
- Preparation of a preliminary national action plan preliminary
- Designing a national climate change website

- Organizing five national workshops on climate change
- Preparation of public awareness brochures
- Preparation of the initial national communication to the UNFCCC
- Implementation of Phase II of the climate change enabling activity for future national communications (www.climate-change.ir)

The Impact of Climate Change on Dry-Land Agro-Ecosystems

For dry-lands with low inherent levels of biological productivity, coping with climate change presents particular problems. The world's dry-lands cover over 40% of the global terrestrial area and house more than 2 billion inhabitants. The world's poorest people live in these areas and they will be hit hardest by the adverse effects of climate change. The effects will manifest themselves not through increased temperatures per se but rather via changes in hydrological cycles characterized by both increased droughts and paradoxically, increased risks of flooding.

Key impacts of climate change and climate variability on dry-land agro-ecosystems include:

- Reductions in crop yields and agricultural productivity with subsequent threats to the food security of dry-land countries
- More erratic rainfall patterns and difficulties in determining timings of sowing and harvesting, and the selection of suitable crops with varying durations
- Reduced availability of water in already water scarce regions coupled with extreme rainfall events with increased loss of water via run off, etc.
- Complete loss of crops resulting from extreme events such as prolonged droughts and torrential rains
- Slow pervasive loss of soil fertility through loss of soil carbon from erosion and higher decomposition of soil organic matter as a result of higher temperatures, reduced soil moisture and moisture storage capacity
- Lower livestock productivity from heat dissipation and reduced availability of feed and fodder
- Alterations in pest and disease risks for both crops and animals (and humans) as temperatures increase
- Changes in agro-ecologies and the threats from new invasive plant and animal species.
- Reduction of biodiversity of key crop species through habitat change and loss
- Increased vulnerability of pastoralists because of erratic rangeland production, through shifts in rainfall patterns and loss of vegetative land cover

These impacts will further constrain the livelihoods of rural communities in dry areas resulting in greater poverty, reduced livelihood opportunities and increased rates of migration. It is clear from the above that there is an urgent need to improve the management of natural resources (land, water and biodiversity) and the ability of populations to prepare for and respond to, future climate conditions.

ASSESSMENT OF DIRECT ADVERSE IMPACTS OF CLIMATE CHANGE IN IRAN

Temperature and Precipitation

To provide an insight into what will happen if the GHGs emissions issue is not properly managed, six scenarios have been designed. These scenarios were selective combinations of two GCMs (HadCM2 and ECHAM4) models, three emission scenarios and three different climate sensitivities. Low emission combination resulted in an increase in temperature ranging from 1° to 1.5°C. Changes for the second combination range from 2.5° to 4.1°C and the third combination resulted in an increase in temperature ranging from 5.9° to 7.7°C. The same patterns were used to portray precipitation variations in the country. The resulting fluctuations appear in the following ranges: 11 to 19.1% of the baselines for low emission rate, 30.9 to 50% of the baselines for medium emission rate and 58 to 80% of the baselines for high emission rate (Eslamian and Feazi, 2007).

Water Resources

Research on the global warming effects on hydrology and water resources in Iran has been undertaken on several rivers and lake basins by using historical hydro-meteorological data and runoff models in combination with the global warming scenarios. The result of historical runoff data surveys collected at 398 hydrometric stations shows that the Flood Index has changed in 47% of them. In addition, of 600 climatologically stations studied, 68 indicate climate changes during 1990-2000. The long-term runoff model applied to 30 basins shows that the temperature rise increases the runoff volume during winter and decreases it during spring as rising temperature melts snowfall into rain and hastens the time of snow melt. It also indicates that temperature increase affects runoff of basins and decreases the amount of runoff variation of rainfall.

Agriculture

The predicted increase in temperature due to global warming may lead to spike let sterility in rice, loss of pollen viability in maize, reversal of verbalization in wheat and reduced formation of tuber bulking in the potato for the areas near the threshold (Amiri *et al*., 2009). The changing climate will affect wheat, which is the main staple crop. The historical data indicates that as a result of drought and reduction of rainfall, wheat production will be sharply reduced. Losses inflicted by the 1998-1999 droughts on wheat production nationwide are estimated at about 1,050,000 tons of irrigated wheat and 2,543,000 tons of rain fed wheat. The values indicate that agricultural areas are highly vulnerable to climate change.

