Islamic Republic of Iran

Third National Communication to UNFCCC

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U N D P

United Nations Development Programme

Department of Environment

Islamic Republic of Iran
Third National Communication to UNFCCC
December 2017

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Third National Communication
to
United Nations Framework Convention on Climate Change
(UNFCCC)

December 2017

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Any comments on this report and inquiries for further copies may be addressed to:

Department of Environment,
National Climate Change Office,
No. 152, Environmental Research Center,
Pardisan Eco-park, Hakim Expressway,
Tehran, Iran.
P.O.Box: 14155-7383
Tel : +98 (21) 8823 3236
Fax: +98 (21) 8823 3092
Email: info@climate-change.ir
Web : www.climate-change.ir & www.doe.ir

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In recent years, the Islamic Republic of Iran has been taking more decisive actions in the field of climate change, inspired by Article 50 of its Constitution to insure legal protection of the environment. Forward to international cooperation: Iran presented Initial and Second National Communications to the United Nations Framework Convention on Climate Change (UNFCCC) in 2003 and 2011, respectively. In this continuous process, the Third National Communication (TNC) to UNFCCC is also fulfilling the country's commitment, as a Non-Annex I Party to the Convention, to prepare and present the Convention with updated reports on national greenhouse gas (GHG) emission inventory, national GHG mitigation policies, vulnerability and adaptation, national strategies, a Global Climate Observation System (GCOS), research and education and economic assessments.
Iran's National Climate Change Office (NCCO) among other responsibilities, including raising public awareness and national coordination of the Sub-committee for Sustainable Development, has built national capacity to systematically address climate change thorough measures such as providing Iran's Low-carbon Economy Document, Intended National Determined Contribution (INDC) and the National Strategic Plan on Climate Change all of which necessitated a considerable amount of duly recognized effort in providing these inputs.

The field research involved in the compilation of these documents has provided Iran its greatest ever capacity to implement the strong actions needed to address climate change. However, there are still many areas that need improvement and enhancement of national capacity including cross-sector coordination, inadequate data and information collection, as well as other uncertainties and constraints that hinder the smooth implementation of the project for preparation of National Communications.

In line with IPCC guidelines, a number of professional groups were considered to carry out the necessary research, collect the requisite data and prepare the sectoral chapters. In addition, the National Action Plan was elaborated in more detail compared to the previous versions presented, as per Iran's First and Second National Communications. This GEF supported Enabling Activity Project was supervised and approved by the Steering Committee comprised of representatives from relevant ministries and organizations whose members reviewed the sectoral and final reports.

On behalf of the Islamic Republic of Iran, I am hereby pleased to share Iran's TNC with the international community.

Masoumeh Ebtekar
Vise president &
Head of the Department of Environment
Islamic Republic of Iran

Preface

It is my pleasure to present the Islamic Republic of Iran's Third National Communication (TNC) in fulfilment of the commitment under the United Nations Framework Convention on Climate Change (UNFCCC). In addition to meeting Iran's obligations to the Convention, the Communication is an efficient instrument in decision-makings on climate change national policies and strategies. Responding to climate change phenomenon is a national priority in Iran. Urban and rural communities, the productivity of agriculture, fisheries and livestock, natural resources and coastal zones are already affected by climate change. The increase in temperatures and the decrease in precipitation and available water resources are the present reality for the country.

As a highly vulnerable country to the impacts of climate change, despite the provided National Strategic Plan on Climate Change, Iran needs concrete actions on implementing the recognized strategies and policies. Therefore, Iran's Department of Environment is decisive in taking strengthened steps in this regard. The financial and technical support of international communities is an essential factor for Iran's climate actions to be more influential in terms of adaptation and mitigation policies.

I would like to express my sincere appreciation to the Global Environment Facility, the United Nations Development Program in Iran, and the Secretariat of the United Nation Framework Convention on Climate Change for the financial and technical support and also ministries, organizations, institutes and national experts that had contributions in preparing this national report.

Dr. Saeed Motesaddi
National Project Director, and
Deputy Head for Human Environment
Islamic Republic of Iran

Acknowledgments

Considerable number of experts and organizations, governmental and private, have contributed through preparation of the Iran's Third National Communication (TNC) to UNFCCC who allocated their time, expertise and efforts to serve this report to be established and enhance Iran's future. We gratefully acknowledge the invaluable cooperation and extend our sincere thanks to them.

We are grateful for financial support of Global Environmental Facility (GEF) and United Nations Development Program (UNDP) Country Office in Tehran for cordial support and technical assistance of this Enabling Activity. Pursued support and coordination by ministry of the Foreign Affairs as the "GEF Operational Focal Point" is appreciatively acknowledged.

In addition, deserving special recognition and gratitude are the Ministries of Energy, Petroleum, "Industry, Mine and Trade", Roads and Urban Development, Agriculture (Jihad-e-Agriculture), Interior, Health and Medical Education, Guidance and Islamic Culture, Education, "Science, Research, and Technology", Justice, Economic Affairs and Finance and Vice Presidency for Science and Technology, Meteorological Organization, the Forest, Range and Watershed Management Organization, University of Tehran, Presidency Office, Iranian National Institute for Oceanography and Atmospheric Science, I.R.I Broadcasting Organization, Plan & Budget Organization, Iranian National Standards Organization and Pertinent GOs, for technical assistance and providing the requisite data throughout the project. These organizations had invaluable contribution in providing National Strategic Plan on Climate Change which has been prepared by Iran's National Climate Change Office (NCCO); the summarized strategies presented in chapter six of this report. List of individual names and organizations contributed in preparation of the TNC is provided in Annex of this report.

Last but not least, we extend our special gratitude to Dr. Masoumeh Ebtekar, Vice President and Head of Department of Environment and Dr. Saeed Motesaddi, Deputy Head for Human Environment and National Project Director, who shouldered with the office all the project activities and also our colleagues and the staff of NCCO who contributed to the outcome of this project.

Dr. Mohsen Nasseri
National Project Manager
National Climate Change Office
Department of Environment
Islamic Republic of Iran

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Executive Summery

Introduction

Following the submission of Iran's First and Second National Communication to UNFCCC[1] in March 2003 and December 2010, respectively, the Islamic Republic of Iran continued with the implementation of its Phase III Enabling Activities on Climate Change. Similar to previous reporting improvements, several novel sections were undertaken in the Third National Communication (TNC), not presented in the Second National Communication (SNC), including "Economic Effects of Emission Reduction Commitments and Economic Diversification". Furthermore, general policies, strategies and related aims on climate change adaptation for different sectors, presented in chapter six, is significantly more comprehensive and detailed compared to previous report. It's worth mentioning that since Technology Needs Assessment (TNA) report is being submitted to UNFCCC, it is not presented in this report.

In preparing the TNC, the UNFCCC's User Manual for National Communications from Non-Annex I parties (2003) and the IPCC 2006 Revised Guidelines for GHG inventory were used. In addition, the UNDP's NEX Guidelines (2004) for project implementation provided project management and operational guidance. Where possible, GPG 2000 and GPG-LULUCF 2003 for Forestry and other sectors were also used. TNC comprises of the following chapters:

Chapter One: National Circumstances
Chapter Two: National Greenhouse Gas Emission Inventory
Chapter Three: National Greenhouse Gas Mitigation Policies
Chapter Four: Vulnerability and Adaptation
Chapter Five: Other Information (including GCOS, Research and Education and the Economic Effects of Emission Reduction Commitments and Economic Diversification)
Chapter Six: National Strategies and Action Plan on Climate Change.

These individual chapters as well as the whole report have been extensively reviewed by the Steering Committee members comprising of the representatives of all relevant organizations and ministries and ultimately approved over the course of 14 meetings.

Chapter One: National Circumstances

The Islamic Republic of Iran with an area of about 1,648,000 km² and arid and semi-arid climate is located in the southwest of Asia. Apart from the coastal areas, the temperature in Iran is varied between 22°C to 26°C and the average annual rainfall is about 240 mm. Total precipitation provides 417 bcm water, of which 299 bcm (72%) evaporates. In addition to the 117 bcm, 13 bcm enters the country from neighboring countries which makes 130 bcm of water available. It is estimated that 29 bcm either goes into the underground reservoirs or is added to surface water. More than half of Iran's land consists of mountains, with one quarter being plains and deserts and less than one quarter constituting arable land.

Iran has two separate coastlines at its north and south with more than 3000 km coastal lines. These coastal zones have very different climatic and environmental characteristics and also suffer from various coastal issues. While the northern coastal area is over-populated and its sensitive and unique habitats must be protected

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from degradation, most of its southern coastal areas are undeveloped and deserted.

Iran encounters several natural disasters. This country is one of the most seismically active countries in the world, where several major fault lines cover at least 90% of the country. In addition, due to less precipitation and more droughts, fire in forests is growing and vast area of the country, 91 million ha, is prone to floods. More than 22 billion cm of runoff is created from floods which lead to soil erosion. Drought is another natural hazard which is mostly due to water resources mismanagement. Furthermore, central and eastern parts of the country are the main regions affected by sandstorm. Contrary to the sandstorm, dust storm distributes mostly in western provinces. It originates mainly from Wadi areas of Iraq and Saudi Arabia as a result of degraded ponds.

Population of the country stood at 75 million in 2011 Census. Share of urban population was 71.4% in 2011, with Tehran province, having the highest share of 16.2%. This is due to the migration and conversion of big villages to cities. Population concentration in cities has many impacts and some of which can be aggravated by climate change. Iran's Human Development Index (HDI) was 0.67 in 1991 which reached to 0.819 in 2009 and during 2006-2011, men life expectancy increased one year and reached to 72.1 years and women life expectancy improved 1.5 year and extended to 74.6 years.

Based on a study, Iran's economy has been ranked as the 17th largest economy in the world. Its GDP, in terms of purchasing power parity, was 906 billion US $ in 2010 and reached to 929 $ in 2012. The country's income from petroleum and natural gas exports typically provides the largest share of government revenues. During 2005-2010, the budget increased to the annual average rate of 19% and average growth of income was 24% which was 2% lower than the plan's target. Share of the oil income in the first year of the plan, 2005, was 66.9% while the contribution of tax and other incomes were 33.1%. But during the last two years, 2009 and 2010, share of oil income reduced to 56 and 47%, respectively.

Chapter Two: National Greenhouse Gases (GHGs) Inventory

The national GHGs inventory was calculated for the year 2010 based on the UNFCCC guidelines to preparing the national communications for Non-Annex I Parties. As mentioned in the introduction above, the IPCC 2006 revised guidelines was used for the compilation of the GHGs emission inventory. To ensure quality control and quality assurance, key source analysis and uncertainty management, IPCC 2000 Good Practice and Uncertainty Management Guidelines and IPCC 2003 Guidelines for Good Practice Guidance for Land Use, Land-Use Change and Forestry have also been used. In addition, the UNFCCC software was used for GHGs calculations. Compared to the GHG inventory that was reported in the previous reports, this inventory has been improved with respect to the quality of activity data, scarce national emission factors notwithstanding. Furthermore, activity data is still not being collected on a continuous and systematic basis with systematic compilation of activity data requiring improvement in the future. All direct and indirect GHGs encompassing all sectors, i.e. the energy, industrial processes, agriculture, forestry and waste have been calculated.

Total GHG emission for all sub-sectors in 2010, presented in TNC, is 832,043 Gg while this amount in 2000 and 1994, presented in INC and SNC, is 491052.6 and 417012.1 Gg, respectively. As it is obvious, there is a considerable difference between reported total amount of GHG emission in TNC compared to two previous reports, regarding the fact that more detailed GHG emission calculation is undertaken in last report and more GHGs are included in the study, including HFCS, SF_6, CF_4 and C_2F_6.

In 2010, energy sector contributed 81% of total emissions in the country while other sectors' emission including Industrial Processes and Product Use (IPPU), agriculture, forestry and waste were relatively inconsiderable in comparison with energy sector (8%, 5 %, 3% and 3%, respectively). In addition, CO_2 had the highest contribution in total GHGs emission, 77.5%, and CH_4, has the second place, 18.9% while other gases had no significant contribution including N^2O, HFCs, SF6, CF_4 and C_2F_6 (3%, 0.05%, 0.015%, 0.39% and 0.055%, respectively). Comparison of GHGs emission in the years 2000 and 2010 in Iran shows that no changes seem significant in sectors' and gases' contributions. To be more exact, it seems that contribution of energy, IPPU and forestry sectors increased slightly while other sectors experienced a decrease.

Chapter Three: National GHG Mitigation Policies

Considering the mitigation options in both the energy and non-energy sectors, GHGs mitigation potential is relatively high in Iran. The energy sector with a mitigation potential of more than 148 million tons of CO_2 equivalent in 2025, has the largest potential followed by IPPU (9.9 million tons), waste (9.4 million tons), agriculture (7.2 million tons) and forestry (5.01 million ton) sectors, respectively.

Iran GHGs inventory could be smaller by 11% in 2025 with respect to BAU scenario, provided that there would be constructive international cooperation regarding technology transfer and financial aids. This new mitigation regime, if implemented properly, could prevent cumulatively up to 897.5 million tons of CO_2-eq. (740 of which as a result of mitigation measures in energy sector and 157.5 million tons from non-energy sectors) from being released into the atmosphere. IPPU, waste and agriculture activities are the major sources of GHGs emissions in the non-energy sectors.

In 2025, the overall GHGs mitigation potential is 179.5 million tons, with energy sector being responsible for 148 million tons, while the GHGs mitigation potential in non-energy sectors is about 31.5 million tons CO_2 eq. IPPU with some 9.9 million tons, have the highest mitigation potential in non-energy sector, while land use change and forestry with 5.01 million tons have the lowest GHG mitigation potential.

Chapter Four: Vulnerability and Adaptation (V & A)

- ***General Perspective of Iran's Future Climate***

Long-term change in maximum, minimum and average temperature and changes of precipitation in each basin of the country for the period 2015-2030 compared to the period 1982-2009. According to the results related to precipitation changes in the average scenario, few cities will experience precipitation decrease, especially Ahvaz which faces the most decrease in precipitation, 8.8%. While precipitation range increases between 0.2% to 10.8%. In addition, ranges of average temperature change in pessimistic, average and optimistic scenarios are 0.8%-1.4%, 0.5%-0.8% and 0.1%-0.4%, respectively.

- ***Climate Change Impact on Water Resources***

Summary of climate change impact on water resources is as follows:

- The evaporation volume of the country increased by 27.3 billion cubic meters due to the increase of two centigrade degrees in the temperature of the country;

- Recharge of the groundwater decreased by 20%, due to the increase of two degrees in the temperature of the country;

- The amount of snowfall reduced by 5% and the snowmelt time shift one month earlier. Also, the snow level increased to 200 meters. This trend will continue into the future;

- The possibility of severe droughts and severe floods will increase in the future;

- The precipitation trends that are less than 5 mm and 10 mm will continue to decrease;

- According to the pessimistic scenarios, runoff changes in all basins are decreasing. The highest percentages of runoff changes are -65.5, -60.5 & -55 that respectively happened in Bandar Abbas-Sedij, Karkheh and Karoun basins;

- This indicates that the main basin of the Persian Gulf and the Sea of Oman, which covers the southern part of the country, based on the pessimistic scenario, would be the most critical area in terms of reducing runoff;

- According to the medium scenario, the highest percentage increase in runoff is 6% that occurs in plain-Jazmurian and Bandar-Sedij basins. In addition, according to this scenario, the highest percentage of runoff reduction is 20% observed in Karoon basin. After that, the Zohreh Jarahi, Loot desert, and Dranjyr desert have the most reduction of runoff percentage by 15%;

- Drinking water supply in most major cities of the country will be difficult in the future;

- Warmer and more humid conditions increase the prevalence of diseases in the tropical country; and

- The calculation of the percentage changes in the income from the surface runoff shows that the highest losses would be found in the province of Khuzestan, Fars, and Hormozgan, respectively.

- ***Adaptation Strategies in Water Resources***

- Trying to achieve healthy community with welfare, food security, equal opportunities, proper income distribution and benefited from favorable environment;

- Promoting the productivity, considering the economic, security, political and environmental values of water in order to achieve a desirable utilization, supply, maintenance and consumption;

- Enhancing efficiency and sustainability in using shared water resources in close collaboration with neighboring countries;

- Inter-basin water transfer and water exchange;

- Spatial planning and integrated management of water resources;

- Comprehensive approach to water resources management;

- Strengthening public participation;

- Providing financial resources and investment as well as implementation of the "Policies of Article 44 of the Constitution";

- Water and sustainable development; and

- Drinking water and sanitation services.

- ***Climate Change Impact on Agriculture***

- Irrigated Crops

Based on the temporal analogical results, irrigated production system is less sensitive to climate change than a rain-fed system. However, availability of water for irrigation has detrimental effects on the area under cultivation and final crop yields. The rise in mean yearly temperature, particularly in the winter, could extend the growing season in these areas, and allow for the cultivation of long-maturing crop varieties, or two crops per year. Net irrigation requirements of irrigated wheat and alfalfa will increase, while it will decrease for irrigated forage corn in most parts of the country during 2016-2030 timeline. The potential yields of irrigated wheat, alfalfa and forage corn will also decrease in most parts of the country during the same timeline period.

- Fisheries

The vulnerability of fisheries section to future climate change was assessed for three general fisheries activities in Iran, including fishing in the Caspian Sea, the Persian Gulf and Oman Sea, and aquaculture in inland waters. Results related to effects of some factors on marine stocks as affected by climate change in 2016-2030 period show that fish species will be mostly affected negatively. In addition, climate change will have negative impact on balance of species. However, the nutrition and growth of these species will be influenced in positive way. Moreover, effects of different factors on aquaculture production as affected by climate change in aforementioned period, has been studied which show that the negative impacts will be less significant so that for most species, the balance will positively be affected by climate change.

- ***Adaptation Strategies in Agriculture, Livestock and Fisheries***

- Agriculture

◦ Sustainable soil management (conservation tillage, sustainable soil fertility and salinity management);

◦ Sustainable water management (reduction of water losses, irrigation management and integration of sustainable technologies with modern technologies);

◦ Seed and seedling management (plant breeding, appropriate agronomic techniques and utilization of halophytes and xerophytes);

◦ Integrated management of biotic stresses (weeds, pests and diseases);

◦ Selection of appropriate crops (drylands, irrigated lands and marginal lands)

◦ Sustainable production systems (agroforestry, integrated production systems, halo culture and organic agriculture);

◦ Agricultural water resources management (motivational and regulatory policies and laws and action plan for management of water resources); and

◦ Socio-economic policies for reduction of poverty in rural areas (territorial spatial planning, extraterritorial agriculture, prevention of land fragmentation, farmers income stabilization fund, rewards for environmental services, subsidies, reduction in agricultural wastes, expansion of agricultural insurance and diversification of the economic activities).

- Livestock

◦ Capacity building (expansion of livestock and poultry insurances, income stabilization fund, settlement of nomads, and rewards and subsidies for environmental services); and

◦ Infrastructure development and expansion (balanced grazing, protection of the biodiversity of Iranian animal breeds, breeding programs, forage production, expansion of integrated production systems, promotion of organic livestock and poultry production, management of animal diseases and expansion of industrialized production units).

- Fisheries

◦ Capacity building (management and protection of marine stock resources and sustainable aquaculture management); and

◦ Socio-economic policies (expansion of insurances, income stabilization fund for fishermen and producers and rewards and subsidies for environmental services).

◦ Capacity Building among Stakeholders

◦ Cultural awareness;

◦ Education and transfer of knowledge; and

◦ Public awareness.

- ***Climate Change Impact on Forest and Rangelands***

The impact of temperature, on forest biomass, in pessimistic scenario comparing to the optimistic scenario for the period of 2016-2030 will be more positive and effective. While the impact of precipitation on forest biomass in the pessimistic scenario for the period of 2016-2030 would be much more negative and unacceptable. Meanwhile, increasing forest biomass under optimistic scenario for the period of 2016-2030 will be very positive and in the opposite direction of pessimistic outcomes.

- ***Adaptation Strategies in Forest and Rangelands***

The adaptation strategies can be listed as follows:

- need to use Criteria and Indicators for Sustainable Forest Management (C&I for SFM);

- Programmatic actions (such as National Plan of Action, import of wood, etc.);

- Socio-economic actions (such as nomads, forest cooperatives, etc.); and

- Technical activities (such as forests rehabilitation, range preservation, desert windbreakers, domestic livestock management, agriculture irrigation control, etc.).

- ***Climate Change Impact on Coastal Zones***

- Caspian Sea

Trends of time series data show that temperature will increase over the Caspian Sea at a higher rate than global average. As the Caspian Sea level is controlled mainly by the precipitation and evaporation over the catchment basin, it seems that the sea level will not change dramatically and will be stable between -26 to -28 m below mean sea level. The Caspian coast of Iran will be drier and hotter in future. This will certainly be influential on coastal sensitive ecosystems, agricultural activities, and tourism. Increasing freshwater consumption and changes in physical and chemical properties of sea water are the consequences of the atmospheric changes that in turn lead to desertification, vegetation changes and soil erosion in the eastern coast of the Caspian Sea. Any changes in Caspian water level could affect the development of coastal wetlands and bays. This event will be more dramatic in low-lying coast of the eastern Caspian coast.

- The Persian Gulf

The worse scenario of sea level rise for 2100 in the coast of the Persian Gulf will inundate the low lying coast of Khuzestan Province and some locations in Hormozgan Province and in turn, could affect underground freshwaters. Moreover, the sea level rise will change the sedimentation and erosion rates of coast depending on the coastal setting. The weakening of Shamal wind in line with increasing temperature in next decades will decrease the mixed layer and change physical properties of the water. This condition could consequently affect sensitive ecosystems such as coral reefs, mangroves, and coastal wetlands.

- The Oman Sea

While the Persian Gulf experiences a weaker Shamal wind, the Oman Sea meets more strong winds and more frequent tropical storms in next decades. This could pump more deep oceanic water to the Northern Arabian Sea and the Oman Sea and consequently the sea will be more productive. Moreover, stronger storms could lead to coastal erosion of rocky shores of Makran. More dust storms over the Oman Sea and the Persian Gulf in line with increasing Sea Surface Temperature (SST) could provide an adequate condition for more frequent algal blooms.

- ***Adaptation Strategies in Coastal Zones***

- Caspian Sea

Water resources management, integrated coastal zone management and saving coastal ecosystems by domestic approaches are the main approaches at the national level. More political coordination is needed to conduct adaptation plans for the region in view of data and information exchange and joint research projects.

- The Persian Gulf and the Oman Sea

Exploration of new sources of freshwater resources such as fossil waters and submarine freshwaters is recommended. In addition, lack of enough data on the rate of the sea level rise and its consequences necessitate more regional efforts in data and information exchange as well as joint researches. It is crucial for the Islamic Republic of Iran to engage in international oceanographic researches, especially in the Indian Ocean. Increasing the population along the coasts, regarding future migrations due to climate change, needs infrastructures and facilities improvement, which should be considered in future development plans.

- ***Climate Change Impact on Human Health***

Based on the climatology information and using Time-Series Regression modeling, Khuzestan and Hurmozgan - south provinces of the country, as well as important country border cities will have the highest risk for Vector-Borne and also the waterborne incidence up to 2030. The comparison between economic loss and total cases of all diseases revealed that the CCHF is very important in view of cost of one case. Then, the priorities would be implemented based on the highest economic loss. If global emissions decrease rapidly and there is a major scale-up in protection, the annual affected population could be limited to about 200 people. Considering the estimated national rate of heat-related deaths (less than 6 deaths per 100,000 persons annually between 1961 and 1990), under a high emissions scenario it will be around 70 deaths per 100,000 persons by 2080. A rapid reduction in global emissions could limit heat-related deaths in the elderly to about 16 deaths per 100,000 in 2080.

- ***Adaptation Strategies in Human Health***

The most important strategies for vector-borne and water-borne disease are as follows:

- Vector-Borne:
    - Implementing climate-adaptive health programs in vector-borne sector;
    - Developing early warning systems and emergency measures for vector-borne diseases;
    - Developing climate-health cooperation program;
    - Adapting new rules for Quarantine System;
    - Community awareness about vector-borne diseases;
    - Borderline collaboration for vector-borne diseases;
    - Quarantine establishment in the high-risk areas;

◦ Effective vector control;

◦ Applied research about climate change impacts on vector-borne diseases; and

◦ Establishment of a surveillance system for epidemic forecasting based on forecasted temperatures.

- Water-Food Borne Diseases:

◦ Developing a monitoring system and preparation of a database for water & food-borne related diseases affected by climate change;

◦ Acquiring the support of politicians and senior managers for strengthening the system of controlling food-borne diseases;

◦ Strengthening programs supportive of nutritionally vulnerable individuals/groups (targeted subsidies, safety nets, etc.) for households aiming at promoting direct access to nutritious and safe foods;

◦ Institutionalizing inter-sectoral cooperation for food and nutrition policy and program- planning, especially for times of crisis;

◦ Acquiring the support of politicians and senior managers for strengthening the system of controlling food-borne diseases;

◦ Establishing and developing nutrition counseling unit in PHC system;

◦ Designing an efficient food quality control system for times of crisis, especially climate-related ones;

◦ Strengthening the laboratory network in both public and private sectors, for proper diagnosis of food-borne diseases;

◦ Providing safe piped/drinking water in all urban and rural areas of the country; and

◦ Establishing the border surveillance system.

- ***The Threat to Biodiversity***

In general, reasons of biodiversity loss include natural factors and human factors such as changes in land use, encroachment on natural forests, wildlife and plants trade, excessive exploitation of flora and fauna, water pollution and climate change. Climate change causes threats on biodiversity especially on fish fauna, bird fauna and mammal fauna. Iran is attempting to protect country's biodiversity. The number of protected sites in the country is equal to 274, which includes 29 national parks, 44 wildlife refuges, 35 national natural monuments, 166 protected areas and 10 Biospheres; while the number of protected sites in the country was 194 sites in 2010.

- ***Adaptation Strategies in Biodiversity***

One of the goals of the Islamic Republic of Iran and Iran's Department of Environment is to pursuit twenty Aichi targets in the country. Among twenty Aichi targets, the seventh goal in Iran was a priority in this regard. The number of sites under the protection of the country has changed from 194 sites in 2010 to 274 in 2014. The seventh goal is as follows:

- Aichi Target 7: By 2020, areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity. To achieve the seventh Aichi target, the following actions are being carried out in Iran. (The Fifth National Report, 2015, to the Convention on Biological Diversity).

◦ Reviving of a Council comprised of key ministries and head of the Department of Environment, chaired by the President, to control the development of the country according to environmental goals;

◦ Increasing the protected areas. Saving the endangered species such as Asiatic Cheetah from extinction;

◦ Establishment and enforcement of necessary laws and regulations; and

◦ Establishment of National Sustainable Development Committee.

- ***The Direct and Indirect Economic Impacts of Climate Change on Agricultural Sector***

Base on the results, the total economic losses resulting from climate change in Iran, in pessimistic and median scenarios is estimated around 52997.5 and 19747.5 billion Rials per year, respectively. In contrast, the total direct and indirect effects of optimistic climate scenario which anticipated 23.4% increase in rainfall, is estimated about 42351.5 billion Rials increase in the gross domestic product of all economic sectors. The proportion of consumers from the total losses (benefits) of climate change in scenarios varied between 55 to 86 percent in the pessimistic and optimistic scenario, respectively. The proportion of crop and livestock producers from these losses (benefits) changes from 16.9 to 9 percent and for other sectors of the economy (indirect effects) varies from 13.6 to 24.5 percent.

Reduction of added value of chemicals production activities, due to the diminishing of agricultural production, was estimated 1175.6 billion Rials under the pessimistic scenario. After applying chemical in agriculture sector, the most vulnerable economic activities to climate change on the demand-side are road transportation (458.9 billion Rials), financial intermediation (38.2 billion Rials), basic metals manufacturers (307.2 billion Rials), private buildings (283.3 billion Rials), production of petroleum refineries (272.8 billion Rials), other business activities (265.2 billion Rials), collection, purification and distribution of water (232.6 billion Rials), extraction of crude oil and natural gas (226.5 billion Rials) and other service activities (225 billion Rials). Given that part of agricultural productions is also used in itself as inputs (seed), climate change also affects this sector indirectly (878 billion Rials). Totally, the demand-driven multiplier effect of agricultural activity is 1.8. Supply side analysis also has the same assumptions and direct impacts with demand driven model, but with less total impacts (14689 billion Rials). The most vulnerable sectors in the value-added reduction of crops and livestock sub-sectors are agriculture downstream activities that use products of this sector as input in their production process. For example, the largest decline in value added belongs to food and beverage industry whose value is estimated to be approximately 2530.4 billion Rials. After that, the most vulnerable sectors are textile production activities (529 billion Rials), private buildings (103.3 billion Rials) and commercial activities (72.1 billion Rials). Supply-driven increasing coefficient of agriculture sector is

1.72. This means that each 1 unit reduction in this sector value added will bring a total of 0.72 Rial reduction in value added of other economic sectors that use agricultural products as inputs in their production processes.

Chapter Five: Other Information

This chapter in the TNC includes information on:

- Global Climate Observation System (GCOS);
- Research and Education; and
- The Economic Effects of Emission Reduction Contributions (ERC) and Economic Diversification.

- ***Global Climate Observation System (GCOS)***

In this report climate observation systems were surveyed in the following three areas:

- Meteorological and Atmospheric Observations;

- Oceanographic Observations; and

- Hydrology, Hydrometeorology and Terrestrial Observations.

- Meteorological and Atmospheric Observations

Islamic Republic of Iran Meteorological Organization (IRIMO) operates 391 synoptic stations, the data of which are internationally exchanged through the Global Telecommunication System (GTS). Parameters that are normally applied to air traffic control are being measured in 64 aeronautical stations, which in fact are synoptic stations located in the vicinity of the country's airports. 225 out of 2498 rain gauge stations of IRIMO were equipped with Data Logger. The Ministry of Energy (MOE) operates a separate rain gauge network.

Meteorological, biological and agricultural data are measured simultaneously in 34 agrometeorological stations by IRIMO. Height and period of waves, Sea Surface Temperature (SST), and some other oceanic parameters are measured in 20 marine meteorological stations. The number of upper air stations including Radiosonde and Pilot balloon are 15.

A project related to a national network of weather radar stations, with the aim of covering the country, has already been started during last two decades. In the first phase, 6 radars were purchased from Gamatronic Company and installed under the Modernization and Information Technology Development Program (MITD) of IRIMO. These 8 radar stations are operational and their data are used in forecasting and other purposes. The second phase of radar installation includes the provinces of Khorasan Razavi, Isfahan, Fars, Tehran, Bandar Abbas, Isfahan, and Gilan.

Road weather network is started to be installed jointly by IRIMO and the Road Toll and Road Transport Department for the purpose of recording specific meteorological data to issue weather forecast along the roads and finally to severe weather phenomena warnings such as quick snow melting especially in mountainous areas, severe wind blowing on bridges and various phenomena that affect reducing vision and etc. By the end of 2014, this network included 66 stations distributed in different parts of the country, mostly in mountainous areas and the roads with high risk at extreme events occurrence. So far, roughly 220 automatic weather stations have been operated to measure meteorological parameters by IRIMO.

Atmospheric observation is divided into two parts; ozone monitoring and space based sub-system. As for ozone monitoring, there are two stations under the supervision of the IRIMO and one with the cooperation of the Geophysics Institute that is affiliated with the University of Tehran, in which the ozone measurement facilities are installed and used. In addition, Satellite images are received and applied for the purpose of forecasting and issuing warnings for climatic disasters by 26 weather stations located mostly in provincial centers.

- Oceanographic Observations

Three methods are implemented by marine organizations in I.R.Iran to collect oceanographic data, including space-based observing systems, temporary and fixed marine stations and organizing marine cruises. Marine organizations including IRIMO, Ports and Maritime Organization (PMO), National Cartographic Center (NCC), Iranian Fisheries Organization (IFO), Department of Environment (DOE), Iranian National Institute for Oceanography and Atmospheric Science) INIOAS), National Geographic Organization) NGO(, Iranian Space Agency (ISA), Geological Survey of Iran (GSI) and MOE cooperate in this context.

- Hydrology and Hydrometeorology Observations

Different types of existing measurement and monitoring stations of the MOE are as follows:

A) Supplementary Stations: This group includes the stations which are established due to areal covering or feature writing (topographical) of different regions. Their short-term data extend to long-term data using correlation with reference stations when necessary;

B) Reference Stations: These stations have been established to evaluate atmospheric precipitations in the country. These stations' data are listed in monthly reports which are published in collaboration with IRIMO (Islamic republic of Iran meteorological organization).

C) Rain Gauge Stations Classification due to Their Equipment: Rain gauge stations can be divided into three categories in terms of their equipment:

- Standard Rain Gauges which are normally visited and measured twice a day by the station's observer;
- Recording Rain Gauges which measure durability, intensity, and distribution of rainfall; and
- Reserve Rain Gauge which is used in the measurement of seasonal atmospheric precipitation in areas where there is not the possibility of continuous monitoring.

• Research and Education

In order to update the climate change research and educational activities of the country, more ministries, organizations, and universities than the second report were surveyed up to 2015. It was found that from 2008 to 2015 the number of journal papers related to climate change has increased by 86, projects by 48, theses by 140 and the published books by 23 compared to pre-2008 activities. The findings also showed that most studies have focused on evaluating the impact of climate change and mitigation options. In other words, the fields of climate change adaptation strategies and scientific knowledge of climate change have been considered less in the researches. So, two approaches were considered. The first approach is to strengthen the educational courses at postgraduate degree with the launch of climate change in any of the fields related to climate change. In the second approach, we tried to propose some climate change research and educational strategies for relevant ministries and institutions in Iran. These strategies were evaluated in a number of meetings with more than 50 experts from universities, industries, and NGOs. These strategies were proposed in four disciplines; mitigation of climate change, water resources management, agriculture and food security, and the environment.

- ***The Economic Effects of Emission Reduction Contributions (ERC) and Economic Diversification***

The results of GHGs emission inventory show that the intensity of the GHGs emissions in the whole economy of Iran is about 0.089 million tons of CO_2 per one thousand billion Rials of production. This figure in the agricultural sector is about 0.059 and in extraction of crude oil, natural gas and other minerals has been calculated about 0.134. Moreover, in producing food and beverage products is about 0.065, and for textiles and wood and paper products are about 0.032 and 0.028 million tons of CO_2 per one thousand billion Rials of production, respectively. The most energy intensity among various economic activities is related to the transport sector, so that in this sector per one thousand billion Rials of production value, about 0.466 million tons of CO_2 is emitted directly.

Results of adjusted multipliers and economic losses caused by restrictions on the level of production (reduction of thousands tons of carbon dioxide) for 14 collective activities are presented. Adjusted multipliers obtained 1.725 for the agricultural sector indicates that if the restrictions imposed on the production capacity of this sector increase by one million Rials, the losses caused will be 1.725 million Rials in the whole economy. In addition, the amount of reduction of 16.95 for the agricultural sector shows that if one thousand metric tons of GHGs reduction in agriculture sector is set as the goal, the production value of this sector would reduce by 16.95 billion Rials. The amount of production reduction in the agriculture sector, through its adjusted increasing multiplier (1.725), will impose a loss of about 29.237 billion Rials to the whole economy.

The amount corresponding to this loss for the extraction of crude oil, natural gas and other minerals sector is around 7.836 billion per thousand tons of GHGs reduction. This value for the food and beverage sector, wood and paper and wood products, clothing and textiles, and finally petroleum and oil refining are equal to 35.138, 56.625, 51.321, and 121.333 billion Rials, respectively. The least economic damage caused by one thousand tons of CO2 emission reduction, with 3.575 billion Rials is related to the transport sector and to the contrary, the largest value with 122.117 billion Rials is related to transmission and distribution of electricity and water.

The results of multi-objective optimization models show that achieving a particular goal in development planning requires a trade-off with other goals. For example, the cost of pursuing the policy of reducing GHGs emission might be the loss of a part of the production value. The policy should be a combination of different purposes and consequences of a choice to make. On this basis, the policy-maker must choose a combination of different goals and consequences caused by it. Based on the results, if choosing the combination of the economic structure is only based on the maximization of the production value (basic conditions), the entire economy with available resources can create production value of 2503.9 trillion Rials annually and depletion of 222575.3 tons of CO2 in the atmosphere on an annual basis. In this case, if the second economic structure is implemented, the production value and carbon dioxide emissions would be decreased respectively 1.74% and 4% compared with the first model.

Chapter Six: National Strategies and Action Plan on Climate Change

Third National Action Plan differs from the previous ones. The differences are as follows:

- Its content is considered in a 15-year period, the period of three National Five year Development Plans, while the emphasis is on the first plan which will commence from early 2017;
- Action Plan reports has a structure with two phases. The first one consists of the policies which some of them are specific and many are general; both with specific responsibilities of relevant Governmental Organizations (GOs). This is similar to previous report;
- The first phase of the Action Plan will be approved in the cabinet. According to the cabinet approval, all GOs are bound to prepare the detailed information of the second phase.

- ***Emission Reduction***

General policies:

- Mainstreaming the reduction of emission and carbon footprint in socioeconomic development plans;

- Developing international and regional cooperation; and

- Promoting climate change knowledge.

- ***Adaptation in Water***

General policies:

- Strengthening sectoral management and institutionalizing inter-sectoral cooperation;

- Promoting awareness, technical knowledge, and culture of climate change;

- Establishment of adaptation based sustainable management of water supply and demand; and

- Developing international cooperation on adaptation.

- ***Adaptation in Agriculture and Food Security, Farming and Horticulture, Livestock and Poultry, and Fishery***

General policies:

- To review agricultural macro policy making based on integrated and adaptation approach;

- Adaptation based Technical, economic, and social capacity development;

- Increasing international relations;

- Adaptation based planning for farming and horticulture;

- Adaptation based policy making and capacity development;

- Conservation and development of capacity of traditional animal husbandry based on carrying capacity;

- Increase of productivity in livestock and poultry production;

- Ecosystem management of aquatic reserves of the country; and

- Aquatic management.

- ***Natural Resources and Biodiversity***

General policies:

- Climate oriented rural and regional development;

- Establishment of climate compatible management system;

- Establishment of supportive and compensatory system;

- Research, cultural, public education, and training development; and

- Developing regional and international cooperation.

- ***Health***

General policies:

- Improving the health system and resilience to mitigate adverse effects of climate change;

- Enhancing professional knowledge and public culture of adaptation in health sector; and

- Development of regional and international cooperation.

- Monitoring and Evaluation (M&E) System

Regarding the obligations of the I.R. Iran under the Climate Change Convention and the new structure of strategy and Action Plan, an active Monitoring & Evaluation system is required. After the approval of the report by the government, details will be determined. The reason for it is the nature of phase 2. Upon the approval of the second phase, all GOs are bound to identify their actions in view of their location, time of construction, budget and manufacturing issues. Preparation of transparent and articulated guidelines is of great importance for those who are supposed to report activities, which ultimately leads to emission reduction/ adaptation. On the other hand, Climate Change Project lacks the capacity to handle such an extensive work. It seems that outsourcing is the best solution. It can be more productive when the results of the implementation and goal indicators are collected in a GIS environment.

The following points are some of the main specifications of it:

- It is a participatory M&E,

- Provincial universities, NGOs, and experts are the evaluators,

- Short term training can increase quality of M&E,

- Reporting forms will be prepared collectively,

- Best practices will be used for replication.

National Circumstances

Chapter 1

1.1. Government

Iran is an Islamic republic established through a referendum, and based on a constitutional system adopted through a democratic and participatory process. The constitution prepares the background for all members of Iranian society to enjoy equal rights, regardless of the tribe or ethnic group to which they belong, color, race and language, and to participate in all stages of political decision making as well as the making of decisions that shape their destiny. This is to assure that each person, in the process of human development, is involved in and assumes responsibility for growth, augmentation and leadership.

With inception of the Islamic Republic of Iran in 1979, the supreme authority in the governance system of the country has been vested in Velayat Faghih (the Supreme Jurisprudent-the Leader). Under his supervision, there are three authorities, namely; the Executive, the Legislative and the Judiciary.

The President, as the second highest-ranking official, is elected to a four-year term (there is a two-term limit) by the people as the head of the executive branch. The Islamic Consultative Assembly (Majlis) is the legislative branch with 290 members who are also elected to a four-year term, by their constituencies. As for the Judiciary branch, the leader appoints the head for a five-year term that can be extended once. The 12-member Council of Guardians that vets candidates for the presidency and the Majlis, also has a supervisory role in overseeing the elections. In addition, it ensures that legislations passed by parliament are in accordance with the Constitution and Islamic precepts.

The Expediency Discernment Council was formally incorporated into a revised Constitution in July 1989. The Leader designates its members for a five-year term and they rule on legal and theological disputes between the Majlis and the Council of Guardians.

1.2. Natural and Geographical Situation

1.2.1. National Situation

The Islamic Republic of Iran with an area of about 1,648,000 km2 is located in the southwest of Asia and lies approximately between 25° and 40° of the North (in latitude) and between 44° and 64° of the East (in longitude).

Iran with an area of more than 1.6 million square km, is the sixteenth largest country in the world. Iran is placed in the Middle East and surrounded by the Armenia, Azerbaijan, Turkmenistan and Caspian Sea on the north, Afghanistan and Pakistan on the east, Oman Sea and Persian Gulf on the south and Iraq and Turkey on the west.

Alborz and Zagros ranges are the most important mountains in Iran. Alborz and Zagros mountains stretch in northwest-northeast and northwest-southeast direction respectively. These mountains play an important role in determining the non-uniform spatial and temporal distribution of climatic condition (precipitation, humidity, temperature and so on) in the whole country. Damavand peak in the Alborz reaches 5600 m above mean sea level while the Caspian Sea level is roughly 28 m below the free mean sea level. Iran consists of six main basins which have 30 sub-basins. (Table 1.1)

Table (1.1): Main Basins by the Area and Number of Sub-basins

Main basin	Area (*ha*)	No. of sub-basins
Caspian	17,505,418	7
The Persian Gulf and Oman Sea	42,343,512	9
Urmia Lake	5,195,775	1
Central Plateau	82,403,672	9
Eastern border	10,336,009	3
Ghareh-Ghom	4,402,526	1
Total	**162,186,912**	**30**

1.2.2. Climate

The country's climate is mainly arid and semi-arid, except the northern coastal areas and parts of western Iran. The climate is extremely continental with hot and dry summer and very cold winter particularly in inland areas. Apart from the coastal areas, the temperature in Iran is characterized by relatively large annual range, about 22°C to 26°C. The rainy period in most of the country is from November to May followed by dry period between May and October with rare precipitation. The average annual rainfall of the country is about 240 mm with maximum amounts in the Caspian Sea plains, Alborz and Zagros slopes with more than 1,800 and 480 mm, respectively. Iran has climatological diversity with three types of climate: 1) dry and semi-dry climate: large parts of internal lands and southern border of Iran have this climate; 2) Mountainous climate, which itself is subdivided into two categories of cold and moderate mountainous climate; 3) Caspian climate: a narrow and small area between Caspian Sea and Alborz Mountain Belt with 600-2000 mm annual rain.

The diverse climate of Iran is the result of extension in geographical latitude and longitude, long mountain belts, remarkable altitude variation and the position of country in relation to seas and oceans.

1.2.3. Water Resources

Rain and snow constitute about 70 and 30 percentage of total precipitation. Total precipitation provides 417 bcm water, of which 299 bcm (72%) evaporates. Average annual evaporation is 1500-2000 mm. It is one third of the world average. In addition to the 117 bcm, 13 bcm enters the country from neighboring countries which makes 130 bcm of water available. It is estimated that 29 bcm either goes into underground reservoirs or is added to surface water. Utilization of the water by the sectors is illustrated in table 1.2. Underground water has been overused so that land subsidence is expanding.

Table (1.2): Consumption of Water by Different Sectors in 2010

Sector	Consumption (billion m3)	Share (%)
Agriculture and aquaculture	87.2	91.5
Industry and mining	2	2
Urban and rural water supply	6.45	6.5
Total	**95.65**	**100**

Source: Ministry of Energy

1.2.4. Forest and Rangeland

In Iran, forests contribute 8.8% of the country's area, 14,319,063 ha, and are divided into two categories: northern and outside of northern forests. Northern forests consist of Caspian and Hyrcanian ones. Dense and semi-dense forests, thin forests and planted forests contribute 36.6%, 56.6% and 6.6% of the total area, respectively.

In addition, total economic value of the forests has been estimated 10 billion US and per capita forest in Iran is 0.17 ha whereas it is 0.62 ha in the world.

About 54% of the country's area is rangeland. It includes approximately 8000 plants species. In addition, its per capita in Iran, is 1.32 ha while world per capita is 0.82 ha. The value of one hectare of rangeland comprises fodder products (25%) and environmental services (75%). Fodder products are assessed 10.7 million tons during one year with normal precipitation. Moreover, the annual value of medicinal herbs in rangelands is more than 2 billion US $.

During the past decades, vast area of rangelands has been degraded. Some of the major factors contributing to the degradation of rangelands are as following:

- Overgrazing; especially untimely grazing (early or late grazing);
- Inefficient management of range and livestock in transhumance;
- Competitive utilization of range among transhumant groups;
- Collecting fuel; and
- Plowing rangelands and expansion of the area of rain fed farms with low yield on slopes.

1.2.5. Coastal Areas

Iran has two separate coastlines at its north and south with more than 3000 km coastal lines. These coastal zones have very different climatic and environmental characteristics and also suffer from various coastal issues. While the northern coastal area is over-populated and its sensitive and unique habitats must be protected from degradation, most of its southern coastal areas are undeveloped and deserted. Three provinces of Gilan, Mazandaran, and Golestan with total population of 7.5 million, constitute the northern green belt, adjacent to the Caspian Sea. Southern coasts neighbor four provinces; including Khuzestan, Bushehr, Hormozgan, and Sistan and Baluchistan with total population of more than 10 million, i.e. 23% of the country's population lives in these seven provinces.

Intense oil and gas exploitation activities in the Caspian Sea region by its littoral states and neighboring countries and the occurrence of two wars in the Persian Gulf region during the last two decades have made hydrocarbon pollution a major issue in the marine and coastal environments. Biodiversity is under threat in some areas and natural resources are deteriorating. To overcome these problems, Integrated Coastal Management has been considered by Iran's government as a long-term solution.

In Iran's Integrated Coastal Zone Management (ICZM) study project, baseline studies along with social, economic, and spatial planning studies in the coastal provinces are carried out in order to achieve the desired outcomes as a number of strategic plans for the coastal areas that are to be implemented by a coastal management entity. Providing the required laws and regulations for establishing such a management body is also underway.

1.2.6. Natural Hazards

In this section of the report, different natural hazards such as earthquake, forest fire, flood, drought, sand and dust storm are addressed. Iran is one of the most seismically active countries in the world, where several major fault lines cover at least 90% of the country. As a result, earthquakes often occur in Iran and are destructive. It is well known for its long history of disastrous earthquakes. Not only have these earthquakes killed thousands, but they have also destroyed valuable natural resources. Since 1900, at least 126,000 fatalities have been resulted by earthquakes in Iran.

Due to less precipitation and more droughts, fire in forests is growing. Even national parks suffer from this hazard. A community-based body has begun to extinguish forest fire in western forests through Small Grants Program/GEF[1]/UNDP[2] project. It has achieved considerable results by the locals.

Vast area of the country, 91 million ha, is prone to floods. More than 22 billion cm of runoff is created from foolds which leads to soil erosion. Annual average of soil erosion in basins is about 25-30 tons which is three-four time more than that of Asia and five-six time more than that of the world. Annual average sedimentation is 10 tons per ha in Iran though the world average is less than two tons. Degradation of the forests and vegetation, in general, is an essential factor of recent floods.

Drought is another natural hazard which is mostly emanated from decreasing precipitation. However, regarding to climatological information, what is happening in Iran is mainly related to management of the drought and water. It can be displayed in Uremia Lake. The impact of the drought is highlighted in the area around the central desert of the country where villagers have migrated. Increase of water consumption in cities during the summer and cautionary announcements of the Ministry of Energy have been a routine process.

Desert area is over 32.5 million ha and wind storm covers almost 20 million ha of the desert. Central and Eastern parts of the country are the main regions affected by sandstorm. Sistan and Baluchistan province is the area where mostly suffers from the sandstorm. Kerman and Hormozgan provinces are in the next ranks in the list of affected areas by the sandstorm, respectively.

Contrary to the sandstorm, dust storm disturbs mostly in western provinces. It originates mainly from Wadi areas of Iraq and Saudi Arabia as a result of degraded ponds. Dust storms last for few days and their impact is multifaceted.

1.3. Population, Labor force, and Human Development

1.3.1. Population

1.3.1.1. Population Trend

Population of Iran was more than 75 million in 2011 Census. Table 1.3 shows the trends of population since 1956. It indicates that after a period of high population growth rate, Iran has being experienced an era of lower population growth rate.

1 Global Environment Facility

2 United Nations Environment Program

Nearly one-fourth of Iranians are under 15 years of age. The country's post-revolutionary boom in births has slowed substantially, with a birth rate of 1.29%, slightly lower than the world average.

Internal migration from rural areas to cities was a major trend beginning in 1960s (some three-fifths of Iranians are defined as urban). Internally, migration to the cities has continued. In addition, Iran has absorbed large numbers of refugees from neighboring Afghanistan and Iraq.

Table (1.3): Population and Average Growth Rates 1956-2011

Year	Population	Average annual growth %
1956	18,954,704	-
1966	25,788,722	3,1
1976	33,708,744	2,7
1986	49,445,010	3,9
1991	55,837,163	2,5
1996	60,055,488	1,5
2006	70,495,782	1,6
2011	75,149,669	1,3

Source: Iranian Statistical Center

1.3.1.2. Life Expectancy

During 2006-2011, men life expectancy increased one year and reached to 72.1 years. During the same period, women life expectancy improved 1.5 year and extended to 74.6 years (Table 1.4).

Table (1.4): Life Expectancy by Gender (Years)

Year	2006		2011	
Sex	Men	Women	Men	Women
Life expectancy	71,1	73,1	72,1	74,6

Source: Iranian Statistical Center

1.3.1.3. Main Age Groups

Combination of main age groups has experienced a significant change (Table 1.5). During 45 years, proportion of 14 years old and less doubled. Meanwhile, share of the 15-64 years group increased significantly. In addition, population of the elderly group increased.

Table (1.5): Population of Main Age Groups 1976-2011

Year	0-14	15-64	65+
1976	23,4	70,9	5,7
1986	25,1	69,7	5,2
1996	39,5	56,1	4,3
2006	45,5	51,5	3
2011	44,5	52.00	3,5

Source: Iranian Statistical Center

1.3.1.4. Population Density

Population density has been increased by 200% during the past 55 years. Average density of the country was 46 individual per square kilometer in 2011 (Table 1.6). Tehran, Alborz, Mazandaran, and Gilan provinces have the highest density which are 471, 890, 177, and 129 persons per ha, respectively. Population density of 17 provinces is higher than that of national average. Such densities mainly located in the cities, along with unsustainable patterns of production and consumption, land use, water and waste which have triggered ecological disturbances.

Table (1.6): Population Density (Individual per Square Kilometer)

Year	Density
1956	21
1976	21
1986	30
1996	37.00
2006	43.00
2011	46.00

Source: Iranian Statistical Center

1.3.1.5. Urbanization

Share of urban population was 71.4% in 2011, with Tehran province, having the highest share of 16.2%. The number of cities was 201 in 1956 and reached to 1331 in 2011. Indeed, the number of cities increased considerably since 1996 from 612 to 1012, i.e. 40 cities annually (Table 1.7). At the same period, rural population decreased and its growth rate is negative now. This is due to the migration and conversion of big villages to cities. Population concentration in cities has many impacts and some of which can be aggravated by climate change.

Table (1.7): Number of Cities

Year	Cities
2011	1331
2006	1012
1996	612
1986	496
1976	373
1966	271
1956	201

Source: Iranian Statistical Center

Table (1.8): Labor Force in the Sectors (%)

Year	Agriculture	Industries	Services
2002	25	30	45
2003	23	30	47
2004	23	30	47
2005	25	30	45
2006	23	32	45
2007	23	32	45
2008	21	32	47
2009	21	32	47
2010	19	32	49
2011	19	33	48
2012	19	33	48

1.3.2. Labor Force

Roughly one-third of Iran's labour force is involved in manufacturing and construction. Almost one-fifth of the country's labor force is engaged in agriculture, and the remainder is involved in services, transportation and communication, and finance (Table 1.8). Meanwhile, some of the numerous refugees in the country have work permit.

At the national level, unemployment experienced fluctuations with a limited range (Table 1.9). However, it shows a mild increasing trend. Urban unemployment is higher than national rate but its trend is almost similar to national one. Rural unemployment is less than national rate; however, its increasing trend is more evident.

Table (1.9): Unemployment by Urban and Rural Areas (%)

Year	2006	2007	2008	2009	2010	2011	2012
National	11.3	10.5	10.4	11.9	13.5	12.3	12.1
Urban	13.4	12.5	12.0	13.5	15.3	13.7	13.8
Rural	7.1	6.6	7.2	8.3	9.1	8.9	8.2

Source: Iranian Statistical Center

1.3.3. Human Development Index, Participation, and Women

This index consists of three indicators of Gross Domestic Product (GDP), education, and life expectancy at birth. Iran's Human Development Index (HDI) was 0.67 in 1991 and It reached to 0.819 in 2009 (Table 1.10). Average annual growth rate was more than 1% which indicates a considerable improvement. The objective for HDI in 4th Development Plan almost was realized. For the first time in 2010, the Islamic Republic of Iran was placed in the category of "high human development countries". In 2010, it ranked as the 88th country and the first in South West Asia region.

Table (1.10): Objective and Performance Indicators of Human Development during the 4th Development Plan

Indicators	2005	2006	2007	2008	2009	2010
Objective	0.77	0.782	0.795	0.807	0.82	-*
Performance	0.777	0.784	0.792	0.795	0.804	0.819

**It was added to 4th Development Plan in 2010.*

Regarding regional indicators, Iran's social development indicators are high. Most of the HDI social indicators improved by government's efforts. In 2009, almost all children registered in elementary schools. Enrollment in high schools increased from 66% in 1990 to 84% in 2009. As a result, adolescent literacy ratio rose from 77% to 99% in the same period. Girls had a higher growth rates both in high schools and higher education.

Mortality rate decreased from 65 per 1000 live birth in 1990 to 27 in 2009. In addition, Iran's health indicators are higher than that of the region.

Participation is an ever growing phenomenon in Iran. As articulated in several articles of the Constitution, the government is obliged to secure the participation of the entire population in determining their political, economic, social, and cultural destiny.

Women's presence in the socio-political arena has increased since the Revolution and the Iranian government has tried to promote increased participation of women, even though a continuous shortage of female professionals and women's representation in key posts is evident where macro politics and planning are decided. Few indicators on women's participation are introduced. Based on the table 1.11, the indicators point to the growing rate of literacy among women so that it transcended the aims of 4th Development Plan. Proportion of the women employment increased as well.

Concerning the role of women in urban and rural societies, especially in culturalization and education of the children, they are considered as significant agents in awareness-raising and society participation. Not only is such a performance in accordance with climate change requirements, but also meets the development necessities. They can influence life style, especially consumption patterns. In fact, the experiences of Small Grants Program in Iran and many other developing countries confirm it.

Table (1.11): Key Indicators of Women Social Activities in the 4th Development Plan (%)

Indicators	2005	2006	2007	2008	2009	2010
Literacy rate	80.3	80.34	82.03	83.24	84.1	85.15
Economic participation rate	17	16.4	15.6	13.6	14.5	14.1
Share of women employment	8.12	12.5	11.6	10.5	9.9	12

1.4. Economic Structure

1.4.1. Economic Growth

Based on a study, Iran's economy has been ranked as the 17th largest economy in the world. Its GDP, in terms of purchasing power parity, was 906 billion US $ in 2010and reached to 929 $ in 2012. Wide industries of oil and gas sector, relatively small private bussinesses, and effective role of government in production and financial activities are the most important characteristics of Iranian economy. In 2010, share of service sector, including the government was 55% of GDP. Industiral, agricultural, and oil and gas sectors share of GDP were 22, 14, and 9%, respectively.

1.4.2. Gross Domestic Product

During 2005-2010, GDP rate fluctuated. In the first three years, economy experienced a growth due to high oil price and financial and monetary policies expansion. In addition, annual economic growth rate,including oil sector, was 6.2. However, in 2008, it decreased to less than 1% as a result of some monetary policies to control inflation and world economic crisis. In 2009, economic growth improved and its rate increased to 3%. Despite Western sanctions, economic growth rate reached to 5.8 in 2010 and per capita GDP was 7,253,000 IRR (approximately 726 USD) which shows a 4.4% growth compared with the base year.

1.4.3. Targeted Subsidies Law

The most important economic event was the Targeted Subsidy Law enacted in 2009 and has implemented since December 2010. Prior to this law, subsidies were indirect and it was about 77 billion US $, 27% of GDP, in 2007.

The goal of the subsidy reform has been to replace subsidies on food and energy (80% of total) with targeted social assistance, in accordance with Five Year Economic Development Plan and move towards free market prices in a 5-year period. According to the government, approximately 100 billion US $ per year is spent on subsidizing energy prices (45 billion US$ for the prices of fuel alone) and many consumable goods including bread, sugar, rice, cooking oil and medicine. On the other side, subsidies reduction will decrease air pollution by reducing car traffic in Tehran. Finally, the Subsidy Plan will increase social justice through targeted social assistance. Table 1.12 shows the first price increase.

Table (1.12): Fuel Prices before and after the Targeted Subsidies Law

Commodity (or service)	Old Price (as of 12/17/2010)	New Price/Increase (as of 12/18/2010)
Gasoline	10 cents/liter; 40 cents/liter (beyond 60 liters/month)	40 cents/liter; 70 cents/liter (beyond the quota, except for public service cars which receive a higher quota)
Diesel	$0.06/gallon	$0.6/gallon ($1.4/gallon on the open market)
Natural gas	1-1.3 cents/m^3 for households and 0.5 cents/m^3 for power plants	>500% price increase; on average 7 cents/m^3 for households and industry and 8 cents/m^3 for power plants
Compressed Natural Gas (CNG)	4 cents/m^3	30 cents/m^3
Electricity	1.6 cents/KWh	<300%
Water	9 cents/m^3	25–37 cents/m3; 300-400% increase (2,500 IRR/m3 or about 0.25 USD/m3 for household usage; 4,128 IRR/m^3 or 0.41 USD/m^3 for industrial usage)
Bread (loaf of brick oven bread)	5–20 cents; Wheat: 1 cent/kg	200% (40 cents); Wheat: 28–30 cents/kg. Price of bread increased again to 45 cents in April 2011

Source: Khaledi. M. Agricultural value chain Agriculture

1.4.4. Budget

Income from petroleum and natural gas exports typically provides the largest share of government revenues; however, this part of income varies with the fluctuations in world petroleum markets. Taxes include those on corporations and import duties.

During the 4th Development Plan, 2005-2010, the budget increase to the annual average rate of 19%. Average growth of income was 24% which was 2% lower than the plan's target.

\Share of the oil income in the first year of the plan, 2005, was 66.9% while the contribution of tax and other incomes were 33.1%. This ratio remained almost similar until 2008. But during the last two years, 2009 and 2010, share of oil income reduced to 56 and 47%, respectively. Share of tax income increased partly due to the implementation of the value added tax law and partly as a result of more tax collection.

1.4.5. Inflation

Comparison of the target and performance rates of inflation during 4th Development Plan indicates that the aim of the plan was not realized. In the first two years, 2005-2006, performance rates were less and equal to the target. But from the third year, actual inflation rate preceded the annual aims.

Inflation had a descending trend from 14.6 to 9.9% whereas the actual rate of inflation experienced an ascending trend, from 10.4 to 14.8%.

Among the main groups which make consumable commodities and services index price, share of the "foods and beverages" group was 32.8% in increasing price index of commodities and services. The effect of the second group price index including housing, water, electricity, gas, and other fuels, on the total price index was 31.8%. The effect of these two groups was 64%.

1.5. Sectors

1.5.1. Energy

Energy efficiency indicator has not changed significantly during 2001-2010. As shown in figure 1.1, the energy intensity fluctuated between 0.255 to 0.28 kg/2005 USD[1]. Despite policies and measures, national status of energy efficiency is still very low and needs more attention and efforts. The considerable decline in energy intensity in 2009 is a result of implementing the first stage of national energy subsidy removal plan[2].

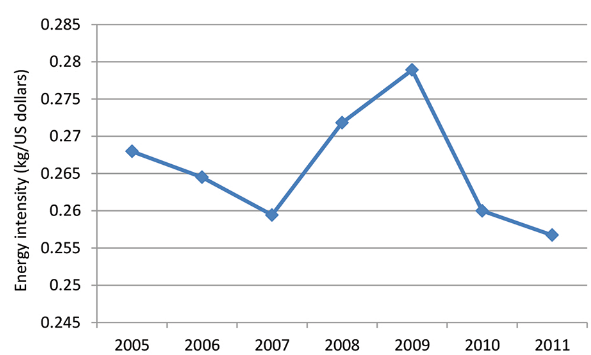


Figure (1.1): Energy Intensity in Iran. (Ref. IEA 2013, CO2 Emissions from Fuel Combustion)

In recent years, natural gas has dominated as the main source of energy carrier in national fuel mix. Substitution of liquid fuels with natural gas is one of the main policies to move towards low carbon economy in national economy-wide. Development of natural gas network was one of the priorities in the 3rd and 4th National

1 2005 Purchasing Power Parities

2 national targeted subsidies law

Development Plans and as a result of city gas network expansion, 320 cities were equipped with natural gas during 2004-2010. Total number of the cities with piped gas was 872. At the same period, 6,735 villages were equipped with piped gas. In fact, total number of villages with piped gas increased to 10,186.

The gap between production and consumption of gasoline in 2005 and 2006 increased to 25 and 30 million liters daily, respectively. However, by implementation of rationing, it was reduced to 19, 23, 21 and 17.6 million liters per day in 2007-2010. In addition, Gasoline consumption reduced from 67 million liter/day in 2005 to 61.3 million liter/day in 2010. Gasoil consumption increased from 79.4 million liter/day in 2005 to 95.4 million liter/day in 2010. Kerosine consumption reduced substantially from 20 million liter/day in 2005 to 14 million liter/day in 2010. Increase of natural gas utilization was the main cause of the reduction.

Electricity production was 223 billion kw/h in 2010, whereas it was 163 billion kw/h in 2004. On the utilization side, it was 124.5 billion kw/h in 2004 and reached to 84.2 in 2010. There are two main factors which affect electricity production: 1) technological needs of power plants to increase their efficiencies; 2) considerable electricity wastes, due to the obsolete transmission lines. As a result of urbanization, population growth, higher standard of living and development of business and industry, electricity consumption increased. Therefore, managing of consumption is of great importance.

Iran is rich in potentialities of renewable energies. Sun, wind, geothermal, and tidal energies are either under production or Research & Development (R&D). Development of renewable energies not only can improve the environment situation but also create many job opportunities. Nuclear power is another source of alternative energy. Government buys renewable energy at guaranteed prices in Iran in order to encourage its market. Iran has progressed significantly in its know-how and has planned to develop its applications in different peaceful fields. Energy prices increased markedly after December 2010. Although prices mentioned in table 1.13 are in IRR, the increases are very evident.

Table (1.13): Prices of Fuel Products before and after the Targeted Subsidies Law (IRR)

Year / Products	2010				2011
	Before TSL[1]		After TSL		
	Quota	Non quota	Quota	Non quota	
Regular gasoline	1,000	4,000	4,000	7,000	1000,4000,7000
Super gasoline	1,500	5,400	5,000	8.000	1500, 5000, 8000
Kerosene	165		1,000		1000
gasoil	165		1500,3500		1500,3500
Mazut	94.5		2000		2000
Liquid gas	57.2		1800, 4860, 5400		1800, 4860, 5400

1.5.2. Water

This sector is characterized by a wide discrepancy in coverage of water and sewerage services, as well as between urban and rural areas. According to related estimates, in 2011, access to an improved source of water supply was 98% in urban areas where more than two thirds of Iranians live and the mentioned value in rural areas was 90% (87% house abutments). Access to sewerage in urban areas was estimated at 19% in the late 1990s and access to improved sanitation was estimated at close to 100%.

The total water withdrawal was estimated at about 70 billion m3 in 1993, rising to 93 billion m3 in 2004, of which 91.5% was used for agriculture and aquaculture purposes and 6.5% and 2% for urban and rural water supply and industry and mining, respectively. Although, this is equal to 51% of the actual available renewable water resources, annual abstraction from aquifers is already more than the estimated safe yield (46 billion m3). Of the 4.3 billion m3/year in 1993 (6.2 in 2004) used for domestic purposes, 61% is supplied from surface water and 39% from groundwater.

Water harvesting has been reported at around 104 billion m3 which is approaching to the limit of renewable water resources (130 billion m3). In other words, 80% of water potential is consumed. However, for ecological sustainability 40% is recommended. More than 55% of the water consumption (60 billion m3) is provided through groundwater. While maximum capacity of this resource is 50 billion m3, drop in water level and negative balance of reservoirs are due to this kind of unsustainable consumption pattern.

Unsustainable water harvesting lessened ground water quality and caused conveyance of salty water to surface soils. This has led to intensification of soil salinity, reduction of productivity, farming pattern change, and consequently migration of farmers. According to the World Bank, economic value of water efficiency in Iran is US 20 cents for one m3 water while world average is 1 US $. The whole situation points to inefficient water management exacerbating water shortage.

1.5.3. Agriculture

Regarding the oil and gas share, agriculture contributed to 8.9-10.8% of the Gross National Product (GNP) during 2004-2010. Excluding oil effect, its share of GDP increases to 12-14%. Nearby 20 % of the national labor force has been employed in agriculture sector, excluding oil contribution on GNP (Table 1.14). About 11% of Iran's land is used for agriculture. Some northern and western areas support rain-fed agriculture, while others mostly require irrigation.

Table (1.14): Share of Agricultural Sector of GDP with and without Oil 2004-2010 (%)

Year	2004	2005	2006	2007	2008	2009	2010
Including oil	10.8	9.3	9.2	9.4	8.9	10.3	10.2
Excluding oil	14.2	12.9	12.6	13.0	12.0	12.9	13.1

Source: Central Bank of Iran

Acreage of cucurbits, vegetables, fodder, gardens, and industrial products are fundamentally irrigation based and their shares are between 95.3-81.3%. Grains and legumes are typically rain fed land (79.8 and 55.3%, respectively). Regarding the production, irrigation is more than the rain fed except for legumes.

Construction of multipurpose dams and reservoirs along rivers in the Zagros and Alborz mountains has increased the amount of water available for irrigation. Agricultural production is increasing as a result of modernization, mechanization, improvements of crops and livestock as well as land redistribution programs. Iran is the world's largest producer of saffron, pistachios and berries and the second largest date producer. Since the 1979 revolution commercial farming has replaced subsistence farming as the dominant mode of agricultural production. By 1997, the gross value reached to $25 billion. General self-sufficiency in agriculture has been estimated around 85%. In terms of products, Iran is self-sufficient in some of them such as vegetables and fruits and relatively dependent on some others such as wheat and rice. In the case of meats, especially poultry, it seems that Iran is almost self-sufficient.

In 2007, Iran reached self-sufficiency in wheat production and for the first time became a net wheat exporter. In 2008 and 2009, cold weather and drought has caused substantial decline in agricultural production. In addition, low precipitation has drawn more consideration to the importance of efficient water management and regional compatible farming.

By 2003, a quarter of Iran's non-oil exports were of agricultural products, including fresh and dried fruits, nuts, animal hides, processed foods, and spices. Iran exported 736 million US$ worth of foodstuff in 2007 and 1 billion US$ (~600,000 tons) in 2010. A total of 12,198 factories are engaged in the Iranian food industry, i.e. 12% of all factories in the industry sector. The sector also employs approximately 328,000 people or 16.1% of the workforce of entire industry sector. Table 1.15 shows Iranian agricultural products listed according to the largest global producer rankings in 2011.

Table (1.15): Ranks of Agricultural Products of Iran 2011

Ranks	Products
1	Berries, nes; Fruit, stone, nes; Pistachio
2	Dates
3	Cucumbers; eggplant; Melons; walnuts with shell; Watermelon
4	Fruit, fresh, nes; Pumpkin and squash;
5	Figs; Onion, dry;
6	Cherries, sour; Almond with shell; Lettuce; Vegetable, fresh;
7	Chick peas; Hazelnuts with shell; Peaches and nectarine; Spinach; Tomatoes;
8	Apples; Mushrooms; Tangerine, Mandarins, clementine; Tea
9	Grapes; Lemon, lime;
11	Asparagus; Lentil; Pulses, nes;
12	Orange;
13	Potatoes; Sugar beets;
14	Bean, green; Safflower
15	Garlic
16	Wheat
18	Carrots and turnips; Fruit, citrus
20	Cabbage and other brassicas
23	Cotton seed
27	Cauliflower and broccoli

Source: FAO

Comparison of the important crops yields such as wheat, rice, tomatoes and maize indicates that there is potentiality to increase the products. According to official data, close to 20% of the production is lost from farm to the end use which is the food of 15 to 20 million individuals.

In two separate studies, economic effects of climate change on wheat and corn and its impacts on the farmers' income were investigated. Results indicated that temperature increase and rain decrease would cause 41% decline in wheat output or 777,000 IRR (approximately 77.8 USD) decline per hectare. For corn, output decline was 29% or 584,000 IRR (approximately 54.9 USD) decline per hectare.

1.5.4. Industry

Shares of industrial sector in GDP with and without oil are shown in table 1.16. With oil's share in GDP, industrial share of GDP was 18-19.5% during 2004 to 2010 which reflects an increasing trend. Regardless of oil, its share rose by 5.7% and reached to a quarter of GDP in 2010 (Table 1.16). All indicators point to the second rank of industry in economy. According to a report by the Economist, Iran has been ranked 39th by producing 23 billion US$ of industrial products in 2008. From 2008 to 2009 Iran has leaped to 28th place from 69th place in annual industrial production growth rate. The government of Iran has plans for the establishment of 50-60 industrial parks by the end of the fifth Five-Year National Socioeconomic Development Plan, by 2015. Small industries constitute 92% of Iranian industries, 45% of the country's industrial employment, and 17% of the country's production. Over the past years, Iran has progressed rapidly in various scientific and technological fields. Major advancements have taken place in the petrochemical, pharmaceutical, aerospace, defense, and heavy industry sectors.

Iran's oil and gas industry is the most active industry cluster of the country. Iran has the fourth largest reserves of oil and second largest reserves of gas in the world. Iran's automotive industry is one of the most active industries of the country, after oil and gas industry. Iran's automobile production crossed production of one million cars in 2005.

Construction is one of the most important sectors in Iran, accounting for 20 to 50% of the total private investment. The Central Bank of Iran indicates that 70% of the Iranians own homes. The housing industry is one of the few segments of the Iranian economy where state capital shares as little as two per cent of the market, and the remaining 98% is private sector investment.

Table (1.16): Share of Industrial Sector of GDP with and without Oil 2004-2010 (%)

Year	2004	2005	2006	2007	2008	2009	2010
With oil	18.1	17.5	17.6	17.5	18.7	18.4	19.5
Without oil	23.8	24.3	24.1	24.3	25.0	23.1	25.2

Source: Central Bank of Iran

Trend of industrial value added growth rate reflects fluctuation during 2003-2011. The lowest growth rate was in 2009 and the highest was in 2003 and 2006. In addition, Labor productivity shows a similar trend (Tables 1.17 and 1.18).

able (1.17): Trends of Value Added of Industrial Units with 10 Employees and More (2003-2011)

Year	Value added growth rate (%)
2003	29.4
2004	27.3
2005	14.8
2006	29.4
2007	29.2
2008	17.3
2009	3
2010	17.5
2011	26.2

Source: Central Bank of Iran

Table (1.18): Labor Productivity of Industrial Units with 10 Employees and More (2003-2010)

Year	Labor productivity (IRR)	Growth rate (%)
2003	131,220	
2004	168,356	28.3
2005	196,172	16.5
2006	251,450	28.2
2007	306,621	21.9
2008	323,581	5.5
2009	336,202	3.9
2010	396,945	18.1

Number of active mines was 3125 in 2003 and it reached to 4426 in 2009. Energy efficiency has an increasing trend during 2002-2006 (Tables 1.19 and 1.20).

Table (1.19): Mines Energy Efficiency (2002-2006)

Year	Energy efficiency (%)
2002	19.3
2003	16
2004	15
2005	42
2006	28.5

Source: Central Bank of Iran

Table (1.20): Mines Value Added Growth Rate (2003-2009)

Year	Value added growth rate (%)
2003	-
2004	67.0
2005	40.1
2006	23.4
2007	42.4
2008	16.9
2009	-3.9

Source: Central Bank of Iran

1.5.5. Transportation

Iran has an extensive paved road system linking all cities and towns. In 2011, the country had approximately 195000 kilometers roads, including freeways, highways, main roads, by-way roads, and rural roads and there were approximately 200 cars for every 1000 inhabitants. Trains operated on 8169 kilometers of track. The country's major port of entry is Bandar-Abbas on the Strait of Hormuz. Imported goods are distributed by trucks and freight trains. Other major ports include Bandar Anzali and Bandar Turkmen on the Caspian Sea, and Khorramshahr and Bandar Imam Khomeini on the Persian Gulf.

Most of provincial capitals have passenger and cargo airports. All large cities have bus transit systems and private companies provide intercity bus services. Tehran and Mashhad have underground railways. Shiraz, Tabriz, Ahvaz and Isfahan are constructing underground railways. More than one million people work in the transportation sector, accounting for more than 10% of 2010 GDP.

Considering the quantity and quality of roads, railways, and air fleet, the transportation sector is one of the main sources of GHG emission. More than 90% of passengers and cargoes are moving through road transportation. Road transportation is of great importance in Iran which has led to high emission considering the scattering of agricultural and industrial services, religious and touristic centers, population unbalanced dispersion and constrains of railways and air fleets.

There are considerable number of vehicles which have been planned to be replaced by the new ones due to fuel consumption and environmental issues. However, it should be accelerated to keep up with the increasing number of worn-out cars.

1.5.6. Health

The constitution entitles Iranians to basic health care. By 2008, 73% of Iranians were covered by the voluntary national health insurance system. Although over 85% of the population uses an insurance system to cover their medication expenses, the government heavily subsidizes pharmaceutical production and importation. The total market value of Iran’s health and medical sector was estimated to be 24 billion US $ in 2002 and to rise to 50 billion US $ by 2013. In 2006, 55 pharmaceutical companies in Iran produced 96% (quantitatively) of the medicines for a market worth 1.2 billion US $. This figure is projected to increase to 3.65 billion US $ by 2013. It is estimated that health care spending is 4.2% of GDP. Paragraph 19 of the General Policies of the Fifth Economic, Social, and Cultural Development Plan declares,” emphasizing every facet of a lifestyle of a healthy citizen:

- Raising indicators of clean air, safe food and environment, and physical and mental health;
- Reducing health-threatening pollution; and
- Enhancing the nutrition pattern by improving the food composition and its soundness.

According to Ministry of Health and Medical Education, there were 1.32 physicians for every 1000 of population. Ratio increased by 0.02% in 2010. On the contrary, increase of dentists was prominent, from 2.7 doctors per 10,000 populations in 2005 to 7.9 doctors per 10,000 population in 2011.

1.6. Environment

1.6.1. Environment and Climate Change

Iranian habitats support about 8000 species of flowering plants (belonging to 167 families and 1200 genera), of which almost 1700 are endemic. These plant species growing on four Ecological Zones have different physiographical and climatic conditions. These four ecological zones are Hyrcanian, Zagross, Iran-o-Turanian (Plains and Mountain), and Khalij-o-Ommanian. They support specific plant species. Most of Iranian territory is located in the Iran-o-Turanian zone.

Although more than 10,000 plant species have been identified in Iran, the natural vegetation in most of the country has been threatened by land use conversion. Natural forests consisting of beech, oak, other deciduous trees, and conifers grow in parts of the Alborz Mountains. Some regions of higher elevation in the Zagros Mountains contain wooded areas consisting primarily of oak. Wild fruit trees, including almond, pear, pomegranate, and walnut, grow in both the Alborz and Zagros mountain ranges. In the more arid central part of the country, wild pistachio and other drought-resistant trees grow in areas that have not been disturbed by human activity. Tamarisk and other salt-tolerant bushes grow along the margins of the Dasht-e Kavir.

A wide variety of native mammals, reptiles, birds, and insects inhabit in Iran. Many species of mammals—including wolves, foxes, bears, mountain goats, red mountain sheep, rabbits, and gerbils—continue to thrive. Others—including Caspian tigers, Caspian seals, desert onagers, three species of deer, gazelles, and lynx—are endangered despite the establishment of special wildlife refuge areas and other government programs initiated to protect them. Some 502 species of birds inhabit in Iran and more than 200 species are migratory birds that spend part of the year in other countries. Paragraph 19 of the General Policies of the Fifth Economic, Social, and Cultural Development Plan declares," Emphasizing every facet of a lifestyle of a healthy citizen:

- Unity in setting policy, planning, evaluation, supervision, and allocating public resources;
- Raising indicators of clean air, safe food and environment, and physical and mental health.
- Reducing health-threatening pollution.

1.7. Framework for Preparation of the National Communication and Institutional Arrangement

1.7.1. The Framework for Preparation of the National Communication

The National Communication of the Islamic Republic of Iran to the United Nations Framework Convention on Climate Change (UNFCCC) is prepared by the National Climate Change Office of the Department of Environment, in cooperation with other ministries and governmental administrative organizations, consultancy of private experts and academicians and under the supervision of the Steering Committee (see the chart in Annex). The following working groups were responsible for preparing different chapters of the report:

1. National Circumstances;
2. National Greenhouse Gases Inventory;
3. Greenhouse Gases Mitigation Policies;
4. Vulnerability and Adaptation;
5. Mitigation Policies and Economic Diversification;
6. Conducting the Needs for Monitoring and Observing Network, and Climate Change Researches;
7. Conducting the Technological Needs;
8. Education and Public Awareness Planning;

and

9. Integration and Preparation of National Action Plan.

After preparing the draft of reports by working groups, the results were finalized in the Steering Committee. In order to improve the current processes of the national report preparation and to enhance the participation of all governmental offices and relevant ministries, the non-centralized preparation approach was conducted. In the new approach, the National Climate Change Office, as a coordinator, was the presenter of all instructions and procedures and finally integrator of activities, in which data collection and studies were conducted by relevant government offices and ministries, under the consultancy of private experts and academicians. The other necessary reform is related to the action plans. Due to synchronicity in the preparation of the 5th Five-Year Development Plan (FYDP) and the Second National Communication, it is expected that the national strategies and macro policies of climate change be considered in National Development Plans.

1.7.2. Institutional Arrangement

Examination of institutional arrangement is of great importance to implement two main strategies of the Climate Change Convention. To overcome the adverse effects of climate change, the "necessary institution" should include three proper pillars of law and regulation, policy, and organization. Such an institutional arrangement is combined of goals and policies; rules and regulations; organizations and budget, their mandates and values; operational programs and procedures; incentives, and accountability.

It should be mentioned that there are interrelations among various aspects of the institutional arrangement. For example, laws support policies; on the other hand, implementation of a policy can strengthen the existing law or leads to a new legislation. Law and policy provide conducive environment for the activities of organizations.

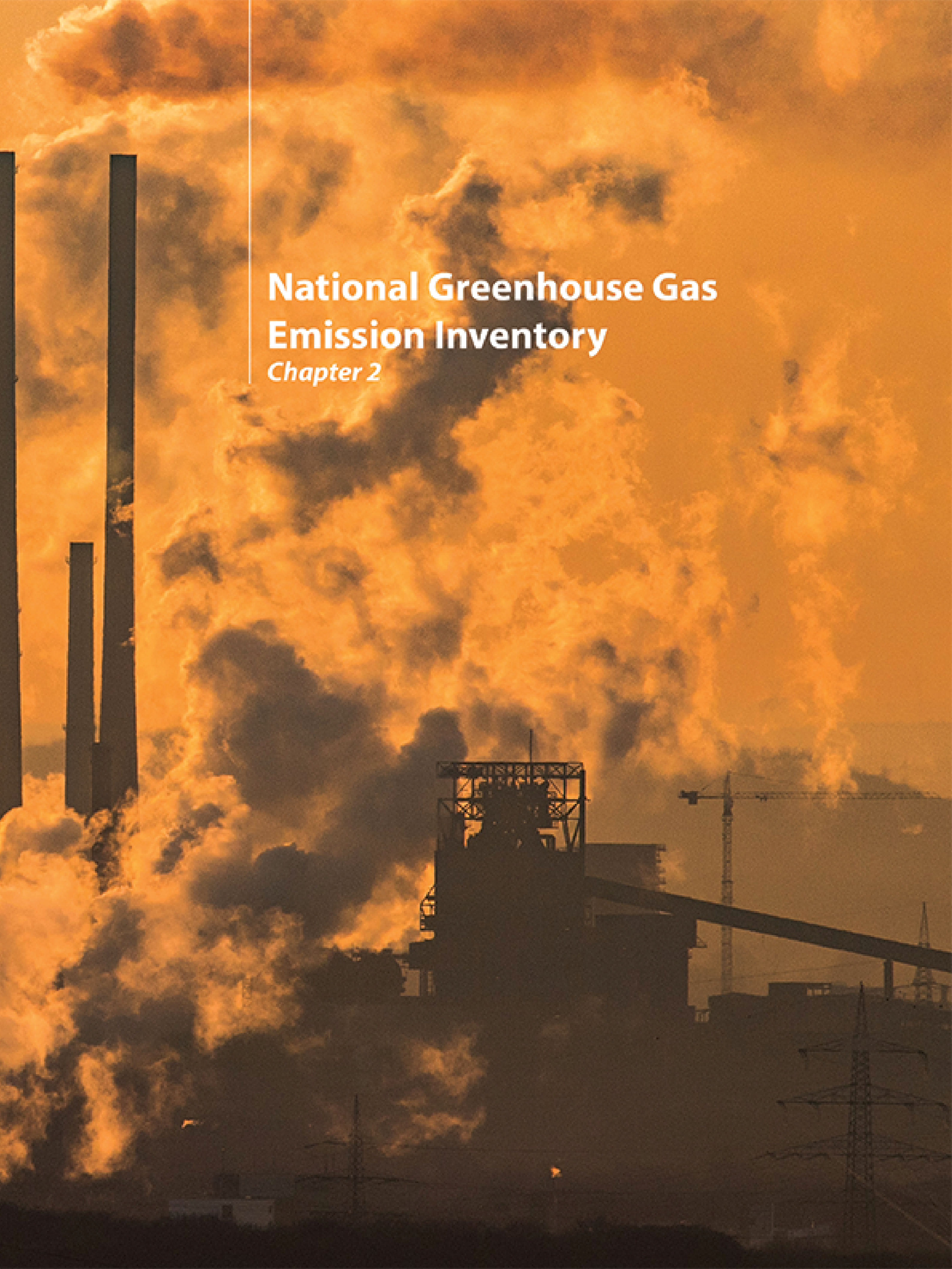
To achieve objectives of the Climate Change Convention in Iran, each aspect of its institutional arrangement should develop effective capacity so that, in general, both strategies of the convention can be realized. Regarding laws and regulations, there is suitable strategy to commence required activities.

The second facet pertains to policies. There are both sectoral and inter sectoral policies such as optimization of the water consumption and locally suitable farming pattern. If these policies are carried out, to a large extent, reduction of greenhouse gas (GHG) emissions and adaptation to climate change effects would be definitely accomplished.

Third pillar is organizational arrangement which encompasses Government Organizations and National Geographic Organization (NGOs). They refer to the individual level (mainly consisting of managers and experts), organizational properties, and interactions among organizations. The lack of necessary capacities in this pillar is considered as one of the main impediments to efficient implementation of the existing laws and policies in the country. Therefore, capacity development together with awareness raising among various stakeholders regarding economic valuation of climate change effects in the country are of great importance to implementation of the Climate Change Convention and facilitation of required measures in this context.

National Greenhouse Gas Emission Inventory

Chapter 2



2.1. Overview

The chapter which contains national Greenhouse Gas (GHG) emission inventory has been prepared based on the available data for the year 2010 for the purpose of Iran's Third National Communication to UNFCCC[1]. In preparing this inventory, the National Climate Change Office of Iran has experienced extreme difficulties in obtaining the Activity Data (AD) required for calculation of emissions as based on IPCC[2] 2006 Guidelines. Consequently, extensive work will be needed in the future to improve the quality of AD and development of local Emission Factors (EF). According to National Rules of Procedure for the Implementation of UNFCCC/KP[3], it is planned the collection of AD and preparation of the sector-by-sector inventory to be undertaken by relevant organizations in preparing future national communications. Furthermore, based on the result of the inventory, it was observed that there is a greater uncertainty vis-à-vis the data gathered on the agriculture and forestry sector, which needs real improvement in future inventories. Also there is large uncertainty in EF for fugitive emissions resulting from oil and gas activities, which needs extensive work for development of local EFs.

The summary of direct GHGs inventory in Iran is shown in table 2.1. As it is evident from this table and figure 2.1, the total CO_2 emissions from different sectors in 2010 is about 668,575 Gg, with the energy sector contributing about 88% of the total emissions and industrial processes and forestry contributing about 9% and 3%, respectively. The total CO_2 equivalent emission is estimated to be about 832,043 Gg in 2010. As shown in figure 2.2, the energy sector has the largest share of 81% and the forestry and waste sector has the lowest share of 3% in overall GHG emissions. An important point is that the forestry sector with its contribution of 3% to CO_2 emissions has itself evolved into a source of emission.

1 United Nation Framework Convention on Climate Change
2 Intergovernmental Panel on Climate Change
3 Kyoto Protocol

Table (2.1): Summary of GHG Emissions Inventory (Gg) for all Sub-sectors in 2010

Gases / Emission Sources	CO_2	CH_4	N_2O	HFCs	SF_6	CF_4	C_2F_6
1. Energy	**584,561.3**	**4,005.2**	**4.4**				
Fuel Combustion	**543,679.3**	**71.1**	**4.4**				
Energy Industries	182,378	2.6	0.9				
Manufacturing Industries & Construction	93,476.0	2.3	0.3				
Transport	125,271.0	47.8	2.6				
Residential Buildings	106,838.1	16.2	0.4				
Commercial & Institutional Buildings	22,116.2	1.2	0.1				
Agriculture, Forestry & Fishing	13,600.1	1.0	0.1				
Fugitive Emissions	**40,882.0**	**3,934.1**	**0.0**				
Solid Fuels	-	14.1					
Oil and Natural Gas	40,882.0	3,920.0					
2. Industrial Processes and Product Use (IPPU)	**61,857.3**	**33.2**	**1.9**	**0.3**	**0.006**	**0.6**	**0.04**
Mineral Production	34,432.8	-	-				
Chemical Production	9,885.4	28.5	1.9				
Metal Production	12,090.6	4.8	-			0.6	0.04
Other	5,448.4	-	-	0.3	0.006		
3. Agriculture	**598.8**	**984.6**	**76.3**				
Enteric Fermentation	-	886.2	0.0				
Manure Management	-	35.4	13.2				
Rice Cultivation	-	44.5	0.0				
Agricultural Soils	-	0.0	62.5				
Agricultural Residues Burning	-	18.6	0.5				
Urea Application	598.8	-	-				
4. Forestry	**21,528.6**	**0.8**	**0.1**				
Change in Biomass Stocks in Forest Land Remaining Forest	-3,959.0						
Land Conversion	25,428.7						
Biomass Burning	58.9	0.8	0.1				
5. Waste	**29.0**	**1,308.2**	**1.3**				
Solid Waste	29.0	27.2	0.0				
Solid Waste Disposal Site (SWDS)	0.0	23.0	0.0				
Biological Treatment	0.0	0.0	0.0				
Open Burning	29.0	4.2	0.0				
Liquid Waste Sector	0.0	1,281.0	1.3				
Domestic Wastewater	0.0	110.0	1.3				
Industrial Wastewater	0.0	1,171.0	0.0				
Total GHG Emissions	**668,575.0**	**6,332.1**	**83.9**	**0.3**	**0.006**	**0.6**	**0.04**
Global Warming Potential (GWP)	1	21	310	1,300	22,200	5,700	11,900
Total CO_2 Equivalent	**668,575.0**	**132,973.7**	**26,023.3**	**442.0**	**133.2**	**3,420.0**	**476.0**

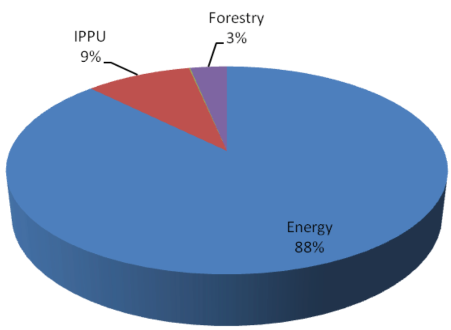


Figure (2.1): Share of Different Sectors in CO_2 Emissions in 2010

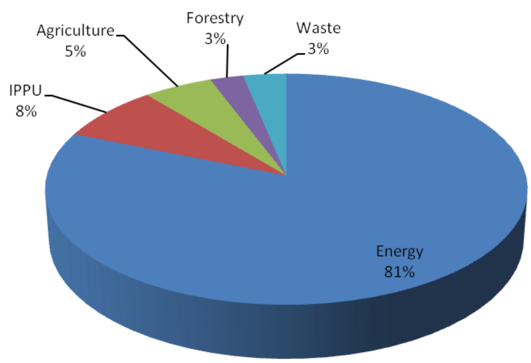


Figure (2.2): Contribution of Different Sectors to total CO_2 Equivalent Emissions in 2010

2.2. Energy

Energy sector is the most important and the largest sector contributing to the inventory of greenhouse gasses in Iran. In order to estimate greenhouse gasses emission including CO_2, CH_4 and N_2O, estimates and calculations have been done using "IPCC 2006 software".

Fuel consumption statistics are adopted from National Energy and Hydrocarbon Balance and EFs are mostly extracted from the "IPCC 2006 guidelines". GHG emissions from fuel combustion have been calculated based on different fuel type's consumption and EFs for different fuels.

2.2.1. GHG Emissions from the Energy Sector

Emissions of direct greenhouse gases CO_2, CH4, N_2O are estimated based on the statistics of AD for the year 2010.

For calculating CO_2 emissions, considering the amount of fuel consumption in the sector and the carbon EF, first the carbon content of the fuel is calculated. Then the specific net and actual carbon emission and the actual CO_2 emission are calculated (in accordance with IPCC 2006 Guidelines tier 1 EFs). In Iran, CO_2 not only comes from fuel combustion, but also the country suffers from significant amounts of CO_2, as fugitive emission, as a result of upstream flaring in oil and gas industry.

The combustive emissions of other greenhouse gases (CH4, N_2O) are calculated considering the amount of fuel consumption and the gas EF. Besides, fugitive CH4 emissions are also estimated due to oil and gas activities. Also, IPCC tier 1 EFs were used to calculate GHGs emission for non-CO_2 gases.

2.2.1.1. CO_2 Emission from Fuel Combustion

Total emission of CO_2 in Iran energy sector in the year 2010 is estimated about 584,561 Gg[1]. 543,679 Gg of this amount comes from fuel combustion and 40,882 Gg from upstream

1 Total CO2 emissions from fuel combustion and fugitive emission

flaring in oil and gas activities which is regarded as fugitive emission according to "IPCC 2006 Guidelines". CO_2 emission in the energy sub-sectors is calculated based on fuel consumption. The highest contribution to CO_2 emission is related to energy industries sectors with 34% of emission, followed by transport, residential, manufacturing industries and construction, commercial and institutional buildings and agriculture, forestry and fishing sectors with shares of 23%, 20%, 17%, 4% and 2% respectively. Table 2.2 and figure 2.3 show emissions and contribution of energy subsectors to CO_2 emissions in the year 2010.

Table (2.2): CO_2 Emissions from Fuel Combustion (Gg) in Energy Sub-sectors in 2010

Emission Sources	CO_2
Industries Energy	182,378
Manufacturing Industries & Construction	93,476
Transport	125,271
Residential	106,838
Commercial & Institutional	22,116
Fishing Agriculture, Forestry	13,600
Total	**543,679**

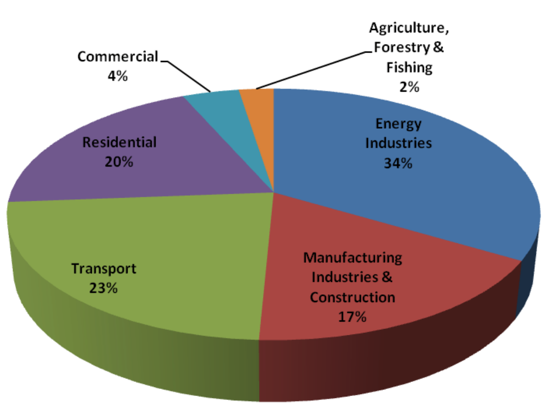


Figure (2.3): Contribution of Different Energy Sub-sectors to CO_2 Emissions in 2010

2.2.1.2. CH_4 Emission

Total emission of CH_4 in 2010 from the energy sector of Iran was 4,005 Gg. This emission was calculated from fuel combustion activities and fugitive emissions. Emissions in these two sectors were estimated as 71 Gg and 3,934 Gg, respectively. A comparison of CH_4 emission in different sub-sectors shows that fugitive emission is responsible for 98.2% of total CH_4 emissions, while the share of fuel combustion is 1.8%. Therefore, the most CH_4 emission in the energy sector is related to fugitive emissions from oil and natural gas activities with 3,920 Gg. CH_4 emissions from solid fuels are estimated to be only 14 Gg. Table 2.3 shows the contribution of different energy sub-sectors in CH_4 emissions.

Table (2.3): CH_4 Emissions (Gg) from Fuel Combustion and Fugitive Emissions in 2010

Emission Sources	CH_4
Fuel combustion	**71**
Energy Industries	3.0
Manufacturing Industries & Construction	2.0
Transport	48.0
Residential Buildings	16.0
Commercial & Institutional Buildings	1.0
Agriculture, Forestry Fishing	1.0
Fugitive Emissions	**3,934**
Coal Mining	14.1
Oil and Natural Gas Activities	3,920
Total Emission	**4,005**

2.2.1.3. N_2O Emission

The total emission of N_2O from the energy sector is estimated at about 4.4 Gg, with the highest contribution of 59.1% attributed to the transport sector. Energy industries, residential, manufacturing industries and construction, commercial and institutional buildings and agriculture, forestry and fishery sectors contribute 19.5%, 9.5%, 7.7%, 2.3% and 2.3% of emission of N_2O, respectively. Table 2.5 shows the amount and contribution of different energy sub-sectors on N_2O emission.

Table (2.5): N_2O Emissions (Gg) in Energy-Consuming Sectors in 2010

Emission Sources	Emissions (Gg)	Share (%)
Energy Industries	0.86	19.5
Manufacturing Industries & Construction	0.34	7.7
Transport	2.6	59.1
Commercial & Institutional	0.1	2.3
Residential	0.42	9.5
Agriculture, Forestry & Fishing	0. 1	2.3
Total	**4.4**	**100**

2.2.3. Summary of the Energy Sector

Total GHG emissions from energy sub-sectors in 2010 are shown in table 2.6. Taking GWP of CH_4 and N_2O into account, the total GHG effect of energy sector was 670,028 Gg CO_2-eq.

Table (2.6): Total Emission of Greenhouse Gasses (Gg) from Energy Sector in 2010

Emission Sources	CO_2	CH_4	N_2O
Fuel combustion	**543,679**	**71**	**4.4**
Energy Industries	182,378	2.6	0.86
Manufacturing Industries & Construction	93,476	2.0	0.34
Transport	125,271	48.0	2.60
Residential	106,838	16.0	0.10
Commercial & Institutional	22,116	1.0	0.42
Agriculture, Forestry Fishing	13,600	1.0	0.10
Fugitive Emissions	**40,882**	**3,934**	**0.0**
Coal Mining		14	0.0
Oil and natural gas Activities	40,882	3,920	0.0
Total GHGs Emission	**584,561**	**4,005**	**4.4**
GWP	1	21	310
Total CO_2eq.	**584,561**	**84,098**	**1,370**

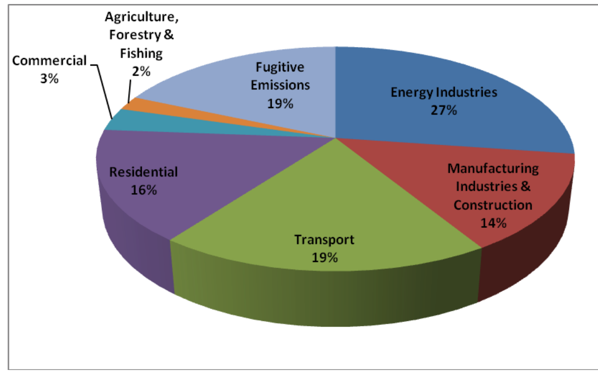


Figure (2.4): Contribution of Different Energy Sub-sectors to total GHG Emissions in 2010 (CO2 eq.)

Also, figure 2.4 shows the contribution of different energy sub-sectors on total CO_2 eq. emission. As is shown in the figure, energy industries and fugitive emissions with 27% and 19% are the largest GHGs emitters, while commercial & institutional buildings and agriculture, forestry and fishing with 3% and 2%, respectively are the lowest emitters.

2.2.4. Gap Analysis

In fact, this is our first experience to work with IPCC 2006 Guidelines. As to making our national data structure fully compatible with IPCC 2006 Guidelines, the following barriers were identified:

- No data available in transport sector, separately for subsectors and different types of cars.
- No energy consumption data available in agriculture sector, individually in mobile and non-mobile sources.
- No data available in industrial sector separately for subsectors in national energy

balances.

- Lack of statistics on energy consumption for sea and air transportation, nationally and internationally.

- National EFs not available in most of the energy sub-sectors.

2.3. Industrial Processes and Product Use (IPPU)

Many of the industrial processes classified in the IPCC 2006 Guidelines, such as iron and steel, cement, aluminum, pulp and paper, petrochemicals, textile, etc, exist in Iran. Greenhouse gasses are emitted through production and/or consumption of raw materials in some of industrial processes. These processes mainly lie within some of country's most critical industries including mineral, chemical and metal industries. Although in these processes, many different greenhouse gases are released to the atmosphere, here we have only calculated direct GHGs (CO_2, CH_4, N_2O, HFCs, PFCs and SF6) which are emanating from industrial processes and activities in the country.

2.3.1. GHG Emissions from Industrial Processes

Due to lack of national EFs, except for the emissions from cement production using clinker data, the values suggested by IPCC 2006 Guideline Tier 1 EFs have been used in the preparation of emission inventory.

2.3.1.1. CO_2 Emissions

Major CO_2 producing sources in Iran's industrial processes lie within mineral, chemical and metal industries, along with the use of non-energy products like lubricants. Table 2.7 shows associated CO_2 emissions from these activities.

Table (2.7): Summary of CO_2 Emission from Different Sources

Emission Sources	CO_2 Emission (Gg)
Mineral Industry	34,432.8
Chemical Industry	9,885.4
Metal Industry	12,090.6
Other (Non- Energy Products from Fuels and Solvent Use)	5,448.4
Total	**61,857.2**

Figure 2.5 shows the contribution of different sources of CO_2 emissions from IPPU.

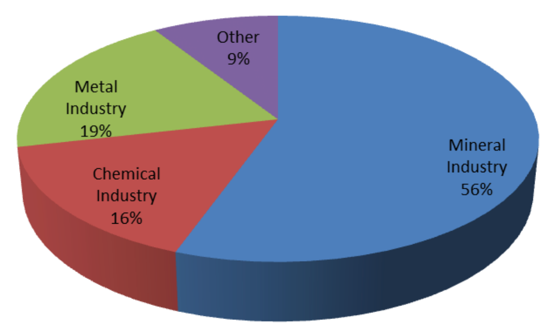


Figure (2.5): Contribution of Different Sources to CO_2 Emissions from IPPU

In chemical industry, ethylene, ammonia and methanol with emissions of 5,657 Gg, 3,001 and 1,227.6 Gg respectively, are three products that CO_2 is produced as a result of their production process. Out of 12,090.6 Gg CO_2 emissions in metal industries, about 10,166 Gg is due to Iron and steel production, 1,517.4 Gg due to aluminum production and the rest goes for other ferroalloys.

Figure 2.6 shows the process-based CO_2 emissions from mineral, chemical and metal industries which are obtained from Iran's past two National Communications.

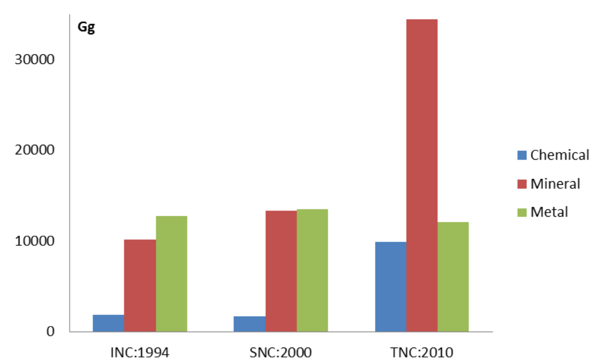


Figure (2.6): Comparison of three National Communications in Process-based CO_2 Emissions

With about 34,432.8 Gg of CO_2 emissions, mineral industries are the most significant source of process-based CO_2 emissions. Corresponding value of CO_2 emission from mineral industries was about 13,300 Gg in 2000 which shows a remarkable increase. Such growth is attributed to the huge boost in the cement production capacity of the country. On the other hand, CO_2 emission from metal industries has decreased in 2010 compared to 2000 figures. The reason is that the structure of iron and steel industry has been shifted from Basic Oxygen Furnace (BOF) steelmaking to Electric Arc Furnace (EAF) during the last decade, which in turn is a result of access to cheaper natural gas. Chemical industries that emitted approximately 1,740 Gg of CO_2 in 2000 are ranked third in the table 2.11 with the value of 9,885.4 Gg of CO_2 in 2010. Again there is a very large gap between 2000 and 2010 calculated values. This is due to two reasons: the first is that Iran has expanded its petrochemical capacity (mainly ammonia production sites) since 2000 and the second reason concerns the methodological revisions made in IPCC 2006 Guidelines concerning the calculation of CO_2 (and of course CH_4) emissions from petrochemical and carbon black production.

2.3.1.2. CH_4 and N_2O Emissions

CH_4 emissions are from two major sources: chemical and metal industries. Table 2.8 shows CH_4 emissions from these two sources which together emitted 33.25 Gg of CH_4 in 2010, with contribution of 85.7% and 14.3%, respectively.

Table (2.8): CH_4 Emissions from Chemical and Metal Industries

Emission Sources	CH4 Emission (Gg)	Share (%)
Chemical Industry	28.48	85.7
Carbide Production	0.00	
Methanol	7.13	
Ethylene	21.13	
Ethylene Dichloride	0.01	
Ethylene Oxide	0.20	
Carbon Black	0.01	
Metal Industry	4.77	14.3
Iron and Steel Production	4.7	
Ferroalloys Production	0.07	
Total	33.25	100

The amount of N_2O emission, whose only source is production of nitric acid, was about 1.88 Gg in 2010.

2.3.1.3. HFCs, PFCs and SF_6 Emissions

Aluminum production activities are the only source of PFCs emission in the country. The calculated value for PFCs emission was 0.64 Gg in 2010. On the other hand, almost 0.34 Gg HFCs are released from various industrial activities.

HFCs, PFCs and SF6 are not produced in Iran. Furthermore, there is no exact information about the quantity of halocarbons and SF6 imported and exported in bulk or contained in existing appliances. Therefore, we have relied upon the data related to consumption and import of HFC134a for estimation of the emission, which makes the estimation of HFCs and PFCs emission to be of the highest uncertainty.

SF_6 is not used in aluminum and magnesium foundries as a cover gas. However, the emission of SF_6 used in the gas-insulated switch, gear and circuit breakers is about 0.006 Gg.

2.3.2. Summary for Industrial Processes

Table 2.9 summarizes the national GHGs emission inventory for different industrial processes. It shows that IPPU activities produce a greenhouse effect of almost 67,609 Gg CO_2 equivalents in 2010, which is much higher than 30,000 Gg in 2000. Most of such a large increase during 2000-2010 is attributed to the huge expansion of cement and petrochemical industries in Iran.

With production of about 34,432 Gg of CO_2, cement industry is responsible for about half of process-based CO_2 emission in the country. Chemical and metal industries are two other major CO_2 producers. Since the most important industrial procedures that emit the bulk of industrial process GHG emissions are the above-mentioned industries, we should consider these industries as priorities of emission reduction in our plans and programs related to climate change mitigation.

Table (2.9): Total GHG Emissions (Gg) for Industrial Processes in 2010

IPPU Subsectors \ GHGs	CO_2	CH_4	N_2O	HFC_{134a}	SF_6	PFCs	
						CF_4	C_2F_6
Mineral Production	34,432.1	-	-	-	-	-	-
Chemical Production	9,885.4	28.47	1.88	-	-	-	-
Metal Production	12,090.6	4.77	-	-	-	0.60	0.04
Other	5,448.4	-	-	0.34	0.006	-	-
Total	61,857.3	33.24	1.88	0.34	0.006	0.60	0.04
GWP	1	21	310	1,300	22,200	5,700	11,900
Total CO_2 Equivalent	**61,857.3**	**698.0**	**582.8**	**442**	**133.2**	**3,420**	**476**

2.4. Agriculture

Agriculture is considered to be one of the most important sectors of Iran's economy. The share of agriculture in Gross Domestic Product (GDP) is about 11 percent and nearly 15 million people (19% of the population) are engaged in this sector. It plays a vital role in achieving self-sufficiency in major staple food crops and ensuring food security for the country's increasing population.

The following section provides an updated GHGs estimation in the agricultural sector. Based on the IPCC 2006 Guidelines for greenhouse inventory, agriculture sector, forest and other related land uses are considered as one package and GHG emissions from these sources are to be estimated by the IPCC 2006 software. The present report provides an inventory of GHGs produced by livestock, managed soils, rice fields, chemical fertilizers and manures management.

The sources of GHG emissions in the agriculture sector are as follows:

- Livestock;
- fermentation;
- Manure management;

- Agricultural soils;
- Crop residues burning;
- Rice fields.

Existence of precise and detailed data is a prerequisite for estimation of reliable emissions from agriculture sector. Based on the available and reliable data, tier 1 default IPCC EFs are used to estimate GHGs emission.

2.4.1. GHGs Emission from Agriculture Sector

2.4.1.1. CO_2 Emissions

Application of N fertilizers in soils during fertilization leads to a loss of CO_2. Urea ($CO(NH_2)^2$ is conve rted to ammonium ($NH4+$), hydroxyl ion (OH^-) and bicarbonate ($HCO3-$) in the presence of water and urease enzymes. Using the IPCC 2006 EF for this branch (0.2 tons of C/tons of urea) with the annual urea fertilization value equal to 816,579.8, there was 598.8 Gg of CO_2 from agriculture sector in 2010.

2.4.1.2. CH_4 Emissions

CH_4 emissions from enteric fermentation of domestic livestock, manure management, rice cultivation and burning agricultural residue are about, 886.26, 35.38, 44.49 and 18.57 Gg, respectively. Therefore, the total CH_4 emitted from the agriculture sector is about 984.6 Gg. Table 2.10 shows the CH_4 emissions from different agricultural sub-sectors in 2010. As indicated in figure 2.8, most CH_4 (90%) is emitted from enteric fermentation, whereas, rice cultivation, manure management and agricultural residue burning are responsible for 4.5%, 3.5% and 2% of total CH_4 emission, respectively.

Table (2.10): CH_4 Emissions (Gg) from Different Agricultural Sub-sectors in 2010

Sources	CH_4 Emissions
Enteric Fermentation	886.2
Manure Management	35.4
Rice Cultivation	44.5
Agricultural Residue Burning	18.6
Total	**984.6**

- ***Data Sources:***

Data related to enteric fermentation are obtained from the Agricultural Statistics published by the Bureau of Statistics and Information Technology affiliated to Ministry of Agriculture-Jihad (MOAJ, 2010), table 2.11.

Table (2.11): Number of Livestock by Subcategories in Agriculture Sector

Livestock	Number(Heads)
Dairy cattle	3,643,410
Other cattle	4,766,590
Buffalo	473,000
Sheep	51,957,990
Goats	25,678,980
Camels	154,810
Horses	177,799
Mules and Asses	1,546,401
Poultry	387,292,863

- ***Choice of Method:***

As it was mentioned above, due to lack of reliable and sufficient data for deriving national EF, the default IPCC "tier 1" EFs are used for estimating GHGs emission from livestock and manure management.

2.4.1.3. N_2O Emission

N_2O emission from manure management during storage and treatment, before its application in soil as the organic fertilizer is emitted directly and indirectly. Nitrous Oxide emissions generated by manure in the pasture, range and paddock system occur directly and indirectly from the soil.

- ***Direct N_2O Emission from Manure Management***

Direct N_2O emissions occur through combined process of nitrification and de-nitrification contained in the manure. The amount of N_2O emission from manure management during storage and treatment depends on the nitrogen and carbon content of manure and also duration of storage and treatment.

- ***Indirect Emission of N_2O from Manure Management***

Indirect emission results from losses of volatile nitrogen in the form of ammonia and NOx. Simple form of organic nitrogen (urea from mammals) and uric acid (from poultry) are rapidly mineralized in the form of ammonia nitrogen, and are highly volatile, which can easily be diffused in surrounding air. In addition, nitrogen can be emitted through runoff and leaching into soils from the solid storage of manure in outdoor areas, feedlots and where animals are grazing in pastures.

- ***N_2O Emission from Managed Soils:***

N_2O is produced in the soil via the process of nitrification and de-nitrification. Emission of N_2O in the soil occurs directly and indirectly.

- ***Direct N_2O Emission from Managed Soils***

An increase in available nitrogen in the soil enhances the rate of nitrification and de-nitrification and hence increases emission of nitrous oxide. The following are the sources of nitrogen envisaged in the IPCC for estimating direct N_2O emission from managed soils:

. Organic N applied as fertilizer, including animal manure, compost;

- Synthetic fertilizer containing N;

- Urine and dung N deposit on pasture, range and paddock by grazing animal;

- N in crop residues including nitrogen fixing crops; and

- Drainage /management of organic soil.

- ***Indirect N_2O Emission from Managed Soils***

Emission of N_2O in soil occurs via two pathways, namely 1) volatilization of N as NH_3 and NOx and deposition of these gases and their products NH_4^+ and NO_3^- onto soil and surface of water bodies, 2) Leaching and runoff from land applied with synthetic and organic fertilizers, crop residues, urine and dung deposited from grazing animals. Table 2.12 shows N_2O emissions from agriculture sector by source in 2010.

Table (2.12): N_2O Emission from Agriculture Sector in 2010

Source of emissions		N_2O-N (Kg/Yr)	N_2O (Kg/Yr)
Direct N_2O emission from Soil	Synthetic fertilizer	8,165,798	12,831,968
	Animal manure	853,354	1,340,985
	Urine and dung deposited on range, pasture and paddock	18,445,066	41,526,939
	Crop residue	4,358,084	6,848,418
Total direct emission from Soil		31,822,302	62,548,310
Indirect N_2O emission from Soil	Synthetic fertilizer	-	-
	Animal manure	-	-
	Urine and dung deposited on range, pasture and paddock	1,946,223	3,058,350
	Soil leaching	4,088,722	6,425,135
	Atmospheric deposition	1,946,223	3,058,350
Total indirect N_2O emission from Soil		7,981,168	12,541,835
Total N_2O emission from agricultural soils (kg)			62,548,310
N_2O emissions from manure management (kg)			13,200,325
N_2O emissions from burning agricultural residues (kg)			540,005
Total N_2O emission (Gg)			76.3

2.4.2. Summary for the Agriculture Sector

Table 2.13 tallies the total CO_2 equivalent of GHG emissions for the agriculture sector. It is shown that the share of CO_2 equivalent of N_2O and CH_4 are about 52.6% and 46% of the entire CO_2 equivalent of GHG emissions. In 2010, the total amount of CO_2 equivalent was about 44,993 Gg. It should be mentioned that there are no emission reports about prescribed burning of savannahs.