Forestry and Land Use

Climate change has a profound impact on the forestry sector. This includes changing the habitat location of forest species, especially the less tolerant ones and the extinction of low tolerant species. The natural regeneration regime of forest plants is upset and results in the reduction of wood and non-wood production in forests. Forests witness pests and plant disease infestation and an intensification of land erosion, particularly in arid and semi-arid zones. Sea-based mangrove forests are degraded and sometimes destroyed because of the rise in sea level in the Persian Gulf and Sea of Oman Environmental conditions for wildlife in forest areas decline sharply as does forage production in rangeland, which can in some cases signal the onset of desertification. Soil erosion is the natural result of destruction of plant cover and all such conditions are exacerbated by high temperature and aridity. One social consequence of this environmental downgrading is population migration because of ecological insufficiency.

Coastal Zones

The northern part of Iran is a center of agricultural production. The southern region is home to the energy industry and hence oil installations and energy exports. The nation's largest ports for export of goods are also located in the south. These characteristics of both

North and South define Iran as being vulnerable to climate change impact. According to the 10-year hourly-recorded data in three sites (Chabahar, Bandar Abbas and Bushehr), the mean sea level in the Persian Gulf and Sea of Oman has been rising at an average value of 4.5 mm/yr, which agrees with the IPCC 1995 scenario. The impact of temperature and sea level rise namely: coastal erosion in the north and south; inundation of low lands such as the Miankaleh peninsula and Gorgan Bay; mass bleaching of the coral reef, salt water intrusion caused by flooding and inundation are all outstanding instances of the vulnerability of Iran's northern and southern coastal zones. From a socio-economic point of view, climate change has a great adverse impact on the availability of fresh water in these regions. Saltwater intrusion both into surface water and groundwater are the most important issues, particularly in the Karun River system, which is the main source of drinking water for the population centers of more than one million people and has been subject to salt water intrusion caused by sea level rise combined with a low river flow.

Health

Climate change will cause direct adverse health effects. Global warming is expected to lead to more cardiovascular, respiratory and other diseases. In particular, one of the major vector born tropical diseases is Malaria, which is prevalent in different provinces of Iran. The research on the exposure rate to Malaria from 1982 to 1998 indicates that the trend cases of those infected are on the rise.

Energy and Industrial Processes

Reduction in efficiency of thermal power plants, decrease in hydropower production resulting from lower water level in dams, destruction of coastal and offshore oil, gas and petrochemical installations in southern coastal zones caused by severe sea storms are the significant impact of climate change. It is estimated that global warming causes an increase in electricity demand of about 20,000 MW in the next 50 years (Eslamian *et al*., 2009a).

GHGS MITIGATION ASSESSMENT

Iran has high potential for alleviating the amount of GHGs emission. In the energy sector, the principal policies being pursued are clean and efficient power generation, environmentally friendly refineries, improved vehicle and public transport and energy-efficient buildings and appliances. Similarly, in the non-energy sector, reduction strategies include modern farm and livestock management, protection of forestlands and other natural resources, plus control and treatment of wastewater, disposal management and recycling of solid wastes.

Energy Sector

Improving Energy Efficiency

Enhancing energy efficiency has proved to be the most economical option for reducing emission of GHGs by as much as 31% in 2021. By rational use of energy, accompanied with changes in the fuel mix, it would be possible to reduce the average annual growth rate of CO_2 emission from 4.2 to 2.4% in the period 1999-2021. Energy efficiency mitigation options, include increasing the share of the combined cycle power generation in power plants, defining better standards for energy consumption in domestic and commercial buildings, mandating the use of energy labels for domestic manufacturing of home appliances and improving vehicle technology (Eslamian *et al*., 2009b).

Fuel Switching

By switching from liquid fuels like gas oil or heavy oil to natural gas, the amount of CO_2 emission from thermal power plants will be reduced from 89.4 million tons in 2000, to 83 million tons in 2005, a decline of 7.2%.

Fuel Switching

Flare gas recovery for oil well injection purposes and the development of GTL (Gas-to-Liquid) technologies can also make an important contribution to GHGs emission reduction.

Use of Clean and Renewable Energy Resources

The Government has taken positive measures for the development of renewable energy sources. These include solar and wind energy, geothermal, wave and tidal energy, hydrogen energy, hydropower and nuclear energy. By 2004, the capacity of hydro, geothermal and nuclear energies in power generation will increase, respectively, to 7,700 MW, 1,200 MW and 1,000 MW.

Non-energy Sector

The non-energy areas, i.e., agriculture, forestry and waste sectors have a rather small share in GHGs emission compared with the energy sector. The major mitigation polices in these sectors include increasing ruminant productivity, improving rice cultivation techniques and management of agriculture residue in the agriculture sector. Afforestation, reforestation of forest, driving livestock from the forests and switching from wood to fossil fuel in the forestry sector are also important policies. Other measures include management of solid waste disposal and recovery of CH4 from landfill in the waste sector.