Table (2.13): Total GHG Emissions (Gg) for Agricultural Sector in 2010

Emission Sources	CO_2	CH_4	N_2O	CO_2 eq.
Enteric fermentation	-	886.2	-	18,610.2
Manure Management	-	35.4	13.2	4,834.9
Rice cultivation	-	44.5	-	934.3
Agriculture soils	-	-	62.5	19,387.4
Agricultural residue burning	-	18.6	0.5	557.4
Urea Application	598.8	-	-	598.8
Total	598.8	984.6	76.3	44,923.0
GWPs	1	21	310	-
Total CO_2 Equivalent	**598.8**	**20,676.6**	**23,653**	**44,923.0**

As shown in figure 2.7, agricultural soils contribute to 43% of the total GHGs emission of agriculture, whereas the share of enteric fermentation, manure management, rice cultiviation, urea application and agricultural residue burning are 42%, 11%, 2%, 1% and 1%, respectivly.

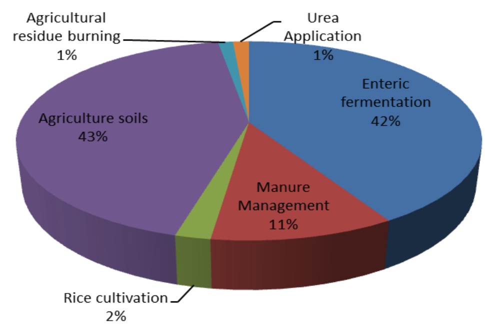


Figure (2.7): Contribution of Agricultural Sub-sectors to Total CO_2 Equivalent Emissions in 2010

CH_4 emission in agricultural sector shows an increasing trend, in which its amount increased from 496 Gg in 1994 to 808 Gg in 2000 and about 886 Gg in 2010. In addition, emission of methane from manure management increased from 19 Gg in 1994 to about 29 and 35.4 Gg in 2000 and 2010 respectively. This trend is mainly due to the increase in the population of livestock and increased use of manure for production of agricultural crops throughout the country.

The CH_4 emission from rice fields shows a decreasing trend, which is not consistence with the increased area of rice cultivation given by the Statistics and Information Technology Center of MOJA. In spite of increase in the area under cultivation of paddy, methane emission shows variation of 114 Gg in 1994 to 61 and 44.49 Gg in 2000 and 2010, respectively. This variation can be partly attributed to introduction of more precise EFs in IPCC 2006 Guidelines.

2.5. Land-use Change and Forestry

Forests, ranges and soils play an important role in the global carbon cycle both as carbon sinks and sources of CO_2. The global carbon cycle is recognized as one of the major bio-geo-chemical cycles because of its role in regulating the concentration of CO_2. In this study, land-use change and its effects on emission and removal of CO_2 in Iran was determined and calculated. The most important land-use changes were:

- Changes in forests and other woody biomass stocks;
- Forests and grasslands conversion; and
- Changes in soil carbon.

2.5.1. Natural Resources Situation in Iran

The country's geographical location makes Iran a place with highly diverse set of ecological conditions. This variety of climate has created an assortment of 7,576 plants, 517 birds, 208 reptiles, 170 fishes, 164 mammals and 22 amphibious species. The most important forests, rangelands and deserts of Iran are summarized below.

2.5.1.1. Forests of the Country

Almost 8.7 percent of Iran's land is covered with different types of forests. The area of these forests is about 143,188 km2 (FRWO, 2013). There are five forest regions in the country described hereunder.

- ***Hyrcanian Forests***

This region stretches as a green narrow strip, from Astara in the northwest of Iran to Golidaqi Valley in the northeast and the total area is about 19,673 km2. This site includes the southern prairie lands of the Caspian Sea and the northern slope of the Alborz Mountains with an altitude ranging from 25 to 3,000 m above sea level. Diversity of species in this habitat with more 80 types of wide leafed trees and shrubs has formed wide-ranging forest communities. The amount of standing plants is 280m^3 per hectare and the annual growth rate is 5m^3 per ha. Only five evergreen species are native to this habitat. Left over Common Hawthorn species from tertiary can be seen in this green humid forest. Hyrcanian forests also have industrial and commercial value. The most important species of Hyrcanian forests are Quercus, Fagus, Carpinus, Fraxinus, Tilia, Zelkova, Buxus, Ulmus and Sorbus species.

- ***Arassbaranian Forests (Semi-humid)***

This small region is in the east and west of Azarbayejan, in northwest Iran with an area of about 1,951 km2 and an altitude that ranges from 285-300 m. Not long ago, the forest cover in this habitat had noticeably greater density; the important specification of this region is the existence of 775 herbaceous species and 97 woody species that illustrates the high level of plant variation.

The Arassbaran region is also considered as a path through various growth regions. Rate of standing trees and plants is 80m^3 per hectare and the annual growth rate is 1.76 m^3 per ha. The most important species in this region are Quercus, Pyrus, Acer, Juniperus, Pistacia and Cornus.

- ***Zagrossian Forests (Semi-arid)***

This forest region is a narrow strip with an area of 75,645 km2, located in the west of Iran along the Zagros Mountains. The absorption of humidity from Mediterranean Sea clouds by the Zagros Mountains provides the necessary conditions for having tree plantation with the Oak species being dominant. The amount of standing trees and plants is 15 m^3 per ha and the annual growth rate is 1.3 m^3 per ha.

These forests are not commercial zones but they have an important role in providing wood as fuel for villagers and livestock grazing which are the two primary destructive agents in forest plantations. The most important species in this region are Acer, Quercus, Pistacia, Amygdalus, and Fraxinus.

- ***Irano Touranian Forests (arid zone)***

This region with an area of 29,631 km2 is the largest plantation zone in Iran and includes the central plateau of Iran and its surroundings except for the south part of the Caspian Sea and the northern strip of the Persian Gulf, Sea of Oman and Zagros Mountains (FRWO, 2013). Most of the salty deserts, sandy places and salt marshes are found in this wide region. Because of altitudinal ranges between 0 to 5,761 m, we can see various plant species such as small trees and shrubs resistant to dryness, heat and salinity. The rate of standing trees and plants is 7 m^3 per ha and the annual growth rate is 0.7 m^3 per ha. Forests of this region are divided into two low-density dry and arid sections. The primary species of these forests are Tamarix, Haloxylon, Zigophilum, Amygdalus, Astragalus and Pistacia.

- ***Gulf Omanian Forests (Subtropical zone)***

This region, also known as Sahara-Sandy, covers 16,288 km2 and is extended from Ghasr-e-Shirin in the west to the northern coast of the Persian Gulf and stretches cross-country to the border of Iran and Pakistan in the southeast. The average precipitation here is less than 100 mm per year and the zone is characterized by a long summer season with hot and dry weather and low floral diversity of subtropical species. Mangrove forests of Avecina officinalis with their concomitant high ecological value, is also an important community of tree species in this region. The rate of standing trees and plants is 7 m^3 per ha and the annual growth rate is 0.7 m^3 per ha. These forests are situated in the tidal coast of the Persian Gulf and the Sea of Oman and are considered significant because of the protective cover they provide for coastal marshes. The other vegetation species of this zone are Acacia, Populus, Prosopis, Pistacia, Zigophilum, Tamarix and Ziziphus.

2.5.1.2. Rangelands

Based on the data of the Forests and Rangelands Organization in 2010, the total amount of rangelands in the country was 84,746,971 ha. Of this amount, based on the crown density, 56,148,951 ha is related to low density rangeland (crown density between 5% to 25%) and 21,422,950 ha is semi-dense rangeland (crown density between 25% to 50%) with another 7,175,071 ha classified as high density rangeland (crown density more than 50%).

2.5.1.3. Deserts

Iran's desert expanses are primarily in the central regions. Based on the latest data of the FRWO, total desert coverage is 32,576,929 ha, which includes sand dunes, out crops, bare land, saline land and so on (FRWO, 2013).

2.5.2. GHGs Emission Inventory from Land-use Change and Forestry

Studies have been carried out in three sections including; change in forest lands remaining forest, forests and grasslands conversion and finally biomass burning. Because of lack of reliable information on changes in soil carbon, this emission estimation of soil has been ignored in Land Use, Land-Use Change and Forestry (LULUCF) inventory. Also, because of differences in definitions, units and so on in various forest zones in our country, the forests have been divided into five separate regions (zones). Each type of forests has been calculated separately and the effect of forests and grasslands in greenhouse gases uptake and release (emission) has been estimated. Finally, by using IPCC 2006 guidelines, modules and coefficients, calculations have been done.

2.5.2.1. Change in Biomass Stocks in Forest Land Remaining Forest

As described earlier, there are five forest regions in four climatic zones in Iran. Forest areas and reforestation activities are changing with a different increase of phyto-mass in every zone. According to the statistics obtained from Iran's FRWO, GHG emission and uptake is due to changes in forests and other wood resources and are estimated in table 2.14.

Table (2.14): CO_2 Emissions/Uptake in Forest Land Remaining Forest in 2010 (Gg)

Emission Sources	CO_2 Uptake	CO_2 Emission	Net Emission (Gg)
Annual biomass gain due to growth	-21,553.3	-	-21,553.3
Annual carbon loss due to wood removals	-	8,094.4	8,094.4
Annual carbon loss due to fuel-wood removal	-	7,480.2	7,480.2
Annual carbon loss due to disturbance	-	2,019.7	2,019.7
Total	**-21,553.3**	**17,594.3**	**-3,953.0**

As is shown in table 2.14, the total CO_2 emission/uptake as result of biomass stock changes in forest land remaining forest is about -3,953. It should be noted that the negative sign in the above figures means GHG uptake from forest sector.

2.5.2.2. Land Conversion

The relation between uptake and release of greenhouse gases, especially CO_2 in forest, grassland and pastures are shown in table 2.15. As table 2.15 reveals, increase in biomass stocks due to growth absorb 46 million tons of CO_2, while loss in biomass due to commercial filings, fuel-wood and disturbance emit 71 million tons of CO_2. Totally, forest and grassland conversion emit about 25,428.7 Gg CO_2.

Table (2.15): CO_2 Emissions/Uptake in Land Conversation in 2010 (Gg)

Emission Sources	CO_2 Uptake	CO_2 Emission	Net Emission (Gg)
Annual increase in carbon stocks in biomass due to growth	-46,090.1	-	-46,090.1
Annual loss or decrease in biomass due to commercial filings	-	63,642.6	63,642.6
Annual biomass loss due to fuel-wood removal	-	7,848.1	7,848.1
Annual carbon loss due to disturbance	-	28.1	28.1
Total	**-46,090.1**	**71,518.8**	**25,428.7**

2.5.2.3. On-site Burning of Forests

In addition to CO_2 emission, some non-CO_2 greenhouse gases such as CH_4, N_2O and NOx are emitted from on-site biomass burning. As shown in table 2.16 these emissions are in trace amounts.

Table 2.16: GHG Emissions (Gg) from On-Site Burning in 2010

GHGs	Emission
CO_2	58.9
CH_4	0.8
N_2O	0.1
NO_X	1.4
CO	23.8

2.5.2.4. Changes in Soil Carbon

Information about soil transformation and organic matter created by land use change, agricultural activities and so on are either unavailable or unreliable. Therefore, no CO_2 emission estimates were made.

2.5.2.5. Summary for Land-use Change and Forestry

GHG emissions and uptake from land-use change and forestry are shown in table 2.17. According to this table, the land use and forestry sectors in Iran are sources for GHG emissions with a net total CO_2 equivalent of about 21,570 Gg. The amount of CO_2 uptake in the land use and forestry sectors is about 67,643 Gg. This reveals that the forest harvesting programs in Iran have not been conducted on a sustainable basis.

Table (2.17): Emissions and Uptake (Gg) in Land-Use Change and Forestry in 2010

Sources	CO_2 uptake	CO_2 emission	CH_4	N_2O	Net GHGs Emission (Gg-CO2 eq.)
Changes in Biomass Stocks in Forest Land Remaining Forest	21,553.3	17,594.3	-	-	-3,959.0
Land Conversion	46,090.1	71,518.8	-	-	25,428.7
Biomass Burning	0.0	58.9	0.8	0.1	100.4
Total	67,643.4	89,172.0	0.8	0.1	21,570.1
GWP	1	1	21	310	NA
Net Total CO_2 Equivalent Emission	21,528.6		17.7	23.9	21,570.1

2.6. Waste

In general, in the activities related to waste, especially in anaerobic decomposition processes of organic waste by bacteria, greenhouse gases, especially methane, are produced. Typically, CH_4 emissions from SWDS are the largest source of GHG emissions in the waste sector. CH_4 emissions from wastewater treatment and discharge may also be important. CH_4 produced at SWDS contributes approximately 3 to 4 percent to the annual global anthropogenic GHG emissions (IPCC, 2001). Incineration and open burning of waste containing fossil carbon, e.g., plastics, are the most important sources of CO_2 emissions in the waste sector.

Based on IPCC 2006 Guidelines, all GHG emissions from waste-to-energy processes, where waste material is used directly as fuel or converted into a fuel, should be estimated and reported under the energy sector.

In addition, CO_2 generated in SWDS, wastewater treatment and burning of non-fossil waste is of biogenic origin and is therefore not included as a reporting item in this sector. N_2O is produced in most wastewater treatments and will be calculated in this sector. The importance of the N_2O emissions varies much, depending on the type of treatment and conditions during the treatment.

Waste and wastewater treatment and discharge can also produce emissions of NMVOCs, NOx, and CO as well as NH_3. However, specific methodologies for the estimation of emissions for these gases are not included in the IPCC guidelines.

The NOx and NH_3 emissions from the waste sector can cause indirect N_2O emissions. NOx is produced mainly in burning of waste, while NH_3 in composting. No methodology is provided for N_2O emissions from SWDS because they are not significant. Overall, the indirect N_2O from the waste sector are likely to be insignificant. However, when estimates of NOx and NH_3 emissions are available, it is good practice to estimate the indirect N_2O emissions for complete reporting.

IPCC guidelines describe two methods for estimating CH_4 emissions from SWDS: the mass balance method (Tier 1) and the First Order Decay (FOD) method (Tier 2).

A) Mass Balance Method

In this method, data such as the physical composition of the waste in the calculation of emission inventory is required. If the amount and composition of disposed waste is remained constant for a long time, in this case the method will give us good results. Table 2.18 shows the results of physical analysis of urban and rural solid waste in Iran (Reference: IMRMO[1]). With increasing the amount of waste disposed, the estimated emission values gained from this method will be overestimated.

Table (2.18): Urban and Rural Waste Analysis

Waste Sources and compositions	Waste generation rate (gr)	Density (kg/m^3)	Paper (%)	Plastic (%)	Putrescible (%)	Metals (%)	Glass (%)	Cloths (%)	Construction & Demolition (%)	Wood (%)	Rubber (%)	Others (%)
Rural	452	375.75	5.9	6.4	52.3	4.9	4.4	4	9.3	3.6	2.8	6.4
Urban	800	254	7.2	8.4	72.9	2.3	1.9	2.3	-	1.2	1.1	3.5

B) First Order Decay (FOD) Method

In IPCC 2006 Guidelines, the use of the mass balance method is strongly discouraged as it produces results that are not comparable with the FOD method which produces more accurate estimates of annual emissions.

In Iran, waste resulting from demolition and construction mainly consists of inert and inactive waste such as tires, cement, reinforcement (rebar) and has no significant effect on the calculation of GHG emissions. In some cases, solid wastes such as plastics (including fossil carbon) or wood (including DOC[2]) were seen among them.

It is noteworthy that in most cases, industrial wastes along with domestic waste is collected and transported to landfill sites. GHG emissions from medical wastes are not significant (IPCC, 2006 Guidelines). In most cases, medical wastes are buried in landfills along with the domestic waste or in some cases separately. In some cases, medical wastes generated in hospitals might be changed into safe materials through autoclave units and then are delivered to the collecting system, and in some few cases they are burnt in

1 Islamic Republic of Iran Meteorological Organization
2 Degradable Organic Carbon

small incinerators and with no standards.

2.6.1. GHG Emissions from the Waste Sector

2.6.1.1. GHG Emissions from Solid Waste (FOD Method)

Data and information required for calculating methane emissions from landfill sites are as follows:

- Urban population in 2010: 52,519000 (Statistical Center of Iran, year 2010)
- Rural population in 2010: 21,639000 (Statistical Center of Iran, year 2010)
- Municipal Solid Waste (MSW) Rate: 800 grams per capita per day
- Rural solid waste generation rate: 452 grams per capita per day
- Fraction of solid waste sent to landfills: 85% (based on the results of the solid waste comprehensive plans of the provinces, 2007 ~ 2013)
- For the DOC values of solid waste, the default values of IPCC were used. The DOCf value was considered 0.5 based on IPCC default value.
- For determining methane correction factor, the following classification, based on the kinds of waste disposal sites in the country, has been considered:

  - Unmanaged – shallow (<5 m waste): 70% with default correction factor 0.4

  - Unmanaged – deep (>5 m waste): 15% with default correction factor 0.8

  - Managed – anaerobic: 10% with default correction factor 1

  - Managed – semi-aerobic: 5% with default correction factor 0.5

So Methane Correction Factor (MCF) is calculated 0.525.

With regard to population and solid waste generation rate in urban and rural areas of the country, the total waste produced in the year 2010 has been estimated about 18906 Gg. Because about 85% of the waste generated is transported to disposal sites, so the tonnage of waste buried in landfills will be equal to 16070.1 Gg. The amount of industrial waste produced in the country is estimated at about 9,000 tons per day (9 Gg/day), (Reference: Parliament Research Center, Office of Infrastructure Research, "The waste industry situation in the country", serial number: 12810, January 2012).

- The methane content in the biogas produced at landfills, based on IPCC default, is 50 percent. This value, in most cases is very similar to the amount of samples taken in Iran disposal sites including landfills of Shiraz, Isfahan, etc.
- One of the specific features of biological wastewater treatment processes is sludge production. The amount of biological sludge production and its qualitative and quantitative characteristics, in addition to the qualitative and quantitative characteristics of the wastewater, depends on treatment process and its operation conditions.

In Iran, the average primary and secondary sewage sludge production rate is estimated to be respectively 0.7 and 2 liters per capita.

According to the above rate, the country's urban population and percentage of population covered by the wastewater treatment system (35.14 %; WWEC[1], 2010), the total amount of sludge produced is estimated at about 50 Gg/year. It is estimated that about 80 % of produced sludge is transported to municipal landfill, so the sludge disposed in landfills will be 40 Gg.

According to calculations based on 2006 IPCC model, the methane emissions from landfills is estimated at 24.2 Gg/year.

It is estimated that about 5% of the methane generated in landfill sites will be recovered in Mashhad, Shiraz, Isfahan, Tehran and Ahwaz landfills. Therefore, aside from methane oxidation, the amount of methane emissions from landfill sites in Iran is calculated about 23 Gg/year.

Due to the activity of about 29 municipal compost plants across the country and producing 5900 tons compost per day, the amount of methane emissions from biological treatment of solid wastes will be 0.0236 Gg/year and the amount of nitrous oxide emissions will be estimated to be about 0.00177 Gg/year.

Considering that in rural areas and small towns about 30% of the generated solid waste, is incinerated as open burning, so the amount of emissions of carbon dioxide, methane and nitrous oxide in 2010 are obtained respectively about 29, 4.18 and 0.00008 Gg.

1 Worldwide Energy Conference

2.6.1.2. GHG Emissions from Liquid Waste Sector

Wastewater can be a source of methane when treated or disposed anaerobically. It can also be a source of nitrous oxide emissions.

According to the "IPCC Guidelines", Carbon dioxide emissions from wastewater are not considered in national inventory, because of its biogenic origin. In the base year (2010) population of 19,596,668 people was under the coverage of wastewater collection systems by municipal water and sewage companies which are covered 35.14% of the country's population. Operational capacities of these wastewater treatment systems are 883546.187 × 10^3 m^3/year (WWEC, 2010).

The extent of CH_4 production depends primarily on the quantity of degradable organic material in the wastewater, the temperature, and the type of treatment system. The principal factor in determining the CH_4 generation potential of wastewater is the amount of degradable organic material in the wastewater. Common parameters used to measure the organic component of the wastewater are the Biochemical Oxygen Demand (BOD) for domestic wastewater and Chemical Oxygen Demand (COD) for industrial wastewater. N_2O is associated with the degradation of nitrogen components in the wastewater, e.g., urea, nitrate and protein.

- ***Domestic Wastewater***

The Ministry of Energy reported that only 15% of cities that contain 24% of the total population were able to treat their domestic wastewater until

2000; other cities discharged their wastewater on land, into rivers etc. The population of Iran in 2000 was estimated at about 67 million and the per capita consumption of water was estimated to be 250 liters per day.

Domestic wastewater CH_4 emissions were estimated using the default IPCC methodology. The EF (0.18 kg CH_4/kg BOD_5) was taken from IPCC Good Practice Guidance (IPCC, 2000). The amount of wastewater BOD_5 that was anaerobically digested was assumed to be approximately 10%. This value also accounts for Iran's septic systems and is based on the data of the Ministry of Energy. According to the above information, CH_4 emissions from domestic wastewater are estimated at about 50.5 Gg in 2000.

- ***Industrial Wastewater***

In order to calculate GHG emissions from Industrial wastewaters, the quantities of products in different industries (ton/year) were collected as shown in tables 2.19 to 2.21, (References: Iranian Small Industries and Industrial Park Organization, Ministry of Industries and Mines, National Union of agricultural products; United Nations Food and Agriculture Organization (FAO) reports (Department of Agricultural Products Statistics of Iran), Statistics and Information Center of MOJA, Consumers and Producers Support Organization, Statistics of Iranian Oil Refining and Distribution National Company & …).

Table (2.19): Production of Petroleum Products in the Country (year 2010)

Product	Production rate (Million liters per day)	Density (g/cm3)	Production rate (Ton/day)	Production rate (Ton/year)
LPG[1]	-	-	4257	1553805
Engine Gasoline	45.8	0.719	32930.2	12019523
Kerosene	18.8	0.78 ~ 0.81	14946	5455290
Oil and gas	85.2	0.82 ~ 0.86	71568	26122320
Fuel oil	74.4	0.97 ~ 0.99	72912	26612880
Sum			**196613.2**	**71763818**

Table (2.20): Pulp and Paper Production in the Country (year 2010)

Company	Production rate (Ton/year)
Wood and Paper Company of Iran (Choka)	- Pulp production with a nominal capacity of 120 thousand tons per year. - Production of paper and kraft liner paperboard, test liner and cardboard with a nominal capacity 150 thousand tons per year.
Mazandaran Wood and Paper Industries	85000
Kahrizak Paper Company	45000
Kaveh Paper Company	30000
Iran Papyrus Company	15000
Sanitary paper products (tissue)	35000
Harir Khuzestan Paper Company	15000
Latif Paper Company	15000
Nozohour Paper Company	5000
Sum	**515000**

Table (2.21): Industrial Products in the Country (year 2010)

Industry Type	Production rate (Ton/year)
Dairy Products	10800000
Fish Processing	735100
Meat & Poultry	2750200
Organic Chemicals	3500000
Petroleum Refineries	71763818
Plastics & Resins	177000 ton plastic, 2800000 ton paint and resins
Pulp & Paper	515000
Soap & Detergents	900000
Starch Production	44000
Sugar Refining	1052666
Vegetable Oils	1600000
Vegetables, Fruits & Juices	11.5 million tons fruits, 18 million tons vegetables & melons, 405000 tons concentrate, 4400000 tons fruit juice
Vinegar	239763
Malt	1790000000

According to the values given in the above tables, wastewater generated (m3/t product), chemical oxygen demand (kg COD/m3 wastewater), methane EFs (kg CH_4/kg COD) and also methane correction factors for different treatment systems or discharge pathways; the amount of methane emissions from industrial wastewater is estimated about 1171050835 kg/year (1171 Gg/year) in 2010.

2.6.1.3. Summary for the Waste Sector

In table 2.22, summary of GHG emissions from waste sector is presented. Total GHG effect of this sector was about 28,000 Gg CO_2, equivalents from which more than 98% is in form of methane.

Table (2.22): GHG Emissions (Gg) from Different Waste Sub-sectors in 2010

Sub-sectors	CO_2	CH_4	N_2O
Solid Waste	29.00	27.20	0.002
SWDS	-	23.00	0.00
Biological Treatment	-	0.024	0.002
Open Burning	29.00	4.18	0.00
Liquid Waste Sector	0.00	1281.00	1.30
Domestic Wastewater	-	110.00	1.30
Industrial Wastewater	-	1171.00	0.00
Total	29.00	1308.2	1.302
GWP	1	21	310
Total CO_2 equivalent	**29.00**	**27472.2**	**403.62**

2.7. Uncertainty Management of GHG Emissions Inventory

2.7.1. Estimation of Uncertainty in GHGs Emission Inventory

In this section, the uncertainty in estimation of greenhouse gases emission from all sectors is presented. As mentioned earlier, except for the energy sector for which some national EFs are available, there are no national EFs for other sectors. This results in significant uncertainties in the estimation of the national emission inventory.

Some factors that cause uncertainty in GHG emissions estimates are as follows:

- Difference in interpretation and/or description of sources, sinks, other definitions, theories, units, etc.,
- Uncertainty in statistics and data of primary economic and social activities that are used in calculations,
- Uncertainty in scientific understanding of key processes resulting in emission and/or omitting of GHGs.

Based on the IPCC 2006 Guidelines, in order to estimate the uncertainty individually for sources and gases in the national inventory, different statistical methods and expert judgments can be used. In this report expert judgment was utilized to estimate the uncertainty.

Furthermore, based on the guideline for managing uncertainty, for estimation of the uncertainty in all sub-sectors both AD and EFs have been considered. The result of sectoral and overall uncertainty for CO_2 emission is shown in table 2.23, which indicates energy and IPPU with uncertainty of 11.1% and 16.8%, respectively, having the lowest uncertainty; while the agriculture and land-use change with 68.4% and 61.0% have the highest uncertainty. Although overall uncertainty of energy sector is low, but fugitive CH_4 emission from oil and gas activities has an uncertainty about 50%. The overall uncertainty of National GHGs Inventory is about 15.4%.

Table (2.23): Overall and Sectoral Uncertainty for GHGs Emission (%)

Sector	Sectoral Uncertainty
Energy	11.1%
Industrial processes	16.8%
Agriculture	68.4%
Land-use change and forestry	61.0%
Waste	19.5%
Overall Uncertainty	**15.4%**

2.7.2. Key Source Analysis and Recommendations for Uncertainty Management

The key factors of uncertainty and recommendations for uncertainty management are shown in table 2.24. Among different sources of GHGs in agriculture, livestock is considered the outstanding source of uncertainty since the AD related to this parameter has the greatest level of uncertainty. As will be discussed in the following sections, one reason for this is that different organizations are responsible for collecting and compiling livestock population data. The other source of uncertainty is the lack of national EFs for livestock that led us to use the Tier 1 IPCC EFs.

As the required data is not collected regularly for this source of GHGs emission, the uncertainty is considered to be relatively high. With respect to methane emissions from rice fields, neither of the concerned research institutions has developed a country-specific EF. The method used for estimating CH_4 from rice fields is based on the annual harvested area. But according to past experiences, for a number of reasons, including overestimation and inefficiency of the existing method of data collection, there may be a bias of ± 5%. Therefore, other uncertainties can be attributed to selecting the EF from the IPCC Guidelines that may not be appropriate for conditions in Iran. Uncertainty in estimation of GHGs emission from agricultural soils can be mainly attributed to:

- Choice of EF;
- AD;
- Lack of appropriate field measurement; and
- Lack of representative data for most cultivated areas.

Additionally, data concerning application of chemical fertilizer in the country is considered to be very rough. Usually the amount of fertilizer distributed is taken equal to the amount actually consumed.

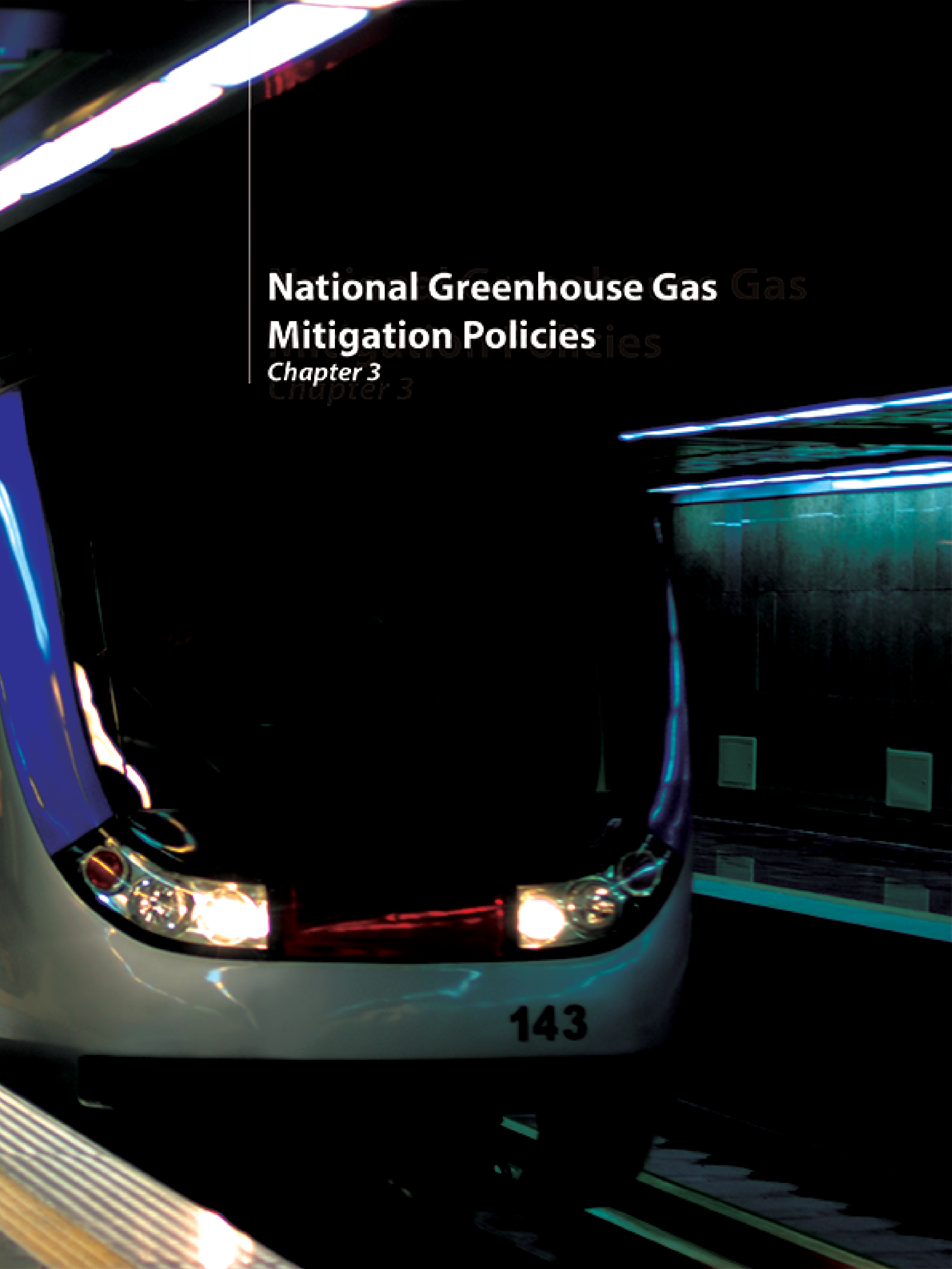
Also there is huge uncertainty in fugitive CH_4 emission from oil and gas activities, because there is a close relation between level of protective repair and maintenance and CH_4 emission in gas processing and especially transmission and distribution.

There are also several uncertainties associated with the estimates of methane emissions from landfills. The uncertainty estimates of current amounts of waste are based on differences among various statistics, and also on expert judgment.

In the liquid waste sector significant uncertainties are associated with the industrial wastewater emission estimates. Wastewater outflows and organic loads vary considerably for different plants and different sub-sectors (e.g. paper versus board, poultry versus meat and food versus juices).

Table (2.24): Sources of Uncertainties and Recommendations for Uncertainty Management

Sectors	Activity Data			Emission Factor		
	Source of uncertainty	Level of uncertainty	Recommendations	Source of uncertainty	Level of uncertainty	Recommendations
Energy	• Fuel smuggling from the borders • Substitution of gasoline consumption in transport sub-sector to solvent application • Uncertainty in volume of gases which is flared in oil and gas activities	• Medium • Low • High	• Strict rules • Precise calculation of other applications • Use IPCC reference approach for estimation of flare gas emission	• EF of CH_4 emission from natural gas processing, transmission and distribution • Fugitive EF of CH_4 from coal mining and handling	• High • Medium	• Development of national EF • Development of national EF
Industrial Process	• Consumption and import of HFCs, PFCs and SF_6	• High	• Establishment of customs clearance codes for HFCs/ PFCs and SF_6 import and export	• Lack of national EF in industrial processes	• Medium	• Development of national EF
Agriculture	• Number of livestock population • Burning of agricultural residues	• Medium • High	• Precise Census of livestock population • Collection of related data	• Lack of national EFs in all agricultural sub-sectors	• High	• Development of national EF
Land-use change and Forestry	• Related statistics in estimation of carbon release	• High	• Preparation of up to date database regarding to generation, consumption and burning of forests	• Lack of national CO_2 emission/absorption factor for each vegetation types and areas	• Medium	• Development of national EF
Waste	• Amount of rural solid and liquid waste • Amount of waste pile and open dump for methane emission	• Medium • Medium	• Establishment of efficient administrative office to gather the statistics • Change in waste management and handling and create an efficient data collecting systems	• Lack of local EF in both solid and liquid waste sub-sectors	• Medium	• Development of national EF



National Greenhouse Gas Mitigation Policies

Chapter 3

Introduction

Greenhouse Gases (GHGs) are the prime cause of global warming and climate change. Therefore, mitigation of GHGs is a high priority in global objective. Mitigation assessments in the country have been carried out in two distinct sectors, energy and non-energy. As mentioned in the previous Chapter (GHG emissions inventory), the energy sector is responsible for about 81% of total GHGs emission; thus a great deal of consideration is needed while assessing mitigation potential in this sector. The outstanding challenge here is that the extant complexity exists both in the energy sector's supply and demand side and that necessitates a comprehensive study of the energy sector of the country.

The following mitigation policies are based on extensive and lengthy consultation with experts, institutions and research undertaken in the country.

3.1. Energy Sector

3.1.1. Overview of Energy Sector

GHGs are the main cause of global warming and climate change. Higher temperatures associated with climate change and global warming shall adversely affect all economic activities and certainly the quality of human life. Therefore mitigation of GHGs is a high priority goal worldwide. These negative effects are more evident in semi-desert countries like Iran. Meanwhile Iran is considered an energy-intensive country. The urbanization and industrialization processes along with population growth in Iran have altered the energy production and consumption patterns in recent decades. Final energy demand which was 610.7 million barrels of oil equivalent (mboe) in 1996, has reached to 1,215 mboe in 2010, experiencing an average annual growth rate of 5%, and primary energy supply has boosted from 816.4 mboe to 1766.4 mboe in the same period (IIES[1] , 2014). As a result of rapid expansion in energy system technologies, GHGs emissions have risen as well. This is because energy sector is responsible for 81% of total greenhouse gas effect in Iran. Main cause of such dramatic situation is intense reliance of country's energy system on inefficient fossil fueled technologies. This has also been exacerbated by some other factors such as the eight-year imposed war and hospitalizing millions of Iraqi and Afghan refugees as well as lack of access to adequate international finance and modern and environmentally sound technologies as a result of unfair sanctions. These factors, in general, have put a number of obstacles in front of timely renovations of industries and undertaking development plans and programs in an energy efficient and environment-friendly manner. In 2010, about 99.1% of primary energy supply was met from country's cheap endowed oil and gas resources. Thus as a necessity, diversification of energy supply mix by other sources should be incorporated in development programs for energy security and moving towards a more environmental friendly system. However, prevailing typical energy utilization patterns makes it difficult to make a breakthrough towards other sources of energy, including renewable ones. In the energy sector, it is possible and reasonable to promote energy efficiency as well as wider utilization of low carbon fossil fuels, in particular natural gas

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and expansion the share of renewable energy resources such as wind and solar in fuel mix. Fortunately, during recent years the government has taken initial steps for mitigation of GHG emissions, some of which are as follows: the increase of natural gas share in primary energy production from 29% in 1996 to 52.2% in 2010, recovery of associated gases in the oil fields for injection into oil wells and greater use of them for feeding expansion turbines to generate electricity, capacity expansion of hydro power plants from 1998 MW in 1996 to 8488 MW in 2010 as well as rationalizing energy subsidies. In the same period between 1996 and 2010, installed capacity of efficient combined cycle power plants has boosted from less than 1000 MW to 13983 MW (MOE[1] , 2014). As for household and industrial sector, compilation of energy consumption standards for domestic and industrial appliances has been carried out as well.

3.1.2. Methodology: Energy System Model Development

The aim of this work is to assess alternative strategies curbing GHGs emissions (specifically CO_2, CH_4 and N_2O) with the following objectives:

1) to develop an integrated bottom-up energy model in order to assess how energy system evolves in the BAU scenario, 2) to identify and analyze options of GHGs reduction in Iranian energy sector, and subsequently propose and develop alternative mitigation scenarios, 3) to evaluate the potential of selected options to mitigate GHGs emissions, their viability and costs and to propose mechanisms and strategies that may allow implementation of the mitigation measures.

In order to get the job done, National Climate Change Office (NCCO) prepared as many data-sheets as the number of all GHGs-producing sectors in Iran. These data-sheets are provided to request the relevant data from national organizations, which are required by the bottom-up model with the Reference Energy System (RES) shown in figure 3.1. The nature of the requested data revolves around techno-economic data, development prospect of each sector and also potential measures to mitigate GHGs emissions and their associated costs.

1 Ministry of Energy

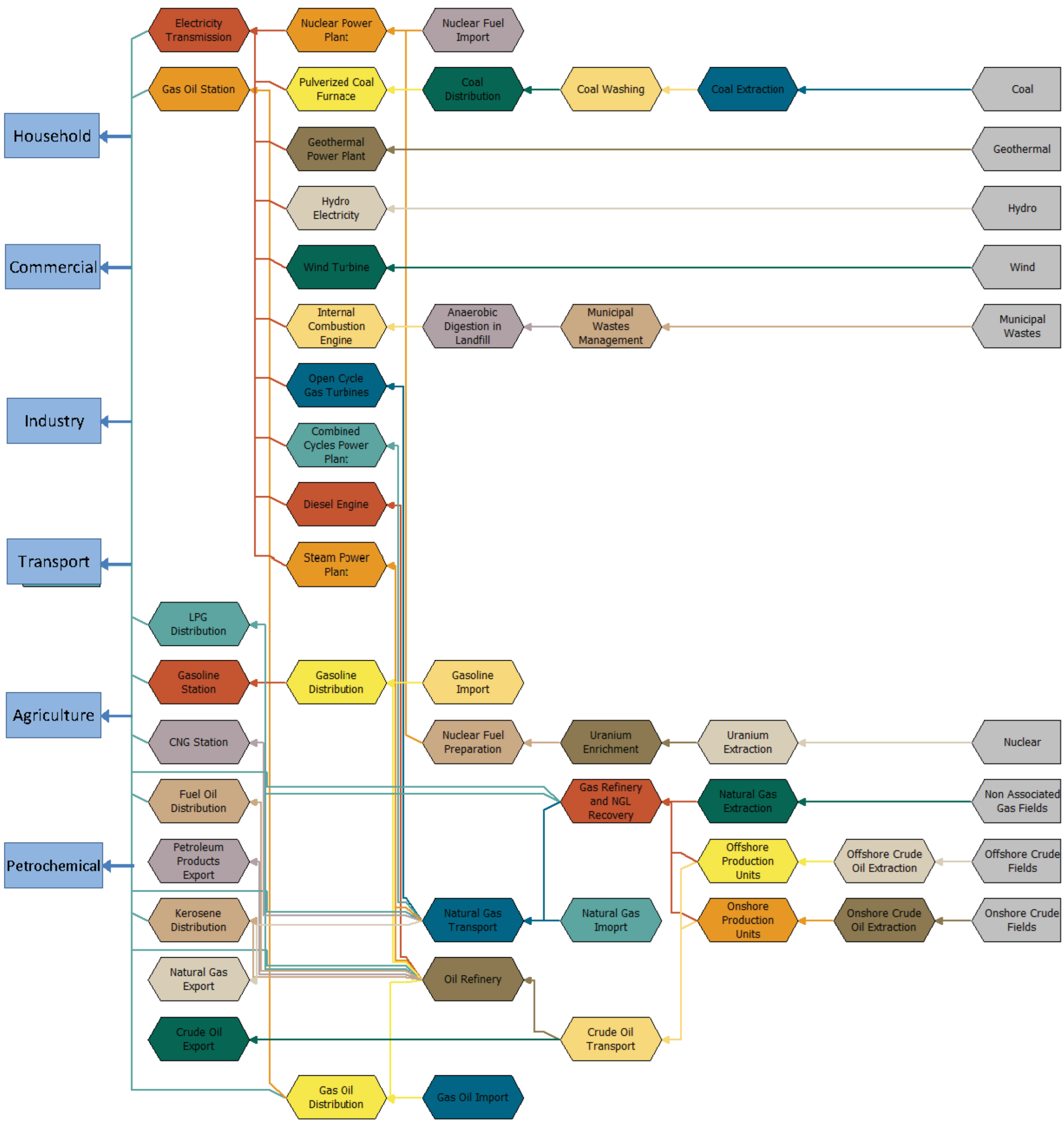

Figure (3.1): Iran's RES

As shown in the RES in figure 3.1, the model must include all extraction, processing, refining, conversion and transmission technologies in Iran's energy supply chain in addition to 6 demand-side sectors, including household, commercial, industry, transport, agriculture and petrochemical industries.

The Long-range Energy Alternatives Planning (LEAP) modeling system, a bottom-up energy-environment simulation tool, is designed to assist energy planners in the identification and quantification of the patterns of future energy consumption and the associated problems, most likely impacts of different policies and integrated resource planning. Thus, it was found useful to apply LEAP for the assessment of future mitigation strategies.

3.1.2.1. Business-as-Usual (BAU) Scenario

In the BAU scenario (2011-2025) all of the exogenous variables of energy modeling vary based on 2005-2010 (2010 is base year) realities and it is assumed that no substantial changes will result from specific measures or introduction of energy conservation programs. BAU simply reflects continuation of past trends in the future and serves as a baseline for comparison between different scenarios. The only remarkable change in BAU scenario compared to 2005-2010 facts concerns the economic growth. According to recent development programs, the government has declared 8% annual growth rate for Gross Domestic Product (GDP) up to 2020 and 6% for 2021-2025. This ambitious growth rate is based on hopes that various unfair sanctions would be lifted as a result of landmark nuclear deal sealed in July 2015 and no new sanction to be re-imposed. Therefore, except for expansion in activity levels, other technical figures in BAU scenario (e.g. energy intensities, process efficiency) remain the same as 2005-2010.

3.1.2.2. Mitigation Scenarios

Iran's mitigation strategies and action plan has been developed in close collaboration with different governmental institutions and stakeholders' consultations. The main mitigation policies and actions are as follows:

Household and commercial sector:

- Improving energy efficiency of central heating systems for residential and commercial buildings: reduction of natural gas consumption by 9.85 to 13.16 million cubic meters per day by improving energy efficiency of central heating systems of residential and commercial buildings

- Switching to natural gas to decrease the level of liquid and heavy fuels consumption in household sector through the expansion of natural gas network to the small cities and rural areas.

Industrial sector:

- Renewal of currently obsolete processing equipment and machinery in order to decrease energy consumption by 1% annually

- Switching to natural gas to decrease the level of liquid and heavy fuels consumption

- Introducing efficient energy conversion technologies (e.g. boilers and electro motors) in manufacturing and mining sector of Iran

- Promoting utilization of high temperature waste heats via Combined Heat and Power (CHP) and Waste Heat Recovery (WHR) technologies

Agricultural Sector:

- Water pumps fuel switching of Agricultural wells: Reducing gas oil consumption by replacing existing diesel engines with electric submersible pumps in 217,000 agricultural wells

Transport Sector:

- Rail transport development: capacity expansion of passenger rail systems from 17.4 billion passenger-kilometers per year to 34.2 billion passenger-kilometers per year in 2024 and freight rail capacity from 21.7 ton-kilometer per year to 75.8 ton-kilometer per year in 2024.

- Renewal of city bus fleets by retirement of 17,000 old diesel powered buses and CNG [1]-powered city buses

- Renewal of city taxi fleets by retirement of 140,000 old gasoline-fueled taxis and introduction of dedicated CNG-powered long range taxis

- Removing shortcomings of public transportation system by introducing 27,000 CNG-powered buses and 500,000 CNG-powered long-range taxis

- Further development of subway network in 8 metropolitans: Ahwaz: 19 km, Tabriz: 17.2 km, Shiraz: 24.5 km, Esfahan: 20.2 km, Karaj: 27 km, Qom: 6.8 km, Kermanshah: 11 km and Mashhad: 19.6 km.

- Renewal of 400,000 old gasoline-powered 125 cc motorcycles and supply of electric powered bikes with equivalent usage

1 Compressed Natural Gas

- Renewal of country's freight fleets by retirement of 450,000 gasoline-fueled pickups and 500,000 diesel-fueled trucks and introduction of CNG-powered pickups and trucks

Power generation sector:

- Installation of 6,000 MW wind and 18,700 MW hydro power plants by 2025. 2013 capacities were 98 MW and 10266 MW, respectively.

- Raising share of efficient combined cycle power plants with thermal efficiency of around 45% in power generation mix from 27.3% in 2015 to 54.2% in 2025. This is done via either upgrading current open cycle gas turbine with steam cycle or installing new combined cycle power plants.

- Installation of another 2,000 MW nuclear power plant with as high plant factors as 90%. With Bushehr 1,000 MW nuclear power plant already operational, total nuclear-derived power production capacity would reach to 3,000 MW.

- Increasing the share of natural gas in power plants fuel mix

Oil and gas activity:

- Recovery of flared gases in offshore and onshore oil extraction facilities

- Flare gas reduction in gas treatment facilities

- Methane leakage reduction in transport and distribution of natural gas

- Accessing Carbon Capture and Storage (CCS) technology supported by adequate finance.

3.1.3. Results and discussion

3.1.3.1. Emissions in BAU Scenario

CO_2 has been and also will remain by 2025 as the most dominant greenhouse gas in the energy sector as shown in figure 3.2. The figure says that if traditional patterns of energy production and consumption are valid in the future, CO_2 emissions in 2025 may hit the record of 1254 million tons (BAU), most of which comes from transport activities, electricity generation and manufacturing industries. Other than offshore and onshore oil extraction facilities that denote fugitive CO_2, emissions from other sectors originate from fuel combustion.

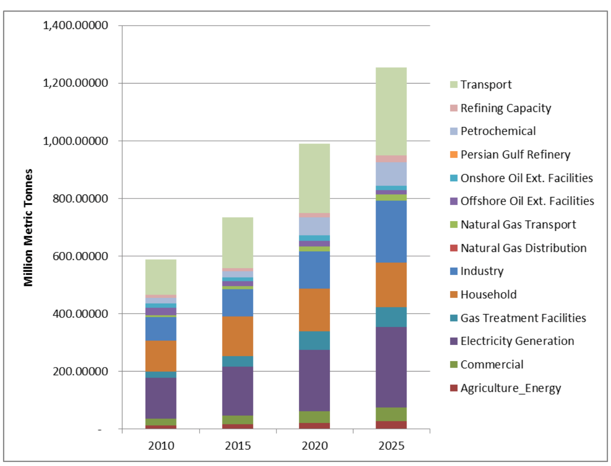

Figure (3.2): CO_2 Emissions from Energy Sub-sectors in BAU Scenario

Figure 3.3 shows total CO_2 equivalents of energy-related emissions (combustion and fugitive) in BAU scenario.

Growing at an average annual growth rate of 4.8%, total greenhouse effect of energy sector may reach from around 700 million tons of CO_2 equivalent in 2010 to 1428 million tons in 2025 if Iran's national actions to mitigate its GHGs are not substantially enhanced by removal of unfair sanctions, and facilitating foreign and international support in the form of adequate finance, transfer of modern and environmentally sound technologies and building necessary capacities. Among all energy subsectors, the highest emission growth with a 5.9% average annual rate goes to transport sector. As shown in figure 3.4, the share of transport sector in total greenhouse gas effect in Iran will soar from 17.9% in 2010 to 21% in 2025, if current patterns continue. Nevertheless, the contribution of each subsector to total GHGs emission inventory during the time horizon is more or less the same as 2010.

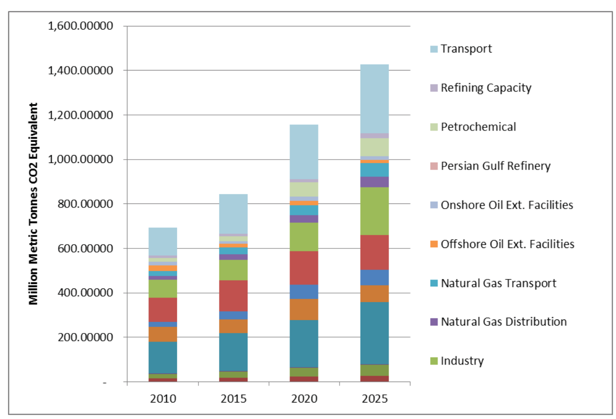

Figure (3.3): Total Greenhouse Effect of Energy Sector in BAU Scenario

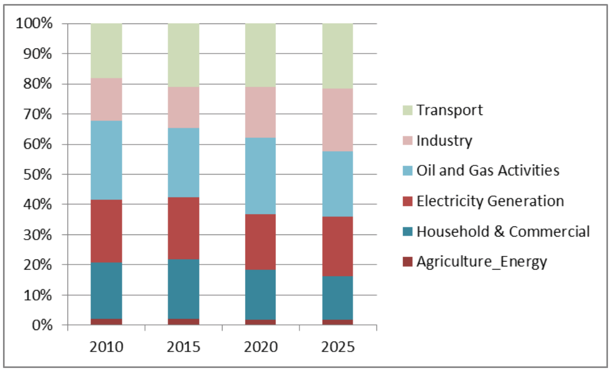

Figure (3.4): Contribution of Energy Sub-sectors to Total GHGs Emission in BAU Scenario

3.1.3.2. Emissions in Mitigation (MIT) Scenario

In this section the aggregate mitigation impact of the measures mentioned in section 3.2.2.2 will be analyzed. First in figure 3.5, total greenhouse gas effect in MIT scenario is compared to BAU scenario. The gap between the two scenarios emerges after 2015 and constantly grows such that in 2025 it reaches to 148 million tons CO_2 equivalent. Compared to BAU scenario, this figure signifies 11% reduction in greenhouse effect in 2025.

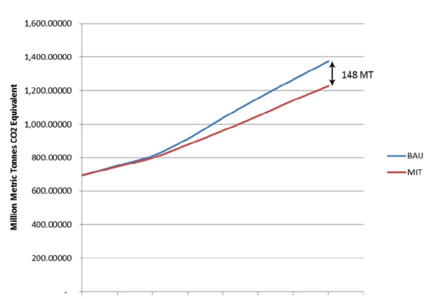

Figure (3.5): Total Greenhouse Effect in MIT Scenario vs. BAU Scenario in Energy Sector

The aggregate impact of all mitigation measures considerably curbs the BAU curve in a way that annual average growth rate descends to around 4.1%. However the investment costs to implement all these measures is estimated to be $70 billion[1] . In order to meet such a heavy cost, Iran's national actions to mitigate its GHGs should be substantially enhanced by removal of unfair sanctions, and facilitated through foreign and international financial support.

Figure 3.6 presents a better view of the contribution of each subsector to total emission reduction in energy sector.

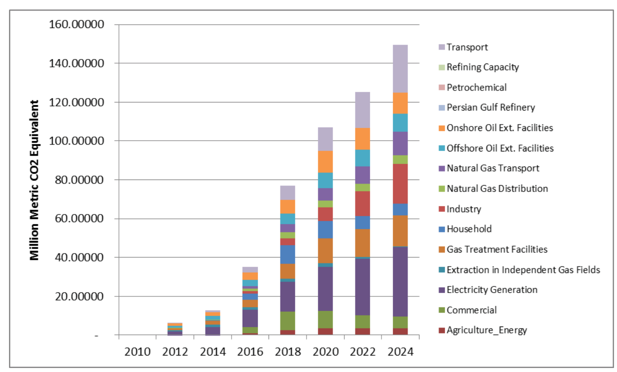

Figure (3.6): Contribution of Energy Subsectors in Total Greenhouse Effect Reduction (BAU vs. MIT)

As are shown in the figure 3.6, the 11% reduction in 2025 mainly comes from four subsectors: industry, natural gas supply chain (gas treatment facilities and transport and distribution network), electricity generation and transport sector, respectively, with the following shares: 2.61%, 2.48%, 2.07% and 2.05%. The reason why electricity generation in figure 3.6 is bigger than others, is because part of electricity savings, as a result of mitigation

1 2015 constant prices

measures in demand-side sectors, are attributed in the graph to electricity generation, while they actually originate from electricity management in other sectors and therefore must be counted for those sectors.

There would be 45.8 million tons of CO_2 equivalent reduction - out of total 148 million tons reduction- in all oil and gas activities in 2025. This includes flare gas recovery and gas supply chain management which are 3.4% of 11% reduction burden.

Table 3.1 summarizes all scenarios, their cumulative costs and benefits during 2010-2025 relative to BAU scenario which are discounted to 2015 with a rate of 18%. Total investment costs to implement all these measures are estimated to be $38.865 billion. Considering that during 2010-2025 about 740 million tons CO2 equivalent has been saved, cost of avoiding GHGs would be $52.5 per ton CO_2e. However, if foreign trade benefits are taken into account, net present value of all costs and benefits will decline to $12.135 billion, which yields an abatement cost of $16.4 per ton CO_2e.

Table (3.1): Costs and Benefits of Mitigation Measure by Sector

Aggregated Measures	Costs Billion US Dollar)	Reduction compared to BAU in 2025 (%)
Household and Commercial	4.00	0.65
Transport	15.02	2.05
Industry	7.10	2.61
Agriculture	1.815	0.18
Electricity Generation	8.45	2.07
Gas Supply Chain	0.45	2.48
Oil Ext. Facilities	2.03	0.93
Foreign Trade	-18.35	
Opportunity Cost	-8.38	
Net Present Value	12.135	Total GHGs Savings during 2010-2025: 740 Million Tons CO_2e
Cost of Avoiding GHGs (U.S. Dollar/Tonne CO_2e)	16.4	

3.2. Non-energy Sector

The non-energy sector study is concentrated on sub-sectors like industrial processes, agriculture, forestry and land-use change and waste. The detailed study of these sectors takes into account all possible sources of GHG emissions; for instance the industrial processes sector, cement industry, iron and steel industry, nitric acid, etc are all considered as sub-sectors. Sub-sectors for waste and agriculture sectors are "liquid and solid waste" and "agriculture and animal husbandry", respectively. In-depth studies of these sub-sectors provided us the opportunity to assess the mitigation potential in the non-energy sector comprehensively. In general, the framework of the study for the non-energy sector is identical for all sub-sectors and is based on developing two different scenarios (like energy sector): BAU and Mitigation. We choose the year 2010 as the base year and the period from 2010 to 2025 as the time horizon of the study. All variants of the scenarios and assumptions within them are discussed in the following sections.

3.2.1. Industrial Process and Product Use (IPPU)

Greenhouse gas emissions are produced from a wide variety of industrial activities. The main emission sources are releases from industrial processes that chemically or physically transform materials. Through these processes, many different greenhouse gases, including CO_2, CH_4, N_2O, HFCs and PFCs, can be produced.

Almost all the following categorized industrial processes exist in Iran:

a) Mineral Industry (Cement production, lime production, limestone use, etc.)

b) Metal Industry (Iron and Steel Production, Aluminum Production, etc.)

c) Chemical Industry (Nitric Acid Production, Ethylene Production, etc.)

d) Other Industrial Processes (Pulp and Paper Production, Food and Drink Products, etc.)

The results of inventory group studies (Greenhouse Gas Emission Inventory for Industrial Process, August 2014) shows that 93 percent of GHG emissions of mineral industry subsector, 97 percent of GHG emissions of metal industry subsector and 98 percent of GHG emissions of chemical industry subsector are emitted from cement, iron and steel (50% of metal subsector), aluminum (47% of metal subsector), ethylene (50% of chemical subsector), ammonia (31% of chemical subsector), methanol (11% of chemical subsector) and nitric acid (6% of chemical subsector) productions, respectively. Furthermore, these special industries are given priority to consider the various aspects of the task.

First, we tried to gather reliable information of production plans. This long procedure was done with reference to imperfect information which is accessible at the following centers:

- Iranian Mines & Mining Industries Development & Renovation Organization (IMIDRO);

- Ministry of Industries and Mines;

- Management and Planning Organization;

- Statistical Center of Iran; and

- Cement Technology Magazine (http://www.cementechnology.ir/).

The GHGs emission was calculated according to above mentioned extracted information between 2010 and 2015. There are not national emission factors for industrial processes in Iran; therefore the default methods proposed by IPCC 2006 Guidelines was used to estimate emissions and depending upon the process type and quality of product, the emission factors was selected. Iran's fourth and fifth development plans, and "Iran's 20-years Outlook" were used to foresee the production between 2015 and 2025 and the GHG emissions was calculated accordingly.

3.2.1.1. Definition of Scenarios and Key Assumptions

Based on historical consumption and emission levels of greenhouse gases in Iran from 2010 to 2015, emission forecasts until 2025 are elaborated for each individual sector, with and without additional abatement measures in the following scenarios:

- Business as Usual (BAU): The BAU scenario was developed to show the effects of Iran's official development plans which are codified in "Iran's fourth and fifth development plans" and "Iran's 20-years outlook" on the emission of industrial process. To develop this scenario, the mentioned plans were examined and probable effects were considered in emissions calculations.

- Mitigation Scenario (MIT): The emission reduction scenario assumes that existing technology potentials for abating or substituting emissions are exploited in each individual emission sector. To evaluate mitigation options, all related registered Clean Development Mechanism (CDM) projects and approved methodologies in United Nations Framework Convention on Climate Change (UNFCCC) website were contemplated. The appropriate ones for each subsector were chosen according to Iran's industries and their projected effects were implemented in the emissions calculations.

3.2.1.2. Emissions in BAU Scenario

'BAU' emissions from the industrial processes in 2025 are projected to be 160 Mt CO_2-e. This shows more than 2.5 times increase over the 2010 level and is due to the following factors.

- Chemical Industry: The majority of GHGs in this sector is emitted from the production of four chemicals which are projected in table 3.2.

Table (3.2): Production and Emission Projection of Key Chemical Products (CO_2 equivalent)

Chemical Industries	2010		2025	
	Production 1000 tone	Emission Gg	Production 1000 tone	Emission Gg
Ethylene	3922	6185	17888	26,483
Ammonia	3200	3001	13157	13121
Methanol	3100	1406	41922	18,626
Nitric Acid (100%)	203	544	259	695

It is clear that the increasing chemicals production capacity is one of Iran's priorities. Moreover, there has been too much attention to the development of the petrochemical plants in Iran's fourth, fifth and sixth development plans and Iran's 20-years Outlook. Thus, emissions from this sector are projected to increase from 11,045 Gg CO_2 equivalents in 2010 to about 58,953 Gg CO_2 equivalent in 2025.

- Mineral Industry: Cement production is one of the major sources of emissions in the industrial processes. As a result of economic growth and the necessity of cement production in infrastructural development, and according to the Iran's fifth development plan, cement production capacity are projected to grow from 66.87 million ton in 2010 to 90 million ton in 2015. It is, nevertheless, planned to reach to the production capacity of 110 million ton in 2025 based on Iran's 20-years Outlook.
Historical data show that the "real production" to "production capacity" ratio is 90.18%. Considering this amount, the cement production is projected to grow from 61.65 million ton in 2010 to 104.2 million tons in 2025 (MIMT[1] , 2014), and BAU emissions from this sub-sector are projected to grow by 69 percent between 2010 and 2025. The selected emission factor for this subsector is 0.4985 ton CO_2/ton produced cement according to IPCC 2006 guideline.

- Metal Industry: Iranian government is paying special attention to iron and steel production because of its importance in infrastructure development. It is projected to produce about 45 million tons at the end of the 5th Development Plan (based on Economic Council Directive). Steel production capacity shall reach to 55 million tons in 2025 as it is mentioned in 20-year Outlook (MIMT, 2014).
Therefore, steel production is projected to grow from 12.72 million tons in 2010 to about 38.87 million tons in 2025. GHG emissions from process-related sources at iron and steel facilities will vary, depending on the type of facility

1 Ministry of Industry, Mine and Trade

and the different production processes used at the facility. About 30 percent of produced steel in Iran until 2015 has been produced by indirect reduction (blast furnace) and oxygen converting. The remaining 70 percent has been produced through the direct reduction manner and using electric arc furnace. The same ratio is considered for projection of steel production until 2025. The emission factor for the process are 1.46 and 0.78 (ton CO_2/ton steel) respectively. It shall be considered that about 20 percent of electric arc furnace volume is filled with recycled steel scrap (with emission factor equal to 0.08 ton / tone steel) that is combined with pig iron.

The emissions from the aluminum production sector were 1,517 Gg CO_2-e in 2010. This rises to more than 5,784 Gg CO_2-e in 2025, an increase of 400 percent. This large growth is due to high annual growth rates in the manufacturing of aluminum. The aluminum production in 2010 was 303,000 tons and it is projected to grow to more than 1,155 thousand tons in 2025. The emission factor considered for emission calculations is 1.6 tons of CO_2, 0.4 Kg of CF_4 and 0.04 Kg of C_2F_6 per ton of produced aluminum. The majority of produced PFC is CF_4 with a Global Warming Potential (GWP) equal to 7300.

Figure (3.7) shows the projected BAU emissions from industrial processes by sub-sectors.

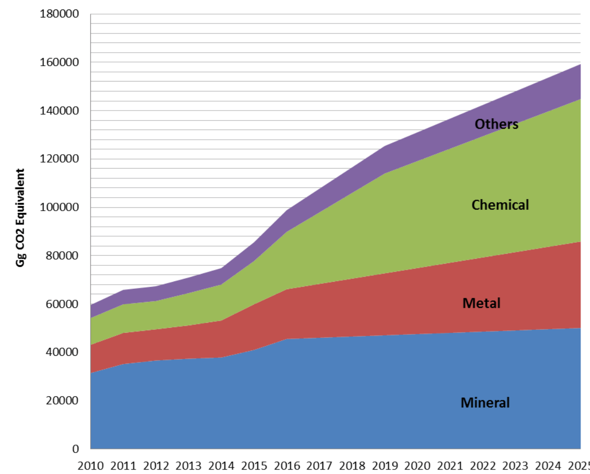

Figure (3.7): BAU Emissions Projection by Sub-sector for Industrial Processes.

It is shown that the total emission from industrial processes increases from 61,857 Gg in 2010 to about 159,284 Gg in 2025.

3.2.1.3. Emissions in MIT Scenario

Production of clinker causes large emissions of CO2. In pozzolanic (blended) cement, a portion of the clinker is replaced with industrial by-products such as blast furnace slag (a residue from iron making), or other pozzolanic materials (e.g. volcanic material). These products are blended with clinker to produce a homogenous product; blended cement. The future potential for application of blended cements depends on the current application level, on the availability of blending materials, and on standards and legislative requirements.

The suitable amount of iron-furnace slag in cement ingredients is 20 percent and it can be increased by 30 percent according to the slag production process. Also, it is assumed that 30 percent of total annually produced cement in

Iran will be produced as blended cement.

Iron and Steel Production: As mentioned before, the emission factors for various steel production processes are different. It is 1.6 ton CO2 per ton of produced steel for indirect reduction manner (blast furnace) and 0.705 ton CO2 per ton of produced steel for direct reduction process. So, the effective method to emission reduction is the change of production process from blast furnace to direct reduction and using the recycled steel scrap in electric arc furnace (with emission factor equal to 0.08 ton pet tone produced steel). Therefore, although expansion of iron and steel production capacity is the priority of the government, but there is no limitation in GHGs emission from this sector, because all development programs are based on direct reduction method and using 20 percent of steel scrap.

Aluminum Production: PFCs are formed as intermittent byproducts during the occurrence of Anode Effects (AEs). When the alumina ore content of the electrolytic bath falls below the optimal levels, chemical reactions take place and rapid voltage increases occur. These AEs reduce the efficiency of the aluminum production process, in addition to generating PFCs.
The frequency and duration of AEs depend primarily on the cell technology and process operation. Emissions of PFCs, therefore, vary from one aluminum smelter to the next, depending on these parameters. As a result, to reduce PFC emission each smelter must develop a strategy, which may include some or all of the following measures.

- Improving Alumina Feeding Techniques

by installing point feeders and regulating feed with computer control. Point feeding consists of adding small amounts of alumina-about one kilogram-at various short intervals, usually less than one minute. This is the best alumina feeding method at present, and point feeding is now an important feature in all new cells, as well as in modernization or retrofitting projects for older cell lines.

- Using Improved Computer Controls

to optimize cell performance. These systems monitor the different parameters that contribute to the built-up of AEs. System operators would be alerted before an AE can take place, thus reducing the AE frequency. Improved computer controls can also work in conjunction with point feeders.

- Training Cell Operators for methods and

practices to minimize frequency and duration of AEs. Also, operators can be trained to maintain strict control over alumina properties and cell operating parameters, and to provide timely and appropriate mechanical maintenance.

Utilizing PFCs reduction measures can reduce the emission factor from 0.4 to 0.04 kg CF_4, and from 0.04 to 0.004 kg C_2F_6 per ton produced aluminum. Because of the high GWP of PFCs, the CO_2 equivalent emission reductions are relatively high. The projected CO_2 equivalent emission reduction from this sector is about 3,543 Gg/year in 2025 and about 26,500 Gg until 2025 in comparison with BAU on a cumulative basis.

Ethylene Production: Ethylene mostly produced through the Dehydrogenation of Ethane. The types and mixture of feedstock used in steam cracking for ethylene production vary by region, and include ethane, propane, butane, naphtha, gas oil, and other petrochemical feedstock. In Iran, most ethylene (about 70%) is produced from steam cracking of ethane. The rest ethylene (about 30%) is produced from naphtha. Iran has enough gas reservoirs to produce all ethylene from ethane; therefore, piecemeal change of the ethylene production feed from naphtha to ethane is rational and leads to GHG emission reduction.

Use of this method can reduce the emission factors from 1.73 to 0.95 (ton CO_2/ ton produced ethylene) and from 6 to 3 (Kg CH_4/ ton produced ethylene) on average. So, the projected CO_2 equivalent emission reduction from this sector is about 2,137 Gg in 2025 and about 13,138 Gg cumulatively until 2025 in comparison with BAU.

Nitric Acid Production: Nitric acid is produced through catalytic oxidation of ammonia at high temperatures, which creates N_2O as a reactionary by-product released from reactor vents into the atmosphere. Nitric acid production comprises the majority of N_2O emissions from industrial process. N_2O abatement option has several variations developed by different companies, all involving the decomposition of N_2O into nitrogen and oxygen using various catalysts. The average estimated reduction efficiency is approximately 90 percent. Using of these methods can reduce the emission factor from 9 to 2 (Kg N_2O/ton produced acid) on average. So, the projected CO_2 equivalent emission reduction from this sector is about 550 tons annually in comparison with BAU.

Methanol and Ammonia Production: Currently, there is no effective method to reduce the process-wise GHG emission reduction from these subsectors.

3.2.1.4. Overall GHGs Emission in Industrial Process

Table 3.3 shows the emission reduction potential by industrial subsectors in addition to total investment cost for each subsector.

Table (3.3): Emission Reduction Potential by Subsector (Gg).

Year / Sources	2020	2025	Total Investment Cost (Million US $)
Mineral Industries	3853	4508	11.87
Chemical Industries	2069	2651	5.60
Metal Industries	2872	3543	144

It illustrates that the mineral and chemical sub-sectors have the maximum and minimum effect on GHGs emission reduction respectively.

Figure 3.8 shows the GHG emission in BAU scenario versus aggregate impact of all GHGs emission mitigation measures in MIT scenario from industrial processes.

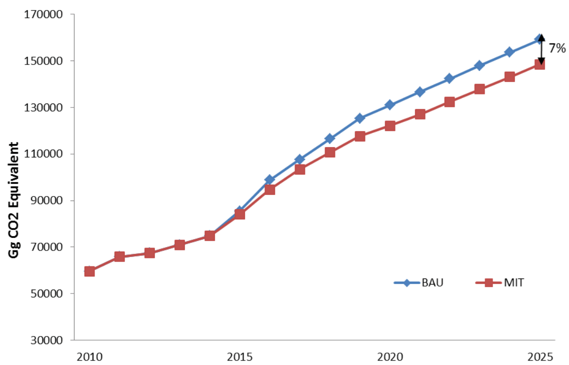

Figure (3.8): BAU Scenario vs. MIT Scenario for Industrial Process and Product Use.

As is shown in figure 3.8, the total mitigation potential of industrial process on GHGs emission is about 10,751 Gg CO_2-equivalent in 2025 (7% below BAU). Also overall cumulative GHGs emission reduction from 2010 to 2025 in industrial process is about 108,000 Gg, with an abatement cost of about 3.5 US dollar per ton of CO2-equivalent. As a result, the mitigation measures in industrial process are as below:

- Piecemeal change of the ethylene production feed from naphtha to natural gas;

- Replacing a portion of the clinker with industrial by-products such as blast furnace slag in cement industry;

- Improving Alumina feeding techniques and using improved computer controls in aluminum sector; and

- N_2O abatement via a catalytic process while producing nitric acid.

3.2.2. Waste

In general, one of the most effective ways of reducing methane emissions from existing landfill sites in the country is Landfill Gas (LFG) collecting and burning which is produced in these places.

Along with this process, the conversion of organic wastes through the other methods of treatment and disposal of waste and to reduce the volume and area of landfill sites will play a significant role in future GHG emission reduction in this sector.

On the other hand, increasing the efficiency of biogas generation and its utilization will reduce GHG emissions from wastewater treatment plants.

The most important factor in the production of GHGs in the liquid waste sub-sector is the use of different methods of treatment (aerobic or anaerobic).

As reported in the inventory section, the main part of the GHG emissions in the liquid waste sub-sector is related to industrial wastewater. The total amount of GHG emissions from waste sector has been estimated about 27,578 Gg CO_2 eq in 2010 (table 3.4).

Table (3.4): Total GHG Emissions (Gg) in the Base Year (CO_2 eq.)

Year	Solid waste sub-sector	Liquid waste sub-sector	Total CO_2 eq. emissions
2010	775.5	26803	27,578.5

To identify and provide efficient methods and appropriate mitigation measures in line with the framework of national programs, basic data and information of affecting factors in the process of GHG emissions, especially methane, in different parts of waste management systems is needed.

3.2.2.1. Mitigation Scenario (MIT) in Solid Waste Subsector

LFG generated at SWDS can be recovered and combusted in a flare or energy device. Along with this process, the conversion of biodegradable and organic wastes through other methods of treatment and disposal of wastes and to reduce the volume and area of landfill sites, can have a significant impact on the amount of future GHG emissions in this sector. On the other hand, wastewaters and remaining sludge have a great GHG emissions potential, especially methane emissions. Methane is produced in this sub-sector when wastewater or sludge treated or stored under anaerobic conditions and the generated gas release into the atmosphere.

Proper control and optimal management of wastewater treatment plants and also the use of biogas produced in the anaerobic wastewater treatment methods will significantly decrease GHGs emissions.

There are different methods for reducing CH_4 emission from waste landfill sites depending on region technical, economic and social conditions. The major mitigation policies are categorized as follows:

A) Sanitary-engineering Landfills with Appropriate Biogas Collection and Recovery Systems as Well as Changing Landfill Sites from Anaerobic to Semi-aerobic

Biogas gathered in the municipal landfill sites can be used in the following ways as an energy source or be burned.

- Burning LFG in Open or Enclosed Flares

According to the Solid Waste Management Act and its executive regulations and guidelines (particularly Clause 2, Article 17 of the regulation) it can be predicted that by the end of 2025, the gas recovery will reach to about 7 percent of total Municipal Solid Waste (MSW) landfills.

- LFG Recovery in order to Generate Electricity

Recovered biogas can be used in an electricity generator in the site. Electricity generation requires relatively large amounts of LFG and therefore, is not proposed for small landfills in rural areas. Considering country's national plan for electricity generation from LFG under Solid Waste Act and capacity of the country to absorb financial support from international organizations, it would be projected that about 2% of total recovered LFG in 2025 converted to electricity.

- Utilization of LFG as a Medium BTU Gas

With respect to availability of highly subsidized natural gas within the country, recovery and utilization of LFG for heat generation will not be realized.

- Changing Landfill Sites from Anaerobic to Semi-aerobic

2% of methane emission from landfills can be mitigated by altering the condition of the landfills from anaerobic to semi-aerobic till 2025.

B) Proper Waste Collection and Suitable Transportation to Disposal Sites

Proper planning, collection frequency, collection method, suitable transportation to disposal sites, capacity and type of waste containers, especially in hot zones of country could reduce methane emission. This reduction is predicted to reach about 2% till 2025.

C) Reduction in Utilization of Waste Transfer Stations

Reducing waste transfer stations as well as direct transportation to landfill sites will result in 2% reduction in methane emission in 2025.

D) Recycling, Source Separation and Public Participation

One of the most effective ways of reducing GHG emissions in urban and rural areas is adequate training programs in various sectors of society and public participation attractions.

Due to extensive programs in the field of public training and public awareness in both governmental and non-governmental sectors as well as increasing recycling industries, it is predicted that at least 12% reduction in GHG emissions by the end of 2025 is reachable.

Mitigation potential in different solid waste sub-sector policies is summarized in table 3.5.

Table (3.5): Mitigation Policies in Solid waste Sub-sector

Mitigation policy	GHGs Reduction by 2025 (%)
Sanitary-engineering landfills with appropriate biogas collection and recovery systems as well as changing landfill sites from anaerobic to semi-aerobic	11
Proper Waste Collection and Suitable Transportation to Disposal Sites	2
Reduction in Utilization of Waste Transfer Stations	2
Recycling, Source Separation and Public Participation	12
Total	27

3.2.2.2. Mitigation Scenario (MIT) in Liquid Waste Subsector

In general, there are different methods for reducing methane emissions from wastewater treatment plants. Basic and effective options in this regard are as follows:

A) Wastewater Collection and Treatment

In several parts of the country especially in rural areas, domestic/industrial wastewater is under anaerobic conditions, and as such has high potential for GHGs emission. Therefore urban/rural wastewater collection and proper treatment is one of the most important approaches to reducing GHGs emission to the atmosphere. Bearing in mind developing the new treatment plants and accomplishing the plants under construction, it is predicted that GHG reduction will reach to 9 % till 2025.

B) Wastewater Treatment Process Optimization

Considering country's national plan on wastewater treatment, the optimization of treatment plants may result in 2% reduction in GHGs emissions till the end of 2025.

C) Implementation of Modern Facilities which are Compatible to Existing Situation of the Country

Implementation and utilization of modern and suitable facilities which are compatible to existing situation of wastewater treatments in the country can be considered as an option with a 1.5% mitigation potential in liquid waste sub-sector.

D) Recycling and Reuse of Treated

Wastewater

Recycling and reuse of treated wastewater will have inevitable effects and will result in methane emission reduction of about 2% till the end of 2025.

E) Aerobic Treatment of Domestic and Industrial Wastewater and Sludge

Aerobic primary wastewater treatment is achieved by sustaining sufficient oxygen levels during the primary phase of wastewater treatment, using controlled organic loading techniques or providing oxygen to the wastes through mechanical/diffusion aeration. Aerobic secondary treatment consists of stabilizing wastewater by prolonging its exposure to aerobic microorganisms which result in reducing GHGs emissions. Finally land treatment involves applying wastewater to the upper layer or the surface of soil, which acts as a natural filter and breaks down the organic constituents in the wastewater. With regard to development of aerobic wastewater treatment plants in Iran, the amount of reduction from this option is estimated to be about 6 % till the end of 2025.

F) Methane Recovery from Anaerobic Wastewater/Sludge Digesters

Anaerobic controlled condition makes it possible for methane to be recovered and used as a source of energy. Based on executive guideline of Iran Solid Waste Management Act, MOE is responsible to buy the electricity generated from methane recovery. Amount of GHGs reduction due to this policy is estimated to reach about 2.5% till 2025.

G) Public/Industries Training Program for Improving Water Consumption Patterns

Increasing productivity in industries in order to reduce water consumption or reuse it, is one of the most effective methods for GHG emission reduction in liquid waste sub-sector. With regard to country national plan, it seems that GHGs emission reduction will occur at about 9% ill the end of 2025. Mitigation potential for different liquid waste sub-sector policies is summarized in table 3.6.

Table (3.6): Mitigation Policies in Liquid Waste Sub-sector

Mitigation policy	GHGs Reduction by 2025 (%)
Wastewater Collection and Treatment	9
Wastewater Treatment Process Optimization (both aerobic and anaerobic processes)	2
Implementation of Modern Facilities which are Compatible to Existing Situation in the Country	1.5
Recycling and Reuse of Treated Wastewater	2
Aerobic Treatment (both in primary and secondary stages) of Domestic and Industrial Wastewater and Sludge	6
Methane Recovery from Anaerobic Wastewater/Sludge Digesters	2.5
Public/Industries Training Program for Improving Water Consumption Patterns	9
Total	**32**

3.2.2.3. Emission in Mitigation Scenario (MIT)

According to the above-mentioned policies; GHGs emission in the mitigation scenario could be presented in table 3.7.

Table (3.7): Total GHGs Emission (CO_2 eq.) in Mitigation Scenario (Gg)

Year	emissions from solid waste	emissions from liquid waste	Total GHG emission
2010	775.5	26803	27578.5
2015	818	27020	27838
2020	780	24500	25280
2025	670	19900	20570

Figure 3.9 shows the GHG emissions (CO_2 eq.) in mitigation scenario compared to BAU scenario in the waste sector. It is shown that the implementation of all mitigation measures which were discussed could bring about 31% reduction in 2025 compared to BAU.

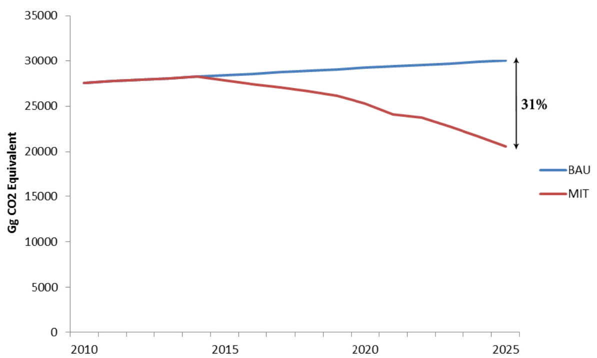

Figure (3.9): The Trend of Total GHG Emissions in Mitigation Scenario Compared to BAU

3.2.2.4. Cost analysis of MIT Scenario

Cost of Saved Carbon (CSC) for different mitigation measures in waste sector (solid and liquid waste) are estimated and shown in table 3.8.

Table (3.8): Investment Estimation for GHGs Mitigation Options in Solid Waste Sub-sector

Waste Sub-sector	CSC (US$/ton CO2 Eq.)
Mitigation measures in solid waste	184.5
Mitigation measures in liquid waste	9.34

It can be inferred that mitigation cost per ton CO_2 eq. for solid waste has estimated about 184.5 US $, while for wastewater sub-sector, it is estimated about 9.34 US $. The major cause for huge difference in CSC ratio between solid and liquid waste is that establishment of landfills with LFG recovery system is costly in comparison to liquid waste mitigation actions.

3.2.3. Agriculture

Agriculture is considered to be an important economic sector in Iran. Its share in GDP is about 12%, providing employment for 33 million people. It plays a vital role in food security of the growing population and providing major portion of domestic needs of food crops in the country. Nevertheless, domination of production oriented approach and less attention to sustainability of production resources has already resulted in degradation of basic resources including crop land, forest and rangeland.

Livestock, paddy fields, burning of crop residues and agricultural soil are 4 major sources of emissions' from agriculture. This report provides information regarding emissions from the above said sources by considering two scenarios, namely business as usual and mitigation scenario.

3.2.3.1. Business-As-Usual (BAU) Scenario

BAU scenario is developed based on the past figures of the main factors (during 2000-2010) and continuation of them by 2025. In this scenario due to limitations in the agriculture sector during past two decades, especially perpetuated droughts and depletion of water resources, increase in area of crops, in particular high water consuming crops, was predicted in a way to match the available and future land and water resource development. In case of animal population, due to the plans for modernization of dairy farms and development of livestock subsector in the country a reasonable growth rate is considered for this vital sub-sector of agricultural industry. Before we get started with projecting emission in BAU scenario, we take a look at the trend of GHGs emission from agriculture activities in table 3.9.

Table (3.9): Trend of Emission of CH_4 and N_2O GHGs from Agriculture Sector

Source	CH_4			N_2O		
	2001	2006	2010	2001	2006	2010
Enteric Fermentation	903.59	859.78	780.72			
Manure Management	35.94	34.60	31.70	3.82	4.35	3.62
Rice Fields	41.02	50.14	44.68			
Agricultural Soils				52.02	40.81	54.75
Total	980.55	944.52	857.1	55.84	45.16	58.37

As shown in table 3.9, CH_4 emissions undergo a decreasing trend and have decreased from 980 Gg in 2001 to 944 in 2006 and then to 857 Gg in 2010, which is mostly attributed to decreased sources of emission, especially the number of animals. In case of emission from manure management the changes are not significant. Having said that, continuation of past trends in agriculture sector leads GHGs emission in BAU scenario is increased gradually, which are shown in table 3.10 and figures 3.10 and 3.11.

Table (3.10): GHG Emission from Agricultural Activities in BAU Scenario

Year / Source	Base year 2010 (Gg)		Business As Usual 2015 (Gg)		2020 (Gg)		2025 (Gg)	
	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O	CH_4	N_2O
Enteric Fermentation	780.7		859.5		948.0		1043.6	
Manure Management	31.7	3.62	34.47	4.01	38.34	4.29	42.1	3.62
Rice Fields	44.68		40.39		36.51		33	
Agricultural Soils		54.75		61.02		74.37		82.65
Total Emissions	857.1	58.37	934.35	65.03	1022.7	78.6	1118.7	86.27
Total Emissions (CO_2-e)	17999	18094.	19621	20159	21478.6	24384.6	23493.9	26743.7
Total GHGs emission (CO_2-e)	36093.8		39780.6		45863.2		50237.6	

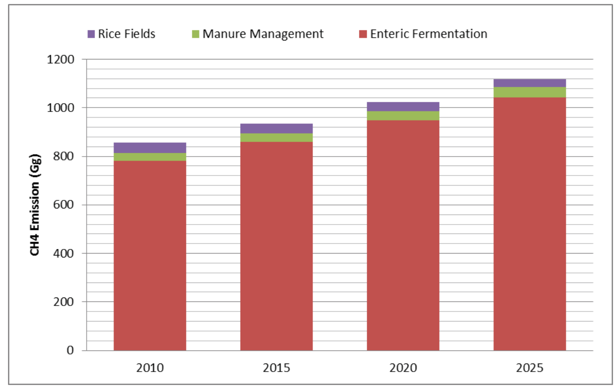

Figure (3.10): Trend of CH_4 Emission from Agricultural Activities in BAU Scenario

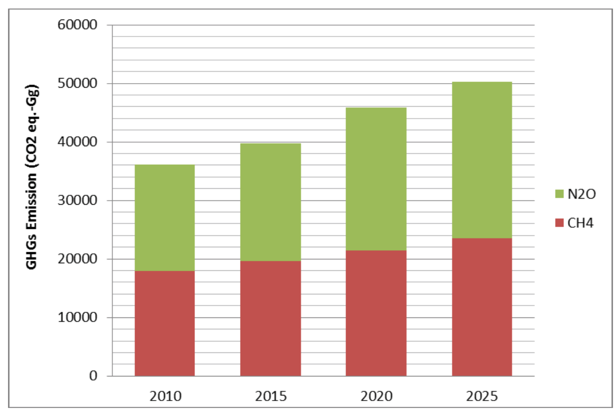

Figure (3.11): Trend of GHGs Emission from Agricultural Activities in BAU Scenario

3.2.3.2. Mitigation (MIT) Scenario

There are a number of options for reducing emissions of GHGs in the country, the most important of which is the reduction of CH_4 emissions in livestock. These measures are as follows:

A) Enteric Fermentation

CH4 generated by ruminants can be reduced through reducing the quantity of feed per production unit (milk, meat) in conjunction with improving quality of diet and increasing livestock productivity by substituting parts of maintenance diet with production diet. As a result, by improving productivity, part of the feed used for maintenance is reduced which can reduce CH_4 emission. So the major mitigation options for reduction of CH_4 emission from enteric fermentation are as follows:

- Processing livestock feed
- Enriching wheat straw with urea
- Addition of complementary materials like molasses in feed
- Genetic improvement

B) Manure Management:

CH_4 is produced from decomposition of organic components of animal wastes at anaerobic condition. The amount of CH_4 produced depends on the quantity of the wastes. In addition, the emission of the CH_4 can be reduced, if the wastes are collected as dry or spread on the fields and rangeland. However, due to nitrogen cycle, N_2O is emitted from the wastes, when it is spread. Manure can be used as animal fertilizer for production of agricultural crops, feed for animals and complementary feed for aquatics.

Using Biogas Recovery System: One of the main challenges encountered by the livestock producers is managing animal wastes. Using biogas recovery system has many benefits including environmental benefits like odor control, reducing ammonia and more importantly mitigating methane emission as a GHG.

Biogas is a natural product of anaerobic digestion, which typically has 60 to 70 percent Methane, 30 to 40 percent CO_2 and small amount of other gases. Biogas can be utilized for generating heat and electricity. Therefore, some of the costs related to energy can be compensated by generated gas and electricity. On the hand land, since anaerobic digestion can reduce ammonia loss, the manure produced through the process of digestion has more nitrogen content for fertilizing plants and enhance soil fertility. There are two general types of digesters.

- Small scale digesters:

These structures are suitable for medium and small dairy farms in rural areas. The capacity of these digesters varies from 4-5 m3 to 75-100 m_3, with a capacity of 2.9 m_3 per day. By utilizing these systems, methane emission can be reduced by up to 70%.

- Large scale digesters:

These digesters have the same working principle as the small scale digesters, but they are suitable for large dairy farms, with capacity of handling wastes produced by few hundred up to few thousands animals. These installations can produce 0.25 to 0.6 m_3 of biogas per every kg of volatile solid manure kept at 30 to 35 degree Celsius. These digesters have high efficiency, are equipped with gas recovery systems, and are able to reduce methane emission by up to 70% or more.

- Covered digesters:

Methane produced in lagoons can be recovered by non-penetrable digesters, which are sealed.

The amount of biogas recovered by these systems varies from 187 to 375 m3 biogas per every ton of volatile solid waste. Considering that each animal produces 10 kg of volatile solid waste per day, the rate of daily biogas recovered can be from 112 to 225 m3 per every 100 heads of livestock.

C: Reducing Methane in Paddy Lands

Methane produced in paddy lands can be mitigated by:

- Reducing the area under cultivation of paddy lands

- Intermittent flooding and midterm drainage

- Rice cultivars with short term growth

D: Mitigating Carbon Emission in Agricultural Soils

Carbon emission can be reduced by adopting the following agricultural practices:

- No tillage cultivation

- Minimum tillage cultivation

- Reducing the number of livestock from rangeland

As it was mentioned, there are a number of options to abate GHGs emission in agricultural sector of Iran. Some of the options are expensive and cannot be adopted by the farmers and some of them are costly, time consuming, and cannot be afforded by the majority of poor farmers and owners of dairy farms. However, the following options can be proposed to mitigate the effects of the GHGs in the country:

- Reducing area of rice cultivation

- Manure management and biogas recovery

The impact of mitigation policies on GHGs emission reduction are shown in figure 3.12. The results show that the GHGs emission in Mitigation Scenario is 14.3 % lower than BAU emission in 2025.

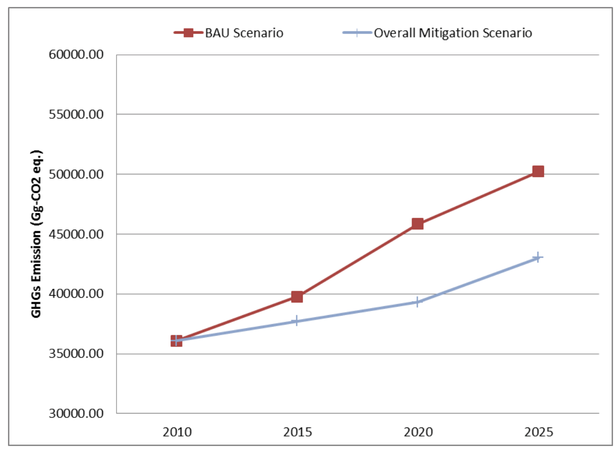

Figure (3.12): GHGs Emission in BAU and Mitigation Scenario for Agriculture (Gg-CO_2 eq.)

3.2.4. Forestry and Rangeland

In land-use change and the forestry sector there are two types of GHGs mitigation policies and measures, which are:

- Decreasing the emission by using correct management rules, development of protective operations, public awareness and reduction of villagers and tribes' reliance on forests and rangelands by supplying their life necessities; and

- Increasing the CO_2 uptake by rehabilitation of forests, afforestation and reforestation.

Based on these policies, the mitigation measures in forestry and land-use change are as follows:

- 20% reduction of illegal wood harvesting, forest and range land conversion to other land-uses per annum;

- 10% annual decrease in wood harvesting for fuel through the development of fossil fuel distribution systems such as natural gas and supplying the necessary fuels for villagers and tribes;

- 10%, annual decrease in forest fire through the implementation of fire management plan; and

- Increasing forest rehabilitation operations and forest development such as;

  ◦ Implementing 10 years reforestation and afforestation plan in Arasbaranian forests, Irano-Touranian forests and Khalidjo-Omanian forests;

  ◦ Rehabilitation of damaged lowland and highland forests in the north of Iran (reforestation);

  ◦ Afforestation in the highlands of the northern slopes of the Alborz Mountains; and

  ◦ Reforestation and afforestation in west of the country in the Zagros Mountains.

Through the implementation of 10 years afforestation/reforestation and forest management plan, 5 million ha will be added to area of forest land.

- Rangeland rehabilitation and development by dissemination of endemic species with higher capacity in CO_2 absorption and more resistance to drought and soil salinity.

- Balancing the amount of livestock to grazing capacity of ranges by developing animal husbandry (most importantly by fixing the habitation of traditionally nomadic tribes and changing the lifestyle of villagers and tribes based on using other rangeland ecological capacities such as secondary crops, pharmaceutical plant cultivation, beekeeping, aquaculture, etc).

Through the implementation of these measures, in the mitigation scenario, the net CO_2 emission of the forestry sector will be decreased from 21,570 Gg in 2010 to 16,560 Gg in 2025.

3.3. Overall Mitigation Assessment

Considering the mitigation options in both the energy and non-energy sectors, as described above, it is obvious that GHGs mitigation potential is relatively high in Iran. The energy sector with a mitigation potential of more than 148 million tons of CO_2 equivalent in 2025 has the largest potential followed by IPPU[1] (9.9 million tons), waste (9.4 million tons), agriculture (7.2 million tons) and forestry (5.01 million ton) sectors, respectively. This is the maximum amount of available potential for mitigation of GHGs in Iran which may be achieved, in case the international funding and technologies become available. A comparison of GHGs emissions' trends with BAU scenario is depicted in figure 3.13. The curve indicated by "MIT_Nonenergy" label, simulates only those mitigation measures in non-energy sector, while "MIT" includes all energy and non-energy measures.

1 Industrial Processes and Product Use

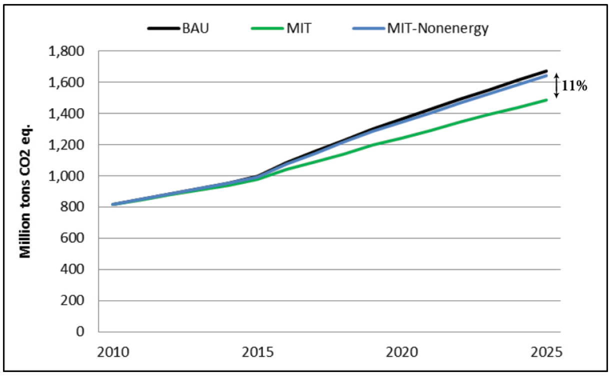

Figure (3.13): GHGs Emissions Trend in Different Scenarios for All Sectors

We can conclude that according to figure 3.13, Iran GHGs inventory could be smaller by 11% in 2025 with respect to BAU scenario, provided that there would be constructive international cooperation regarding technology transfer and financial aids. This new mitigation regime, if implemented properly, could prevent cumulatively up to 897.5 million tons of CO_2-eq. (740 of which as a result of mitigation measures in energy sector and 157.5 million tons from non-energy sectors) from being released into the atmosphere.

IPPU, waste and agriculture activities are the major sources of GHGs emissions in the non-energy sectors. According to our study in different sectors we have calculated mitigation potential in various non-energy subsectors.

As is indicated, in 2025 the overall GHGs mitigation potential is 179.5 million tons, with energy sector being responsible for 148 million tons, while the GHGs mitigation potential in non-energy sectors is about 31.5 million tons CO_2 eq. IPPU with some 9.9 million tons, has the highest mitigation potential in non-energy sector, while land use change and forestry with 5.01 million tons have the lowest GHG mitigation potential.

Vulnerability and Adaptation

Chapter 4

4.1. Introduction

In this section, Iran's temperature and precipitation changes in previous periods are discussed firstly. Then, the effects of climate change on water resources, agriculture, forest and rangelands, health, coastal zones, biodiversity, and the economy in the 2016-2030 periods are presented. In addition, in each section the adaptation strategies are introduced.

4.2. Past and Future Climate of Iran

4.2.1. Detection of Climate Change in Past Periods

In order to detect changes in Iran's temperature and precipitation variables in previous periods, long-term data from stations with proper dispersion throughout the country is required. However, in terms of both statistical duration and spatial distribution, meteorological stations in Iran lack a good coverage to detect climate change in previous periods. On the other hand, time series duration of meteorological variables is short in most stations. Figure 4.1 shows the distribution of synoptic stations in Iran whose recording data has begun since 1975. So far, several studies about detecting changes in temperature and precipitation variables have been carrying out in Iran that in the latest of which carried out by Soltani et al. (2016), the changes in the maximum and minimum temperature, precipitation, and 27 extreme variables of temperature and precipitation including warm nights (TN90p), cool nights (TX90p), hot days (TN10p), cold days (TX10p), Consecutive Dry Days (CDD), etc. are studied.

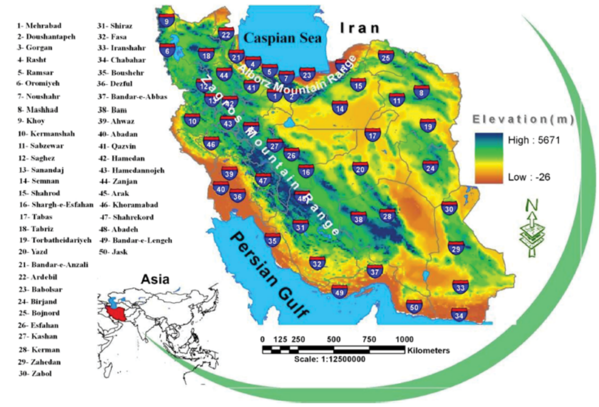

Figure (4.1): Distribution of Synoptic Stations of Iran with the Starting Year 1975 (Soltani et al. (2016))

Soltani (2016) estimated maximum and minimum temperature trend in Iran in 1975-2010 period. According to the results of this study, trend of maximum temperature is 0.03°C /decade, while minimum temperature trend is 0.06°C /decade which is double of the maximum temperature trend during this period. In addition the results show that the trends of maximum and minimum temperatures changes in winter are more than those of in summer. In other words, the trends of maximum and minimum temperatures in winter are 0.05 and 0.07°C/decade and those of summer are 0.02 and 0.06°C / decade, respectively. Minimum temperature trend being double of maximum temperature trend has been proven in other studies. But in the investigation carried out by Rahimzadeh and Nasaji (2013), the trend for maximum temperature is between 0.2-0.3 °C/decade and that of minimum temperature is between 0.4-0.5°C/decade that was much greater than the represented increase in the previous study (Figure 4.2). The first reason is that in the study of Rahimzadeh and Nasaji (2013), the study period of 1960-2010 has been considered. Secondly, the stations that have a non-homogeneous problem among the synoptic stations of Iran have been collected. That's why the number of stations was reduced to 32 stations in the study conducted by Rahimzadeh and Nasaji (2013).

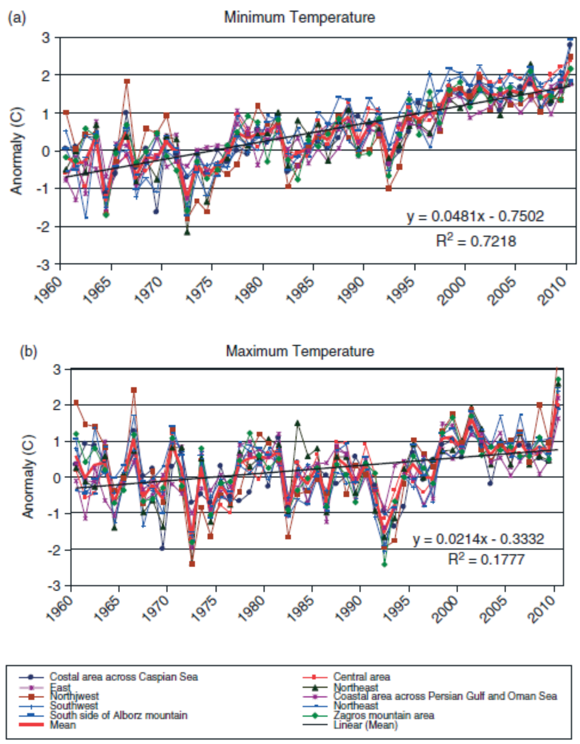

Figure (4.2): Maximum and Minimum Temperature Trends in Iran during 1960-2010 (Rahimzadeh and Nasaji (2013))

Based on the results presented in figure 4.3, in most stations of Iran, the trend related to warm nights (over 90% of the stations) and warm days in the period of 1975- 2010 has been increasing, while the increasing trend of warm nights is more than that of warm days. In contrast, the opposite is observed for cold nights and days in Iran. Based on figure 4.4, cold days and nights have experienced a downward trend in most stations of the country in the period of 1975-2010.

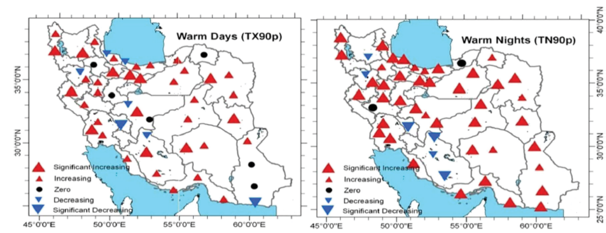

Figure (4.3): The Spatial Distribution Trend of Hot Days (TX90p) and Hot Nights (TN90p) in Iran during 1975-2010 (Soltani et al. (2016))

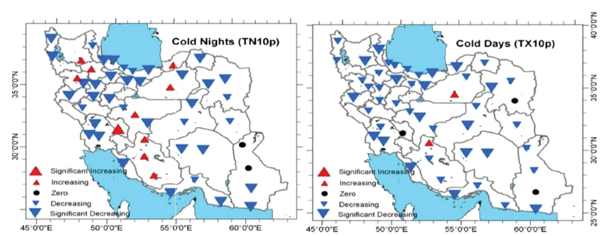

Figure (4.4): The Spatial Distribution Trend of Cold Days (TX10p) and Cold Nights (TN10p) in Iran during 1975-2010 (Soltani et al. (2016))

Unlike temperature which has significant increasing trend in most parts of the country between1975 and 2010, the trend of annual rainfall changes is not significant and is less than -1 mm per decade. However, the greatest decline in rainfall is in the West of Iran (-3.34mm / decade), and center of Iran was the only region with increased precipitation (0.11mm /decade) in the period of 1975-2010 (Table 4.1). According to these results, summer precipitation of Iran in this period has a positive trend (0.16mm/ decade) and that of winter has a negative trend (-0.75mm /decade). While the largest increase in summer precipitation patterns (1.81mm/ decade) occurred in the north of the country, the largest decrease in winter precipitation (-5.51mm /decade) occurred in the North East. However, the trends of annual and seasonal precipitation in most parts of Iran in the period of 1975-2010 are not meaningful.

Regions	Trends of total precipitation (mm/decade)		
	Winter	Summer	Annual
Northwest	-1.12	-0.17	-2.20
North	-2.77	1.81	-1.04
North east	-5.51	0.12	-0.75
West	-1.49	0.13	-3.34
Central	0.41	-0.01	0.11
East	0.04	0.02	-0.55
Southwest	-0.48	-0.01	-0.65
South	-0.79	0.20	-0.94
Southeast	-0.78	-0.04	-0.43

Table (4.1): Linear Trend of Annual and Seasonal Precipitation (mm/decade) in 9 Areas of Iran during 1975-2010 (Soltani et al. (2016))

Although in 1975-2010, seasonal and annual precipitation variations are not significant, extreme precipitation studies (Figure 4.5) show that in this period, changes in the amount of Consecutive Dry Day (CDD) has been increasing in most of the country's stations which cause a shortage of available water resources in the country in this period. According to figure 4.5 (the right one), average precipitation on wet days in most stations of the country has increased which can raise the risk of flooding because of the soil moisture reduction.

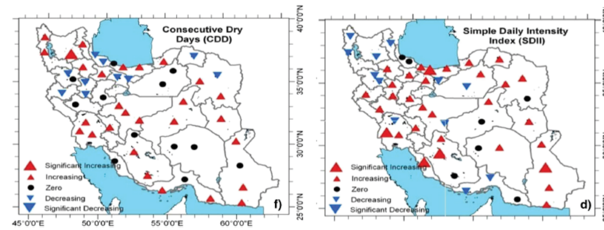

Figure (4.5): The Trend of Consecutive Dry Days and Average Precipitation on Wet Days in Iran between 1975 and 2010 (Soltani et al. (2016))

4.2.2. Projection of Temperature and Precipitation in Future Periods

Although many organizations and universities are working on climate change issue and its modeling, the only organization that works professionally on climate change modeling in Iran is "Climatology Research Institute-Mashhad". The primary projects of Mashhad Organization consist of the following:

- Supplying seasonal forecast of the country, including:

  - Preparing seasonal forecast maps using 3 seasonal forecast models TCC[1], HADCM, ECMWF[2] and presenting the analyses and the process. (Precipitation maps are prepared by 2 averaging ways, and then processing Meteorological Research Institute Coupled Atmosphere-Ocean General Circulation Model (MRICGCM) data and temperature maps are prepared by averaging).

- Supplying seasonal forecast for the Economic Cooperation Organization (ECO) region.

1 Tokyo Climate Center
2 European Centre for Medium-range Weather Forecasting

- Supplying annual reports for ECO region related to the organization's tasks.
- Country drought pre-awareness and measurement, including:

  - Supplying measurement and pre-awareness maps using Standardized Precipitation Index (SPI) for country drought.

- Presenting annual reports to World Meteorological Organization about regional and national activities of national climatology center.
- Presenting annual reports about limited climate events of the country to the World Meteorological Organization.
- Modeling Iran's climate in scale of decade for upcoming decades until 2100 dynamically, including:

  - Dynamically: REGCM[3], PRECIS[4]

  - Statistically: LARS-WG[5], SDSM[6]

- Conducting researches in the following fields:

  - Atmospheric climatic disaster events.

  - Seasonal forecast and drought pre-awareness.

  - Analyzing the impacts of climate change on water, hygiene, agriculture, Atmospheric climatic disaster events.

- Collecting all the conducted works by regional center of natural disaster risk management and climate regional centers.
- Cooperating with Climatology Committee and World Program of World Meteorological Organization's climatic services as the official representative of Iran Weather Organization.
- Cooperating with universities and research groups related to climate issues, and to give tips on students' theses and dissertations using the center's facilities.
- Holding workshops for ECO members and also in Iraq, Syria, and Sudan.
- Updating the database.

  - Updating national climate center and Eco Natural Disaster Risk Management Center's website.

  - Holding workshops, seminars, and conferences.

In order to simulate the upcoming years (2016-2030) temperature and precipitation of Iran, LARS-WG and Bias correction/spatial downscaling were used. Thus, 15 models of Atmosphere-Ocean General Circulation Model (AOGCM) were downscaled under 3 GHG scenarios (B1, A2, A1B) using two mentioned methods. (Table 4.2)

3 Regional Climate Model system
4 Providing Regional Climates for Impacts Studies
5 Lars Weather Generator (A Stochastic Weather Generator for Use in Climate Impact Studies)
6 Statistical Downscaling Model

Model Name	Acronym	Center	Resolution	SRES Scenario
HadCM3	HADCM3	UKMO (UK)	2.5°×3.75°	A1B, A2, B1
ECHAM5-OM	MPEH5	MPI-M (Germany)	1.9°×1.9°	A1B, A2, B1
CSIRO-MK3.0	CSMK3	CSIRO	1.9°×1.9°	A1B, A2, B1
GFDL-CM2.1	GFCM21	NOAA/GFDL (USA)	2°×2.5°	A1B, A2, B1
CCSM3	NCCCSM	NCAR (USA)	1.4°×1.4°	A1B, A2, B1
CNRM-CM3	CNCM3	CNRM (France)	1.9°×1.9°	A1B, A2, B1
MRI-CGCM2.3.2	MIHR	MRI (Japan)	2.8°×2.8°	A1B, A2, B1
IPSL-CM4	IPCM4	IPSL (France)	2.5°×3.75°	A1B, A2, B1
BCM2.0	BCM2	BCCR (Norway)	1.9°×1.9°	A1B, A2, B1
CGCM33.1 (T47)	CGMR	CCCma (Canada)	2.8°×2.8°	A1B, A2, B1
FGOALS1.0-g	FGOALS	LASG (China)	2.8°×2.8°	A1B, B1
GISS-AOM	GIAOM	GISS (USA)	3°×4°	A1B, B1
HadGEM1	HADGEM	UKMO (UK)	1.3°×1.9°	A1B, A2
INM-CM3.0	INCM3	INM (Russia)	4°×5°	A1B, A2, B1
PCM	NCPCM	NCAR (USA)	2.8°×2.8°	A1B, A2, B1

Table (4.2): AOGCM-AR4 Model Used for Projection of Temperature and Precipitation in Iran

4.2.2.1. Minimum Temperature

According to the projections, minimum temperature during all the seasons will increase in the period of 2016-2030 in comparison with the baseline period of 1982-2009 (Figure 4.6). This rising is presented as the following:

- ***Spring:*** Total increase in temperature is between 0.1 and 1.4 °C. While the most increase belongs to the west of Iran (0.4 and 1.4 °C), the least increase is for North of the country (0.1 and 1 °C).
- ***Summer:*** The most increase is for East of Iran in the range of 0.1 and 1.5 °C, and the least one is for North which is between 0.2 and 1 °C.
- ***Autumn:*** Simulation shows that the increase of minimum temperature for spring is more than that of the others. The most increasing rate belongs to East of Iran (0.3 and 1.6 °C) and the least one is for North (0 to 0.9 °C).
- ***Winter:*** According to the simulation, the least increase in minimum temperature relates to this season. Most parts are going to have 0 to 0.9 °C increase in minimum temperature.
- ***Annual temperature:*** Due to obtaining results from the simulation, minimum temperature will raise in all parts. The increase in minimum temperature in all the western parts fluctuates between 0.2 and 1.1 °C and that of central parts is between 0.2 and 0.9 °C. According to figure 4.6 Northwestern parts have the least increase which is between 0.1 and 0.8 °C.

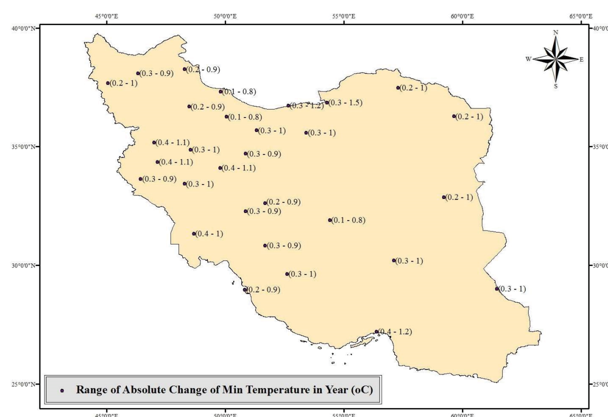

Figure (4.6): Range of Minimum Temperature Change in Iran in 2016-2030 in Comparison to 1982-2009

4.2.2.2. Maximum Temperature

Based on the projections of 15 Atmosphere-Ocean General Circulation Model-Fifth Assessment Report (AOGCM-AR5) models (Table 4.2), it is concluded that maximum temperature during all seasons will increase in the period of 2016-2030 in comparison with 1982-2009 (Figure 4.7). The seasonal and annual increases are as follows:

- ***Spring:*** The increasing range will vary throughout the country. The lowest increasing range is for north of Iran, between 0 and 0.7 °C, and the highest one fluctuates between 0.3 and 1.5 °C in the Northeast.

- ***Summer:*** Increased temperature of summer is more than that of spring so well that the lowest increasing temperature is for North with the range of 0.1 and 1°C and the highest one is in Northeast with 0.2 and 2.2°C.

- ***Autumn:*** Simulation shows that the increase of maximum temperature during this season is more than that of spring and summer, with the range of 0.4 to 1.3 °C for the most increase in the northwestern parts and 0 to 1 °C for the least one in northern parts.

- ***Winter:*** The lowest increase belongs to Northern parts of Iran with the range of 0.1 and 0.8 °C and the highest temperature relates to western parts which fluctuate between 0.2 and 1.4 °C.

- ***Annual temperature:*** The difference in the increase of annual maximum temperature throughout Iran in the period 2016-2030 and the period of 1982-2009 is represented in figure 4.7. According to this figure, the maximum temperature will rise in all regions of the country. This increase fluctuates between 0.2 and 1 °C in west, middle and south parts and 0.2 to 1.3 °C in the east and northeast regions of Iran.

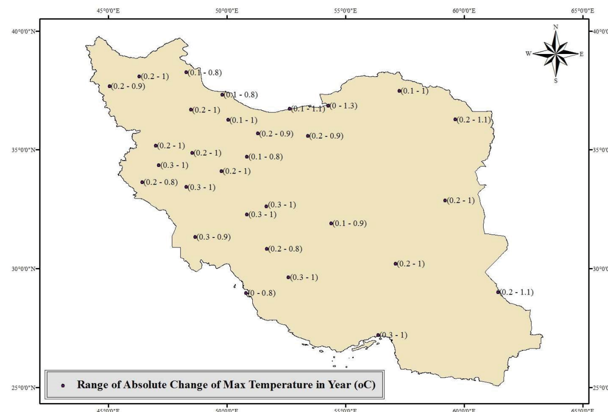

Figure (4.7): Range of Maximum Temperature Change in Iran in 2016-2030 in Comparison to 1982-2009

4.2.2.3. Mean Temperature

The projections of mean temperature based on 15 AOGCM models under 3 SRES[1] emission scenarios for Iran show that the mean temperature will increase in the whole country in 2016-2030 period compared to the 1982-2009 baseline period. So, the temperature is estimated to increase up to 0.9 degrees Celsius in the winter and spring in the south and southwest, and up to 1.3 degrees in the north and northeast of the Iran. Meanwhile, the increase of summer temperature will be more than that of winter and spring temperature and is expected to rise up to 1.5 degrees in the western and northern regions of the country. In the autumn, the increase of temperature is more than spring and winter temperature and is estimated to rise up to 1.5 degrees in most part of the country.