CONCLUSIONS

The human development indicator provides a global assessment of country achievements in different areas of human development. The HDI for Iran is 0.759 (0.746 in 2006), giving the country a ranking of 94 (96 in 2006) out of 177 countries; The Human Poverty Index value for Iran is 12.9%, giving it a rank of 30 (35 in 2006) among 102 developing countries with data. Iran ranks 87th (71st in 2006) out of 177 countries in the gender empowerment measure (GEM), with a value of 0.347 (0.326 in 2006) (Most of the data are for 2005).

Climate change is not just a future scenario. Increased exposure to droughts, floods and storms is already destroying opportunity and reinforcing inequality. Meanwhile, there is now overwhelming scientific evidence that we are getting closer to an irreversible ecological catastrophe. This could lead to an unprecedented reversal in human development in our lifetime and acute risks for our children and their grandchildren (IPCC, 1996, 1998, 2007). Climate change is affecting the Earth's ecosystems. We depend on these ecosystems for a range of services and resources – from water to agriculture to livelihoods and many others. Therefore, climate change poses a serious threat to our ability to meet the eight Millennium Development Goals. The fact that the poor are already seeing its impacts only underscores the worsening situation if significant efforts to stop climate change are not taken (Schellnhuber *et al*., 2006). The Human Development Report 2007/2008: Fighting climate change: Human solidarity in a divided world" seeks to understand the implications of climate change on the opportunities the world has at present and its implications for the future of human development. One of its distinctive features is the work done for the understanding how climate events impact on the poor. Climate change is the defining human development challenge of the 21st Century. Failure to respond to that challenge will stall and then reverse international efforts to reduce poverty. The poorest countries and populations will suffer the earliest and most damaging setbacks, even though they have contributed least to the problem. Looking to the future, no country-however wealthy or powerful-will be immune to the impact of climate change. The poor are suffering and will suffer more with climate change. Given that 40 per cent of the world's population live in poverty and are unable to meet their daily basic needs, these 2.6 billion people are at risk to face firsthand the impacts of dangerous climate change and human development reversals. The Report makes a case for the urgency with which climate change needs to be addressed. Time matters for all of us. Today we are living with what we did yesterday; tomorrow we will all live with what we do today. We need to take action now. We estimated in this Report that if all of the world's people generated greenhouse gases at the same rate as some developed countries (i.e., Canada and the United States), we would need nine planets (to absorb the GHGs and avoid dangerous climate change). With 15% of the world's population, rich countries account for almost half of (annual, global) emissions of CO_2. We estimate that avoiding dangerous climate change will require rich nations to cut emissions by at least 80% by 2050, with cuts of 30% by 2020. Emissions from developing countries will peak around 2020, with cuts of 20% by 2050. Some 262 million people were affected by climate disasters annually from 2000 to 2004, over 98% of them in the developing world. Global temperature increases of 3-4°C could result in 330 million people being permanently or temporarily displaced through flooding. Over 70 million people in Bangladesh, 6 million in Lower Egypt and 22 million in Vietnam could be affected. With 3°C of warming, 20-30% of land species could face extinction. An additional 220-400 million people could be exposed to malaria-a disease that already claims around 1 million lives annually.

RECOMMENDATIONS

Iran climate change and variability are a part of global climate change, if it occurs will definitely effect agriculture. In Iran the change and variability of climate elements in every Agro-ecological regions are difference. In general temperature is increasing sunshine duration is decreasing typhoon is moving in the South. The effect of climate change and variability and ENSO phenomena on agriculture are not similar in difference agro-ecological region of Iran. For sustainable development on agriculture to cope with each climate change scenario will have to change the cropping calendar, cropping pattern, cropping rotation for every agro-ecological regions (Amiri and Eslamian, 2009). To select adaptation crop, varieties for every agro-ecological regions and for every crop season. At present and near future should be use climate index and ENSO index in early agrometeorological monitoring and forecasting crop yield especially for rice and food crops, for conserving with food security in Iran and west ASIA region (Amiri *et al*., 2009).

In order to establish above mentioned strategies and tactics as well as to improve the application of those results in agricultural practices should be continued research project on impact of climate change, extreme climate event (ENSO phenomena), climate disaster on agriculture, food security and measures to cope with them for every agro-ecological zones in Iran and west ASIA region. Enhance capability agrometeorological application of climate and ENSO forecast and information for end users, farmers in Iran. Especially we have to continue study: The impact of climate change and variability on agriculture, forestry and food security in Iran and strategies to cope with them. Strengthening capability agrometeorological networking and monitoring and advisory for agriculture on sustainable development in Iran. There is a window of opportunity for avoiding the most damaging climate change impacts, but that window is closing: the world has less than a decade to change course. Actions taken-or not taken-in the years ahead will have a profound bearing on the future course of human development. The world lacks neither the financial resources nor the technological capabilities to act. What is missing is a sense of urgency, human solidarity and collective interest.

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