Finally, the projection results showed that the annual mean temperature in all parts of Iran in the 2016 -2030 period will increase in the

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range of 0.2 to 1 degree Celsius compared to the 1982-2009 period (Figure 4.8).

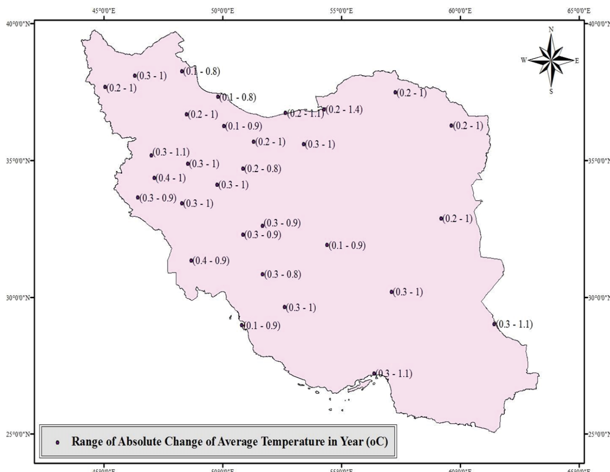


Figure (4.8): Range of Mean Temperature Change in Iran in 2016-2030 in Comparison to 1982-2009

In addition, figure 4.9 shows annual absolute temperature changes in 2035 in comparison to 1961-1990 for average scenario.

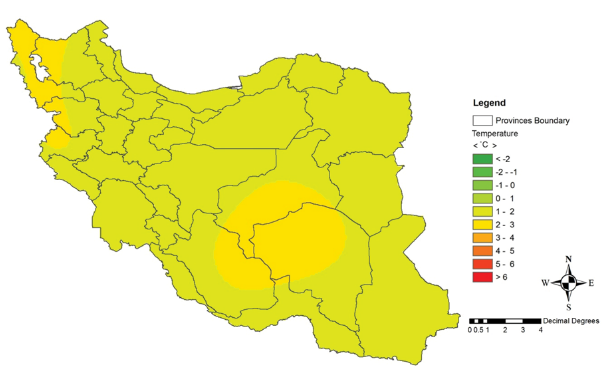


Figure (4.9): Annual Absolute Temperature Changes in 2035 in Comparison to 1961-1990 for Average Scenario

4.2.2.4. Precipitation

The projections of precipitation in 2016-2030 show that in contrast with temperature, precipitation does not hold a regular change during the seasons throughout the country. In other words, AOGCM models simulate a variety of differences for one region under the same GHG scenario. It means that changes of precipitation do not have a specific pattern in the period of 2016-2030 in comparison with the period of 1982-2009. It proves lack of certainty in precipitation projection for the upcoming years. In order to have a prediction of precipitation changes in the upcoming years, the mean scenarios' results, obtained from the different model projections, were studied. Seasonal changes' maps which belong to these scenarios are shown in figures 4.10 to 4.13.

According to figure 4.10, spring precipitation in upcoming years will decrease in comparison with baseline period in some western, northwestern, southern and central parts of Iran. These decreases are about %10 in the northwest and about %30 in south parts of Iran. In other parts, precipitation has no fluctuation. Eastern parts also have about %10 increase in precipitation.

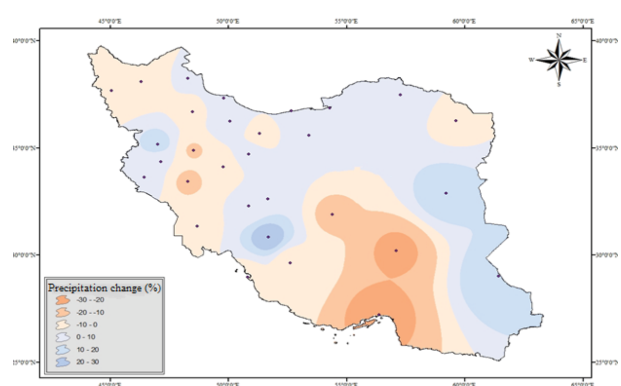


Figure (4.10): Spring Precipitation Change in Iran in 2016-2030 Comparison to 1982-2009

According to figure 4.11, summer precipitation does not fluctuate relatively throughout the country except in southeastern and western parts which increase in terms of quantity. Due to having the least precipitation in summer and insignificant seasonal precipitation, it won't affect annual precipitation in Iran.

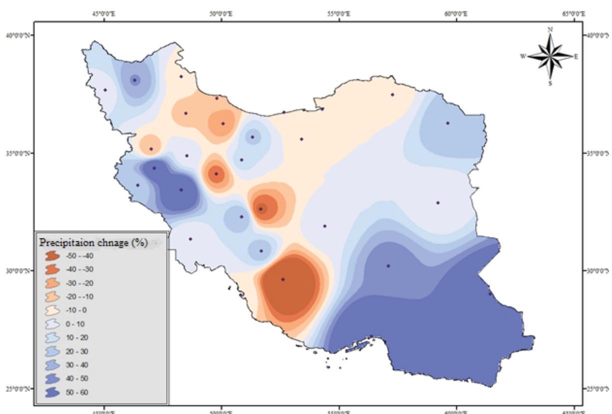


Figure (4.11): Summer Precipitation Change in Iran in 2016-2030 Comparison to 1982-2009

Figure 4.12 shows that autumn precipitation in the east and northeastern parts as well as west and southwestern parts of Iran will decrease about %20. Whilst southeastern and northwestern parts won't have fluctuation or if they have some, it will be about %10 increase in precipitation.

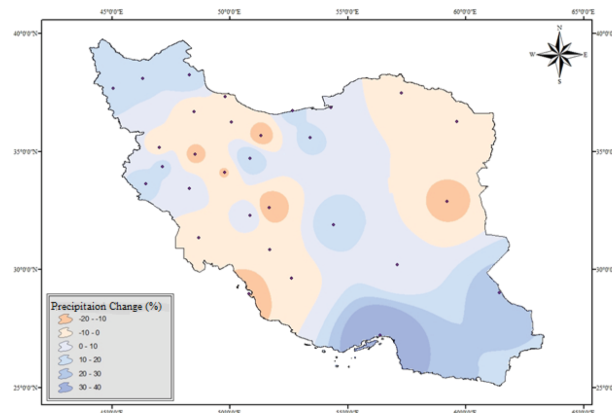


Figure (4.12): Autumn Precipitation Change in Iran in 2016-2030 Comparison to 1982-2009

According to the results, winter precipitation in east, northwest and southwest parts of the country will face a %20 decrease. Changes in precipitation of the other parts of the country comparing with seasonal long term average will not be significant (Figure 4.13).

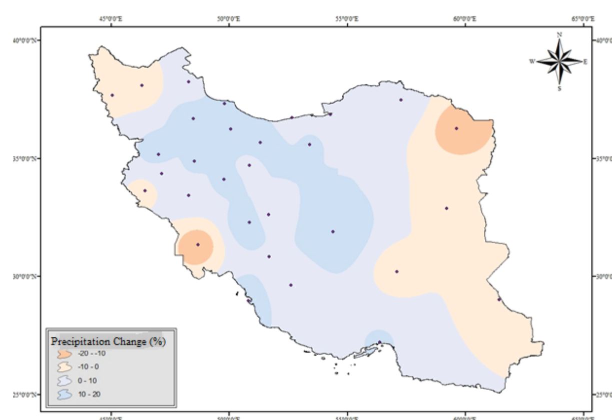


Figure (4.13): Winter Precipitation Change in Iran in 2016-2030 Comparison to 1982-2009

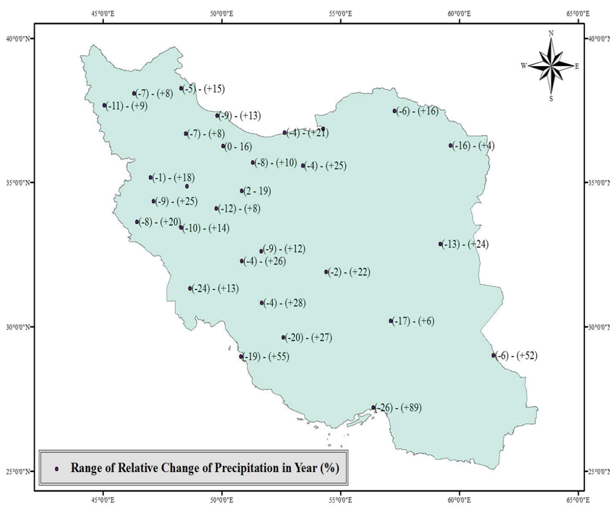


Figure (4.14): Range of Long-term Annual Average Precipitation in 2016-2030 in Comparison with 1982-2009

Range of long-term annual average precipitation in period of 2016-2030 in comparison with period of 1982-2009 is shown in figure 4.14.

4.2.2.5. General Perspective of Iran’s Future Climate

Long-term change in maximum, minimum and average temperature and changes of precipitation in each basin for the period 2016-2030 compared to the period 1982-2009 is presented in table 4.3.

According to the results related to precipitation changes in the average scenario, few cities will experience precipitation decrease, especially Ahvaz which faces the most decrease in precipitation, 8.8%. While precipitation increases range between 0.2% to 10.8%. Ranges of average temperature change in pessimistic, average and optimistic scenarios are 0.8%-1.4%, 0.5%-0.8% and 0.1%-0.4%, respectively.

Range of long-term annual average precipitation, maximum temperature and minimum temperature in 2016-2030 in comparison with 1982-2009 are shown in figures 4.14, 4.7 and 4.6, respectively

Table (4.3): Max, Minimum & Average Long-term Annual Temperature and Precipitation Changes of All Provinces of Iran in the Period of 2016-2030 Compared to the Period of 1982-2009 (the temperature is in the centigrade, and the precipitation is in percent)

Arrow	Provincial capital	P (%)			Tave			Tmax			Tmin		
		The pessimistic Scenario	The Average Scenario	The Optimistic Scenario	The pessimistic Scenario	The Average Scenario	The Optimistic Scenario	The pessimistic Scenario	The Average Scenario	The Optimistic Scenario	The pessimistic Scenario	The Average Scenario	The Optimistic Scenario
1	Arak	-11.9	-1.5	+7.3	1	0.7	0.3	1.0	0.7	0.3	1.1	0.8	0.4
2	Ardebil	-5.1	+6.8	+15.4	0.8	0.6	0.1	0.8	0.6	0.1	0.9	0.6	0.2
3	Urmia	-10.9	+0.3	+8.9	1.0	0.7	0.2	0.9	0.7	0.2	1.0	0.7	0.2
4	Isfahan	-9.0	+0.3	+12.0	0.9	0.6	0.3	1.0	0.7	0.3	0.9	0.6	0.2
5	Ilam	-6.4	+4.1	+20.0	0.9	0.6	0.3	0.8	0.6	0.3	0.9	0.7	0.3
6	Ahvaz	-24.0	-8.8	+7.0	0.9	0.7	0.4	0.9	0.6	0.3	1.0	0.7	0.4
7	Sari	-4.0	+6.1	+20.5	1.1	0.6	0.2	1.1	0.6	0.2	1.2	0.6	0.3
8	Bojnurd	-5.6	+5	+16.1	1.0	0.6	0.3	1.0	0.6	0.2	1.0	0.6	0.2
9	Bandar Abas	-26.4	+13	+89.1	1,1	0.6	0.3	1.0	0.6	0.3	1.2	0.7	0.5
10	Bushehr	-19.4	+3.8	+55.5	0.9	0.5	0.1	0.8	0.5	0.0	0.9	0.6	0.2
11	Birjand	-12.5	+3.5	+23.6	1.0	0.6	0.2	1.0	0.6	0.3	1.0	0.6	0.2
12	Tabriz	-7.3	+0.2	+7.8	1.0	0.7	0.3	1.0	0.8	0.2	0.9	0.7	0.3
13	Tehran	-8.3	+1.5	+10.1	1.0	0.7	0.2	0.9	0.6	0.2	1.0	0.7	0.4
14	Khoramabad	-10.4	+0.3	+14.4	1.0	0.7	0.3	1.0	0.7	0.3	1.0	0.7	0.5
15	Rasht	-9.1	+1.2	+13.1	0.8	0.5	0.1	0.8	0.5	0.1	0.8	0.5	0.1
16	Zahedan	-5.7	+9.3	+52.4	1.1	0.6	0.3	1.1	0.6	0.2	1.0	0.6	0.3
17	Zanjan	-5.1	+0.2	+6.9	1.0	0.7	0.2	1.0	0.7	0.2	0.9	0.6	0.2
18	Sanandaj	-0.5	+8.9	+17.7	1.1	0.8	0.3	1.0	0.7	0.2	1.1	0.8	0.5
19	Semnan	-4.1	+9.0	+24.6	1.0	0.7	0.3	0.9	0.6	0.3	1.0	0.7	0.3
20	Shiraz	-19.7	-0.8	+27.3	1.0	0.6	0.3	1.0	0.7	0.3	1.0	0.6	0.3
21	Shahrekord	-4.1	+9.5	+25.6	0.9	0.7	0.4	1.0	0.7	0.3	0.9	0.7	0.4
22	Qazvin	+0.3	+7.7	+16.0	0.9	0.6	0.1	1.0	0.6	0.2	0.8	0.5	0.2
23	Ghom	+1.8	+10.8	+19.0	0.8	0.6	0.2	0.8	0.5	0.1	0.9	0.6	0.3
24	Karaj	-4.1	+1.5	+10.0	0.1	0.7	0.2	0.9	0.6	0.2	1.0	0.7	0.4
25	Kerman	-19.7	-6.3	+4.2	1.0	0.7	0.3	1.0	0.7	0.2	1.0	0.7	0.4
26	Kermanshah	-4.1	+6.4	+25.3	1.0	0.7	0.4	1.0	0.7	0.3	1.1	0.8	0.5
27	Gorgan	+0.3	+3.4	+15.6	1.4	0.6	0.2	0.7	0.5	0.1	1.5	0.6	0.4
28	Mashhad	+1.8	-4.7	+2.0	1.0	0.6	0.2	1.1	0.6	0.2	1.0	0.6	0.3
29	Hamedan	-4.1	-1.7	+7.5	1.0	0.7	0.3	1.0	0.7	0.2	1.0	0.7	0.3
30	Yasuj	-17.1	+8.0	+27.8	0.8	0.6	0.3	0.8	0.6	0.3	0.9	0.6	0.3
31	Yazd	-8.5	+7.6	+21.6	0.9	0.6	0.1	0.9	0.6	0.2	0.8	0.5	0.1

4.3. Water Resources

4.3.1. Introduction

The study of the effects of climate change on weather condition and water resources in Iran is done by analyzing available long-term data and imaginable changes of water resources in recent years. Thus, it is possible to predict the future state of water resources to some extent. Scenarios of climate change on the hydrological cycle are significant because all their components are affected by changes in energy and mass exchanges. Fluctuations of water are related to climate change because the need for these resources is increased by evapotranspiration in warmer, drier, and sunnier regions.

4.3.2. The Main Information of the Current Situation

The Islamic Republic of Iran, on average, receives 405 billion cubic meters of water from precipitation on its territory annually. From this amount, 282 billion cubic meters goes out of reach through evaporation and evapotranspiration, 89 billion cubic meters turn into surface currents, and 34 billion cubic meters directly go to underground reservoirs (as shown in figure 4.15). The country also receives 9 billion cubic meters of water from cross-border surface currents that add up the available surface water to 98 billion cubic meters. That means the total amount of water available to the country from the surface and underground water will be 132 billion cubic meters, on average, every year. It is estimated that some 34 billion cubic meters of the consumed water will recycle in the underground water resources. According to 2006 statistics, 34 billion cubic meters of the surface water is being regulated by dams, from which 20.51 billion cubic meters is utilized. 17.59 billion cubic meters of surface water is being utilized by pumping and traditional methods. Small utility systems are also accounted for utilization of some 2.5 billion cubic meters of surface water. Considering all those available mechanisms and methods for utilizing surface water it can be concluded that only 40% (or 40.6 billion cubic meters) of available surface water is being made available to consumers in different sectors. Consequently, mechanisms for utilization of groundwater, alluvial springs growth and utilized throughout the country has made 71.7 billion cubic meters of water available to consumers from which 60 billion cubic meters are being consumed. Total utilized water from the surface and ground sources add up to 112.3 billion cubic meters, of which 100 billion cubic meters are being consumed in different sectors.

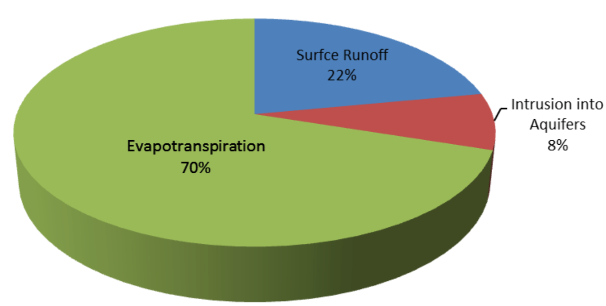


Figure (4.15): Distribution of Rainfalls in Iran

The major water consumers within the country respectively are agriculture and fish breeding sectors with 87.2 billion cubic meters (or 92.5% of available water), urban and rural sectors with 5.7 billion cubic meters (or 6% of available water), and mine and industry sector with 1.4 billion cubic meters (or 1.5% of available water), as shown in figure 4.16.

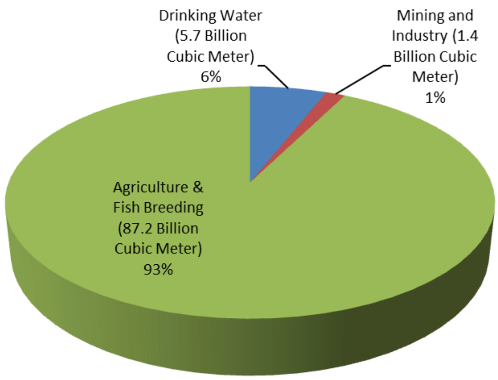


Figure (4.16): Water Consumptions in Iran

4.3.3: Watershed Classification Due to the Severity of Problems in the Water Resources Management in Future

Watershed classification, names, ranks, the possibility of problems intensifying in the future and the overall approach are presented in table 4.4.

Overall approach	The possibility of problems intensifying in the future	Rank	Watershed names	Watershed Classification criteria
Which need special governmental management measures	It is high and difficult to control.	First grade	Salt Lake, Zayandeh Roud, Harir Roud, Kashf Roud, Bakhtegan, Maharlou & Gorgan	Basins that have high population density, and high utilization percentage of potential resources.
Coordination of land use can be very effective	It is high and controllable.	Second grade	Siah Kouh, Dagheh Sorkh, Deranjir, Central, Karshour, Abarqou Sirjan, Jazmourian, Minab, Bandar Abbas, Lout, Roud Gol, Atrak, Meshkin, Khaf & Mond	Basins that have a low population density, and high utilization percentage of potential resources.
Coordination of land use can be very effective	It is high and controllable.	Third grade	Persian Gulf beach, south Balouchestan, Persian Gulf Islands	Basins that have a low population density and high utilization percentage of potential resources, but the development of their water resources has a major natural problem.
Prediction of development projects can be effective	It is low.	Fourth grade	Karkheh, Aras, Dez, Karoun, Talesh, west boundary	Despite the high population density, basins have adequate water resources development facilities.
Prediction of development projects and coordination of land use can be effective	It is the least.	Fifth grade	Maroun, Jarahi, Zohreh, Hamoun Hirmand	Basins that have a low population density and their potential of water resources development are very high.

Table (4.4): Watershed Classification Based on the Intensity of Water Resources Management Problems in the Future in Iran

4.3.4. Groundwater

The groundwater utilization in Iran has increased due to rainfall and run off reduction in the country that led to water demand increase in different sectors such as industry, agriculture and domestic. Thus, the severe deficit of the country's aquifers has happened during recent years as shown in figure 4.17. In the last 15 years, about 5 to 6 billion cubic meters reduction of water in reservoirs has occurred per annum, so the cumulative deficit of aquifers is about 100 billion cubic meters in the 15-year period. It is worth noting that about 80% of the deficit has occurred in 15 years. As shown in figure 4.18 despite the increase in the number of wells and even deeper wells, discharge rate has not increased. This shows a lack of good nutrition because of the intensive low-level of groundwater and critical circumstance of aquifers.

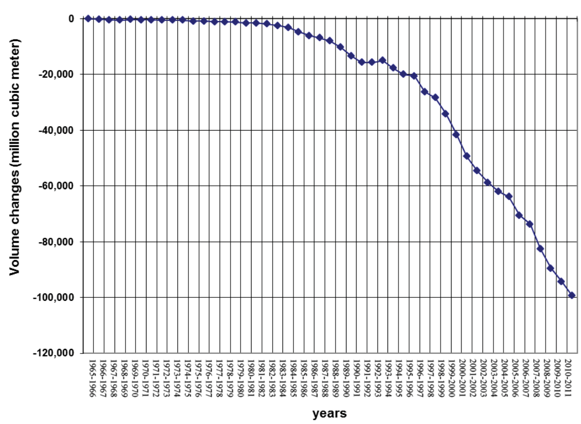


Figure (4.17): Aquifer Reservoir Volume Reduction in Iran from 1964-1965 to 2010-2011

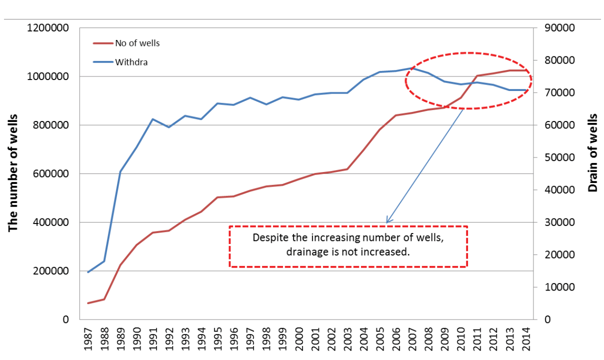


Figure (4.18): Increment of the Number of Wells and Drainage of Groundwater Resources in Iran

4.3.5. Decrements of the Surface Water Resources

Based on statistical analysis, as shown in tables 4.5 and 4.6, there is no significant jump in the process of changes and statistical analysis of monthly and yearly average of rainfall in the country at intervals of 5, 10 and 15 years due to the previous long-term period, but in some watersheds the rainfall decrements are seen. Therefore, the reason for the reduction in surface water in recent years should be studied in the following factors:

- Pattern change in rainfall and increment of the number of CDD (reducing the effective rainfall) that lead to lack of runoff;
- Snowfall reduction from 25% to 15% that lead to lack of runoff caused by evaporation;
- Snow melts one month earlier;
- The increase in average temperature by 0.5 degrees in some areas (in some months) causes evapotranspiration increment;
- Increase of water consumption in general, especially of groundwater consumption and subsequently reducing the flow of rivers; and
- Decrements of the basic discharge of the river because of groundwater consumption increment.

Table (4.5): The Results Related to the Statistical Analysis of the Long-term Average Rainfall in the Last 15 Years (1997-2011) in Iran (million cubic meters)

Parametric and non-parametric tests		Test statistic	Critical values (Statistical table)			Critical values (Resampling)			Result
			a=0.1	a=0.05	a=0.01	a=0.1	a=0.05	a=0.01	
Trend test	Mann-Kendall	-0.398	1.645	1.96	2.576	1.591	1.894	2.459	NS
	Spearman's Rho	-0.533	1.645	1.96	2.576	1.692	1.989	2.581	NS
	Linear regression	-0.582	1.684	2.02	2.702	1.64	1.978	2.68	NS
Jump test	Cusum	4	8	8.918	10.689	8	9	11	NS
	Cumulative deviation	0.875	1.133	1.263	1.506	1.16	1.297	1.567	NS
	Worsley likelihood	1.959	2.868	3.176	3.782	2.862	3.147	4.044	NS
Variation test	Rank Sum	-1.21	1.645	1.96	2.576	1.746	2	2.434	NS
	Student's t	1.341	1.683	2.019	2.699	1.713	2.048	2.575	NS

Table (4.6): Statistical Analysis Related to Long-term Average of Observed Discharge in the Last 15 Years (1997-2011) in Iran (million cubic meters)

Parametric and non-parametric tests		Test statistic	Critical values (Statistical table)			Critical values (Resampling)			Result
			a=0.1	a=0.05	a=0.01	a=0.1	a=0.05	a=0.01	
Trend test	Mann-Kendall	-2.344	1.645	1.96	2.576	1.601	1.873	2.438	S (0.05) Decreasing
	Spearman's Rho	-2.51	1.645	1.96	2.576	1.734	2.09	2.652	S (0.05) Decreasing
	Linear regression	-2.8	1.684	2.02	2.702	1.704	2.064	2.847	S (0.05) Decreasing
Jump test	Cusum	9	8	8.918	10.689	8	9	11	S (0.05) Decreasing since 1997
	Cumulative deviation	1.838	1.133	1.263	1.506	1.116	1.237	1.491	S (0.01) Decreasing since 1997
	Worsley likelihood	4.777	2.868	3.176	3.782	2.813	3.094	3.951	S (0.01) Decreasing since 1997
Change test	Rank Sum	-3.277	1.645	1.96	2.576	1.648	1.951	2.444	S (0.01)
	Student's t	3.394	1.683	2.019	2.699	1.661	1.984	2.526	S (0.01)

Conservation of water resources for water supply is a top priority according to the critical value of water in Iran. Construction of dams, aqueducts and irrigation canals in various parts of the country shows that the people throughout this land want to make any efforts to achieve the best conservation and efficient use of water resources. In fact, population growth causes the increment of consumption, severe restrictions on water resources and the need for new construction projects; so measures must be taken to optimize the use of water resources.

Based on the Falcon index, water stress threshold is equal to 1700 cubic meters of annual available water per capita. By 2025, the mentioned deal in Iran will reach to the less than 1,000 cubic meters per annum, so planning for water resources is seriously needed in the remaining time. Due to the importance of vital strategic management and wise use of water resources, modifying the consumption patterns is considered as a new paradigm for reducing the effects of climate change.

Rainfall and temperature are two important factors that affect many processes related to water resources management, such as changes in runoff and water requirements.

4.3.6. Projection of Climate Change Impact on Runoff

In this report, Iran's precipitation and temperature until 2030 is modeled by results of 16 AOGCM-AR4 models under three SRES emission scenarios (Table 4.2). Then runoff variation due to temperature changes was calculated for all thirty basins by a lumped rainfall-runoff model (Fahmi, 2008).

Evaluations of runoff percentage changes in Iran's provinces due to different scenarios are presented in table 4.7. The percentage change of income from runoff due to runoff changes for each province is expressed in table 4.8.

Table (4.7): Percentage of the Runoff Changes due to the Increasing and Decreasing of the Temperature and Precipitation in Iran's Provinces Based on Optimistic, Medium and Pessimistic Scenarios

Arrow	Provincial capital	The Pessimistic Scenario			The Average Scenario			The Optimistic Scenario		
		Runoff	P %	T avg	Runoff	P %	T avg	Runoff	P %	T avg
1	Arak	-2.7	-11.9	1.0	-0.4	-1.5	0.7	+0.5	+7.3	0.3
2	Ardebil	-12.5	-5.1	0.8	+3.9	+6.8	0.6	+1.0	+15.4	0.1
3	Urmia	-27.0	-10.9	1.0	0	+0.3	0.7	+6.0	+8.9	0.2
4	Isfahan	-22.5	-9.0	0.9	-4.0	+0.3	0.6	+4.0	+12.0	0.3
5	Ilam	-16.0	-6.4	0.9	+2.0	+4.1	0.6	+11.0	+20.0	0.3
6	Ahvaz	-60.0	-24.0	0.9	-20.0	-8.8	0.7	+2.0	+7.0	0.4
7	Sari	-10.0	-4.0	1.1	+2.0	+6.1	0.6	+12.0	+20.5	0.2
8	Bojnurd	-14.0	-5.6	1.0	0	+5.0	0.6	+7.5	+16.1	0.3
9	Bandar Abas	-66.0	-26.4	1.1	+6.2	+13.0	0.6	+30.0	+89.1	0.3
10	Bushehr	-48.0	-19.4	0.9	+1.5	+3.8	0.5	+31.0	+55.5	0.1
11	Birjand	-31.0	-12.5	1.0	0	+3.5	0.6	+12.0	+23.6	0.2
12	Tabriz	-18.0	-7.3	1.0	-0.2	+2.0	0.7	+3.5	+7.8	0.3
13	Tehran	-21.0	-8.3	1.0	0	+1.5	0.7	+12.0	+10.1	0.2
14	Khoramabad	-21.0	-10.4	1.0	0	+0.3	0.7	+7.5	+14.4	0.3
15	Rasht	-20.0	-9.1	0.8	0	+1.2	0.5	+10.0	+13.1	0.1
16	Zahedan	-15.0	-5.7	1.1	+2.0	+9.3	0.6	+20.0	+52.4	0.3
17	Zanjan	-12.0	-5.1	1.0	0	+2.0	0.7	+3.5	+6.9	0.2
18	Sanandaj	-1.5	-0.5	1.1	+5.0	+8.9	0.8	+9.5	+17.7	0.3
19	Semnan	-11.0	-4.1	1.0	0	+9.0	0.7	+12.0	+24.6	0.3
20	Shiraz	-49.0	-19.7	1.0	-2.0	-0.8	0.6	+13.0	+27.3	0.3
21	Shahrekord	-10.0	-4.1	0.9	+5.5	+9.5	0.7	+7.5	+25.6	0.4
22	Qazvin	0	+0.3	0.9	+4.0	+7.7	0.6	+1.0	+16.0	0.1
23	Ghom	0	+1.8	0.8	+5.5	+10.8	0.6	+11.0	+19.0	0.2
24	Karaj	-10.0	-4.1	1.0	0	+1.5	0.7	+12.0	+10.0	0.2
25	Kerman	-42.0	-17.1	1.0	-15.0	-6.3	0.7	0	+4.2	0.3
26	Kermanshah	-21.0	-8.5	1.0	+3.0	+6.4	0.7	+7.0	+25.3	0.4
27	Gorgan	-32.0	-12.3	1.4	+1.5	+3.4	0.6	+9.0	+15.6	0.2
28	Mashhad	-39.0	-15.6	1.0	-12.0	-4.7	0.6	+1.0	+2.0	0.2
29	Hamedan	-25.0	-10.1	1.0	-4.0	-1.7	0.7	+0.02	+7.5	0.3
30	Yasuj	-9.0	-3.6	0.8	+4.0	+8.0	0.6	+12.5	+27.8	0.3
31	Yazd	-8.0	-2.2	0.9	+2.0	+7.6	0.6	+12.5	+21.6	0.1

Table (4.8): Percentage of the Derived Income from Surface Water due to the Average Percentage of Runoff Changes in the Provinces of Iran

Provincial capital	Changes in the Income from surface water (%)	Income from surface water (%)	Run off changes (%)	Area (km²)
Arak	-0.27	10	-2.7	29,127
Ardebil	-7.50	60	-12.5	17,800
Urmia	-15.12	56	-27.0	37,411
Isfahan	-10.80	48	-22.5	107,029
Ilam	-7.20	45	-16.0	20,133
Ahvaz	-49.20	82	-60.0	64,055
Sari	-6.80	68	-10.0	23,842
Bojnurd	-0.42	3	-14.0	28,434
Bandar Abas	-31.68	48	-66.0	70,697
Bushehr	-19.20	40	-48.0	22,743
Birjand	-0.93	3	-31.0	95,385
Tabriz	-13.86	77	-18.0	45,650
Tehran	-15.12	72	-21.0	12,981
Khoramabad	-8.40	40	-21.0	28,294
Rasht	-17.60	88	-20.0	14,042
Zahedan	-1.20	8	-15.0	180,726
Zanjan	-7.92	66	-12.0	21,773
Sanandaj	-0.60	40	-1.5	29,137
Semnan	-1.10	10	-11.0	97,491
Shiraz	-33.81	69	-49.0	122,608
Shahrekord	-7.00	70	-10.0	16,332
Qazvin	0.00	52	0	15,567
Ghom	0.00	18	0	11,526
Karaj	-7.20	72	-10.0	5,833
Kerman	-0.84	2	-42.0	181,785
Kermanshah	-8.40	40	-21.0	24,998
Gorgan	-18.56	58	-32.0	20,367
Mashhad	-1.56	4	-39.0	118,854
Hamedan	-8.75	35	-25.0	19,368
Yasuj	-6.30	70	-9.0	15,504
Yazd	-0.16	2	-8.0	129,285

4.3.7. Result Summary of the Climate Change Impact on Water Resources in Future Periods

- The evaporation volume of the country increased by 27.3 billion cubic meters due to the increase of two centigrade degrees in the temperature of the country.
- Recharge of the groundwater decreased by 20%, due to the increase of two degrees in the temperature of the country.
- The amounts of snowfall reduced by 5% and the snowmelt time shift one month earlier. Also, the snow level increased to 200 meters. This trend will continue in the future.
- The possibility of severe droughts and severe floods will increase in the future.
- The precipitation trends that are less than 5 mm and 10 mm will continue to decrease.
- According to the pessimistic scenarios, runoff changes in all basins are decreasing. The highest percentages of runoff changes are -65.5, -60.5 & -55 that respectively happened in Bandar Abbas-Sedij, Karkheh and Karoun basins.
- This indicates that the main basin of the Persian Gulf and the Sea of Oman, which covers the southern part of the country, based on the pessimistic scenario, would be the most critical area in terms of reducing runoff.
- According to the medium scenario, the highest percentage increase in runoff is 6% that occurs in plain-Jazmurian and Bandar-Sedij basins. In addition, according to this scenario, the highest percentage of runoff reduction is 20% observed in Karoon basin. After that, the Zohreh Jarahi, Loot desert, and Dranjyr desert have the most reduction of runoff percentage by 15%.
- Drinking water supply in most major cities of the country will be difficult in the future.
- Warmer and more humid conditions increase the prevalence of diseases in the tropical country.
- The calculation of the percentage changes in the income from the surface runoff shows that the highest losses would be found

in the province of Khuzestan, Fars, and Hormozgan, respectively.

4.3.8. Adaptation Strategies in Water Resources

- Trying to achieve healthy community with welfare, food security, equal opportunities, proper income distribution and benefited from favorable environment

  - Water sector has a special role in sustainable development, food security, and people's health. Therefore, it is critical to enhance the optimal utilization of water resources in each basin considering the capacity of their ecosystems and situation of their climate.

- Promoting the productivity, considering the economic, security, political and environmental values of water in order to achieve a desirable utilization, supply, maintenance and consumption

  - Increasing the economic efficiency of water use and improving water productivity in all sectors.

  - Determining the value of water (including its intrinsic, economic, security, political and environmental values) in the context of sustainable development guidelines and appropriate applicable pricing policies in the country.

  - Organizing optimal utilization of water resources, especially the exploitation of unconventional resources.

  - Preventing the pollution of water resources and efforts to eliminate the pollutants.

  - Using new procedures for water harvesting and waste water recycling.

- Enhancing efficiency and sustainability in using shared water resources in close collaboration with neighboring countries.

  - This goal will be achieved by allocating four percent of country's budget plans to enhance sustainable management of shared water resources in border areas.

- Inter-basin water transfers and water exchange

  - Inter-basin water transfer and water exchange with neighboring countries to respect the rights of stakeholders (nature and human) and meet their essential drinking and industrial water needs. In addition, water trade (importing of water) will be considered within the framework of national interests.

- Spatial planning and integrated management of water resources

  - Water sector will play a significant role in accounting and determining water needs to develop other sectors in the country level. Therefore, the integrated management of water resources in watershed management units should be considered as one of the principles of land use planning, in the macro planning of the country.

- Comprehensive approach to water resources management

  - A comprehensive approach to water resources, considering the improvement of water utilization efficiency, inter-sectoral and multi-sectoral coordination and water and land management coordination in order to create a sustainable balance between water demand and supply.

- Strengthening public participation

  - Increasing public participation in all stages of design, implementation and operation of water projects, decentralization, reduction of government's involvement, and water catchment management increment in order to optimize the administrative structure and boosting the interaction between beneficiaries and stakeholders.

- Providing financial resources and investment as well as implementation of the "Policies of Article 44 of the Constitution".

  - Providing opportunities for the institutionalization of private sector participation in all stages of planning, research, implementation and operation of water resources.

  - Creating appropriate conditions for attracting internal and external investments in the water sector.

  - Providing and developing mechanisms of integrated public financing and credit institutions.

  - Transferring of (management, ownership or building knowledge of) small dams, irrigation networks, drainage and hydraulic structures to the private sector.

- Water and sustainable development

  - There will be attempts to move water sector toward a sustainable development and environmental conservation by making a balance between quantitative and qualitative resources in watersheds and critical aquifers to prevent water resources destruction and establishing risk management.

- Drinking water and sanitation services

  - Utilization of the urban and rural healthy drinking water and their sanitation systems will be completed during the plans.

4.4. Agriculture

In Iran, agriculture sector accounts for about 18 percent of national Gross Domestic Product (GDP), more than 20 percent of employment, 85 percent of the food supply, 25 percent of non-oil products and 90 percent of raw materials used in agro-industry. According to the 2006 census, 31.4 percent of the population resides in rural areas. In addition, about 22.3 percent of the employed populations of the country were engaged in the agriculture sector. Agricultural activities in Iran are quite diversified and include production of various crops, fruits and nuts, greenhouse, agroforestry, poultry, small and large livestock, honeybee, silk worm, and fisheries. Crop production is practiced under both rain-fed and irrigated conditions. Therefore, it is necessary to assess the vulnerability of this sector to future climate change in order to identify and suggest adaptation strategies to combat the negative effects of climate change and to effectively use the new opportunities that may arise.

4.4.1 Trend in Production of Agricultural Products

Assessment of long-term trends in production indices of agronomic crops can be the first step towards assessing the effects of climate change on the agriculture sector. The assessment period is between the years 1983-2011. The mann-kendal statistical method was used for assessment of trends.

4.4.1.1. Wheat Yield

The trends in yield changes of irrigated and rain-fed wheat in each province are shown in figure 4.19. More than 50% of the provinces had strong positive trends in irrigated wheat yield (Figure 4.19A). All provinces showed a positive trend in irrigated wheat yield, except Qom, Yazd, Isfahan, and Golestan provinces, in which no trends were observed in irrigated wheat yield.

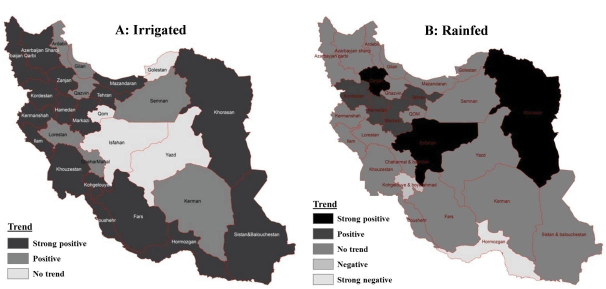


Figure (4.19): The Trend in Provincial Irrigated (A) and Rain-fed (B) Wheat Yield

The main reason for a positive trend in irrigated wheat yield was improved agronomic practices and policies at governmental and field levels. These measures include the following practices:

- Improvement in irrigation management and expansion of electrical pumps;
- Extension of field leveling techniques and subsequently improved fertilizer and water use efficiencies;
- Introduction of new wheat varieties that were more productive and adapted to stress conditions;
- Better and earlier detection of pests and diseases;
- Improvement in fertilizer use, particularly micronutrient fertilizers; and
- Extension of mechanized agriculture from planting to harvesting.

There was no trend in rain-fed yield of wheat in about 80% of the provinces, despite significant improvements in agronomic practices and management (Figure 4.19B). Therefore, it seems that the negative effects of climate change were more pronounced on wheat yields under the rain-fed system than irrigated system. Thus, it seems that climate change did not impose negative effects on irrigated wheat yield. Most probably, increased temperature and atmospheric CO_2 concentration may have had positive effects on irrigated wheat yield. However, it seems that excessive temperature increases and reduced precipitation in some parts of the country caused the observation of no trends in 4 provinces, despite improved agronomic practices. Therefore, rain-fed wheat yield in Iran probably has been affected by climate change.

4.4.1.2. Major Agronomic Crops

The trends in irrigated and rain-fed yields of some major agronomic crops of Iran were also investigated in 1983-2011 period. The trend in

Table (4.9): Trends in Rain-fed and Irrigated Yields of Some Major Agronomic Crops of Iran during 1983-2011

Agronomic Crop	Irrigated Yield	Rainfed Yield
Barley	Strongly positive	Strongly positive
Corn	Strongly positive	No trend
Forage crops	Strongly positive	No trend
Garbanzo bean	No trend	No trend
Cotton	Strongly positive	Strongly positive

irrigated yield of barley, corn, forage crops and cotton were strongly positive, while there was no trend in garbanzo bean yield (Table 4.9). The main reason for a positive trend in irrigated yields of these crops was improved agronomic practices and policies at governmental and field levels. It seems that climate change did not impose negative effects on irrigated yields. Most probably, increased temperature and atmospheric CO_2 concentration may have had positive effects on irrigated yields. Increased temperature and atmospheric CO_2 concentration may have had negative effects on irrigated yield of a garbanzo bean.

Positive trends in barley and forage crops rain-fed yields were observed, while there were no trends in corn, garbanzo bean and cotton rain-fed yields (Table 4.9). Improved agronomic practices and management have caused the increase in rain-fed yields. Increased temperature and atmospheric CO_2 concentration may have had positive effects on rain-fed yields. It seems that the negative effects of climate change were more pronounced on rain-fed yields of some major agronomic crops of the country than irrigated yields.

4.4.2. Impact of Climate Change on Agriculture in Future Periods

4.4.2.1. Irrigated Crops

Irrigation is mandatory in this type of crop production system. Based on the temporal analogical results, irrigated production system is less sensitive to climate change than a rain-fed system. However, availability of water for irrigation has detrimental effects on the area under cultivation and final crop yields.

Frost is a limiting factor in the agricultural production, especially in northwestern provinces of the country. The rise in mean yearly temperature, particularly in the winter, could extend the growing season in these areas, and allow for the cultivation of long-maturing crop varieties, or two crops per year. Net irrigation requirements of irrigated wheat and alfalfa will increase, while it will decrease for irrigated forage corn in most parts of the country during 2016-2030 timeline (Table 4.10). The potential yields of irrigated wheat, alfalfa and forage corn will also decrease in most parts of the country during the same timeline period (Table 4.11).

Table (4.10): The Change in Net Irrigation Requirements (mm/year) of Three Major Irrigated Crops of Iran during 2016-2030 period

Crop	Increase (+) (mm/year)	Decrease (-) (mm/year)
Wheat	North and Northeast: 0.14-6.1 Northwest and West: 0.1-6.47 Central region: 0.08-7.72 South and Southeast: 0.12-8.27	Kerman and part of Sistan and Balochestan: 0.14-9.67
Alfalfa	North and Northeast: 0-3.79 Northwest and West: 0.01-1.16 Central region: 0.16-3.13 South and Southeast: 0.03-5.58	Fars province: 0.025-4.4 Khuzestan and Ilam: 0.07-4.88 Hamadan and Lorestan: 0.02-5.27
Forage corn	Parts of Qom, Hamadan, Zanjan, Alborz, Khorasan Razavi and E. Azerbaijan: 0.34-2.82	North and Northeast: 0.08-2.03 Northwest and West: 0.4-7.98 Central region: 0.09-11.29 South and Southeast: 0.3-1.3

Table (4.11): The Change in Potential Yields (kg/ha/year) of Three Major Irrigated Crops of Iran during 2016-2030 Period

Crop	Increase (+) (kg/ha)	Decrease (-) (kg/ha)
Wheat	Parts of Kerman, W. Azarbayjan, Sistan and Balochestan and Khozestan: 1-81	North and Northeast: 24-100 Northwest and West: 5-88 Central region: 1-150 South and Southeast: 13-156
Alfalfa	Khozestan, Kerman and Sistan and Balochestan: 4-191	North and Northeast: 6.2-234 Northwest and West: 79-486 Central region: 101-467 South and Southeast: 30-493
Forage corn	Parts of Mazandaran, Ardabil, and Zanjan: 31-196	North and Northeast: 7-96 Northwest and West: 19-113 Central region: 14-205 South and Southeast: 13-126

4.4.2.2. Fisheries

The vulnerability of fisheries section to future climate change was assessed for three general fisheries activities in Iran, including fishing in the Caspian Sea, the Persian Gulf and Oman Sea, and aquaculture in inland waters. The vulnerability of these activities is summarized in tables 4.12 and 4.13.

Table (4.12): Effects of Different Factors on Marine Stocks of Iran as Affected by Climate Change in Future Period (2016-2030)

Activity	Temperature	Salinity	Reduced Rainfall	Sea level	River Runoff	Sea Currents	Increase in seawater pH	Algal bloom	Nutrition	Growth	Natural reproduction	Balance of species**
Caspian Sea												
Sturgeons	0*	0	–	±	–	±	–	–	+	+	–	–
Bony fishes	0	–	–	±	–	±	–	–	+	+	–	–
Anchovy	–	0	±	±	0	±	–	–	+	+	–	–
The Persian Gulf, Oman Sea and Indian Ocean												
Large pelagic fishes	–	0	±	±	0	–	–	–	+	+	–	–
Small pelagic fishes	–	0	±	±	0	–	–	–	+	+	–	–
Demersal fishes	0	0	±	±	0	±	–	–	+	+	0	±
Lantern fish	0	0	±	±	0	±	–	–	+	+	0	±
Shrimp	+	0	±	±	0	±	–	–	+	+	+	+
Balance of Index**	–	–	–	±	–	–	–	–	+	+	–	–

** 0 = No effect, + = positive effects, - = negative effects, ± = possible positive or negative effects*

*** In calculation of balances, no effect and ± was set equal to zero.*

Table (4.13): Effects of Different Factors on Aquaculture Production of Iran as Affected by Climate Change in Future Period (2016-2030)

Activity	Temperature	Salinity	Reduced water resources	Sea level	Sea Currents	Coastal and inland areas	Increase in seawater pH	Algal bloom	Nutrition	Growth	Balance of species**
Warm water fishes	+*	0	–	0	0	±	0	0	+	+	+
Tilapia	+	±	–	0	0	±	0	0	+	+	+
Shrimp	+	0	–	0	0	±	0	0	+	+	+
Sturgeons	±	0	–	0	0	±	0	0	+	+	+
Cold water fishes	±	0	–	0	0	0	0	0	±	±	–
Ornamental fishes	+	±	0	0	0	0	0	0	+	+	+
Cage-culture	±	0	0	±	–	0	–	–	±	±	–
Balance of Index**	+	±	–	±	–	±	–	–	+	+	+

** 0 = No effect, + = positive effects, - = negative effects, ± = possible positive or negative effects*

*** In calculation of balances, no effect and ± was set equal to zero.*

4.4.3. Adaptation Options in Different Agricultural Sectors in Iran

According to Iran's future climate change, warmer temperatures, less precipitation and more drought events are expected to occur. In order to increase the capacity and preparedness of the country to combat the existing and future adverse effects of climate change, before the physical, economic and social impacts of climate change reach to critical stages, national adaptation measures should be enhanced. Implementation of these measures needs to be accelerated through adequate access to foreign and international supports in terms of finance, modern and environmentally sound technologies and capacity building.

4.4.3.1. Agriculture

The fundamental adaptation strategy of agriculture sector to mitigate the adverse impacts of future climate change should increase the production level to the potential crop yields. This can be achieved through sustainable soil and water management, sustainable crop management at the farm level, extension and transfer of knowledge and policy making at national and regional level towards enhancement of job security and motivation for agricultural production in rural communities. The capacity building and administrative strategies for adaptation of agriculture sector to future climate change are presented in tables 4.14 and 4.15.

4.4.3.2. Livestock

Future climate change will impact animal physiology and forage production. Warmer temperatures and more frequent droughts are expected in the future. Camel is highly adapted to harsh desert climates and can tolerate a wide array of harsh conditions. Considering the future climate change of the country, this animal can play an important role in the food security and income of the rural populations, particularly in the arid and semi-arid areas of the country. The capacity building and administrative strategies for adaptation of livestock sector to future climate change are presented in table 4.16.

4.4.3.3. Fisheries

Research and development programs at the national and regional level, in line with international organizations programs, are necessary for reduction of vulnerability and enhancement of the adaptive capacity in fisheries sector. Appropriate utilization of available resources and enhancement of production and fishing management for economic enhancement of fisheries activities are the fundamental adaptation strategies in this sector. The capacity building and administrative strategies for adaptation of fisheries sector to future climate change are presented in table 4.17.

Table (4.14): Capacity Building Strategies for Adaptation of Agriculture Sector to Mitigate Adverse Effects of Climate Change

Strategy	General policy	Comments
Sustainable Soil Management	Conservation tillage	• In general, prevention, control, and management of soil erosion are crucial.
	Sustainable soil fertility	• Integrated use of chemical, organic and microbial fertilizers is highly recommended.
	Salinity management	• Improvement of vegetative cover of soil greatly reduces evaporation and upward movement of salts in the soil. • Leaching of salts should be practiced only in those areas with ample supplies of good quality water. • Irrigation management is crucial in prevention of secondary salinity in irrigated lands. • Summer fallowing of lands should be avoided.
Sustainable Water Management	Reduction of water losses	• The fundamental adaptation strategies in water management should increase water productivity and enhancement of water use efficiency at all stages of water extraction, transfer, storage, and its application in the field. • Saline-water resources (surface and underground), treated wastewaters, agricultural drainage waters, and rainwater harvesting.
	Irrigation management	• Expansion of pressurized irrigation systems. • Irrigation management should consider specific crop water requirements at local levels and climatic conditions.
	Integration of sustainable technologies with modern technologies	• Some of the innovative technologies introduced by Iranians are still in use, such as Qanats, Bunds, and flood control techniques (sustainable technologies). • Modern technologies may be combined with sustainable technologies to enhance their performance, increase water supplies and enhance water productivity.
Seed and Seedling Management	Plant breeding	• Development of crop and horticultural varieties tolerant to drought and salinity, as well as, early maturing and lower chilling requirement. • Use of biotechnology, tissue culture and nuclear techniques in conjunction with classic plant breeding methods.
	Appropriate agronomic techniques	• Due to the changes in temperature regimes, the appropriate planting dates should be re-evaluated. • Shorter growing seasons and earlier planting dates can also be considered as an opportunity in some regions.
	Utilization of halophytes and xerophytes	• Iran has a rich diversity and flora in highly salt tolerant (halophytes) and drought tolerant (xerophyte) plant species. • Many of these species produce useful, high-value products and might be introduced as new crops.
Integrated Management of Biotic Stresses	Weeds Pests Diseases	• The general recommendation of United Nations Food and Agriculture Organization (FAO) and International Center for Agricultural Research in the Dry Areas (ICARDA) for adaptation to future climate change. • Monitoring of their population growth trends and migration

Table (4.14): Capacity Building Strategies for Adaptation of Agriculture Sector to Mitigate Adverse Effects of Climate Change

Strategy	General policy	Comments
		routes, and possibly appearance of new species, is mandatory.
Selection of Appropriate Crops	Drylands	• Selection of appropriate crops for cultivation will have positive effects on water management and efficient water use at farm level. • Should be based on local climate and future climate change as well as available resources. • It is recommended that annual crops in drylands be replaced with perennial crops, such as fruits, nuts, and woody trees. • Considering the biodiversity of the area, it is possible to commercially cultivate some of the local natural plant species as forage, wood or medicinal herbs.
	Irrigated lands	• It is highly recommended to shift from cultivation of crops with high water requirement to ones with low water requirement. • Some of the horticultural crops with high water requirements may be cultivated in a greenhouse, which will enhance the water productivity and water use efficiency.
	Marginal lands	• Marginal lands are often degraded and/or salinized, and at the moment are considered unuseful. • Marginal lands may be brought under cultivation of useful plants with appropriate management. • Various plant species, highly tolerant to drought and/or salinity, grow naturally in these lands. Many of them possess useful and economical values as forage, medicinal, oil crops and wood. In addition, they offer valuable ecological services.
Sustainable Production Systems	Agroforestry	• Integration of forestry with agronomic crop production. • Agroforestry enhance water productivity, carbon sequestration, soil quality and diversity in the family income.
	Integrated Production Systems	• Integrated production of annual crops, trees (wood, fruits, and nuts) and livestock at individual farm level.
	Halo culture	• Sustainable, integrated production of agricultural products (plant and animals) in highly saline environments. • Highly saline lands can be brought under cultivation of useful halophytes with economic values. • Enhancement of water productivity, environmental services and diversification of family income.
	Organic agriculture	• The most popular nature oriented system of crop production. • The most important limitation in expansion of organic farming in the country is the lack of an internationally recognized agency for certification of organic products.

Table (4.15): Administrative Strategies for Adaptation of Agriculture Sector to Mitigate Adverse Effects of Climate Change

Strategy	General policy	Comments
Agricultural Water Resources Management	Motivational and regulatory policies and laws	• In general, enhancement of water productivity and appropriate water use is mandatory to increase the adaptation capacity of the country. • Encouragement and rewarding the producers who adapt and practice water saving policies and techniques. • Regulation and monitoring of well drilling companies and implementation of tough regulatory laws against illegal well drilling are necessary to protect the fragile underground water resources of the country.
	Action plan for management of water resources	• Compilation and ratification of an action plan for management of water resources at farm level by farmers and local authorities.
Socio-Economic Policies for Reduction of Poverty in Rural Areas	Territorial spatial planning	• Should be based on spatial distribution of agricultural systems, climatic conditions and local capacities.
	Extraterritorial agriculture	• Expansion and investment in agricultural production in other countries that do not face water shortage. • Virtual water concept should be the base for agricultural trading. • Export of products that require high amounts of water, Should be prevented.
	Prevention of land fragmentation	• Reduction of farm sizes will reduce useful areas of lands for agricultural activities. • Farmers' cooperative establishments should be encouraged by appropriate motivational laws and regulations.
	Farmers Income Stabilization Fund	• Reduction the risks of yield and price fluctuations. • Enhancement of farmer's income security.
	Rewards for environmental services	• ICARDA considers this as an effective policy measure for reduction of vulnerability in agriculture sector. • Farmers' adapting agricultural systems, such as agroforestry and organic farming, which contribute positively to environmental quality, and at the same time generate profitable income, can be rewarded by compensating parts of the expenses.
	Subsidies	• Government aids and subsidies are required for encouraging the acceptance and implementation of adaptation technologies and policies by farmers.
	Reduction in agricultural wastes	• Reduction of agricultural wastes is fundamental in improvement of agricultural productivity. • This should take into account all phases of production, processing, and distribution of food products.
	Expansion of agricultural insurance	• Should be upgraded regularly to include more crops and disasters.
	Diversification of the economic activities	• Diversification of economic activities in rural areas will improve adaptation capacity of rural populations. • Agriculture should be the main economic activity in rural areas, but industrial activities, such as small-scale processing and converting factories, and services, such as ecotourism and farm tours, will also contribute to the economic strength of these areas.

Table (4.16): Capacity Building and Administrative Strategies for Adaptation of Livestock Sector to Climate Change

Strategy	General policy	Comments
Capacity Building	Expansion of livestock and poultry insurances	• Should be upgraded regularly to include more types of livestock production activities and disasters.
	Income Stabilization Fund	• Reduction of risks from yield and price fluctuations. • Enhancement of livestock producers' income security.
	Settlement of nomads	• Nomadic communities of Iran are highly dependent on pastures for small livestock productions. Therefore, adverse impacts of climate change will adversely affect their economic conditions. • Motor vehicles have made their migration faster and easier. Thus, rangelands have less time for regrowth, and their quality is degrading rapidly, which in turn will adversely affect their communities. • This has more detrimental effects on degradation of rangelands than climate change itself. • Settlement of migratory nomadic communities will slow down the process of degradation in pastures, and decrease the vulnerability of nomadic communities to future climate change.
	Rewards and subsidies for environmental services	• Adaptation of policies for rewarding those who improve the condition of the rangelands which have rented or obtained the permission for grazing their livestock. • Rewards and subsidies may also be allocated for those who adopt integrated production systems.
Infrastructure Development and Expansion	Balanced grazing	• The balance between the number of animals and grazing capacity of pastures will significantly improve the quality of the pastures and increase grazing capacity. • Re-evaluation of pasture management based on future climate changes
	Protection of the biodiversity of Iranian animal breeds	• Poultry, cattle, and small ruminants. • Protection of their genetic diversity will enhance the adaptive capacity of the sector against unexpected and predicted future climate changes. • Supervision and regulation of live poultry and animal import to the country.
	Breeding programs	• Gradual replacement of low productive breeds with highly productive breeds in industrial and semi-industrial units. • Breeding for the enhancement of forage digestion efficiency.
	Forage production	• Improved irrigation management and water use efficiency in irrigated forage farms. • Introduction of new drought and salt tolerant cultivars. • Reduction in forage losses and wastes. • Re-vegetation and improvement of rangelands. • Utilization of marginal and saline lands for production of xerophytes and/or halophyte forages.
	Expansion of Integrated Production Systems	• Crop-Livestock-Tree production systems for diversification of farmer s ' income and biodiversity in rural areas.
	Promotion of organic livestock and poultry production	• Diversification of agricultural activities in rural areas. • Diversification of farmers' income and quality of living conditions. • Environmental benefits.
	Management of animal diseases	• The outbreak of insect pests and pathogenic agents is expected in future, both in terms of magnitude and frequency. • Common diseases between animals and humans are more important. • Computer models are useful tools for prediction of disease outbreaks.
	Expansion of industrialized production units	• The possibility of controlled production environment in industrialized units decreases the vulnerability of animals to environmental stresses. • Development of industrial camel production systems is highly recommended.

Table (4.17): Capacity Building and Administrative Strategies for Adaptation of Fisheries Sector to Climate Change

Strategy	General policy	Comments
Capacity Building	Management and protection of marine stock resources	• Prevention of the present trends in environmental degradation and pollution of marine ecosystems, for the purpose of reducing the sensitivity and vulnerability of these ecosystems and marine resources. • Appropriate control and monitoring of present conservation areas, and designation of new conservation areas, particularly in the more vulnerable and sensitive areas of the country, for the purpose of protection of endangered species and those that are the most vulnerable to the future climate change. • Continuous monitoring of marine ecosystems and their components, including physical, chemical and biodiversity factors for the purpose of appropriate exploitation and protection of sea environment. • Protection and improvement of reproduction and spawning habitats. • Prohibition of destructive fishing methods, such as bottom trawl and gill net, for the purpose of preventing environmental degradation and protection of marine stock resources. • Artificial reproduction and release of different marine fingerlings, particularly those that are more vulnerable and are facing the danger of extinction and establishment of an artificial shelter and living habitats for vulnerable species. • Equipping the fishing vessels with modern fishing equipment and techniques for the purpose of reducing by-catches and preserving the biodiversity.
	Sustainable aquaculture management	• Integration of aquaculture with agriculture and livestock production practices on farms, for enhancing water productivity and creating additional income for the producers. • Identification of appropriate species for aquaculture in different parts of the country based on local capacities and climatic conditions. • Development and expansion of intensive fish farming in controlled systems, particularly in marine areas. • Development and expansion of circulating and controlled fish farming (closed systems), particularly in inland areas of the country. • Research on the identification and introduction of new marine species tolerant to increased temperature, salinity, and oxygen deficiency. • Research on feeds with high conversion index. • Disease management of aquamarine species.
Socio-Economic Policies	Expansion of insurances	• Should be upgraded regularly to include more types of aquamarine production activities and disasters.
	Income Stabilization Fund for fishermen and producers	• Reduction of risks from yield and price fluctuations. • Enhancement of fishermen and producers' income security. • Equipping the commercial fishing vessels with cold storage and processing facilities, for the purpose of increasing the added value of fishing products and increasing the income opportunities for the fishermen. • Providing the social needs of fishermen, such as fisheries insurance, social security insurance and retirement benefits.
	Rewards and subsidies for environmental services	• Adaptation of policies for rewarding those who prevent contamination of sea and inland water bodies. • Rewards and subsidies may also be allocated for those who adopt integrated production systems.

4.4.3.4. Capacity Building among Stakeholders

The main stakeholders in this report are the producers at field level (i.e. farmers, livestock producers, and fishermen). The capacity building strategies for adaptation of stakeholders to future climate change are presented in table 4.18.

Table (4.18): Capacity Building Strategies among Stakeholders for Adaptation of Agriculture, Livestock, and Fisheries Sectors to Climate Change

Strategy	Comments
Cultural awareness	• In general, the morals of respect for water should be raised or renewed in all population sectors of the country. • These morals were the motivations behind numerous innovations and inventions in various fields of water science by ancient Iranians. • The country has rich indigenous knowledge of adapting to drought and water scarcity. • Comprehensive social, cultural, economic and technical studies of the desert communities and civilizations of Iran will reveal new (old but forgotten) adaptation strategies, which can be incorporated in present-day adaptation strategies.
Education and transfer of knowledge	• Transfer of knowledge to agricultural producers will result in increased production, better water productivity, and enhanced economic efficiency. • In a program implemented by the government, thousands of unemployed agricultural engineers were contracted to supervise wheat farms and transfer the appropriate knowledge and skills to wheat producers. This program contributed positively to raising the production level of wheat in the country. • Farm School is another program that will also be beneficial and help in the process of knowledge transfer at the farm level. • Improvement in technical skills of agricultural producers (i.e. farmers, livestock producers, and fishermen) will result in improved production, reduction of costs and wastes and overall adaptation capacity of the agriculture sector.
Public awareness	• The level of public awareness about various aspects of climate change, particularly among farmers, livestock producers and fishermen should be raised more efficiently. • This will result in the most active participation of the producers in the adaptation process.

4.5. Forest and Rangelands

4.5.1. Introduction

The most important part of vulnerability and adaptation report in forest and range ecosystems considerably depends on the climatic provided data. Consideration of past changes will help future forecasting. According to the available scenarios, the impacts in future can be evaluated and adaptation measures could be provided. The first national report was submitted to the secretariat of the convention of United Nation Framework Convention on Climate Change (UNFCCC) on March 2003. The second report was released in 2008. In the second report, the forest was categorized as a source of emissions.

4.5.2. Assessment Methods

"Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies, UNEP[1], Version 20, October 1998" was used as the main source of the climate change assessments on forest and rangelands. The followings are some of the methods used in this assessment:

- Analogues procedures (incomparable approach);
- Expert judgment according to the experts' views;
- Field survey with collecting field data;
- Experimentation according to research results; and
- Modeling in some cases which were possible.

4.5.3. Vulnerability Assessment and Adaptation Measures

Impact and vulnerability assessment on natural ecosystems including forest, range, and desert, not only in Iran but also in developed countries, is a difficult and complicated issue. Since 1950s, some changes in temperature (mainly increase) and precipitation (mainly decrease) of northern Hyrcanian forest have been reported.

There are plenty of reports on extreme events such as floods in different regions of forests, ranges or deserts. In some regions total precipitation decreased but its density increased and drought period also extended.

4.5.4. Assessment Method

- Selection of eight meteorological stations which its data presentation can cover most parts of the country (Figure 4.20 and Table 4.19).
- Data from two years of 2004 and 2014 were analyzed to compare a ten years period.
- In each year data from January (as the middle month of the winter season) and July (as the middle month of the summer season) were used for analyses.
- Temperature and precipitation were used as main effective climatic factors.
- For temperature, mean temperature of January and July, as well as annual mean temperature, were used.

1 United Nations Environment Program

- For precipitation, total precipitation of January and July, as well as total annual precipitation, were considered.
- In addition to data comparison, its correlation was evaluated.
- Days with highest and lowest temperature in 2004 and 2014 and also maximum wind speed are provided in table 4.20.

Figure (4.20): Names and Locations of Stations on the Map

Table (4.19): Names and Locations of Selected Stations

Stations	Location
Arak	Data reported by the weather station: 407690 (OIHR) Latitude: 34.1 | Longitude: 49.7 | Altitude: 1720
Babulsar	Data reported by the weather station: 407360 Latitude: 36.71 | Longitude: 52.65 | Altitude: -21
Iranshahr	Data reported by the weather station: 408790 (OIZI) Latitude: 27.2 | Longitude: 60.7 | Altitude: 591
Kermanshah	Data reported by the weather station: 407660 (OICC) Latitude: 34.26 | Longitude: 47.11 | Altitude: 1320
Mashhad	Data reported by the weather station: 407450 (OIMM) Latitude: 36.26 | Longitude: 59.63 | Altitude: 989
Shiraz	Data reported by the weather station: 408480 (OISS) Latitude: 29.53 | Longitude: 52.58 | Altitude: 1486
Tabriz	Data reported by the weather station: 407060 (OITT) Latitude: 38.08 | Longitude: 46.28 | Altitude: 1367
Tehran – Mehrabad	Data reported by the weather station: 407540 (OIII) Latitude: 35.68 | Longitude: 51.35 | Altitude: 1204

4.5.5. Impact of Climate Change

According to the pessimistic and optimistic scenarios, predicting precipitation and maximum temperature changes (Table 4.6) and their impacts on forest Net Primary Productivity (NPP) calculated for 2016-2030 period. The impact of temperature, precipitation, and combination of both factors, based upon pessimistic and optimistic scenarios were calculated for the period of 2016-2030.

The impact of temperature, on forest biomass, in pessimistic scenario comparing to the optimistic scenario for the period of 2016-2030 will be more positive and effective. While the impact of precipitation on forest biomass in the pessimistic scenario for the period of 2016-2030 would be much more negative and unacceptable. Meanwhile, increasing forest biomass under optimistic scenario for the period of 2016-2030 will be very positive and in opposite direction of pessimistic outcomes. This fact can be applied for a combination of temperature and precipitation factors (Table 4.21).

Table (4.20): Days with Highest and Lowest Temperature in 2004 and 2014 and Also Maximum Wind Speed

Stations	Days of extreme historical values in 2004	Days of extreme historical values in 2014
Arak	The highest temperature recorded was 38.8°C on 7 August. The lowest temperature recorded was -11.6°C on 21 December. The maximum wind speed recorded was 64.8 km/h on 23 February.	The highest temperature recorded was 40.4°C on 27 July. The lowest temperature recorded was -22°C on 10 January. The maximum wind speed recorded was 51.9 km/h on 18 October.
Babulsar	The highest temperature recorded was 33.4°C on 20 August. The lowest temperature recorded was 2.4°C on 4 December. The maximum wind speed recorded was 57.6 km/h on 17 December.	The highest temperature recorded was 33.8°C on 20 August. The lowest temperature recorded was -3.6°C on 3 February. The maximum wind speed recorded was 81.7 km/h on 5 October.
Iranshahr	The highest temperature recorded was 46.4°C on 7 August. The lowest temperature recorded was 2°C on 2 December	The highest temperature recorded was 47.3°C on 12 July. The lowest temperature recorded was 1°C on 7 February. The maximum wind speed recorded was 50 km/h on 29 September.
Kermanshah	The highest temperature recorded was 42.3°C on 19 August. The lowest temperature recorded was -9°C on 24 February. The maximum wind speed recorded was 57.6 km/h on 15 February.	The highest temperature recorded was 42.2°C on 25 July. The lowest temperature recorded was -14°C on 6 February. The maximum wind speed recorded was 72 km/h on 28 April.
Mashhad	The highest temperature recorded was 42.4°C on 13 August. The lowest temperature recorded was -12°C on 20 March. The maximum wind speed recorded was 72 km/h on 16 February.	The highest temperature recorded was 41.6°C on 22 July. The lowest temperature recorded was -17.4°C on 3 February. The maximum wind speed recorded was 48.2 km/h on 1 February.
Shiraz	The highest temperature recorded was 41°C on 10 August. The lowest temperature recorded was -5°C on 29 December. The maximum wind speed recorded was 108 km/h on 13 March.	The highest temperature recorded was 42°C on 2 August. The lowest temperature recorded was -5°C on 9 January. The maximum wind speed recorded was 74.1 km/h on 31 March.
Tabriz	The highest temperature recorded was 38°C on 19 August. The lowest temperature recorded was -18°C on 23 February. The maximum wind speed recorded was 82.8 km/h on 5 March.	The highest temperature recorded was 39.8°C on 17 July. The lowest temperature recorded was -14°C on 7 January. The maximum wind speed recorded was 74.1 km/h on 29 March
Tehran – Mehrabad	The highest temperature recorded was 39.4°C on 12 August. The lowest temperature recorded was -11°C on 20 January. The maximum wind speed recorded was 72 km/h on 15 February.	The highest temperature recorded was 42°C on 27 July. The lowest temperature recorded was -7.6°C on 6 February. The maximum wind speed recorded was 111.1 km/h on 2 June.

Table (4.21): Pessimistic and Optimistic Changes of Forests NPP in 2016-2030 in Different Region of Iran

	Pessimistic Scenario Mg ha^{-1} yr^{-1}	Optimistic Scenario Mg ha^{-1} yr^{-1}
Arak	-795172	520059
Babulsar	-3.2E+07	1.78E+08
Iranshahr	-1.2E+07	58249908
Kermanshah	-2.1E+07	65508403
Mashhad	-5.3E+07	8289448
Shiraz	-2.6E+08	3.64E+08
Tabriz	-3757134	4767382
Tehran – Mehrabad	-815181	987437.5

4.5.6. Climate Change Challenges and Adaptation Program

The challenges of Iran's forests and rangeland area are:

- Limited precipitation and high potential evaporation;
- Non concurrency of precipitation occurrence and time of plant needs;
- Low humidity in most parts of Iran;
- Low plant cover, especially in center, east and south of Iran;
- droughts and dryness ;
- Significant role of people in deforestation and desertification; and
- Socioeconomic impacts of climate change on environment and sustainable development.

And the opportunities are:

- Great availability of solar energy;
- Great diversity of climate, temperature, and energy for plant growing; and
- Great source of wind energy.

Based on the aforementioned challenges and opportunities the adaptation strategies can be listed as follows:

- A need to use Criteria and Indicators for Sustainable Forest Management (C&I for SFM);
- Programmatic actions (such as National Plan of Action, import of wood, etc.);
- Socio-economic actions (such as nomads, forest cooperatives, etc.); and
- Technical activities (such as forests rehabilitation, range preservation, desert windbreakers, domestic livestock management, agriculture irrigation control, etc.).

To achieve the objectives of adaptation strategies, monitoring should be undertaken in all levels of related activities and programs. Accordingly, evaluation should also be done in three forms to assess the level of progress: routine evaluation, extensive evaluation, and intensive evaluation. In general, the focus of evaluation and monitoring activities can be listed as follow:

- Compliance – law and regulations;
- Effectiveness;
- Validation;
- Social and economic issues; and
- International agreements.

To undertake the evaluation effectively, clear indicators, such as the followings should be identified:

- Functional-based indicators;

- Structure-based indicators; and
- Species-based indicators.

4.6. Coastal Zones

4.6.1. Introduction

Iran is bordered by three main water bodies. The Caspian Sea stretches more than 800 km along the northern border of Iran. The Caspian Sea is the largest landlocked water body in the world, characterized by subtropical humid climate in the coastal area of Iran. The climate of the region is influenced by cold Arctic air masses, humid temperate air masses from the Atlantic Ocean, dry and cold masses of Siberian High Pressure, and Mediterranean warm air masses. However, orography of the coastal area (especially the Alborz range in Iranian side) is a determining factor in regional climatology of the coast. The southern water bodies of Iran are the Persian Gulf and Oman Sea, connected through the Strait of Hormuz. In fact, these water bodies are the marginal seas of the Indian Ocean.

The Persian Gulf is a semi-enclosed epicontinental water body and is characterized by its warm and high salinity water. The Persian Gulf has a length of more than 900 km and the maximum width of 370 km. The climate condition over the Persian Gulf is hot, dry, and unfavorable. Dust storms are common in this region and annually contribute 60–200 x 10^6 tons of soil dust, which is about 50% of the total dust emissions into the troposphere.

4.6.2. Detection of Changes in Past Periods

4.6.2.1. Caspian Sea

According to the landlocked nature of the Caspian Sea, the major controllers of the sea level are precipitation and evaporation over the basin. The sea level dropped 3 meters from 1929 to 1978 and then it has risen for less than 3 meters until 1995 (Figure 4.21). New studies show that the sea level changes could be matched with mean annual changes of air temperature as well as sea surface temperature (Molavi et al., in preparation).

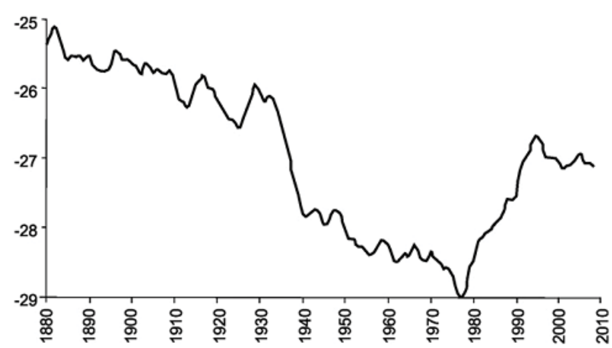


Figure (4.21): Instrumental Records of the Caspian Water Level (meter) for Period of 1880–2010

Since 1956, climatological time series data show that precipitation over the coastal area has decreased that is notable in most part of western the Caspian coast of Iran (Figure 4.22). During this period, the temperature generally increased for more than 1°C in the coastal area of Gilan Province that is much more than global average (0.6°C).

The share of climate change has not been indicated in declining trend of fish stock and increasing number of endangered marine species living in the Caspian Sea. Researchers believe that the share of overfishing and pollution is much more than climatological factors in the environmental changes, but this has not been improved, efficiently.

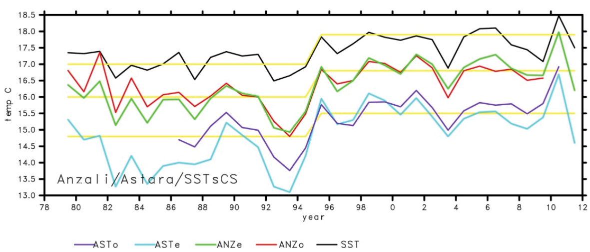


Figure (4.22): Annual mean precipitation at Anzali, Ramsar, Lahijan and Rasht, Units of precipitation (left axis): mm/y

4.6.2.2. The Persian Gulf

Decadal time series data of tide gauges show that the sea level has been increased to 2.34 mm/yr and 4.5 mm/yr in Bandar Abbas and Kuwait, respectively (Figure 4.23).

The air temperature over the coastal area of the Persian Gulf increases more than 1.4 °C per century while precipitation decreases about 0.6 mm/yr in this region (Figure 4.24). Coral bleaching has been reported repeatedly for 1996, 1998, 2002 and 2007 as well as 2012 in some parts of the Persian Gulf that is compatible with El Niño–Southern Oscillation (ENSO) activity.

Shamal wind has an important role in mixed layer formation of the Persian Gulf and ecological

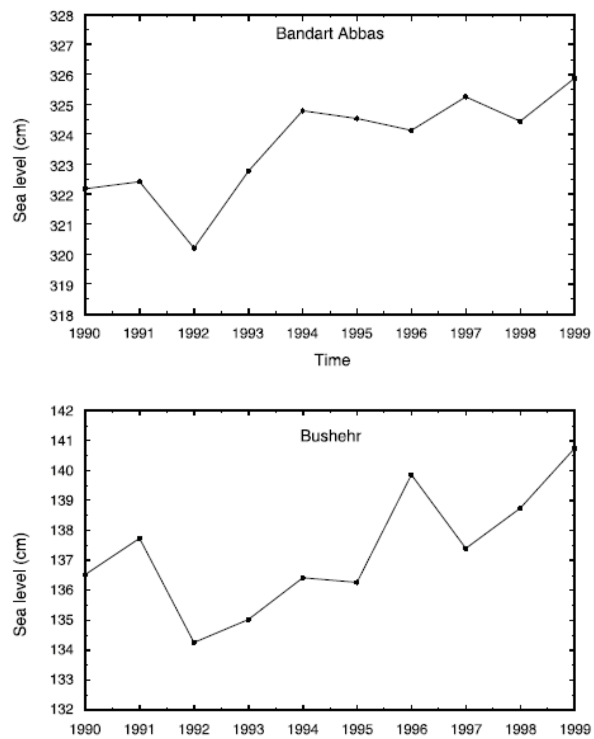


Figure (4.23): Sea Level Changes in Bandar Abbas and Bushehr during 1990 to 1999 (Hossenibalam et al., 2007)

consequences (Figure 4.24). The mean wind speed has decreased during the last 50 years and it is predicted that the speed decreases dramatically in the future. Water acidification has been studied in Kuwait coast for more than 10 years since 1999 and the results show that pH has decreased during the measurement period. Although the frequency of dust storms has been decreased in the western part of the Persian Gulf region, the intensity and the coverage of dust storms has increased during the last 20 years.

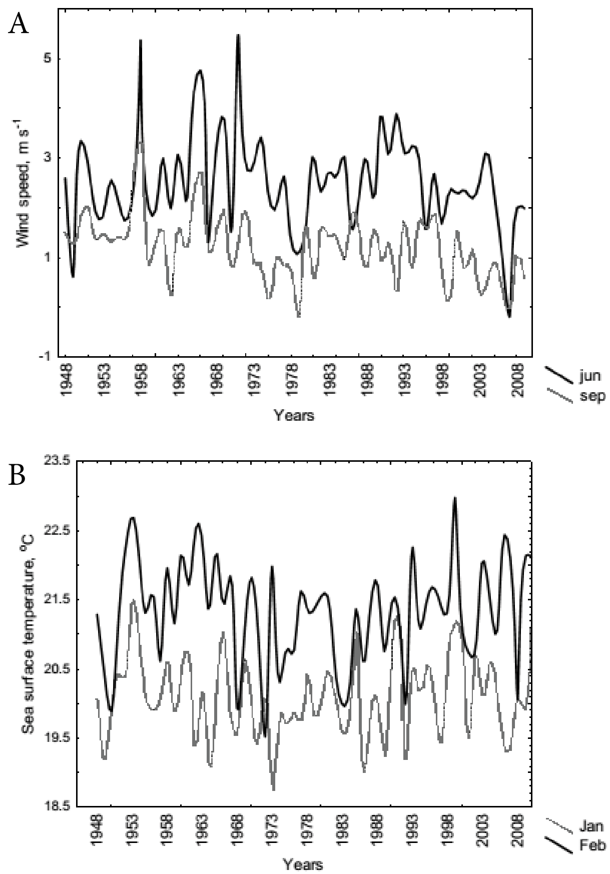


Figure (4.24): Mean Annual Wind Speed (m/s) Changes (A) and Mean Annual Sea Surface Temperature Changes (B) between 1943 to 2008 in the Persian Gulf (Piontkovski et al., 2012)

4.6.2.3. The Oman Sea

Studies show that the condition of precipitation in view of chemistry over the Oman Sea changes seasonally depending on the monsoonal wind direction. Based on this finding, the percentage of pollutants in precipitation has increased during five years of measurements. The source of the pollutants is in Asia and brought to the basin by northwest winds during the winter monsoon.

Sea level measurement in Makran coast is a complicated issue due to the active tectonics of the coast. However, it seems that the sea level rises more than 1.8 mm/yr in Chabahar station while the coast uplifts between 0.8 to 1.1 mm/yr at the same station.

The Makran coast is influenced by Indian Ocean tropical storms, occasionally. Studies show that the frequency and intensity of the storms have increased since 1895 (Figure 4.25).

The Oman Sea is a basin for dust particles that come from Asia (especially Iran), Africa and Arabian Peninsula. Water shortage and lakes disappearance in Eastern Iran make this area a major source of dust particles for the Oman Sea.

4.6.3. Impact and Vulnerability Assessment in Future Periods

4.6.3.1. Caspian Sea

The catchment basin of the Caspian Sea extends to high latitude of temperate climate where precipitation will be higher in future. On the other hand, trends of time series data show that temperature will increase over the Caspian Sea at a higher rate than global average. As the Caspian Sea level is controlled mainly by the precipitation and evaporation over the catchment basin, it seems that the sea level will not change dramatically and will be stable between -26 to -28 m below mean sea level (Figure 4.26).

The Caspian coast of Iran will be dryer and hotter in future. This will certainly be influential on coastal sensitive ecosystems, agricultural activities, and tourism. Increasing freshwater consumption and changes in physical and chemical properties of sea water are the consequences of the atmospheric changes that in turn lead to desertification, vegetation changes and soil erosion in the eastern coast of the Caspian Sea.

Any changes in Caspian water level could affect the development of coastal wetlands and bays. This event will be more dramatic in low-lying coast of the eastern Caspian coast.

4.6.3.2. The Persian Gulf

The worse scenario of sea level rise for 2100 in the coast of the Persian Gulf will inundate the low lying coast of Khuzestan Province and some locations in Hormozgan Province and in turn, could affect underground freshwaters (Figure 4.27). Moreover, the sea level rise will change the sedimentation and erosion rates of coast depending on the coastal setting.

The weakening of Shamal wind in line with increasing temperature in next decades will decrease the mixed layer and change physical properties of the water. This condition could consequently affect sensitive ecosystems such as coral reefs, mangroves, and coastal wetlands.

4.6.3.3. The Oman Sea

While the Persian Gulf experiences a weaker Shamal wind, the Oman Sea meets more strong winds and more frequent tropical storms in next decades. This could pump more deep oceanic water to the Northern Arabian Sea and the Oman Sea and consequently the sea will be more productive. Moreover, stronger storms could lead to coastal erosion of rocky shores of Makran.

More dust storms over the Oman Sea and the Persian Gulf in line with increasing Sea Surface Temperature (SST) could provide an adequate condition for more frequent algal blooms.

4.6.4. Adaptation Strategies

4.6.4.1. Caspian Sea

National and regional efforts are needed to protect the Caspian Sea from harmful effects of climate change. Water resources management, integrated coastal zone management and saving coastal ecosystems by domestic approaches are the main approaches at the national level.

As the Caspian Sea is shared by five rim countries of Iran, Turkmenistan, Kazakhstan, Russia and Azerbaijan, more political coordination is needed to conduct adaptation plans for the region. This coordination should focus on data and information exchange and joint research projects in the water body.

4.6.4.2. The Persian Gulf and the Oman Sea

The main challenge for the hot and dry region of southern Iran is access to freshwater. Currently, 60 % of desalination plants of the world are installed in the Persian Gulf region. These facilities consume huge amounts of fossil fuels that in turn emit considerable GHGs to the atmosphere. In order to prevent GHG emission from these plants it is necessary to diversify the power sources such as atomic energy and hydroelectric sources. Moreover, exploration of new sources of freshwater resources such as fossil waters and submarine freshwaters is recommended. Due to the accessibility of deep oceanic water in the Oman Sea, development of Ocean Thermal Energy Conversion (OTEC) is recommended as a green energy source.

The low-lying coastal area of Iran along the Persian Gulf and the Oman Sea are threatened by sea level rise. Lack of enough data on the rate of the sea level rise and its consequences necessitate more regional efforts in data and information exchange as well as joint researches.

It is crucial for the Islamic Republic of Iran to engage in international oceanographic researches, especially in the Indian Ocean. Some projects and programs such as The Indian Ocean Global Ocean Observing System (IOGOOS) could provide a suitable platform to conduct such efforts.

The rich rim countries of the Persian Gulf could be a destination of migration due to climate change effects in Africa, Middle East, and South Asia. Moreover, water shortage in central Iran could force people to move to the coast of the Persian Gulf and the Oman Sea for living. Increasing the population along the coasts needs infrastructures and facilities improvement, which should be considered in future development plans.

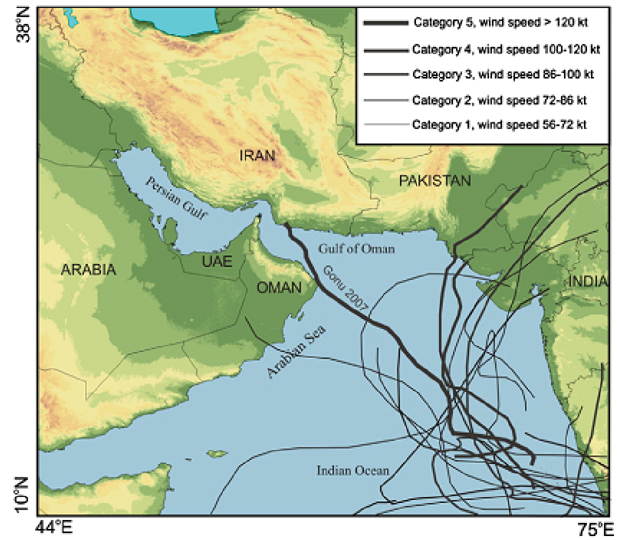


Figure (4.25): Tracks of Northern Indian Ocean Tropical Storms with Wind Speed Higher than 56 Knots (104 km/h) from 1900 to 2009. Data from the IBTrACS[1] Database (Knapp et al., 2010). Cyclone Gonu (2007) is the Only Recorded Category 5 Storm in the Oman Sea Since 1900 (Shah-hosseini et al., 2011)

1 International Best Track Archive for Climate Stewardship

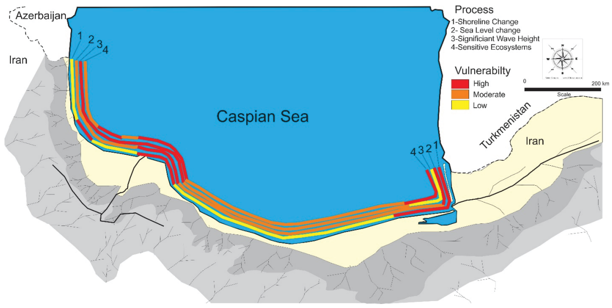


Figure (4.26): Coastal Vulnerability to Relative Caspian Coastal Changes Driven by Climate Change. The Index is Not Based on Modeled Data and the Output is Qualitative

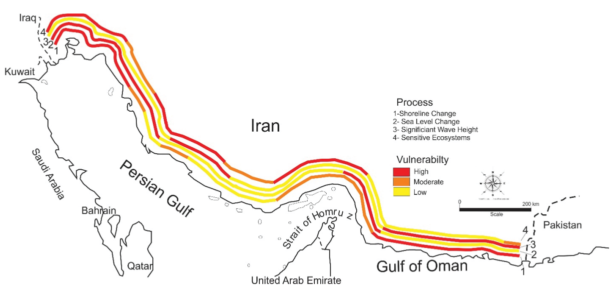


Figure (4.27): Coastal Vulnerability to Relative Coastal Changes along the Persian Gulf and the Oman Sea. The Index is Not Based on Modeled Data and the Output is Qualitative

4.7. Human Health

4.7.1. Introduction

Today, global warming and climate change are the most significant challenges worldwide. According to the fifth IPCC report (2013), the impacts of climate change are global and all countries face the consequences of this problem. In October 2008, the World Health Organization (WHO) Eastern Mediterranean Regional Committee issued a Regional Committee Resolution (EM/RC55/R.8) at its fifty-fifth session. The resolution on climate change and health aims at protecting human health from the impacts of climate change. It also urges the Member States to implement the endorsed Regional Framework for Health Sector Action to protect health from the effects of climate change. A significant focus of the resolution is on capacity building in the health sector of the Member States through encouraging the health systems to undertake an assessment of health vulnerability to climate change in order to proactively prepare and address the health impacts of climate change.

Climate change could result in increased heat-related mortality, airborne disease, and food insecurity, disruption of livelihoods, internal migration and changing distribution patterns of infectious and vector-borne diseases. Iran is developing an official national climate change action plan, which could prove beneficial for mitigation and adaptation strategies that target public health in the context of climate change. Iran has envisioned climate change within the broader objective of achieving sustainable development.

4.7.2. Methodology

The study on health sector has been carried out in four phases with the overall objectives of developing National Adaptation Programs of Action (NAPA) based on assessing vulnerability and the adaptation status of the Iranian population's health and Iran's public health system with respect to current and future climate change, with special focus on the following major climate-sensitive health issues (both mortalities & morbidities), as mentioned below:

- Vector-borne diseases; and

- Water-borne and Food-borne diseases.

In Phase (I), the researcher(s) provided current situation of the major health issues. The trend analysis was performed by Mann-Kendall trend test for three important stages.

Phase (II) included the impact assessment of climate variability on major health topics based on selective scenarios from 2016 to 2030 compared with 2000 (as the baseline year). Temperature has been identified as the main variable for disease projection based on meteorological data on the baseline. The statistical approaches were used for determining the relationship between climate variability and disease incidence. Non-linear regression methods applied to incidence projection of disease in future time points. Projections are shown on the country maps (Figures 4.28-4.33). Phase (III) provides an adaptation plan of activities. The final strategies were chosen based on the urgent and immediate concerns in relation to adaptation to climate change for future works.

4.7.3. Climate Variability

Average of temperature estimated based on 45 scenarios were applied in this report for a future period. Based on the modeling workgroup report, the long-term average temperature for 2016-2030 period will be increased in comparison with the baseline period (1982-2009). In the spring seasons, the average increase will be 0.4 ^{0}C for Bushehr and 0.9 ^{0}C for Arak. In the summer times, the estimated increase of temperature will be 0.3 to 1 ^{0}C for Birjand and Kermanshah, respectively. In autumn seasons, the temperature will increase by 0.5 and 0.8 ^{0}C for Birjand and Mashhad, respectively. It will be variable all over the country at summer time. The predicted increased temperature for the winter season will be 0.1 for Ghazvin and 0.7 for Hamedan. The long-term temperature for the period 2016 to 2030 will be increased by 0.2-1.1 0C in comparison with the baseline (1982-2009).

4.7.4. Disease Projections Based on the Projected Temperature

4.7.4.1. Malaria

Malaria is the most important mosquito-borne disease in Iran. Although it has had a decreasing trend in the country during the past few years, autochthonous cases are reported from southeastern parts. The total cases of Malaria are 17,749 at baseline (2000). The projection of this disease in the future period shows that in most part of the country the number of cases will increase (Figure 4.28). Khuzestan will experience the hightest number of cases while Sistan-Balchestan will face lowest number of cases. (The total projected up to 2030 will be 20,000 cases. The total economic loss will be about 13 million US dollars).

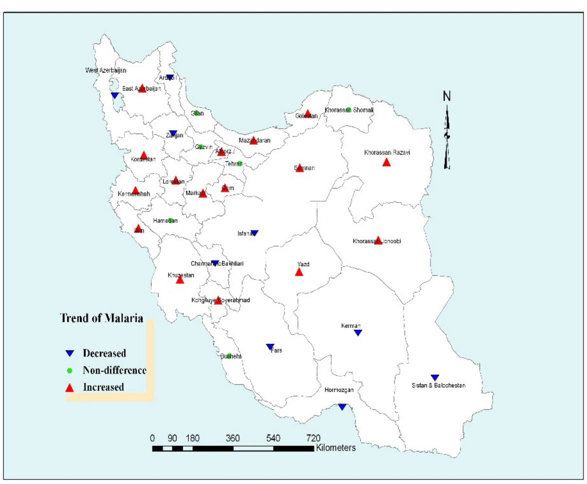


Figure (4.28): Projected Malaria Cases in the Period of 2016-2030 in Comparison with the Year 2000

4.7.4.2. Cutaneous Leishmaniasis

Cutaneous leishmaniasis (CL) is now common in 17 out of the 31 provinces of Iran and is mainly concentrated in a belt from northeast to southwest of the country, with more than 20,000 annual cases. The total cases of CL are 14,117 at baseline. In 2016-2030, the most cases are projected for Hormozgan and the least one is Khorasan-e-Razavi (Figure 4.29). The total projection up to 2030 will be 15,000 cases. The total economic loss will be about 5 million US dollars.

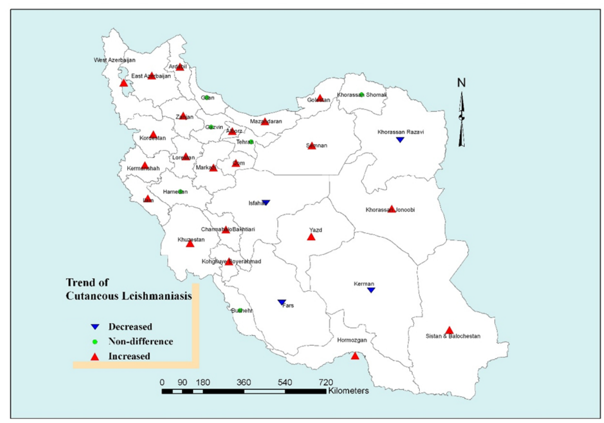


Figure (4.29): Projected Cutaneous Leishmaniasis Cases in the Period of 2016-2030 in Comparison with the Year 2000

4.7.4.3. Visceral Leishmaniasis

Visceral leishmaniasis (VL) is one of the common health issues that can be influenced by climate variability. Iran is one of the endemic areas in the world for the VL. The total cases of VL are 501 at baseline (2000). For 2016-2030, the most cases are projected for Hormozgan and the least one is for Khuzestan (Figure 4.30). The total projection up to 2030 will be 500 cases. The total economic loss will be about 3 million US dollars.

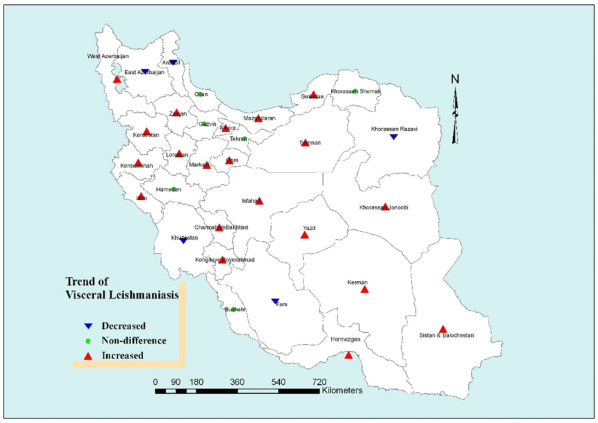


Figure (4.30): Projected Visceral Leishmaniasis Cases in the Period of 2016-2030 in Comparison with the Year 2000

4.7.4.4. Crime-Congo Fever

Crimean-Congo Hemorrhagic Fever (CCHF) is a viral disease carried by ticks. Iran is one of the endemic areas in the world for CCHF. The total cases of CCHF are 22 in the baseline year (2000). In future period (2016-2030) the most cases are projected for Hormozgan and the least one is Sistan-Balochestan (Figure 4.31). The total projection up to 2030 will be 22 cases (without any changes, compared with baseline year).

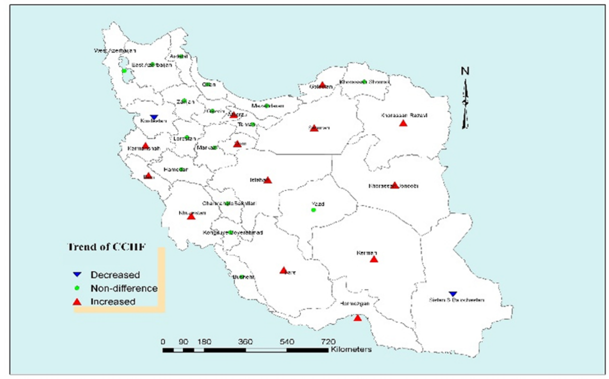


Figure (4.31): Projected Crimean-Congo Hemorrhagic Fever Cases in the Period of 2016-2030 in Comparison with the Year 2000

4.7.4.5. Typhoid

Typhoid Fever is a water-food borne disease. Iran is one of the endemic areas in the world for this disease. In recent years, the number of Typhoid cases decreased as a result of improvements in health facilities and urbanization. Total cases of Typhoid Fever are 1,751 in the baseline year for selected provinces. In 2016-2030, the most cases are projected for Yazd and the least one is Sistan-Balochestan (Figure 4.32). The total projected cases up to 2030 will be 1800 (small increase compared to baseline year). The total economic loss will be about 6.5 million US dollars.

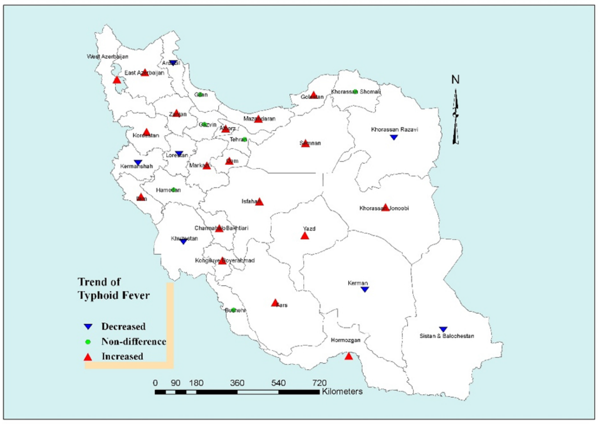


Figure (4.32): Projected Typhoid Fever Cases in the Period of 2016-2030 in Comparison with the Year 2000

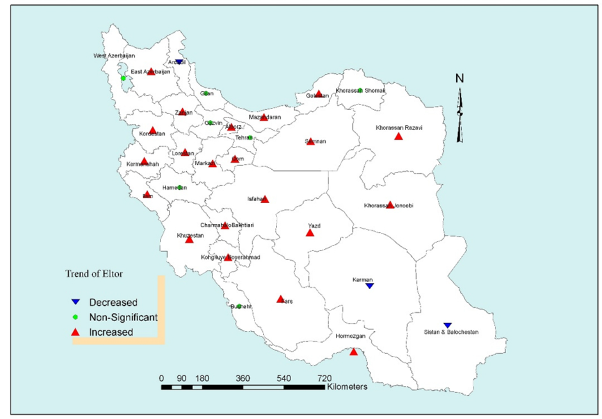


Figure (4.33): Projected Eltor Cases in the Period of 2016-2030 in Comparison with the Year 2000

4.7.4.6. Eltor

Eltor is a water-food borne disease. Iran is one of the endemic areas in the world for this disease. In recent years, the number of Eltor decreased as a result of providing better health facilities and urbanization. Total cases of Eltor are 343 in the baseline year (2000). In 2016-2030, the most cases are projected for Hormozgan and the least one is Sistan-Balochestan (Figure 4.33). The total projected cases up to 2030 will be 343. The total economic loss will be about 2.4 million US dollars as well.

4.7.5 .Outdoor Air Pollution Exposure

Dust storm and many climate change drivers, such as inefficient and polluting forms of energy and transport systems, also contribute to air pollution. Air pollution is now one of the largest global health risks, causing approximately seven million deaths every year. There is a significant opportunity to promote policies that both protect the climate at a global level and also have large and immediate health benefits at a local level. Short-lived climate pollutants such as black carbon, methane and tropospheric ozone released through inefficient use and burning of biomass and fossil fuels for transport, housing, power production, industry, waste disposal (municipal and agricultural) and forest fires contribute to a substantial part of global warming as well as air pollution related deaths and diseases.

A dust storm is a meteorological phenomenon common in arid and semi-arid regions. In dust storms, soil and dust particles move from one place and deposit in another. This phenomenon makes limitation in natural horizontal viewing (between 1 and 2 km) that also this is very harmful for respiratory patients. This phenomenon occurs in different provinces of Iran especially in west and south provinces.

Outdoor air pollution can have direct and sometimes severe consequences for health. Fine particles which penetrate deep into the respiratory tract subsequently increase mortality from respiratory infections, lung cancer and cardiovascular disease. (Figure 4.34)

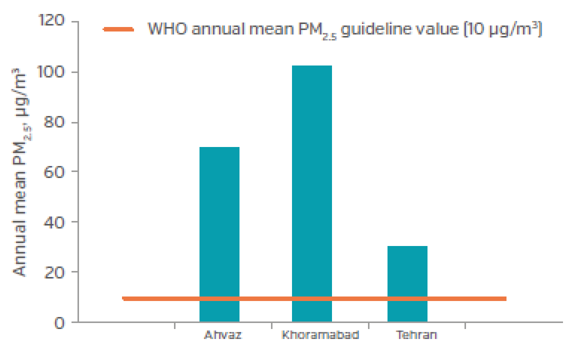


Figure (4.34): Outdoor Air Pollution in the Cities of Iran Annual Mean PM2.5 (μg/m³) 2010. The Cities for Which There Was Air Pollution Data Available in 2010 Had Annual Mean PM2.5 Levels that Were Above the WHO Guideline Value of 10 μg/m³

4.7.6. Heat-related mortality

Climate change is expected to increase mean annual temperature and the intensity and frequency of heat waves resulting in a greater number of people at risk of heat-related medical conditions. The elderly, children, the chronically ill, the socially isolated and at-risk occupational groups are particularly vulnerable to heat-related conditions.

Under a high emissions scenario heat-related deaths in the elderly (65+ years) are projected to increase to almost 70 deaths per 100,000 by 2080 compared to the estimated baseline of under 6 deaths per 100,000 annually between 1961 and 1990. A rapid reduction in global emissions could limit heat-related deaths in the elderly to about 16 deaths per 100,000 in 2080.

4.7.7. Annual exposure to flooding due to sea level rise (period 2010–2070)

In addition to deaths from drowning, flooding causes extensive indirect health effects, including impacts on food production, water provision, ecosystem disruption, infectious disease outbreak and vector distribution. Longer term effects of flooding may include post-traumatic stress and population displacement.

Under a high emissions scenario, and without large investments in adaptation, an annual average of about 184,700 people is projected to be affected by flooding due to sea level rise between 2070 and 2100. If global emissions decrease rapidly and there is a major scale up in protection (i.e. continued construction/rising of dikes) the annual affected population could be reduced to about 200 people. Adaptation alone will not offer sufficient protection, as sea level rise is a long-term process, with high emissions scenarios bringing increasing impacts well beyond the end of the century.

4.7.8. Conclusion

Based on the climatology information and using Time-Series Regression modeling, Khuzestan and Hurmozgan - south provinces of the country - as well as important country border cities will have the highest risk for Vector-Borne and also the waterborne incidence up to 2030. The comparison between economic loss and total cases of all diseases revealed that the CCHF is very important in view of cost of one case. Then, the priorities would be implemented based on the highest economic loss.

If global emissions decrease rapidly and there is a major scale up in protection, the annual affected population could be limited to about 200 people. Considering the estimated national rate of heat-related deaths (less than 6 deaths per 100,000 persons annually between 1961 and 1990), under a high emissions scenario it will be around 70 deaths per 100,000 persons by 2080. A rapid reduction in global emissions could limit heat-related deaths in the elderly to about 16 deaths per 100,000 in 2080.

4.7.8. Strategies

The most important strategies for vector-borne and water-borne disease based on the Ministry of Health and Medical Education (MOHME) policies are the following:

- Vector-Borne:

  - Implementing climate-adaptive health programs in vector-borne sector;

  - Developing early warning systems and emergency measures for vector-borne diseases;

  - Developing climate-health cooperation program;

  - Adapting new rules for Quarantine System;

  - Community awareness about vector-borne diseases;

  - Borderline collaboration for vector-borne diseases;

  - Quarantine establishment in the high-risk areas;

  - Effective vector control;

  - Applied research about climate change impacts on vector-borne diseases; and

  - Establishment of a surveillance system for epidemic forecasting based on forecasted temperatures.

- Water-Food borne diseases:

  - Developing a monitoring system and preparation of a database for water & food-borne related diseases affected by climate change;

  - Acquiring the support of politicians and senior managers for strengthening the system of controlling food-borne diseases; and

  - Strengthening programs supportive of nutritionally vulnerable individuals/groups (targeted subsidies, safety nets, etc.) for households aiming at promoting direct access to nutritious and safe foods;

  - Institutionalizing inter-sectoral cooperation for food and nutrition policy and program- planning, especially for times of crisis;

  - Acquiring the support of politicians and senior managers for strengthening the system of controlling food-borne diseases;

  - Establishing and developing nutrition counseling unit in PHC system;

  - Designing an efficient food quality control system for times of crisis, especially climate-related ones;

- Strengthening the laboratory network in both public and private sectors, for proper diagnosis of food-borne diseases;

- Providing safe piped/drinking water in all urban and rural areas of the country; and

- Establishing the border surveillance system.

4.8. Biodiversity

4.8.1. Introduction

The complex and varied climates, life-history background and also a high potential of speciation make Iran a favorable habitat for various species of plants and animals. There are some areas like the Caspian regions, deserts, mountains and tropical areas in the vicinity of the Persian Gulf that provide a variety of habitats which in turn affect the biodiversity of Iran. This diversity has led to substantial enrichment of plants in Iran. 8000 plant species have been detected in Iran, in which the number of plant species in Iran is 80 percent of all of Europe’s plant species. On the other hand, a variety of wild mammals that have been identified is over 194 species. There are 21 species of amphibians, 215 species of reptiles, 155 species of fish and 520 species of birds. Figure 4.35 shows the biodiversity of vertebrate animals in Iran.

Figure (4.35): The Biodiversity of Vertebrates in Iran

Iran can also ecologically be divided into 5 groups of Zagros, Hirkani, Persian Gulf and the Oman Sea, Arasbaran, and Irani-Torani. (Figure 4.36)

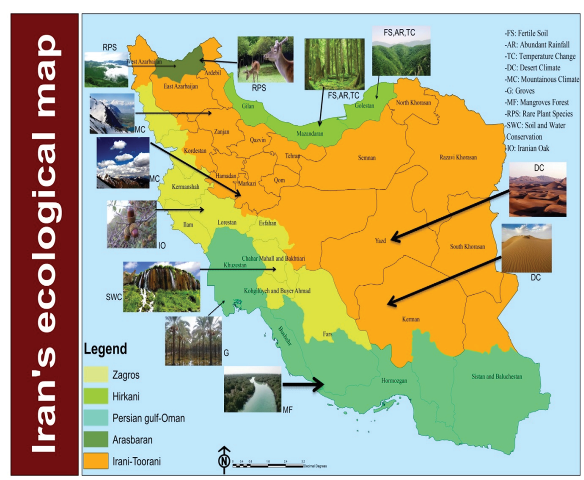


Figure (4.36): Ecological Classification of Iran

4.8.2. The Threats to Biodiversity in Iran

In general, reasons of biodiversity loss include natural factors and human factors such as changes in land use, encroachment on natural forests, wildlife and plants trade, excessive exploitation of flora and fauna, water pollution and climate change.

Specifically, any of the following factors is known as threatening factors of country's fauna, which include:

- ***Threats of fish fauna:*** Unsystematically overexploitation of water resources (dam construction, water withdrawals for agricultural purposes), non-systematic exploitation of fish stocks (excessive harvesting, wrong harvesting), contamination of water resources, habitat destruction and transferring the species and climate change.
- ***Threats of bird fauna:*** Including the loss of habitat due to human activities, pollution (oil, insecticides, pesticides, etc.), indiscriminate hunting, accidental death happened by installations (constructions, electricity towers, etc.), competition and hunting, replacing by invasive species and climate change.
- ***Threats of mammal fauna:*** The reasons for lack of awareness about importance of protecting various sectors of society to protect wildlife and lack of motivation are stipulated below:

  Lack of facilities in Iran Department of Environment in order to apply the rules and regulations for hunting and fishing, availability of a large number of illegal weapons in the hands of the people particularly nomads and villagers, destruction of habitat due to irregular entry of livestock, occupation of springs and watering place by ranchers, food competition and the spread of disease between livestock and wildlife especially wild mammals, herd dogs chasing wild mammals and mammal hunting in pregnancy seasons, breastfeeding and getting alive babies, indiscriminate road construction and habitat degradation, wild mammals' habitats conversion to agricultural lands, industrial ones and environmental pollution, the use of chemical pesticides such as poisoned bait in order to eliminate wolves and leopards and climate change.

4.8.3. Conservation and Restoration of Iran's Biodiversity

The number of protected sites in the country is equal to 274, which includes 29 national parks, 44 wildlife refuges, 35 national natural monuments, 166 protected areas and 10 Biospheres; while the number of protected sites in the country was 194 sites in 2010. (Figure 4.37)

There are also 10 international projects in different parts of Iran are carrying out in the field of biodiversity conservation as below:

- Conservation of Asiatic Cheetah;
- Conservation of Iranian wetlands;
- Conservation of biodiversity in central Zagros mountains;
- Conserving and managing the biodiversity of Anzali wetland;

- Conservation of Caspian Hyrcanian forest biodiversity;
- Integrated natural resources management in Iran agro-Ecosystems;
- Rehabilitation of degraded lands;
- Sustainable management of land and water Hablehroud;
- Conservation against desertification by carbon sequestration; and
- Establishment of breeding centers and gene banks.

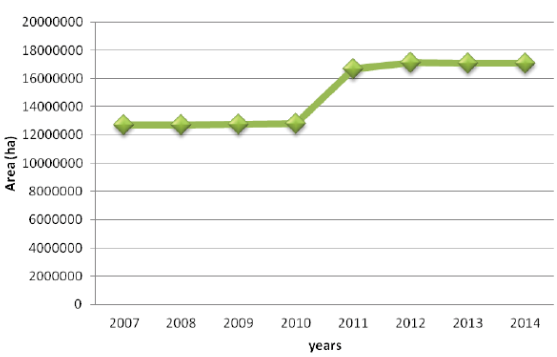


Figure (4.37): The Area of Environmental Protection in Iran

4.8.4. Biodiversity Strategy for the Period of 2011-2020 in Iran

One of the goals of the Islamic Republic of Iran and the Iran's Department of Environment is to pursuit twenty Aichi targets in the country. Among twenty Aichi targets, the seventh goal in Iran was a priority in this regard. The number of sites under the protection of the country has changed from 194 sites in 2010 to 274 in 2014. The seventh goal is as follows:

- Aichi Target 7: By 2020, areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity. To achieve the seventh Aichi target following actions are being carried out in Iran. (The Fifth National Report, 2015, to the Convention on Biological Diversity).

  - Reviving of a Council comprised of key ministries and head of the Department of Environment, chaired by the President, to control the development of the country according to environmental goals;

  - Increasing the protected areas. Saving the endangered species such as Asiatic Cheetah from extinction;

  - Establishment and enforcement of necessary laws and regulations; and

  - Establishment of National Sustainable Development Committee.

4.9. The Economic Effects of Climate Change

4.9.1. The Direct and Indirect Economic Impacts of Climate Change on Agricultural Sector

4.9.1.1. Introduction

Specific climatic and hydrological condition of Iran has created many restrictions for agricultural production. Shortage of water resources and high frequency of droughts occurrence are the most important issues (Salami, 2008). It is predicted that the occurrence of climate change intensifies these conditions by increasing temperature and changing patterns of rainfall. Of about 12.1 million hectares of agricultural lands are under cultivation, 6.2 million hectares are rain-fed crops cultivation (about 51 percent), with 8 million tons of annual crops production comprising a considerable portion of main products production such as wheat (4.5 million tons), barley (1.06 million tons) and bean (0.283 thousand tons). Production and economic stability in the country directly and strongly depends on the amount of annual precipitation and its time distribution and evapotranspiration rates. Decreasing rainfall not only reduces the yield of these crops, but also if the rainfall decrease exceeds its threshold limit, harvesting of agricultural lands practically may finish which leads to going out of production cycle. On irrigated lands, particularly in parts of the country that their dependence on surface water resources are high, climate change leads to increased water demand, reduced crops yield and cultivation area. Investigation of long-term time series of some crops yield shows a significant reduction in the crops yield which is comply with years which severe drought prevailed in the country (1988, 1996, 1998 and 1999) or certain atmospheric phenomenon have emerged (e.g. severe frosts of 2007) in the country. Looking at the statistics of production and imports of essential agricultural products (Table 4.22) shows the instability of agricultural production (due to the instability of climatic conditions). The most obvious examples of this instability can be seen in grain production that despite the national declaration of self-sufficiency in its production in 2004, amount of imported wheat in later years were significant. During 2001 to 2004 that the country's precipitation condition was almost close to "normal", the agricultural crops production was also relatively stable, and the value of imports has been minimal. With droughts outbreak and a decrease in rainfall to 139 mm in 2008, agricultural crops production has been reduced severely. For example, production of 15.9 million tons of wheat in 2007 with a 50 percent reduction reached to around 7.96 million tons in 2008. In this year, reduction of domestic production of barley, corn, rice and bean was 50.2, 24.7, 18 and 45 percent, respectively. The result of the reduction in domestic production was a significant increase in the amount of imports. According to the national customs reports, the volume of agricultural products imports in 2008, with a 77.3 percent increase (compared to 2007 with 9269 thousand tons), has reached to 16427.3 thousand tons. In this year, 5.9 thousand tons of livestock and hard wheat, 1.3 million tons of barley, 3.4 million tons of maize and about 1.39 million tons of rice are imported, that is much more than corresponding figures of the previous year.

Table (4.22): Trend of Domestic Crops Production and Import Amount

Year	Annual average climate variables		Domestic production (1000 tons)					Import (1000 tons)				
	Precipitation (mm)	Temperature (°C)	Wheat	Barley	Corn	Paddy	Bean	Wheat	Barley	Corn	Paddy	Bean
2002	254.0	15.8	12450	3085	1439	2887	670	2839	24.8	1705	1047.5	0.0
2003	246.7	15.6	13439	2908	1653	2931	671	733.3	191.1	2630	857	0.1
2004	242.0	16.2	14568	2940	1926	2542	665	170.4	844.5	2000	1142.4	1.1
2005	280.1	16.8	14307	2857	1995	2737	639	105.2	1209.3	2114	1044.6	25
2006	211.5	16.5	14668	2956	2166	2612	678	1152	375	2908	1220.5	134
2007	280.5	17.3	15887	3104	2361	2664	711	189.3	199.7	2683	1067.2	100.3
2008	139.0	16.9	7957	1547	1777	2184	388	5919	1334	3397	1389	124.5
2009	207.9	16.9	13485	3446	1643	2253	508	5060	1296	3854	1290	141

The first possible adverse effect of climate change is the reduction of agricultural production, so the income of farmers and value added of this sector will decrease. Reduction in agricultural production ability affects a wide range of macroeconomic and the agricultural sector variables. The most important effects are increased imports of agricultural products, reducing of the rate of exports, changes in the pattern of agricultural trade, increasing the currency outflow from the country, reducing the capacity of job creation of agricultural sector, increasing domestic prices of agricultural goods, reducing economic welfare of consumers and producers of these goods and finally decreasing gross domestic product of other economic sectors (through forward and backward linkages) and the whole economy of the country.

4.9.1.2 Direct Economic Impact of Climate Change on Agricultural Sector

The economic component of agricultural sector is presented which specifically includes acreages and cropping pattern, domestic prices of agricultural products, products domestic consumption demand, and ultimately welfare and economic surplus of producers, consumers and the society as a whole in the 2016-2035 period. Table 4.23 shows the result of climate change impacts on the agricultural sector in 2016-2035 period in 3 different scenarios base on the result of table 4.6 and baseline condition for comparison.

Table (4.23): The Summary of Economic Impact of Climate Change on Agriculture Sector in 2016-2035 Period

Agricultural products	Normal (baseline)	Optimistic Scenario		Median Scenario		Pessimistic Scenario		Very pessimistic	
		Amount	% change	Amount	% change	Amount	% change	Amount	% change
Activity level (1000 ha)									
Wheat	7661	8661	13.04	7679.6	0.2	7045.4	-8	______	______
Paddy rice	501	473.5	-5.5	515.7	2.9	495.6	-1.1	______	______
Potato	148.3	141.4	-4.6	147.4	-0.6	148.4	0.1	______	______
Oil seeds	32	371.2	6.0	220.7	-4.9	154.7	-33.3	______	______
Sugarbeet	167.7	188.5	12.4	156.5	-6.6	101.6	-39.4	______	______
Livestock (1000 heads)	125870	133989	6.5	122707	-2.5	116484	-7.5	______	______
Production amount (1000 tons)									
Wheat	18008.3	20781.6	15.4	17244.7	-4.2	14726.3	-18.	______	______
Paddy rice	2452.6	2359.4	-3.8	2399	-2.1	2249.8	-8.3	______	______
Potato	3903.6	297.7	-2.5	3741.7	-4.1	3668.8	-6	______	______
Oil seeds	452.7	756	67	443.9	-1.9	330	-27.1	______	______
Sugar beet	6687.8	7844.8	17.3	6094.5	-8.9	3738	-44.1	______	______
Red meat	1005.9	1071.3	6.5	989	-1.7	894.7	-11.1	______	______
Chicken	2101	2172.4	3.4	2059	-2	1964.9	-6.5	______	______
Production amount (1000 tons)									
Wheat	15847.3	17416.2	9.9	15562.8	-1.8	15439.4	-2.5	______	______
Paddy rice	2884.3	2794.9	-3.1	2850.1	-1.2	2752.5	-4.8	______	______
Potato	3020.3	3183.4	5.4	2994.2	-0.9	2935.9	-2.9	______	______
Plant Oil	1322.3	1371.2	3.7	1319.9	-0.2	1288	-2.55	______	______
Sugar	1185.7	1294.8	9.2	1180.3	-0.5	1175.6	-0.4	______	______
Red meat	1094.6	1129.6	3.2	1074.1	-1.9	1029.6	-7	______	______
Chicken	1806.3	1815.3	0.5	1770	-2	1690	-7.2	______	______
Foreign trade volume(1000 tons)									
Total of import	10132.5	9281.3	-8.4	10608	4.7	13099.4	29.3	14381.2	41.9
Total of export	742.9	750.2	2.2	742.9	0.0	634.3	-14.6	634.3	-14.6
Total of net export	-9389.6	-8522.1	9.2	-9865.1	5.1	-12465.1	32.8	-13746.9	46.4
Economic surpluses (billion Rials)									
Total economic surplus	549658.4	584286.9	6.3	538068.9	-2.1	532119.3	-3.2	527967.3	-3.9
Consumers surplus	431280.8	436456.2	7.6	420436.4	-2.5	409752.9	-5.0	399647	-7.3
Producers surplus	316611.4	340673.9	1.2	312975.8	-1.15	319843.1	1.02	325263.6	2.7
Welfare loss / total income of crops and livestock sector	-	10.9		3.7		5.54		6.85	

4.9.1.3. Indirect Economic Impact of Climate Change on Iran's Economy

In order to estimate the wider economic impacts, which is a direct effect of the climate change in Iran's agriculture sector, the Input-Output framework is used. Backward and forward linkages of 52 economic activities based on the demand-driven model of Leontief and supply driven or Ghosh model were calculated. Backward linkages for given sector determine the amount of its demand for use of other sectors outputs as inputs and indicate how much other sectors benefits from the investment in that sector. Forward linkages, in turn, show the number of products supply in a given sector which is used in other sectors. In fact, this number is a criterion which shows required amount of one sector to outputs of another specific sector. The coefficients of backward linkages of Iranian crops and livestock sub-sectors are 1.797 and 2.235 and forward linkages coefficients are 1.719 and 1.482, respectively. Table 4.24 shows direct and indirect economic effects of climate change on the agricultural and non-agriculture sector, as well as on the whole economy in different scenarios of climate change.

Climate scenarios	Direct economic impacts		Indiect economic impacts		Total (direct+indirect) economic impacts
	Consumers	Producer s	Demand-driven	Supply-driven	
pessimistic	-31483.5	-8548.5	-6815.0	-6140.5	-52997.5
Madian	-10782.0	-3482.7	-2776.6	-2506.2	-19747.5
optimistic	32777.3	3799.3	3039.4	2735.5	42351.5

Table (4.24): Total Economic Impacts of Climate Change in Iran in the Period of 2016-2035

Base on the results, the total economic losses resulting from climate change in Iran, in pessimistic and median scenarios is estimated around 52997.5 and 19747.5 billion Rials per year, respectively. In contrast, the total direct and indirect effects of optimistic climate scenario which anticipated 23.4% increase in rainfall, is estimated about 42351.5 billion Rials increase in the gross domestic product of all economic sectors. The proportion of consumers from the total losses (benefits) of climate change in scenarios varied between 55 to 86 percent in the pessimistic and optimistic scenario, respectively. The proportion of crop and livestock producers from these losses (benefits) changes from 16.9 to 9 percent and for other sectors of the economy (indirect effects) varies from 13.6 to 24.5 percent.

Considering that chemicals as one of the most common inputs are used in the agricultural sector, agricultural production reduction diminishes the demand for products of this sector. Reduction of added value of chemicals production activities, due to the diminishing of agricultural production, was estimated 1175.6 billion Rials under the pessimistic scenario. After applying chemical in agriculture sector, the most vulnerable economic activities to climate change on the demand-side are road transportation (458.9 billion Rials), financial intermediation (38.2 billion Rials), basic metals manufacturers (307.2 billion Rials), private buildings (283.3 billion Rials), production of petroleum refineries (272.8 billion Rials), other business activities (265.2 billion Rials), collection, purification and distribution of water (232.6 billion Rials), extraction of crude oil and natural gas (226.5 billion Rials) and other service activities (225 billion Rials). Given that part of agricultural productions is also used in itself as inputs (seed), climate change also affects this sector indirectly (878 billion Rials). Totally, the demand-driven multiplier effect of agricultural activity is 1.8. This means that each 1 unit reduction in the value added of this sector will cause about 0.8 Rial reduction in added value of other economic sectors that agriculture sector uses their products as inputs in its production process. Supply side analysis also has the same assumptions and direct impacts with demand driven model, but with less total impacts (14689 billion Rials). The most vulnerable sectors in the value-added reduction of crops and livestock sub-sectors are agriculture downstream activities that use products of this sector as input in their production process. For example, the largest decline in value added belongs to food and beverage industry whose value is estimated to be approximately 2530.4 billion Rials. After that, the most vulnerable sectors are textile production activities (529 billion Rials), private buildings (103.3 billion Rials) and commercial activities (72.1 billion Rials). Supply-driven increasing coefficient of agriculture sector is 1.72. This means that each 1 unit reduction in this sector value added will bring a total of 0.72 Rial reduction in value added of other economic sectors that use agricultural products as inputs in their production processes.

4.10. Energy Sector

Changes in regional temperature and precipitation patterns may have significant implications for the existing and future power system infrastructure. Weather and climate may affect all major aspects of the electric power sector, including thermal power plants, hydropower, solar and wind energies, transmission and distribution systems and end-user demand for power. A new study of the impact of climate change on the power and energy sector was not carried out during the course of the TNC as the estimates of the impacts and adaptation measures were made in this sector in the Initial National Communication. For more information on the vulnerability of energy sector as result of climate change and also adaption policies were explained very detail in Iran's Initial National Communication to UNFCCC.

4.10.1. Power Sector

- Effect of rise in sea level

As mentioned earlier, the rise in sea level, both in the Caspian Sea and Persian Gulf are of major concern to electrical power plants. These plants use the once-through cooling system and located near the sea (e.g. the Neka power plant at the Caspian Sea shore and the Bandar Abbas power plant on the Persian Gulf coast). To prevent physical damage to these facilities, it is necessary that coastal erosion be harnessed by costly structural works (such as concrete sea walls, etc.).

- Effect of sea water temperature

For thermal power stations situated near the sea in the north and south of Iran, water temperature is very important for the condenser operation of these steam power plants. It is estimated that an increase of 1°C in water temperature will result in a 3% efficiency drop at a steam power plant. This is primarily because the higher temperature of cooling water affects the condenser vacuum, thereby decreasing the efficiency of the steam turbine. In addition, higher water temperature may cause vibration of the low pressure steam turbine blades and more frequent shut downs of the power plant.

- Effect of ambient air temperature

The effectiveness of thermal power plants is also greatly influenced by the ambient temperature. Gas turbine power plants are designed to operate with an average ambient air temperature of 30°C. The output of typical gas plants or combined cycle power plants suffer from temperature rises of even 1°C. It is estimated that increasing the ambient air temperature by 1°C will cause a 2% loss in the power output of a thermal power plant.

4.10.2. Oil, Gas, Petrochemical Industries

- Rising of sea level and it's impact

Sea level rises have resulted in the destabilization of off-shore oil platforms. Apart from the damages caused, there are resulting extra costs for dredging, repair and maintenance due to mud build up on these installations. Vast sums are also spent to remedy the degradation of pumping stations and transmission lines resulting from erosion at on-shore and off-shore facilities.

- Quntity and Quality of Water

Due to the limitation in water resources in the country, both quality and quantity of the water entering to the instalation of water, electricity and vapor production cause damages to the instalations which needs the implemetation of projects for promoting the raw water entering to the instalations and also changes in the refrigeration cooling circuits and the processes in producing industrial water and the related circuits.

- Impact of sea storms

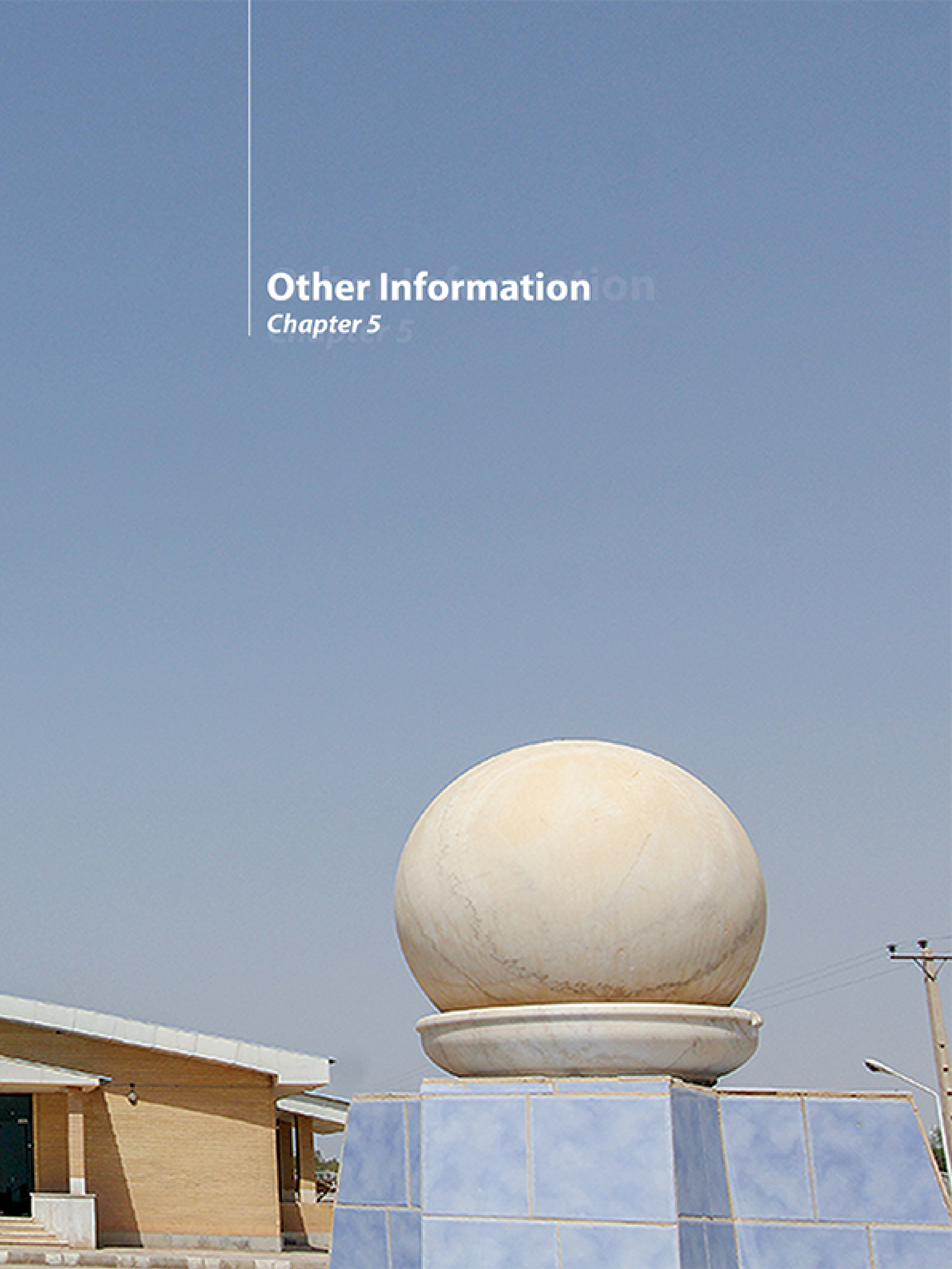
Sea storms also damage oil platforms and on-shore petrochemical units. At Bandar Imam petrochemical complex in particular, salt ponds that provide the unit's raw material are regularly impaired. While a rise in sea level could have positive effects on tanker traffic around the ports, yet storm conditions mean a rise in tanker fuel consumption and hence a higher cost for crude oil transportation.

- Impact of rising air and water temperature on cooling systems

Air and water temperature increases impede the efficiency of industrial cooling systems like air fans, heat exchangers, cooling towers and air coolers. Consequently, to compensate for this, larger volumes of fluid should be displaced, which in turn, raises overall energy consumption. In addition, relative increase of air temperature leads to an increase in evaporation of light oil products which should be considered in modifying the current tanks and designing the new ones. Furthermore, rising temperature decline the efficiency of gas process turbines and production of electricity and trasfering oil and related products.

Other Information

Chapter 5



5.1. Introduction

This chapter includes Iran's activities in the field of Global Climate Observation System (GCOS), research and education in various aspects of climate change and the economic effects of Emission Reduction Contributions (ERC) and economic diversification. This information was first addressed in Iran's Second National Communication (SNC) to United Nation Framework Convention on Climate Change (UNFCCC) and it has been updated in this report.

5.2. Global Climate Observation System (GCOS)

5.2.1. Meteorological and Atmospheric Observations

5.2.1.1. Introduction

I.R. of Iran Meteorological Organization became an independent organization in 1958, which has evolved into the present Islamic Republic of Iran Meteorological Organization (IRIMO). The main objective of IRIMO, along with obtaining national and international goals, is to protect life. The required services have been developed to get access to IRIMO deliverable products and services through portals. In this sense, these products and services are divided into two groups: "short-term, mid-term, and long-term products" and "basic atmospheric and climatic information". This historical information is used in research projects and high-level management policies in order to make plans in different fields. IRIMO is composed of eight divisions, namely:

- Research and Scientific Investigations;
- Administration;
- Technical Services (laboratories, technical supervision, telecommunication services, electronic and engineering services);
- Network (synoptic, rain gauge, climatology, agricultural stations);
- Operation (forecasting, synoptic observations, aeronautical control, marine meteorology, agrometeorology);
- Information and Data Processing (data processing, data bank, publications);
- Training Department; and
- International Relations and Legal Affairs Bureau.

5.2.1.2. The National Weather and Climate Monitoring System

In table 5.1, the latest information about the number of different types of meteorological stations and in figure 5.1 the location of these stations are presented. Among 391 synoptic stations, 77 stations are operated as Regional Basic Synoptic Network (RBSN) and 13 stations belong to Regional Basic Climatology Network (RBCN), the data of which are internationally exchanged through the Global Telecommunication System (GTS). Parameters that are normally applied to air traffic control are being measured in 64 aeronautical stations, which in fact are synoptic stations located in the vicinity of the country's airports.

225 out of 2498 rain gauge stations of IRIMO were equipped with Data Logger. The MOE operates a separate rain gauge network. It is worth noting that in the past decade these two institutions shared their valuable data.

Meteorological, biological and agricultural data are measured simultaneously in 34 agrometeorological stations by IRIMO, which have been located in strategic agricultural areas.

Height and period of waves, Sea Surface Temperature (SST), and some other oceanic parameters are measured in 20 marine meteorological stations located across the Caspian Sea in the north and along the Oman Sea and the Persian Gulf in the south of the country. The nine marine stations have been equipped with a buoy. In 2007, a research ship was purchased by the meteorological office of Gilan province.

The number of upper air stations including Radiosonde and Pilot balloon are 15. Mashhad station is the only station that has been considered as one of GCOS network stations.

A project related to a national network of weather radar stations, with the goal of covering the country, has already been started during last two decades. In the first phase, 6 radars were purchased from Gamatronic Company and installed under the Modernization and Information Technology Development Program (MITD) of IRIMO. These 8 radar stations are operational and their data are used in forecasting and the other purposes. The second phase of radar installation includes the provinces of Khorasan Razavi, Isfahan, Fars, Tehran, Bandar Abbas, Isfahan, and Gilan. Access to Iranian radar data is possible through http://radar.irimo.ir/default1.asp and ftp://radar.irimo.ir.

Table (5.1): Meteorological Observation Networks

Type of Station	No.
Synoptic	391
RBSN	77
RBCN	13
Upper - air	15
Aeronautical[1]	64
Climatology	266
Rain gauge	2498
- Data logger	225
- Agrometeorological	34
Marine meteorological	20
- Coastal	19
- Buoy	1
- Ship	1
Radiation	461
GAW[2]	1
Ozone	1
Dust monitoring	9
Mobile meteorological station	6
Road weather stations	66
Radar stations	8
CATI , II airport station	14
Automatic Weather Station (AWS)	417
Satellite receivers system	26
GCOS	8

1: Synoptic stations, those are located in the vicinity of airports and 2: GAW: Global Atmospheric Watch.

Road weather network is started to be installed jointly by IRIMO and the Road Toll and Road Transport Department for the purpose of recording specific meteorological data to issue weather forecast along the roads and finally to severe weather phenomena warnings such as quick snow melting especially in mountainous areas, severe wind blowing on bridges and various phenomena that affect reducing vision and etc. By the end of 2014, this network included 66 stations distributed in different parts of the country, mostly in mountainous areas and the roads with high risk at extreme events occurrence.

In addition to upper air and buoy stations that are intrinsically automatic, most of the meteorological offices in Iranian provinces have started to expand automatic weather stations. These stations have been installed in the vicinity of synoptic, climatology or rain gauge stations. So far, roughly 220 automatic weather stations have been operated to measure meteorological parameters by IRIMO. The number of synoptic and climatology stations which have been equipped with automatic instruments since 1993, is equal to 310 and 63, respectively.

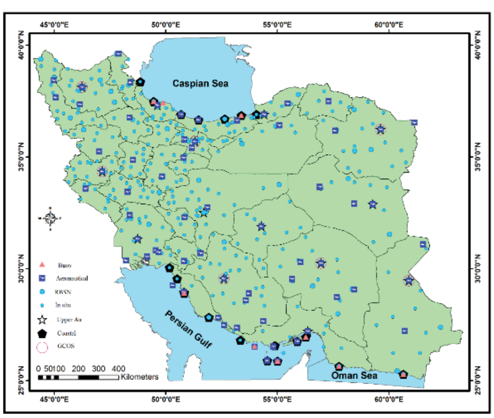


Figure (5.1. a): Synoptic Stations (In situ, Aeronautical, Upper air, Coastal, Buoy, RBSN, and GCOS)

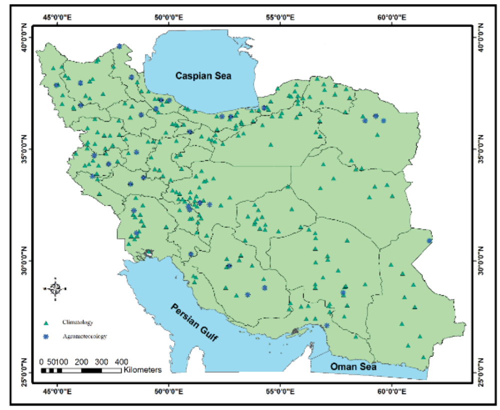


Figure (5.1. b): Climatology and Agrometeorological Stations

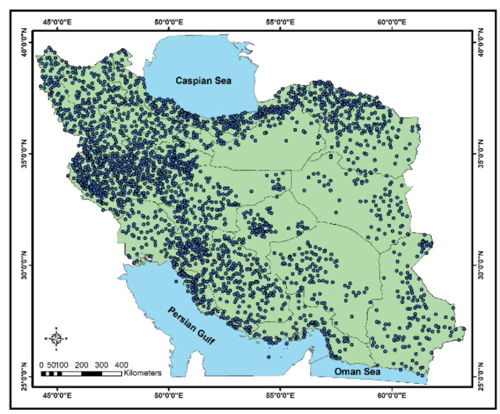


Figure (5.1. c): Rain Gauge Stations

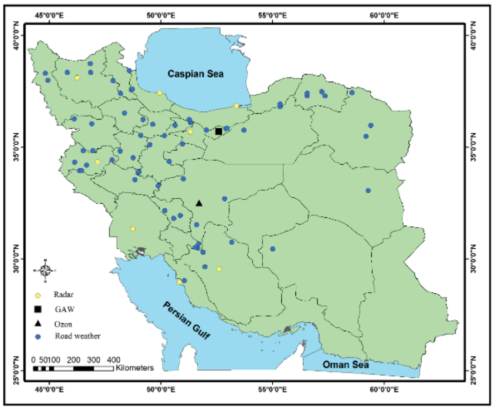


Figure (5.1. d): Special Stations Including Radar, GAW, Ozone and Road Weather

5.2.1.3. Atmospheric Observation

- ***Ozone Monitoring***

There are two stations under the supervision of the IRIMO and one with the cooperation of the Geophysics Institute that is affiliated with the University of Tehran, in which the ozone measurement facilities are installed and in use.

- Esfahan Ozone Station: This station is recognized by an international code of 336 and is connected to the global networking system. Total ozone is being measured using Dobson system since 1994. Since April 2000, Brewer equipment was installed and has been operating at Esfahan station.

- Aminabad Station: Surface ozone outside of urban area has been measured at Aminabad station, located about 40 km from Firoozkooh city that has an altitude of 2976 meters above sea level. The station is a reference station and officially is connected to the World Meteorological Organization's (WMO) GAW. It has been relatively active since 1995; however, since 2013 the activities of this station were extended by replacing new devices and measuring the Total Suspended Particulate (TSP), SO^2, NO, NO^2, O^3, CO and particles with sizes of PM2.5 and PM10. Currently, there is no access to these data from the site of World Ozone and Ultraviolet Radiation Data Center (WOUDC).

- Geophysics Institute Station: Since 1994, the Geophysics institute is mainly responsible for total ozone monitoring, data recording and processing, networking with WOUDC and conducting networking, training, and public awareness campaigns on stratospheric and surface ozone. The center is equipped with a Dobson photo-spectrometer and ancillary data processing and analysis hardware and software systems.

- ***Space Based Sub-system***

Satellite images are received and applied for the purpose of forecasting and issuing warnings for climatic disasters by 26 weather stations located mostly in provincial centers. In table 5.2, some more details about received satellite images are presented.

Table (5.2): Satellite Images Received at the Forecasting Center of IRIMO

Type of satellite	Satellites		Type of images	No. of channels	Region	Time of intervals
Geo stationary	MFG[1]	MeteosatT7	Digital	3	Africa, Europe, Asia , Indian Ocean	Every half an hour
	MSG[2]	Meteosat10	Digital	12	Africa, Europe, West Asia , Atlantic Ocean	15 minutes
	EAST -GOES[3]		Analog	3	Atlantic Ocean, East Pacific, North and South America	One hour
	1R /2 -MTSAT[4]		Analog	4	West Pacific, East Asia, Australia	One hour
Polar orbit				3		Three images per day
				3		Six images per day

5.2.1.4. Telecommunications

- ***IRIMO Telecom Systems: Domestic & International***

IRIMO is one of the Regional Telecommunication Hubs (RTH) that is responsible for gathering meteorological data from Jeddah, New Delhi, Karachi, Sanaa, Baghdad, Kabul, and Moscow. Furthermore, data exchange among selected countries from RA II (Asia) and RA VI (Europe) including Bahrain, Iraq, Kuwait, Pakistan, Republic of Yemen, Saudi Arabia and Former Union of Soviet Socialist Republics (USSR), central Asian countries, adjacent to sea and ocean areas, is carried out in this center. Tehran RTH has an automated data transmission system for collection and dissemination of observational data in accordance with the established schedules and volumes. RTH Tehran is collecting observational data from 230 synoptic and 15 upper air meteorological stations using SSB, PC-telex, and new switching system. The main operational facilities are currently as follows:

- Domestic: Telex lines, Virtual Private Network (VPN) connection (point to multi-point), wireless connection and satellite connection (VSAT[1]).

- International: Internet File Transfer Protocol (FTP) connection, VSAT connection, point to point connection and Digital Video Broadcasting - Satellite - Second Generation (DVB-S2) broadcasting system.

Furthermore, it is facilitated by modern computerized telecommunication system by a local company and also Mateo France International (MFI).

All provinces and some other organizations are connected to Headquarter (HQ) of IRIMO in Tehran via telex lines. In some cases, IRIMO uses wireless to connect some stations and organizations such as briefing and aeronautical stations, bus terminal to HQ. VPN connection (point to multi-point) is used between provincial centers and IRIMO HQ in Tehran, too. Star topology accompanied by Transmission Control Protocol/Internet Protocol (TCP/IP) is used in national VSAT network. For more information, 72 VSAT terminals are operational over the country. The speed of VSAT is 512/128 kbps which can be increased. In addition, the VSAT bandwidth of 15 Mbps is augmentable.

Number of satellites including IS15, IS1002, Badr5 W6, Badr and Eutelsat are used by IRIMO. The Hub in Iran is able to provide a connection with any country through satellite, which is located in our satellites coverage. As a matter of fact, WAN connectivity, improved regularly, is based on VPN over fiber optic, VSAT technology and DVB technology. IRIMO's DVB is based on 2-step process. In the first phase, the data is sent from HQ to the satellite provider by IPSec[2]/VPN connection through the Internet (Figure 5.2(a)). Then, the data is broadcasted to all clients (Provinces, Regions, Internal and External Users and etc.) via DVB carrier from the satellite service provider. On the client side, these data are stored locally.

1 Very Small Aperture Terminal
2 Internet Protocol Security

In the near future, IRIMO is to plan the second step, which has the same scenario, but IRIMO will be NOC and it will generate DVB carrier via specific DVB modulator which will be installed at IRIMO's HQ. So, data will be sent directly to the clients via IRIMO's own DVB carrier (Figure 5.2.b). Nowadays, IRIMO is operating IRIMSAT[1] service for 10 provinces and some of the external users.

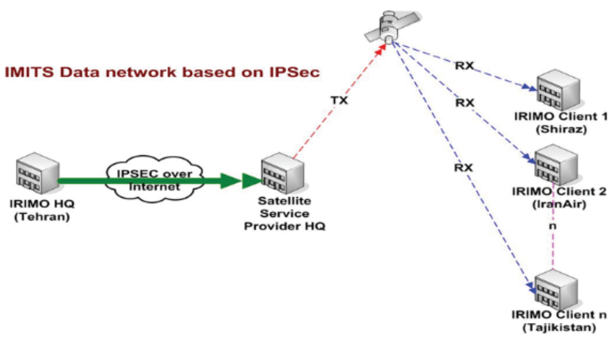


Figure (5.2. a): IPsec/VPN

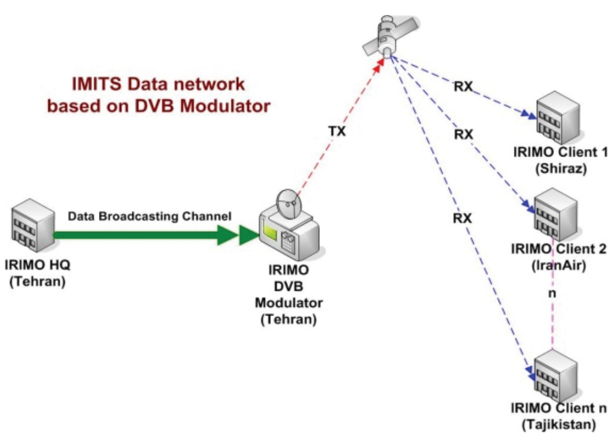


Figure (5.2. b): DVB Solution

- ***Automatic Switching System and Regional Automatic Message Switching System's (AMSS)***

The main Automatic Switching System and regional AMSS's are reliable and integrated too. The current Information System is a distributed and integrated system as a Central Information System.

- IRIMO Local Users: 21 provincial offices, Atmospheric Science and Meteorological Research Centre (ASMERC), Oceanic & Atmospheric Science Centre (OASC) and RTC (Regional Training Center).

- Iran Civil Aviation Organization)CAO(, Natural Disaster Centre, Iran Air Airline, Islamic Republic of Iran Broadcasting) IRIB(, Port and Shipping Organization (PSO), Aseman Airline, Traffic Police.

- International Broadcasting: Yemen, Azerbaijan, Afghanistan, Iraq, Uzbekistan, , Kyrgyzstan, Turkmenistan, Pakistan and Oman.

Upgrading the international connections has been started since two past decades. Table 5.3 shows the current and ultimate purpose of international connections.

1 A DVB-S2 satellite broadcasting service operated by the Islamic Republic of Iran.

Table (5.3): The International Connections

No.	Circuit	Current status	Future
1	New Delhi-DEMS	64 Kbps	256 Kbps & Also FTP over internet
2	Jeddah-OEJD	64 Kbps	256 Kbps & Also FTP over the internet
3	Karachi-OPKC	64 Kbps	256 Kbps & Also FTP over internet
4	Sana-OYSN	-	FTP over internet
5	Moscow-RUMS	FTP over the internet	VPN over the internet
6	Dushanbe-UTDD	VSAT (512/128kbps) & FTP over internet	Also FTP over internet
7	Toulouse-LFBO	FTP over the internet	-
8	Offenbach-EDZW	FTP over the internet	-
9	Ankara-LTAA	FTP over the internet	-
10	Tokyo	VPN over the internet	-
11	Baku-UBBB	-	FTP over internet
12	Baghdad-ORBI	FTP over internet	-
13	Kabul-OAKB	FTP over the internet	-
14	Tashkent-UTTT	-	FTP over internet
15	Bishkek-UAFM	-	FTP over the internet
16	Ashkhabad-UTAA	-	FTP over internet
17	Nepal-VNKT	-	FTP over internet
18	Oman	-	FTP over internet

The Internet connection bandwidth is 50Mbps and the future plan is to have 100Mbps Bandwidth. All data exchange protocols are based on FTPWMO protocol and also socket programming.

- ***Global Information System Centers (GISC)***

IRIMO launched a vast and general project called MITD aiming to modernizing of all technical and human components of the organization up to the highest world standards and for providing better services to the community and the government. Rapid changes in Telecommunication and Information Systems and migration to WMO Information System (WIS) made authorities to consider Tehran WIS project for implementing the IRIMO modernization plan.

To implement the WIS, WMO members have been asked to volunteer to implement and run GISC. GISCs are required by WIS as infrastructure centers, similar to the RTHs known from the GTS. In 2009, IRIMO volunteered to implement a GISC. The year 2011 has seen the going into operation of three GISCs (DWD[1], JMA[2], CMA[3]) and the going into a pre-operational mode of two others (MF[4], UKMO[5]). IRIMO has made significant progress with its GISC pilot, as seen in the demonstration to the WMO Cg XVI[6], and it was fully endorsed by the WMO Executive Committee (EC) in 2013, when the conditional endorsement of initially proposed GISCs expired.

IRIMO intends to develop its own GISC solution and do not rely on the commercial solutions available in the market, so as to develop capacity and help with the regional implementation of WIS. To do this, IRIMO’s proposed architecture makes extensive use of its existing systems, such as the GTS AMSS, as well as freely available software components and only makes the needed adjustments and adds the components not covered by what is available. This would be a key strategy if implementation of the progress is quick and it will require a focus on what is essential to implement the WIS functional specifications and to leave other, not-essential functionality, which can be implemented later.

1 The Deutscher Wetterdienst (German weather forecasting service)
2 Japan Meteorological Agency
3 China Meteorological Administration
4 Météo-France
5 United Kingdom Met Office
6 Sixteenth World Meteorological Congress

5.2.1.5. Data Management

- ***Data Collection and Processing***

National and international observational data and products are received via the GTS by data processing center of IRIMO (Figure 5.3). If they pass the zero level of quality control, they are stored in appropriate formats. Then, by other processes, production of data on daily, two-days, weekly, monthly and 30-year average (normal) basis as well as production of extreme events data are done. By using a special port, each province can have access to most of the statistics. Using a central database system, graphical reports such as wind rose, time series figures, and various types of meteorological and climatology reports in different formats are produced quickly and are presented to the end users. After a specified time, databases are delivered on tape storage and retrieved to be used as needed.

In order to develop the IRIMO database, coastal data storage has begun since 2013. Database of IRIMO (MESSIR-CLIM) including climatic database management system, is based on PostgreSQL. The main functions of the system are to receive and store all kinds of weather and climatic data. The system is able to collect and process massive amounts of information and provide meteorological products (such as charts, maps, tables, and reports). Figure 5.4 shows the operational stages of the database system in IRIMO.

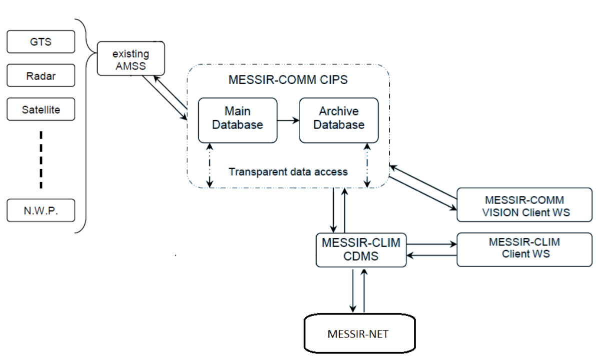


Figure (5.3): Data Circulation in IRIMO

Data quality control is applied in three layers which are as follows:

- Layer 0: Contains the control of syntax check and plausible values;

- Layer 1: Basic quality control, including internal consistency of climate variables; and

- Layer 2: Advanced quality control, including temporal consistency and spatial consistency

The observed data are stored in the IRIMO database after quality-control processes. Efforts have been made to establish a database which is in compliance with the configurations in the

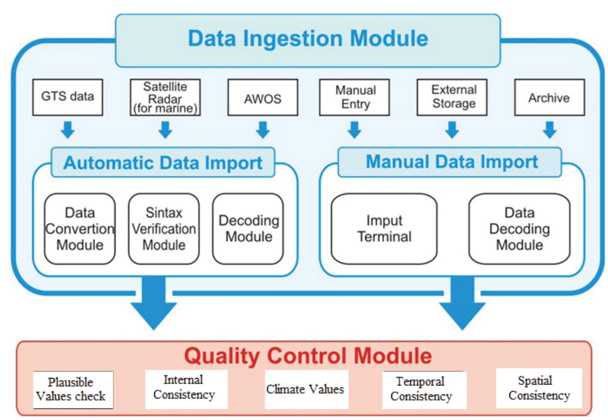


Figure (5.4): The Operational Stages of the Database System in IRIMO database of WMO reports. By applying the user interface of MESSIR-CLIM, including two (three) dimensional diagrams, time series analysis, regional maps, wind rose, upper air analysis, different type of charts at different scales (hour, day, month, year), bulletins and frequency distribution, many products are manufactured. In order to access to the products and climate data, a web-based system for sending and receiving (MESSIR-NET) was launched. Users are able to choose the methods for saving satellite data, radar and model's output. Then, the data stored in Observational Database (ODB) of IRIMO are refreshable by various tools such as forecasting system (MESSIR-VISION).

5.2.1.6. Public Weather Services

There are a variety of public weather services provided by IRIMO during the last decade (Table 5.4).

Table (5.4): Different Kinds of Public Weather Services to Be Provided by IRIMO

Type	Example	Type	Example
Touchscreen	Mehrabad Airport (Terminals 2, 4 and 5) Central Railway Terminal	Air view	Mehrabad Airport (Terminals 1,2, 4, and 6) Central Railway Terminal South and West Passenger Terminals
Radio		TV	
Newspapers	Most of widely circulated newspapers	IVR: Interactive Voice Response	134 phone numbers
Publications	Weekly, monthly, seasonal and annual Bulletin, climatic reports	SMS WEB	09123055005 1000305
Site	www.weather.ir www.irimo.ir	Mobile software	

5.2.1.7. Participation in Global Climate Observing System

- ***Global Surface Network (GSN) Stations***

Islamic Republic of IRAN hosts 7 GSN stations in Kerman, Mashhad, Shiraz, Tabriz, Kermanshah, Zahedan and Tehran-Mehrabad stations, that observe major parameters such as wet and dry-bulb temperatures, precipitation, sky cloudiness, dew point, horizontal and vertical visibility, cloud base height, cloud types, radiation, pressure (QFE[1], QFF[2], QNH[3]), maximum and minimum temperature, humidity, wind speed and direction, sunshine duration, evaporation and present weather.

- ***Global Upper-Air Network (GUAN)***

Islamic Republic of Iran operates 15 upper-air observing stations all over the country and Mashhad station is part of GUAN network.

- ***Global Atmospheric Watch (GAW)***

A GAW station observes air pollution and meteorological parameters regularly in Firoozkooh and sends the data to world ozone and Ultraviolet (UV) radiation center in Toronto, Canada since 1995. It should be noted that the station is not included in the GCOS network because of some technical issues and it has spare parts problems not solved by the manufacturer.

1 Atmospheric Pressure (Q) at Field Elevation
2 Atmospheric Pressure Converted to Mean Sea Level Elevation
3 Atmospheric Pressure (Q) at Nautical Height

- ***Lead Centers for GCOS***

Commissions for Basic Systems (CBS) Lead Centers for GCOS have been designated by WMO. CBS is responsible for monitoring the performance of GCOS networks, in particular GCOS Surface and Upper Air Networks (GSN, GUAN), and supporting any follow-up action in designated areas of responsibility (for all WMO Regional Associations). Islamic Republic of Iran is responsible for GSN and GUAN stations in RA II (Asia) and RA VI (Europe) which include Afghanistan, Armenia, Azerbaijan, Bahrain, India, Iran, Jordan, Kazakhstan, Kyrgyzstan, Maldives, Nepal, Oman, Pakistan, Qatar, Russian Federation, Saudi Arabia, Sri Lanka, Syria, Tajikistan, Turkey, United Arab Emirates and Yemen.

5.2.1.8. IRIMO's Strategic Plan

- ***Desires***

IRIMO's desires are as follows:

- To improve the protection of people and property and the safety of transport on land, sea and air;

- To improve the quality of life, sustainable livelihoods, health, food security, access to water, energy, economic growth and sustainable development; and

- The sustainable use of natural resources and environmental quality improvement.

- ***Goals***

- Atmosphere Monitoring and Data Production: To generate meteorological data with the help of capable human resources, network of meteorological stations and advanced equipment and to support the collection and storage of visual information;

- Processing and Production: To produce high accuracy, timely and valid output, such as forecasting and early warning systems of weather, climate, and other environmental parameters; and

- Participation in Decision Making in the Management of the Country and People's Daily Affairs: Recovery of data and products distribution systems of the Organization to be accessed easily by all users and to develop the culture of optimal use of their own affairs.

- IRIMO's Strategies

Strategy 1: Capacity Building

Capacity building includes internal and external parts and is organized as follows:

1-1 Specialized courses within the organization, including short and long-term training courses at home and abroad;

1-2 The education and making culture for key user groups, such as using various IRIMO products in crisis management, road traffic police, road maintenance, fishery, agriculture, shipping and public education. IRIB is one of the most comprehensive tools to educate people; and

1-3 Private sector support in developing the country's meteorological technical capacity and terminating the dependence on external support, and cooperation with and assistance to local companies to develop and enhance their technical knowledge of meteorology in the country.

- ***Strategy 2: Scientific Research and Technological Development***

Some items that can be done in this strategy are listed as follows:

2-1 Scientific research in the areas of

◦ Production of very short-term forecasts , one to six hours ahead;

◦ Production of long-term ,seasonal, yearly and decadal climate outlook;

◦ Prediction of thunderstorms formation and their movements;

◦ Quantitative assessment of provided predictions and outlooks;

◦ Improvement in performance of seasonal forecasts in different sectors of the country, such as transportation, energy, and agriculture;

◦ Development of atmospheric chemistry and prevention of air pollution and environment;

◦ Production and application of numerical weather and ocean-atmosphere interaction models to understand the behavior of the atmosphere, ocean and their interactions;

◦ Conducting climate studies and applying the results for adaptation to climate change;

◦ Automatic monitoring of atmospheric and related environmental factors; and

◦ Collaboration with universities and research centers in specialized fields (including agricultural meteorology, hydrology, etc.).

2-2 Technological development, including

◦ Development of surveillance systems to collect more accurate data in real time basis;

◦ Development of telecommunication networks for the faster, more reliable, more powerful and cheaper data and products of IRIMO at national, regional and global levels;

◦ Development of processing systems for faster, safer, and cheaper processing and implementation of numerical weather and climate models; and

◦ Development of information systems to perform faster, more reliable, more comprehensive and cheaper to serve a vast range of users.

- ***Strategy 3: Service***

◦ This strategy that can be implemented or improved includes the following items:

◦ Development of communication systems management software to take advantage of their full power;

◦ Development of systems for data collection, quality control and archiving data and products to integrate correct and reliable data in a center;

◦ Development of a database for easy referencing and access to required data and products;

◦ Establishing a direct and continuous communications system for the survey and a better understanding of the users' demands and increasing the ability and knowledge of the organization to meet these demands, especially for key users;

◦ Development of methods for a provision of information to influence users more and better; and

◦ Improve early warning systems in order to reduce the impact of climate and weather-related natural disasters.

- ***Strategy 4: Participation***

Providing scientific and technical advice in order to support decision-making of government officials in management of the country, especially in matters of sustainable development and the implementation of international agreements is one of the main strategies of the organization. Some of the items that can be adopted in this strategy are listed below:

◦ Introducing the capabilities related to those sectors of the country that need to work collaboratively;

◦ Maintaining a central and active role for the organization to guide joint projects;

◦ Increasing the ability of the organization to use partners capabilities in order to develop and improve its services and information; and

◦ Increasing joint activities among internal departments for creating a culture of teamwork and reducing the gap between them.

- ***Strategy 5: Efficacy and Effectiveness***

◦ This strategy can be pursued by implementing the followings:

◦ Increasing the efficiency and effectiveness of the administrative and technical departments through the formation of administrative and professional development working groups ;

◦ Paying attention to main assets i.e. specialized and committed human force and the need to have a long-term scientific program to retain and motivate them.

◦ Linking plans and budget allocations to strategic plans in order to control credits and optimize the costs of the organization; and

◦ Conducting comprehensive studies on the structure, programs, priorities and performance of the organization to provide a feedback on the related activities and ensure the efficiency of the administrative system reform road map.

5.2.2. Oceanographic Observations

5.2.2.1. Introduction

The vastness and complexity of Iranian marine environments, both in north and south, from fragile coastal systems across the extensive Exclusive Economic Zones (EEZ) to the high seas, poses considerable challenges for sustainable development. It requires large and crosscutting data sets and information along with specialized collection and monitoring systems. Several governmental organizations are responsible for collecting the data and monitoring the marine environment (Table 5.5).

Table (5.5): Major Iranian Organizations that Are Responsible for Collecting Data and Monitoring the Marine Environments

Organization	Major governmental Body	Main tasks	International Body
Islamic Republic of Iran Meteorological Organization (IRIMO)	Ministry of Roads and Urban Development	Monitoring and data production	World Meteorological Organization (WMO)
Iranian Ports and Maritime Organization (IPMO)	Ministry of Roads and Urban Development	Monitoring and data production	International Maritime Organization (IMO)
National Cartographic Center (NCC),	Presidency Office	Monitoring and data production	World Hydrographic Organization (WHO)
Iranian Fisheries Organization (IFO)	Ministry of Agriculture	Monitoring and data production	FAO
Department of Environment (DOE)	Presidency Office	Monitoring and data production	United Nations (UN)
Iranian National Institute for Oceanography and Atmospheric Science (INIOAS)	Ministry of Science, Research and Technology	Research and data management	Intergovernmental Oceanographic Organization (IOC)
National Geographic Organization (NGO)	Ministry of Defence	Monitoring and data production	WHO
Iranian Space Agency (ISA)	Presidency Office	Research and Data Production	-
Geological Survey of Iran (GSI)	Ministry of Industry, Mining and Trade	Mapping	UN
Ministry of Energy (MOE)	Ministry of Energy (MOE)	Monitoring and data production	UN

5.2.2.2. Current Status of the Oceanographic Data Collecting Network in Iran

According to table 5.6, different methods are implemented by marine organizations in I.R.Iran to collect oceanographic data.

Table (5.6): Different Oceanographic Data Collection Methods Used by Marine Organizations in I.R.Iran (for finding the abbreviations, please see table 5.5)

Organization	Space-based observing systems	Temporary and fixed marine stations	Organizing marine cruises
IRIMO	X	X	-
PMO	-	X	-
NCC	-	X	X
IFO	-	-	X
DOE	-	X*	X
INIOAS	X	X	X
NGO	X	-	X
ISA	X	-	-
GSI	-	-	X
MOE	-	X	X

** DOE has started to install some stations in the Persian Gulf for monitoring pollution.*

- ***Islamic Republic of Iran Meteorological Organization (IRIMO)***

IRIMO is a governmental organization which operates as a subset of the Ministry of Roads and Urban Development. The main obligations of IRIMO in marine observation are as follows:

- Providing meteorological data and weather forecasts to domestic and International shipping as well as transportation services; and

- Studying the atmospheric conditions and physical status of the sea for oil exploration, fishing, port operations and sea currents. (Table 5.7)

Table (5.7): Marine Weather Station Network for Iranian Coastlines Implemented by IRIMO

No.	Station Number	Station Name	Establishment Year	Marine Area
1	40875	Bushehr	1984	Persian Gulf
2	40872	Bandar Dayer	1993	Persian Gulf
3	40846	Bandar Deylam	2001	Persian Gulf
4	40898	Chabahr	1965	Oman Sea
5	40709	Astara	1985	Caspian Sea
6	40718	Bandar Anzali	1949	Caspian Sea
7	40737	Ramsar	1955	Caspian Sea
8	40734	Nowshahr	1986	Caspian Sea
9	40736	Babolsar	1948	Caspian Sea
10	40889	Siri Island	1983	Persian Gulf
11	40890	Abumusa Island	1983	Persian Gulf
12	40893	Jask	1982	Oman Sea
13	99675	Qeshm Island	2000	Strait of Hormuz
14	99688	Bandar Lengeh	1996	Persian Gulf
15	-	Kish Island	-	Persian Gulf
16	-	Khark Island	-	Persian Gulf
17	-	Mahshahr	-	Persian Gulf
18	-	Bandar Abbas	-	Strait of Hormuz
19	-	Lavan Island	-	Persian Gulf
20	-	Soleiman Oil Platform	-	Persian Gulf
21	-	Bandar Amirabad	-	Caspian Sea
22	-	Sari	-	Caspian Sea

IRIMO provides all kinds of data including the synoptic and climatological data to its clients through the internet as free and based on application.

- ***Ports and Maritime Organization (PMO)***

PMO is a governmental organization which operates as a subsidiary organization of the Ministry of Roads and Urban Development since 1974. Based on the ongoing projects at PMO, this organization collects data specifically needed for its projects in the limited area at specific time spans. The data is mostly collected in the fields of physical oceanography, meteorology, and sedimentology. In addition to the mentioned activities, PMO has four permanent buoys in the northern and southern marine bodies of Iran and is planning to implement a national buoy network for southern water bodies. Moreover, the PMO has installed several tide gauges in main ports of the southern water bodies.

PMO has conducted several projects at national level along the coastal area, including the "Integrated Coastal Zone Management (ICZM)" project and "monitoring and modeling the coastal processes of Iranian coastal waters". PMO officially is the responsible national body for the coastal area management and collects all the relevant data in this regard. The organization has conducted a national project for monitoring and modeling of Iranian sea waters in collaboration with private sector as well as universities and research institutes including INIOAS.

PMO has planned to conduct the first integrated marine observation system for Iran that includes different data collection methods such as space-based monitoring, buoys, weather stations and tide gauges as well as systematic underway data collection. At present, the organization has installed 11 wave recorder buoys in coastal waters in the framework of the projects and plans to deploy some deep buoys in different Iranian water bodies.

PMO has also launched a website (http://marinedata.pmo.ir) for presenting the latest data of the first integrated marine observation system for Iran. PMO has divided the data into public and limited access data and some data could be offered freely or upon compeleting application forms.

- ***National Cartographic Center (NCC)***

The parent organization of NCC is the Plan and Budget Organization which works directly under the supervision of presidency office. The Hydrography and Coastal Surveys Department of NCC are tasked with tide measurements and bathymetry data collection. This department organized more than ten permanent tide gauges in southern marine bodies and one tide gauge in the Caspian Sea and several temporary tide gauges in different water bodies of Iran.

They have prepared more than 20 nautical charts in the Capsian Sea, 40 nautical charts in the Persian Gulf and several nautical charts in the Oman Sea with different scales and working on more than 60 new nautical charts in different water bodies.

Tide predictions for more than 60 stations in southern water bodies are offered by NCC, available on the internet. Clients should register for getting any data from the website (http://iranhydrography.ncc.org.ir).

- ***Iranian Fisheries Organization (IFO)***

The IFO is working under the auspices of the Ministry of Agriculture. The data collected by the IFO is mainly related to the fisheries and aquacultural activities in the Iranian water bodies.

Periodically IFO organizes some research cruises in northern and southern Iranian water bodies and collects the hydrochemical, physical and biological data. The data as spreadsheets and American Standard Code for Information Interchange (ASCII) files as well as reports are available on the website of the IFO through the following address: http://www.fisheries.ir

- ***Department of Environment (DOE)***

DOE is affiliated with the Office of the President. The President chairs the Council and the Vice-president heads the DOE. Bureau of the Marine Environment as a specialized division of DOE is responsible for natural geographic characteristics, conservation of marine ecosystems in the Persian Gulf, the Oman Sea and the Caspian Sea. Five marine environmental monitoring stations in Hormoz Island (Strait of Hormoz), Chalous (Caspian Sea), Sari (Caspian Sea), Anzali (Caspian Sea) and Chabahar (Oman Sea) are also under the supervision of this bureau.

DOE, in collaboration with other environmental organizations of the Persian Gulf states and United Nations Environment Program (UNEP) have organized a regional organization (ROPME - Regional Organization for Protection of the Marine Environment) for the protection of the environment of the Persian Gulf, the Oman Sea and northern part of the Arabian Sea known as “ROPME Sea Area”. In this regard, ROPME has organized several multidisciplinary marine cruises especially in the Persian Gulf and the Oman Sea. Different oceanographic measurements including hydro-chemical, biological, physical and sedimentological data sets are collected by ROPME. The data are disseminated by means of hard copy of cruise reports and data discs. The data is available only through the chief scientists working on the cruises and at present there is not any database in this regards. (Figure 5.5)

In addition to the above-mentioned activities, the Bureau of the Marine Environment supports research projects financially and logistically related to monitoring the coral reefs, mangroves, and other marine sensitive areas. The bureau monitors the coral reefs of the Persian Gulf in collaboration with INIOAS in the framework of Global Coral Reef Monitoring Network (GCRMN) and ReefCheck programs.

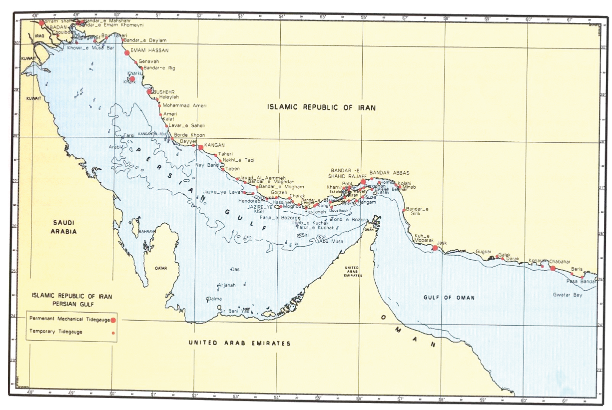


Figure (5.5): The Position and Types of the Tide Gauges of the NCC (Hydrography and Coastal Surveys Department) in the Southern Water Bodies of Iran

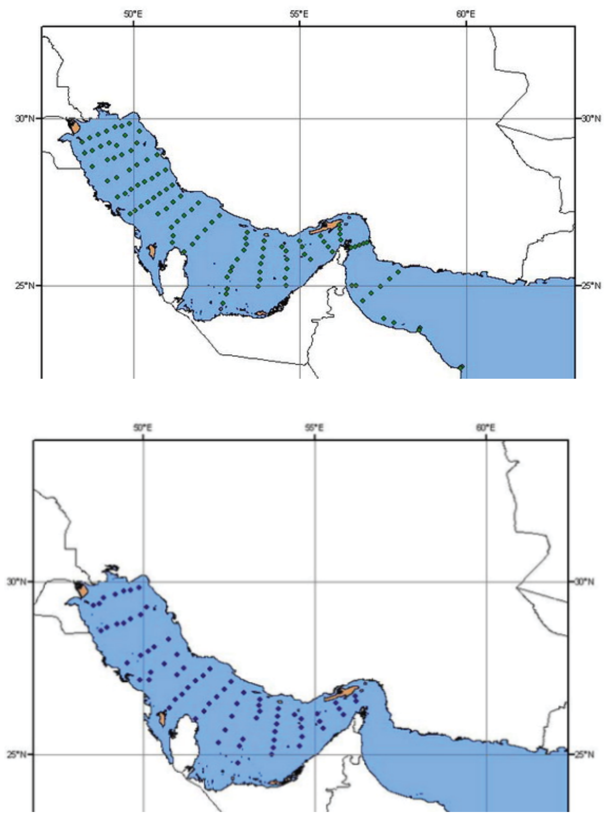


Figure (5.6-down): The Distribution of Measured Stations in the Persian Gulf and the Oman Sea during the 1996 ROPME Research Cruise. Figure (5.6 up) The Distribution of Measured Stations in the Persian Gulf during the 2001 ROPME Research Cruise

- ***Iranian National Institute for Oceanography and Atmospheric Science (INIOAS)***

The INIOAS is a research and educational institute established under the auspices of the Ministry of Science, Research and Technology in collaboration with the United Nations Educational, Scientific, and Cultural Organization (UNESCO) within the framework of an agreement between the ministry and UNESCO in 1992.

INIOAS aims to coordinate and promote research activities by marine organizations as well as those by academic, educational and research groups on a national scale. Moreover, INIOAS has four research centers in the vicinity of the northern and southern water bodies of Iran. In order to promote its research activities in different oceanographic deciplines including physical oceanography, marine biology, marine chemistry and marine geology, INIOAS has conducted several research projects in Iranian water territories in the north and south of Iran. The INIOAS has been recently equipped with a research cruise vessel, called "Persian Gulf Explorer".

The institute has launched several projects for systematic monitoring of the water bodies from an oceanographic point of view. The last research cruise was started in 2012 and ended in 2014 (The Persian Gulf and the Oman Sea

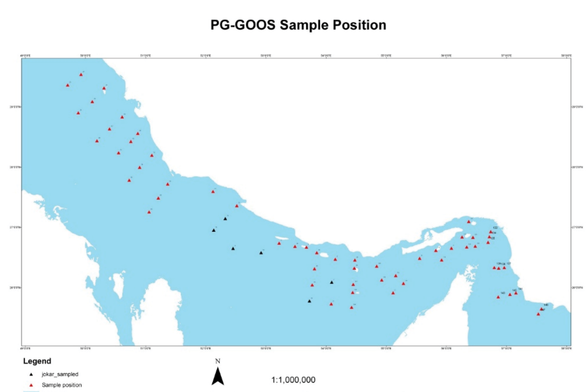


Figure (5.7):The Position of Stations in PG-GOOS Research Cruise (2012-2014)

Oceanographic Study/PG[1]-GOOS[2]). (Figure 5.7)

The INIOAS is one of the few institutes in Iran that works on paleoclimate of Iran. The INIOAS has launched several projects in collaboration with international research institutes to reveal the past climate of Iran during the last 11000 years using different records such as cave deposits, marine and lake deposits as well as peat bogs.

Currently, the INIOAS is involved in an eco-climatological project and plans to expand the project to different parts of the Iranian plateau.

The INIOAS is equipped with wide variety of weather and oceanography instruments such as AWS-2700, CTD[3], RBR[4] data loggers, ADCP[5], RCM9[6], WTR[7] and other oceanographic instruments.

- ***National Geographic Organization (NGO)***

The NGO was established under the auspices of the Ministry of Defence. Marine hydrology section of NGO is responsible for marine environment mapping and monitoring. At present, the marine hydrology section enjoys modern and adequate facilities, including modernized hydrographic footing beats equipped with single and multibeam echo sounders, sonar, satellite, GPS[8] and DGPS[9] systems, softwares and hardwares as well as vast experiences and scientific staff to fulfil its duties. They have successfully prepared large scale maps and charts of some harbors including Shahid Rajayi, Nowshahr, Anzali, Chabahar, Khark, and Hendorabi and working on several locations to prepare new large scale maps.

In addition to mapping the marine environments, the NGO established a ground receiving station to get and process satellite images. The center as multi–mission ground receiving station started its activities by using some satellites. In the near–future, in addition to receiving the mentioned satellite data, it will also be able to receive images of the other satellite orbiting the earth.

There are lots of applications for satellite images, including the study of natural disasters and marine environments. The marine research institutes in Iran, can access to the images based on official requests.

- ***Iranian Space Agency (ISA)***

ISA was established in 2004 under the auspices of the ministry of Information and

1 Persian Gulf & Gulf of Oman Oceanographic Study
2 Automatic Weather Station
3 Conductivity Temperature Depth
4 Radiation Belt Remediation
5 Acoustic Doppler Current Profiler
6 Recording Current Meter
7 Wave and Tide Recorder
8 Global Positioning System
9 Differential Global Positioning System

Communications Technology. The remote sensing group of ISA is responsible for taking different types of satellite images, processing and providing some facilities for researchers and also providing these images for research institutes.

- ***Geological Survey of Iran (GSI)***

GSI was established in 1962, through a special fund project of United Nations and operates on behalf of the Ministry of Industry, Mine, and Trade. The marine geology group is the only group of the GSI that works on the marine environment and regularly organizes some marine research cruises to map the sediment pattern of the sea floor and prepares the geochemical and hydrochemistry atlases of the Iranian water territories.

- ***Ministry of Energy (MOE)***

One of the main obligations of the MOE is the protection and sustainable use of water resources in coastal areas including the estuaries, wetlands and rivers. In this regard, the MOE established some measurement stations in the river mouths at coastal areas, launched a research boat in the Caspian Sea and implemented a buye in the Caspian Sea.

- ***Conclusion***

As a conclusion, the marine related organizations in Iran are individually involved with the oceanographic data collection based on their specific needs. The NCC is responsible for tide gauges. At present, several tide gauges under the supervision of NCC are operational in northern and southern water bodies of Iran, including 1 tide gauge in the Caspian Sea, 2 tide gauges in the Oman Sea and 7 tide gauges in the Strait of Hormuz and the Persian Gulf. The data from 4 tide gauges have been sent to the Global Sea Level Observing System (GLOSS) data center by NCC. In addition, the data is available on the NCC website.The IRIMO is responsible for 22 marine weather stations in the coastal areas of Iran. They have a close relationship with the WMO and National Climatic Data Center (NCDC) and the data is available through their website. IRIMO is not engaged in the Global Ocean Observing System (GOOS) program yet. INIOAS at present develops its facilities and plans to implement 3 deep water mooring buoys in the Oman Sea and the Caspian Sea until 2010. INIOAS works with Intergovernmental Oceanographic Commission (IOC) bodies including International Oceanographic Data and Information Exchange (IODE). Moreover, the INIOAS works closely with the Indian Ocean Global Ocean Observing System (IO-GOOS). The IRIMO and INIOAS are the main collaborators of National Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) in Iran. (Table 5.8)

*Table (5.8): Participation in the Global Oceanographic Observing Systems**

	VOS[1]	SOOP[2]	TIDE GAUGES *	SFC DRIFTERS	SUB-SFC FLOATS	MOORED BUOYS	ASAP
For how many platforms is the Party responsible?	-	-	10	-	-	-	-
How many are providing data to international data centers?	-	-	4	-	-	-	-
How many are expected to be operating in 2010?	-	-	13	-	-	3**	-

** The NCC is responsible for the 9 permanent tide gauges.*

*** It is planned to implement 3 deep water moorings in the Oman Sea and the Caspian Sea until the end of 2010 by INIOAS.*

Lack of an integrated oceanographic data collection program in Iran causes limitations and discontinuity in the collected oceanographic data. Accordingly, to fill the present gaps in the current oceanographic observing system, the Iranian National Center for Oceanography introduced an integrated program for collecting and management of oceanographic data as well as capacity building.

5.2.2.3. Establishment of National Oceanographic Data Center (NODC)

Due to the need for general data collection and information system in the I. R. of Iran, the establishment of a NODC in Iran was facilitated by the resolution of the 27th Session of UNESCO General Conference. In 1993, the draft resolution 153 was adopted and finally in 1995 the Iranian National Center for Ocean Data (INCOD) was established in the INIOAS and introduced as a node for the IODE in Iran.

INCOD is the only national oceanographic data center in the Persian Gulf and the Oman Sea region, tasked with collection, archiving, and quality control of oceanographic data, as well as its exchange with various international bodies and institutions. In line with this objective, the center has embarked on a program of collecting oceanographic data, metadata, and Cruise Summary Reports (CSR) from national and international organizations, which are posted on the INIOAS website on a regular basis. The physical, chemical, and biological data cover the Caspian Sea, the Persian Gulf and the Oman Sea. The hydrological data relate to the water bodies of watershed. The data also includes meteorological readings from the entire Iranian territory. All Oceanographic data are managed in a very sophisticated ocean data portal of Blue Persia that has been developed by the INCOD and is available at https://192.168.2.118/oceandata for a trial test.

5.2.2.4. Integrated Program for Developing the Iranian Marine Meta-data Directory

INCOD division of INIOAS is responsible for the creation and maintenance of the Iranian Oceanographical Metadata. The metadata can include characteristics about the data such as the content, accuracy, reliability and resource.

5.2.2.5. Capacity Building

To build the required capacity for oceanographic data collection and management in the country, INIOAS has performed two main programs as follows:

- Preparation of instruments for oceanographic data collection; and
- Hosting national and regional workshops and training courses.

- ***Preparation of Instruments for Oceanographic Data Collection***

To collect continuous oceanographic data from the Iranian marine bodies, since 2003, INIOAS has been equipped with the various data collecting equipment such as CTD, current meter, permanent and portable weather stations, etc. Moreover, INIOAS has been equipped with a research vessel in 2015 and is planning to build a national fleet of research vessels.

- ***Hosting National and Regional Workshops and Training Courses***

To raise the technical knowledge of the users and increase the ability to use and manage the oceanographic data in the country, Intergovernmental Oceanographic Commission (IOC) with the cooperation of IODE holds related workshops and training courses in the IODE parties in three different levels (primary, intermediate and advance). In this regard, INIOAS with the cooperation of IOC/IODE has held several workshops since 1995 and introduced Iranian begineers to IODE in order to participate in their workshops in their office in Oostend, Belgium.

5.2.2.6. Barriers to Data Exchange

As it was mentioned, different organizations in the country are involved in the collection of oceanographic data. However, the exchange and accessibility of data are very limited due to many problems. The main ones are as follows:

- Lack of any ocean data policy at national and international level for Iran;
- Rivalry between different organization for data collection and preservation;
- Lack of legislation on copyrights for the organization that collect and manage the data; and
- Lack of enough expertise in ocean data management.

5.2.2.7. Strategy for Data Exchange at National and International Level

Oceanographic data exchange through the IOC or IODE data centers is currently well known in many countries around the world as well as I.R. Iran. INIOAS, as an IODE focal point in the country, has some constrains for exchanging data at the international level. However, at national level, the oceanographic data exchange program can not be accomplished due to many barriers as mentioned above. To initiate an integrated data exchange program at national level and consequently at the international level, the first and the fundamental step is the establishment of a national ocean data policy. INIOAS suggested a national model for collecting and exchanging the oceanographic data based on a distributed model of data centers which will be coordinated by the INCOD. In this regard, INCOD aims to collect, manage and distribute the oceanographic data to the relevant users and needs to be supported by receiving data from all marine related organizations in the country. However, the rivalry of the marine organization is a major obstacle for this proposal. To manage the data exchange programs, it is necessary for legislative activities that need the support of parliament as well as decision makers in the government.

5.2.3. Hydrology, Hydrometeorology and Terrestrial Observations

5.2.3.1. Hydrology and Hydrometeorology Observations

Different types of existing measurement and monitoring stations of the MOE are as follows:

A) Supplementary Stations: This group includes the stations which are established due to areal covering or feature writing (topographical) of different regions. Their short-term data extend to long-term data using correlation with reference stations when necessary;

B) Reference Stations: These stations have been established to evaluate atmospheric precipitations in the country. These stations' data are listed in monthly reports which are published jointly with IRIMO (Islamic republic of Iran meteorological organization). Currently, of 104 base stations, 42 stations are related to the IRIMO and others to the Ministry of Energy. Intended "optimized reference network of the MOE includes 102 synoptic stations of meteorological organization and 94 evaporation gauges and rain gauges of the Ministry of Energy.

C) Rain Gauge Stations Classification due to Their Equipment: Rain gauge stations can be divided into three categories in terms of their equipment:

- Standard Rain Gauges which are normally visited and measured twice a day by the station's observer;
- Recording Rain Gauges which measure durability, intensity, and distribution of rainfall. Considering these data enables researchers and engineers to specify rainfall intensity in the effectiveness area of stations and specify time distribution of precipitation by expanding results of adjacent standard rain gauges. Note that the minimum number of recording rain gauges in Publication No. 148 of World Meteorological Organization is recommended 10% in a warm climate and 5% in cold climate. In the local distribution of these rain gauges efforts have been made to locate them in evaporation gauge stations if possible, having regard to uniform geographical expansion in basin areas; and
- Reserve Rain Gauge is used in the measurement of seasonal atmospheric precipitation in areas where there is not the possibility of continuous monitoring. Currently, there are 855 units in the country.

5.2.3.2. Status of Agricultural Terrestrial Observations Network

- ***Agricultural Soils***

The Soil and Water Research Institute is responsible for conducting surveys and investigation on agricultural soils through field measurements. The main objectives of carrying out soil surveys are as follows:

- To assess the irrigation needs for different types of soils;

- To identify contributing factors on soil erosion;

- To identify the drainage requirements of different types of soils;

- To identify crops suitability to be cultivated in different types of soils; and

- To investigate the fields for identifying physical and chemical characteristics of soils.

The physical characteristics of soil measured in the field includes effective soil depth, water infiltration rate, field capacity, bulk density, hydraulic conductivity, relative humidity, soil texture and structure. The chemical characteristics of soils include PH, salinity, alkalinity, SO4++, Cl-, CO3--, saturation percentage, exchangeable sodium, Ca++, Mg++, Na+, and toxic elements.

- ***Agricultural Meteorology***

Ministry of Agricultural Jihad and IRIMO are responsible for measurement of agrometeorological factors. There are 63 agricultural meteorological stations in Iran, out of which 36 stations are under Ministry of Agricultural Jihad and 27 stations are under IRIMO. The Agricultural Metrological Bureau, affiliated to the IRIMO, is responsible for establishing, managing and monitoring the agricultural meteorological stations and observing different fields and horticultural phonological processes and biomass measurements. The Bureau has a long-standing cooperation with the Ministry of Agricultural Jihad and the other related organizations and universities in providing raw and processed data.

There is a regular flow of data from the agricultural meteorological research stations to the Agricultural Meteorological Bureau, where they are processed, saved in digital formats and can be accessed by different users. It should to be mentioned that out of 27 meteorological stations under Ministry of Agricultural Jihad, 16 stations are based on agricultural research stations in different provinces and the rest of 11 stations are controlled and managed by Forest, Range and Watershed Management Organization (FRWO). These stations have been established at higher elevations to record the following climate parameters including rainfall, snowfall, evaporation, air pressure, wind direction, wind speed, snow depth, snow density and air temperature.

- ***Different Types of Data and Information Which Are Measured and Disseminated by the Agrometeorological Stations.***

- Weekly Agrometeorological Information: The agrometeorological data such as plant phenology and weekly thermal units are collected and transferred to the Meteorological Offices. As a general procedure, each agrometeorological research station in every crop year compiles weekly information, composed of 52 sheets;

- Ten Days Period Data: These data include weekly agrometeorological data and 10 days information on soil temperature at different depths. The collected information in meteorological stations is transferred to the meteorological offices for analysis. The information includes 36 sheets of 10 days records. The processed data are finally sent to the IRIMO to be stored in the database and are accessible by users;

- Monthly Crop Bulletin: The findings of biometric measurements and phonological observations from all stations and for a different type of crops are analyzed and compiled as monthly bulletins. This information is available at the agrometeorological offices and is accessible for users; and

- In addition, there are 11 meteorological stations under the FRWO of the Ministry of Agricultural Jihad. These stations have been established at higher elevations for recording climatology parameters including rainfall, snowfall, evaporation, air pressure, wind direction, wind speed, snow depth, snow density, air temperature, soil temperature at depth of 5, 20 and 50 centimeters and radiation. These stations have been established in the provinces of Golestan, Khorasan Razavi, Sistan and Baluchestan, Azerbaijan Sharghi, Kordestan, Hamedan, Tehran, Fars, Hormozgan, Khuzestan, and Mazandaran.

5.3. Research and Education

5.3.1. Introduction

Education is an essential element of the global response to climate change. It helps all people understand and address the impact of climate change, encourages changes in their vision and helps them adapt to climate change-related threats. On the other hand, based on Articles 5 and 6 of the United Nations Convention on Climate Change (UNFCCC, 1992), countries should facilitate climate change research and education at regional and national levels through the following items:

- Support and further develop, as appropriate, international and intergovernmental programs and networks or organizations aimed at defining, conducting, assessing and financing research, data collection and systematic observation, taking into account the need to minimize the duplication of effort; and
- Promote and facilitate at the national and, as appropriate, sub-regional and regional levels, and in accordance with national laws and regulations, and within their respective capacities, the development and implementation of educational and public awareness programs on climate change and its effects.

In addition, Article 12 of the Paris Agreement explicitly declares that "Parties shall cooperate in taking measures, as appropriate, to enhance climate change education, training, public awareness, public participation and public access to information, recognizing the importance of these steps with respect to enhancing actions under this Agreement".

SNC report to the UNFCCC, published in 2010, research and education activities in three fields of climate change (The physical science basis of climate change, vulnerability, and adaptation to climate change and GHG mitigations) were collected. Accordingly, the number of books, theses, projects, and journal papers related to climate change in the following ministries, universities, and institutions, were collected and reviewed:

Ministries: Ministry of Science, Research and Technology, Ministry of Agricultural Jihad, Ministry of Energy, Ministry of Oil, Ministry of Mines and Industries, Ministry of Roads and Transportation, Ministry of Communication and Information Technology.

Universities: Universities in Tehran such as the University of Tehran, Sharif University of Technology, Amirkabir University, Iran University of Science and Technology, Khajeh Nasir University, Shahid Beheshti University, Tarbiat Modarres University, and Azad university. Universities in other provinces such as Esfahan, Shiraz, Mashhad, Gorgan, Mazandaran, Tabriz, Zahedan, Kerman and Shahrekord.

Institutions: The NCCO in the Environmental

Research Center of the Department of the Environment, Water Resources Research Center at Ministry of Energy, Sharif Energy Research Institute, Institute of Geophysics of University of Tehran, the Institute for Scientific and Applied Environmental Research of the Department of the Environment in Karaj, Environmental research Institute and the Energy Research Center of Amirkabir University of Technology, Meteorology and Atmosphere Science Research Center affiliated to IRIMO, Desert Research Center and International Research Center for Desert Coexistence of University of Tehran at Yazd, Center for energy and Environment Research Studies of Azad University, Science and Research Branch and Institute for International Energy studies of the Ministry of Oil.

Results showed that 1140 journal papers, 600 books, 200 theses, and 1100 projects were conducted in Iran until 2007. The results also showed that 642 courses in three undergraduate and postgraduate programs are taught in various technical disciplines such as engineering, agriculture, and natural sciences. However, there is no specific educational program that covers all three fields of climate change (e.g. the physical science basis of climate change, the vulnerability and adaptation to climate change, and mitigation of GHGs). So the syllabuses of table 5.9 were proposed to add to the relevant graduate and postgraduate courses at universities.

Table (5.9): Proposed Climate Change Syllabus in SNC

Item	Topic	Sub-topics
1	The greenhouse effect and theory of human-induced planetary warming	- The greenhouse effect and planetary temperature - Blackbody radiation; terrestrial and solar radiation - Energy balance model and the natural greenhouse effect
2	The history of earth's climate	- A brief history of planet earth - Paleoclimate - Ice ages and role of the orbit and carbon dioxide
3	Climate trends during the 20th century	- The 20th century record of climate: global, regional, local
4	Climate variability and climate change	- Natural variability: El Nino, etc. - Naturally induced changes: solar and volcanoes - Human induced changes: GHGs and aerosols
5	Climate trends during the 20th century: Human or Natural?	- Climate models - Climate sensitivity and feedback - Attribution: climate of the 20th century and the human impact
6	Projections of the future climate	- Emission scenarios: human factor impact: GHGs and aerosols - Climate of 2100: global impacts - Climate of 2010: regional impacts (by continent) - Uncertainty in the projections (emissions and climate models)
7	Impacts of climate change	- Climate change and world food security: global issues - Climate change and world food security: case study - Climate change and marine ecology; global and case study - Climate change and terrestrial ecology; global and case study - Health and climate change - Climate change and water resources
8	Economy and climate change	- Socio-economic impact of climate change - Climate change and economic diversification - Integration of climate change in development plan
9	Energy, technology and climate change	- Mitigation and adaptation technology - Climate friendly energy technology - Environmental energy planning and policy assessment
10	Climate regimes	- Environmental law - International law - Climate regime and the Kyoto Protocol

In the Third National Communication (TNC) report of Iran to the UNFCCC (present report), it was necessary to firstly update the number of climate change research and educational activities of the country, and secondly, to propose a climate change course program that covers all three fields of climate change.

5.3.2. Results

In this report, in order to update the climate change research and educational activities of the country, more ministries, organizations, and universities than the second report were surveyed up to 2015. It was found that from 2008 to 2015 the number of journal papers related to climate change has increased by 86, projects by 48, theses by 140 and the published books by 23 compared to pre-2008 activities.

The findings also showed that most studies have focused on evaluating the impact of climate change and mitigation options. In other words, the fields of climate change adaptation strategies and scientific knowledge of climate change have been less considered in the researches. So, two approaches were considered. The first approach is to strengthen the educational courses at postgraduate degree with the launch of climate change in any of the fields related to climate change. Accordingly, a climate change-water resources course for the postgraduate degree was proposed which its main syllabuses are presented in table 5.10.

Table (5.10): Main Syllabuses of Climate Change-Water Resources Course

No.	Syllabus
1	The Physical Science Basis of Climate Change
2	Numerical Weather Prediction
3	Climate Change Projection
4	Hydrometeorology
5	Climate Change Impact Assessment Methodologies
6	Water Resources Management under Climate Change
7	Methods and Tools to Evaluate Adaptation to Climate Change
8	Air Pollution
9	Climate Regime

In the second approach, we tried to propose some climate change research and educational strategies for relevant ministries and institutions in Iran. These strategies were evaluated in a number of meetings with more than 50 experts from universities, industries, and NGOs. These strategies were proposed in four disciplines; mitigation of climate change, water resources management, agriculture and food security, and the environment. Table 5.11 shows some strategies of these fields.

Table (5.11): An Example of a National Strategy on Climate Change Research and Education

Section	Strategy
Mitigation of Climate Change	Development of climate change education and research activities and promotion of new infrastructures and tools for mitigating GHGs
Water Resources Management	Developing water diplomacy and regional cooperation (development, research, and education)
Agriculture and Food Security	Review and development of technical, educational and research programs aimed at improving adaptability to climate change in agriculture
Environment	Development of research activities, promoting cultural, educational and training human resources

5.4 The Economic Effects of Emission Reduction Contributions (ERC) and Economic Diversification

5.4.1. Introduction

The traditional paradigm of development is focused on the design of economic growth-based development programs in order to achieve significant economic growth without considering adequately the environmental costs. Today, increasing demands for natural resources and their serious limitation on the one hand, and the depletion and reducing the quality of primitive environmental resources on the other hand, has shifted the development orientations from growth-based to sustainable development approaches. In this new development paradigm, the economic, social and environmental indicators are the main values in planning the development scenarios.

According to the Human Development Index in 2011, CO^2 emission in the world (per capita) is equal to 6.4 metric tons, and emission growth rate over the period 1990-2007 is 36 percent. While the CO^2 emission per capita for Iran is 7 metric tons, CO^2 emission growth in Iran has grown more than twice (World Bank, 2011). These statistics clearly describe the adverse level of emissions and inappropriate environmental conditions as one of the obstacles to achieve sustainable development in Iran. Submitted Iran-Intended Nationally Determined Contribution (INDC) presented GHGs emission reduction by 4 percent (unconditional GHGs reduction relying on nationally available resources and capacities), and totally up to 12 percent (including an 8 percent conditional GHGs reduction if current unfair sanctions are totally terminated and foreign and international support in facilitating Iran's access to finance and environmentally sound technologies are met). Pledging GHGs emission reduction normally requires a revision in the economic growth and development strategies and policies that might impose additional costs on the various sectors of national economy due to GHGs reduction. In this regard, there are several fundamental questions for policy-makers and planners:

- How much is the economic cost and what are the social and political impacts of the country's emission reduction programs?
- Which economic sectors have a greater potential to reduce GHG emissions with the least cost or losses?
- To which extent foreign and international support in particular finance and technology and partnership would be available and accessible for Iran to minimize these costs and losses in a facilitative manner?
- Will such support match Iran's specific needs and requirements to reduce its GHG emissions ambitiously as advised in Iran's INDC submitted to the UNFCCC in November 2015?
- What optimal combination of economic activities at the macro level can simultaneously meet the goals of economic efficiency (maximizing the value of production) and environmental sustainability (minimization of GHGs emission.

5.4.2. Methodology

The main objective related to this section of the national communication is to develop an extended input-output model and integrate it in a mathematical programming model to assess the damages caused by ERC on macroeconomics of the country and to determine the optimal combination of the structure of economic activities based on the economic efficiency principles and environmental sustainability. To achieve these objectives, the integrated model of Environmentally Extended Input-Output and linear mathematical programming was used. Analyses have been based on input-output and in various studies for investigation of environmental issues; analyses have been performed by integrating eenergy components and GHG emissions. (Lenzen,2001; Zhao et al, 2009; Wang et al, 2009; Yung-Jaan, 2016; Feng et al, 2011; Bekchanov et al, 2012; Okadera et al, 2015).

To achieve the desired results, integrated model of input-output and mathematical programming was used to estimate the economic effects of GHGs emission reduction goals on the economy and various production sectors. Considering the Iran INDC, the GHGs emission reduction goals have been examined under two policy scenarios.

- Reduction of GHGs emissions by 4% (Unconditional)

- Reduction of GHGs emissions up to 12% (Conditional)

Economic losses resulting from ERC estimated in each sector based on the hypothesis that achieving these goals is attainable through imposing restrictions on the capacity of production sectors. For this purpose, an input-output model is formulated as a mathematical programming for maximizing the value of economic sectors production. Due to the necessity of integrating the economic concerns with ecological criteria in national development plans, a multi-objective planning model was developed, so that it can provide the optimal combination of economic production activities that simultaneously takes into account different objectives of policy-makers, which in turn "might be in conflict" with each other in economic planning. In this model, three objectives are intended as follows in order of priority:

- Achieving maximum gross production value (S1),
- Minimization of GHGs emission (S2),
- Minimization of water consumption (S3),

5.4.3. Results

The results of GHGs emission inventory show that the intensity of the GHGs emissions in the whole economy of Iran is about 0.089 million tons of CO2 per one thousand billion Rials of production. This figure in the agricultural sector is about 0.059and in extraction of crude oil, natural gas and other minerals has been calculated about 0.134. Moreover, in producing food and beverage products is about 0.065, and for textiles and wood and paper products are about 0.032 and 0.028 million tons of CO2 per one thousand billion Rials of production, respectively. The most energy intensity among various economic activities is related to the transport sector, so that in this sector per one thousand billion Rials of production value, about 0.466 million tons of CO2 is emitted directly.

Results of adjusted multipliers and economic losses caused by restrictions on the level of production (reduction of thousands tons of carbon dioxide) for 14 collective activities are displayed in table 5.13. Adjusted multipliers obtained 1.725 for the agricultural sector indicates that if the restrictions imposed on the production capacity of this sector increase by one million Rials, the losses caused will be 1.725 million Rials in the whole economy.

Table (5.12): Estimated Damage Caused by the Reduction of One Unit (tons) Emissions in Each Economic Sector

No.	Activity	g_j	$\ddot{X}_j$	$L_{j, modified}$	Damage
1	Agriculture, animal husbandry, forestry and fishing	0.059	16.95	1.725	29.237
2	Extraction of crude petroleum, natural gas and other mines	0.134	7.46	1.050	7.836
3	Food products, beverages / tobacco	0.065	15.38	2.284	35.138
4	Manufacture of textiles, clothing, leather and leather products	0.032	31.25	1.812	56.625
5	Manufacture of wood and paper, wood and paper products	0.028	35.71	1.437	51.321
6	Petroleum production and oil refining	0.009	11.1	1.092	121.333
7	Production of chemicals, plastics and other non-metallic mineral	0.169	5.92	1.663	9.840
8	Manufacturing of basic metals and metal products	0.106	9.43	1.669	15.745
9	Machinery, communications equipment, transport equipment production and other manufactures	0.008	125	2.300	162.500
10	Generation, transmission and distribution of electricity and gas	0.017	58.82	2.076	122.117
11	Buildings (private and public)	0.042	23.81	1.898	45.190
12	Trade, hotels and restaurants	0.042	23.81	1.357	32.309
13	Transportation	0.466	2.14	1.666	3.575
14	other services	0.042	23.8	1.284	30.571

Is direct diffusion coefficient of (i) sector (million tones / thousand billion), is the necessary reduction in production value (billion) of (i) sector in return of one unit reduction (tons) of direct emissions in that sector, Lj, modified is the adjusted multiplier of production of (i) sector, is the amount related to damage caused by the decline of the publishing unit of (i) sector on the entire economy.

in table 5.12 shows the amount of reduction which is necessary in production value (billion) of each sector to reduce a thousand tons of GHGs emissions happening in those sectors. For example, 16.95 for the agricultural sector shows that if one thousand metric tons of GHGs reduction in agriculture sector is set as the goal, the production value of this sector would reduce by 16.95 billion Rials. The amount of production reduction in the agriculture sector, through its adjusted increasing multiplier (1.725), will impose a loss of about 29.237 billion Rials to the whole economy.

The amount corresponding to this loss for the extraction of crude oil, natural gas and other minerals sector is around 7.836 billion per thousand tons of GHGs reduction. This value for the food and beverage sector, wood and paper and wood products, clothing and textiles, and finally petroleum and oil refining are equal to 35.138, 56.625, 51.321, and 121.333 billion Rials, respectively. The least economic damage caused by one thousand tons of CO^2 emission reduction, with 3.575 billion Rials is related to the transport sector and to the contrary, the largest value with 122.117 billion Rials is related to transmission and distribution of electricity, and gas.

The results of multi-objective optimization models show that achieving a particular goal in development planning requires a trade-off with other goals. For example, the cost of pursuing the policy of reducing GHGs emission might be the loss of a part of the production value. The policy should be a combination of different purposes and consequences of a choice to make. On this basis, the policy-maker must choose a combination of different goals and consequences caused by it.

Table (5.13): Summary Results of Multi-purpose Programming Patterns

Patterns	The total value of production (1000 billion Rials)	The total amount of carbon dioxide emissions (tons)
One purpose (maximizing the value of production)	2503.9	222575.3
Two purpose (maximizing the value of production + minimization GHG emissions)	2460.3	213669.3
change percentage of pattern 2 to pattern 1	-1.74	-4

Based on the results presented in table 4.26, if choosing the combination of the economic structure is only based on the maximization of the production value (basic conditions), the entire economy with available resources can create production value of 2503.9 trillion Rials annually. The result of such production is depletion of 222575.3 tons of CO^2 in the atmosphere on an annual basis. In this case, if the second economic structure is implemented, the production value, carbon dioxide emissions would be decreased 1.74% and 4% compared with the first model.

National Strategies and Action Plan on Climate Change

Chapter 6

6.1. Structure of the Report

Third National Action Plan differs from the previous ones. The differences are as follows:

- Its content is considered in a 15-year period, the period of three National Five year Development Plans, while the emphasis is on the first plan which will commence from early 2017;
- Action Plan reports has a structure with two phases. The first one consists of the policies which some of them are specific and many are general; both with specific responsibilities of relevant Governmental Organizations (GOs). This is similar to previous report;
- The first phase of the Action Plan will be approved in the cabinet. According to the cabinet approval, all GOs are bound to prepare the detailed information of the second phase; (Table 6.1)

Table (6.1): First Phase

1st phase								
General policy	Strategy	Executive policies (aims and manner)					Mitigation/ Adaptation priority (1,2,3)	Responsible Ministry/ Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		

- Second phase of the Action Plan includes the following steps:

  - In this phase, GOs should communicate with industrial units, provincial offices, affiliated organizations, relevant private businesses, etc. to come up with specific actions which can indicate, for instance, how much emission can be reduced in a specific power plant.

  - Relevant GOs are expected to specify spatial and temporal specifications, and size of the actions. Annual plan and budget of GOs should reflect the action;

  - This phase facilitates participation of the main stakeholders, those who are more important than GOs' representatives;

  - Policy making becomes closer to reality(relationship of policy making and executive bodies);

  - In this regard, Monitoring and Evaluation (M&E) process can be participatory which leads to a more efficient and effective system;

  - Required capacities should be more transparent so as commitments can be implemented; and

  - Goals are much more likely to realize.

Table (6.2): Second Phase

2nd phase										
Has it been integrated in the sector?		Characteristics of required activity				Required Capacities			Indicators	
Plan	Annual budget	Project	Province/ County	Budget (amount and source)	Duration	Individual	Group/ organization	System	Implementation	Goal

- The decision on how the result of the second phase should be managed and supervised will be finalized in the bylaw which will be approved by the cabinet;
- M&E system which is proposed here will be finalized in the second phase through participation of GOs and main stakeholders; and
- Emission reduction actions in this report include all the ones which are in Farsi version. To shorten this section, it encompasses more than half of adaptation

actions that are in Farsi version.

6.2. Guiding Principles

Policies of the report are based on the findings of "IPCC CLIMATE CHANGE 2014, Synthesis Report". The findings can also be used as guiding principles. In phase one, many of the actions follow the recommended principles. However, these principles should be considered in a detailed framework in phase two of the Action Plan.

- ***Certainty of Climate Change Impacts and Risks Incidence***

  - "It is virtually certain that there will be more frequent hot and fewer cold temperature extremes on daily and seasonal timescales."

  - Climate change will amplify existing risks and create new risks for natural and human systems. Risks are unevenly distributed and are generally greater for deprived people and communities in countries at all levels of development.

  - New risks for human and nature can be generated as a result of intensifying climate change.

- ***Effective Factors on Greenhouse Gas (GHG) Emission***

  - Socioeconomic factors, such as "population size, economic activity, lifestyle, energy use, land use patterns, technology and climate policy" are predominant causes of GHG emissions;

  - Vulnerability to climate change, GHG emissions and the capacity for adaptation and mitigation are strongly influenced by livelihoods, lifestyles, behavior and culture; and

  - Deprived people are more exposed to the impacts of climate change.

  - Availability and accessibility of foreign and international support in particular finance and new and environmentally sound technologies as well as capacity building supports to Iran shall play a critical role in execution of the actions and achieving the objectives identified in Iran's Intended National Determined Contribution (INDC). Any failure in this respect or renewal of unfair sanctions shall considerably impact enforcement of the conditional actions proposed in its INDC.

- ***Risk Reduction***

  - Prevention of growing likelihood of severe, pervasive and irreversible impacts on people and ecosystems, requires "substantial and sustained reductions in GHG emissions which, together with adaptation, can limit climate change risks" ;

  - Interactions between climate change threats and vulnerability and exposure of human and nature together with their adaptability, generate climate change impacts risk. Therefore, increase of adaptability can reduce the risk;

  - Adoption of a longer term perspective in the context of sustainable development increases the likelihood that more immediate adaptation actions will also enhance future options and preparedness;

  - Adaptation part is comprehensively

considered and context-specific;

- There are many opportunities to link mitigation, adaptation and the pursuit of other societal objectives through integrated responses. Successful implementation relies on relevant tools, suitable governance structures and enhanced capacity to respond;

- Integration of adaptation into planning, including policy design, and decision-making can promote synergies with development and disaster risk reduction;

- Local and traditional knowledge systems and practices, including local community holistic view of community and environment, are valuable resources for adapting to climate change;

- Significant co-benefits, synergies and trade-offs exist between mitigation and adaptation and among different adaptation responses; interactions occur both within and across regions;

- For many regions and sectors, enhanced capacities to mitigate and adapt are part of the foundation which are essential for managing climate change risks;

- Adaptation and mitigation responses are enabling factors which include effective institutions and governance, innovation and investments in environmentally sound technologies and infrastructure, sustainable livelihoods and behavioral and lifestyle choices;

- Improving institutions as well as coordination and cooperation in governance can help overcome regional constraints associated with mitigation, adaptation and disaster risk reduction;

- Adaptation options exist in all sectors and regions, with diverse potential and approaches depending on their context in vulnerability reduction, disaster risk management or proactive adaptation planning;

- Efficient and effective strategies and actions consider the potential for co-benefits and opportunities within wider strategic goals and development plans;

- Behavior, lifestyle and culture have a considerable influence on energy use and associated emissions, with high mitigation potential in some sectors, in particular when complementing technological and structural change; and

- Social acceptability and/or effectiveness of climate policies are influenced by the extent to which they incentivize or depend on regionally appropriate changes in lifestyles or behaviors.

- ***Policy***

- In principle, mechanisms that set a carbon price, including cap and trade systems and carbon taxes, can achieve mitigation in a cost-effective way;

- Regulatory approaches (energy efficiency standards, etc.) and information measures (labeling programs, etc.) are widely used and are often environmentally effective;

- Sector-specific mitigation policies have been more widely used than economy-wide policies;

- Economic instruments in the form of subsidies can be applied across sectors, and include a variety of policy designs, such as tax rebates or exemptions, grants, loans and credit lines;

- An increasing number and variety of Renewable Energy (RE) policies, including subsidies—motivated by many factors—have driven escalated growth of RE technologies in recent years;

- Technology policy (development, diffusion and transfer) complements other mitigation policies across all scales, from international to sub-national. Many adaptation efforts also critically rely on diffusion and transfer of technologies and management practices;

- Strategies and actions can be pursued now which will move towards climate-resilient pathways for sustainable development, while at the same time will help to improve livelihoods, social and economic well-being and effective environmental management; and

- Aligning climate policy with sustainable development requires attention to both adaptation and mitigation.

- ***Governance***

- Local governments and the private sector are increasingly recognized as critical components in adaptation progress;

- Adaptation planning and implementation can be enhanced through complementary actions across all levels, from individuals to governments;

- National governments can coordinate adaptation efforts of local and sub-national governments, for example by protecting vulnerable groups, supporting economic diversification and providing information, policy and legal frameworks and financial support;

- National and provincial governments, private sector, and civil society (communities, households and individuals) should participate in both mitigation and adaptation planning and implementation. However, national government plays key role, especially in commencement of the activities and cooperation;

- Institutional dimensions of adaptation governance, including the integration of adaptation into planning and decision making, play a key role in promoting the transition from planning to implementation of adaptation; and

- Successful implementation depends on relevant tools, suitable governance structures and enhanced capacity to respond.

- ***Technology***

- Innovation and investments in environmentally sound infrastructure and technologies can reduce GHG emissions and enhance resilience to climate change.

- ***Limitations and Weaknesse***

- Common constraints on implementation of adaptation are due to the following:

◦ Limited financial and human resources;

◦ Limited integration or coordination of governance;

Uncertainties about projected impacts;

◦ Different perceptions of risks;

◦ Absence of key adaptation leaders and advocates;

◦ Limited tools to monitor adaptation effectiveness; and

◦ Insufficient research, monitoring, and observation and the finance to maintain them.

- Poor planning or implementation, overemphasizing short-term outcomes or failing to sufficiently anticipate consequences can result in maladaptation, increasing the vulnerability or exposure of the target group in the future or the vulnerability of other people, places or sectors; and

- Underestimating the complexity of adaptation as a social process can create unrealistic expectations about achieving intended adaptation outcomes.

- ***Capacity Development***
  - Capacity development for both mitigation and adaptation at three levels: individuals, groups and organizations, and system/ institutions are of great importance.

- ***International Cooperation***
  - International and regional cooperation can support planning and implementation of adaptation at national and sub-national scales.

- ***Risk Increase***
  - Opportunities to take advantage of positive synergies between adaptation and mitigation may decrease over time, particularly if limits to adaptation are exceeded; and
  - During the time, if adaptation limitations increase overly, opportunities to use synergy between adaptation and emission reduction would diminish.

- ***Enabling Environment***

Many aspects of systemic capacity have been considered in Action Plan. However, considerable number of actions, especially emission ones, are very dependent on macroeconomic situation and international cooperation.

Few years of economic instability and unfair sanctions have delayed mitigation and adaptation measures. Renovation of industries with high emission, environment rehabilitation and conservation require national budget which has decreased due to sanctions on oil sector and exports. This situation even has prevented civil technologies transfer to Iran which has constrained mitigation measures and actions. In this regard, if sanctions are lifted in practice, situation could improve for realization of the emission reduction and sectoral adaptation to climate change. Therefore, I.R. Iran's obligation to reduce emission by 4% can easily be met and larger reduction, up to 12%, also may be realized.

As far as establishment of low carbon economy pertains to reduction of emission and less fossil fuel consumption, it can be accepted as a strategy. However, if it concerns economic structural change, different studies would be required to find out how Iran can move towards economic paradigm. Therefore, absence of these subjects in the Action Plan does not mean, they are neglected.

6.3. Hierarchy of Policies

In formulation of the vision, climate change governance has a special status. Successful and unsuccessful experiences indicate its importance. In this respect:

Iran's policy hierarchy is as following:

- ***Goals:*** Are the purposes which through their realization, vision of the strategy and Action Plan, will be achieved.
- ***Strategies:*** Combination of congruent executive policies, which their implementation will support realization of the relevant goal.
- ***Executive Policy:*** Consists of four parts: an aim, modification of existing laws and regulation; introducing new laws, controlling measures, and preventive measures. The reason for such a categorization is to specify actions. This procedure makes stakeholders to be as clear as possible. Implementation of a set of executive policies can realize relevant strategy.

All tables follow this hierarchy.

6.4. Emission

6.4.1. Emission Reduction

Regardless of climate change impacts, from the economic point of view, renovation of considerable portion of industries, power plants and refineries are important in Iran. It has been a significant issue by itself without considering the importance of climate change.

Emission reduction goals are:

- Mainstreaming the reduction of emission and carbon footprint in socioeconomic development plans;
- Promoting international and regional cooperation; and
- Promoting climate change knowledge.

To realize the above goals, the following strategies have been proposed by related GOs:

1.1 Increasing the energy efficiency;

1.2 Increasing energy efficiency and developing the renewable energies through pricing, incentive and punishment policies;

1.3 Establishing market mechanisms through economic tools and incentives;

a. Maximizing utilization of international resources; and

3.1 Knowledge development on climate change.

For each strategy there are number of executive policies/actions. Table 6.3 shows goals, strategies and the Action Plan of emission reduction.

Table (6.3): Emission Reduction Strategies and Action Plan

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
1) Mainstreaming the reduction of emission and carbon footprint in socioeconomic development plans	1.1 Increasing energy efficiency	Efficiency increase of power plants from 37% to 42%			Through conversion of simple cycle power plants to combined cycle ones; Rehabilitate old steam power plants;	Construction of new power plants with high efficiency	1	Ministry of Energy (MOE)
		Decrease of electricity transmission and distribution loss from 18% to 14%			*		1	MOE
		Promotion of small electricity generators combined with CHP[1], CCHP[2] units by 3200 MW			Private sector 2700 MW Governmental sector 500 MW		1	MOE
		Collect at least 70% of accompanied gas with oil (flares)			*		1	Ministry of Petroleum (MOP)
		Reduction of gas pipelines loss from1.5 to 0.5%			*		1/2	MOP
		Formulation and implementation of energy intensity decrease program by 33%				Production of high energy efficient homes and industrial appliances (1.5 million Grade A refrigerator, 2million Grade C heater and other products.	1	Ministry of Industry, Mine, and Trade (IMT); Ministry of Roads and Urban Development (MRUD)
		Reduction of vehicles' CO2 average emission from 193 grams per kilometer to 140 grams			*		1	IMT
		Decrease of energy intensity in oil, gas, and product transmission and distribution network			*		2	MOP

Table (6.3): Emission Reduction Strategies and Action Plan

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
Mainstreaming the reduction of emission and carbon footprint in socioeconomic development plans		Decrease of energy intensity in oil, gas, and product transmission and distribution network			*		2	MOP
		Reduction of power plants self-consumption by15%			*		2	MOE
		To lessen energy intensity per value-added unit in petrochemical industries			*		1/2	MOP
		Developing inter-city railway transportation and renovation of the fleet in order to			*		1	MRUD

Table (6.3): Emission Reduction Strategies and Action Plan

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
Mainstreaming the reduction of emission and carbon footprint in socioeconomic development plans		decrease energy intensity per value-added unit by 30%						
		Decreasing urban transportation energy intensity by 10% through development of subway network, bus rapid transit, renovation of the fleet, improving traffic management			*		1	Ministry of Interior (MOI)
		Reduction of energy intensity in industrial sector (except petrochemicals) by 10%			*		1	IMT
		Decrease of household energy intensity (decrease of per household energy consumption) by 5%	Modification of national building rules and standards				1/2	MRUD
		Collecting and storing CO2 and infusing it into oil fields to increase oil extraction			*		3	MOP
	1.2 Increasing share of renewable energy in total fuel mix	Increase of renewable energy share in national consumption by 1000MW annually			-500MW light -1000 MW Heat		1	MOE
		Increasing capacity of biogas power plants in				*	2	MOI

Table (6.3): Emission Reduction Strategies and Action Plan

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
Mainstreaming the reduction of emission and carbon footprint in socioeconomic development plans		landfill centers to 20MW						
		Rising the capacity of incinerators to produce electricity and heat by 10MW				*	1	MOI
	1.3 Increasing share of low carbon energies	Rising the share of natural gas in national fuel basket up to 70%				*	1	MOP
		Construction of new nuclear power plants for electricity production				*	1	MOE
	1.4 Increasing the energy efficiency and developing renewable energy by pricing, incentive and punishment policies	To continue energy price adjustment up to global prices (subsidy removal)			*		1	Plan & Budget Organization (PBO)
		Approving of long term incentives in order to develop renewable energies, especially in megalopolises and remote villages		*		*	1	MOE
		Implementing supportive plans for low energy consumption (low emission) and high value added industries		*		*	1	IMT
		Improving industries and combustion			*		1	IMT & PBO

Table (6.3): Emission Reduction Strategies and Action Plan

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
Mainstreaming the reduction of emission and carbon footprint in socioeconomic development plans		processes						
		Removing obstacles of electricity guaranteed purchase from private sector			Adjust price with inflation		1	MOE
		Establishing audit and reporting mechanisms of energy consumption and emissions in relevant units			*	*	1	Iranian National Standardization Organization (INSO)
		Setting environmental penalties for violator units after monitoring, reporting, and verification			*	*	1	Ministry of Justice (MOJ)
	1.5 Establishing market mechanisms through economic tools and incentives	Preventing import and export of energy-intensive products		*			1	IMT
		Developing carbon emission and environmental pollutions trade market			*		1	Ministry of Economic Affairs and Finance (MEAF) and PBO
		Carbon pricing and taxation			*		1	MEAF and PBO
		Formulation of GHGs emission standards					2	Department of Environment (DOE)
		Custom exemption or discount for low carbon and high efficiency machineries and equipment import			*		1	MEAF
		Granting financial				*	1	PBO and DOE

Table (6.3): Emission Reduction Strategies and Action Plan

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		facilities to National Environmental Fund in order to buy carbon certificates from emission reduction projects						
2) Developing international and regional cooperation	2.1 Maximizing utilization of international resources	Developing capacity of relevant ministries and organizations to receive international technical and financial aids				*	2	MEAF
		Review of laws and regulations in receiving international financial aids	*				2	MEAF
3) Promoting climate change knowledge	3.1 Knowledge development on climate change	Supporting R&D departments in scientific institutions and knowledge-based companies			*	*	1	Vice Presidency for Science and Technology
		Promoting environmental concepts and impacts at educational levels				*	1	Ministry of Education and Ministry of Science, Research, and Technology (MSRT)
		Creating integrated climate, energy, water, and food security models to incorporate CC in socioeconomic development plans		*	*	*	1	PBO
		Establishing National system of emission calculation, register, and reporting			*	*	1	DOE

6.5. Adaptation

6.5.1. Water

Although adaptation includes many sectors, water is of great importance for the country. There are few main interrelated issues which should be addressed in water adaptation. Degradation of water resources, both ground and underground waters, has been an urgent issue. It is a strategic subject in 6th National Development Plan. Water degradation has caused both people and environment suffer from less and low quality water. Although water has been a public issue, enough awareness has not been created yet to make people participate and relevant authorities to implement effective actions. In fact, water adaptation should be involved in daily life of the people and concerned authorities.

- ***Water Adaptation Goals:***

  - To strengthen sectoral management and institutionalize inter-sectoral cooperation;

  - To promote awareness, technical knowledge, and culture of climate change;

  - Establishment of adaptation based sustainable management of water supply and demand;

  - Promoting international cooperation on adaptation; and

  - Mainstreaming water footprint in socio-economic development plans and programs.

- ***Strategies:***

  1.1 Water governance;

  1.2 Social participation and strengthening public institutions;

  1.3 Laws and regulations;

  2.1 Integrating climate change impacts in decision making processes;

  2.2 Awareness raising;

  2.3 Capacity development;

  3.1 Improving water resources management;

  3.2 Promoting utilization of water resources, with consideration of the relationship between water, food and energy; and

  4.1 International and regional cooperation. (Table 6.4)

Table (6.4): Water Adaptation by General Policy, Strategy, Executive Policy

General Policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
1) Strengthening sectoral management and institutionalizing inter-sectoral cooperation	1.1 Water governance	Coordination of goals, objectives, and plans in order to improve intersectoral structure of water, food, energy, and climate;	*		*		1	PBO
		Improving M&E system to control water resources and uses more effectively;			*		1	MOE and Ministry of Jihad-e-Agriculture (MOJA)
		Setting up water accounting system		*		*	1	MOE
		To transcend organizational capacities and increase sectoral and inter-sectoral (water, food, energy) productivity	*		*	*	1	PBO
	1.2 Social participation and strengthening public institutions	Promoting participatory approaches in water resources conservation and uses	*			*	2	MOE
		Establishing incentives for investment in water sector		*		*	2/1	MEAF
	1.3 Laws and regulations	Reviewing relevant laws, regulations and standards to prevent adverse effect on			*	*	1	MOE

Table (6.4): Water Adaptation by General Policy, Strategy, Executive Policy

General Policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		water resources and consumption and encourage adaptive behavior						
2) Promote awareness, technical knowledge, and culture of climate change	2.1 Integrating climate change impacts in decision making processes	Integration of climate change impacts in different socioeconomic plans			*	*	A	DOE
		Integration of environmental assessments in all the relevant fields.				*	*	DOE
	2.2 Awareness raising	Public awareness raising on climate change impacts			*	*	1	General Culture Council of Iran
		Modification of water consumption patterns	*		*	*	1	General Culture Council of Iran
		Adding climate change impacts in educational sources			*	*	1	Ministry of Education
	2.3 Capacity development	Establishment of database on climate change impacts to support awareness raising and researches			*	*	1	PBO
		Developing research plans			*	*	2	PBO
		Technology transfer			*	*	2	PBO
		Documentation of traditional and scientific knowledge			*	*	2	PBO
3) Establishment of	3.1 Improving	Estimating volume of water				*	2	MOE

Table (6.4): Water Adaptation by General Policy, Strategy, Executive Policy

General Policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
adaptation based sustainable management of water supply and demand	water resource management	which can be planned regarding climate change impact						
		Determining environmental water rights		*	*		1	MOE
		Reviewing sectoral water allocation; use of new water recycling and lower use technologies	*	*			1	MOE
		To monitor, conserve, and improve quality of water resources.			*	*	1	MOE & DOE
	3.2 Promoting water resources exploitation system considering water, food and energy nexus	To review agricultural systems with respect to water resources sustainability and climate change impacts;			*	*	1	MOAJ
		Utilization of scientific and traditional use of water			*	*	1	MOE
		Developing risk and crisis management				*	2	MOE
4) Developing international cooperation on adaptation	4.1 International and regional cooperation	Capacity development through international and regional cooperation			*	*	2/3	MOE & MOAJ
		Developing water diplomacy with neighboring countries for the benefit of all			*	*	3	MOE

6.5.2. Adaptation (Agriculture and Food Security, Farming and Horticulture, Livestock and Poultry, and Fishery)

According to United Nations Food and Agriculture Organization (FAO), Iran is one of the main agricultural producers among the first 20 countries. However, different socioeconomic and natural factors have changed the situation. Population increase, unsustainable production and consumption patterns, land conversion, soil degradation, unsuitable farming pattern, water overuse, unstable market, increasing dependency on some strategic food items such as livestock and poultry food and recent droughts and cold weather have created a situation in which the necessity of adaptation is increasingly growing. Like emission, inevitability of adaptation dates back to the period before introduction of climate change in Iran. Lifestyle variations, since more than half a century ago have changed traditional adaptation. New "modern" life almost lacks adaptation ability. What have been proposed in the adaptation strategy and the Action Plan are mechanisms to modify way of living so that new adaptation is integrated to it. Table 6.5 reflects the policies in agriculture and food security, farming and horticulture, livestock and poultry, and fishery.

Table (6.5): Adaptation (Agriculture and food security, farming and horticulture, livestock and poultry, fishery) by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
To review agricultural macro policy making based on integrated and adaptation approach	Developing policy and decision making process	Preparing integrated water, food, energy , and climate plans				*	1	PBO
		Agricultural zoning based on climate capacity				*	1	MOJA
		Establishing management of new emerging environmental and bio phenomena			*	*	2	MOJA
		Implementing integrated agricultural system (multiple cropping farming, husbandry, aquaculture…. Climate oriented			*	*	2	MOJA
	Developing agricultural inputs management plan according to adaptation	to implement encouraging and preventive policies in relation to optimum use of agricultural inputs with the priority of vulnerable region	*	*			1	MOJA
		To change cropping pattern; increase efficiency in food products			*		1	MOJA

Table (6.5): Adaptation (Agriculture and food security, farming and horticulture, livestock and poultry, fishery) by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		and relevant industries						
Adaptation based Technical, economic, and social capacity development	Increase in economic, social and cultural capacity levels	Capacity building of different agricultural producers on climate change impacts and adaptation methods			*	*	2	MOJA
		Strengthening agricultural insurance fund			*	*	2	MOJA
		Subsidizing adaptable technologies	*	*			3	PBO
		Using monetary policy and pricing to encourage productivity and adaptation	*				1	MOJA
		Modification of pricing system in farming and horticulture subsectors	*				1	MOJA
		Mobilizing farmers and their associations to realize adaptation plans			*	*	2	MOJA
		Decreasing agricultural loss			*		1	MOJA
		Implementing complementary and alternative income			*	*	A1	MOJA

Table (6.5): Adaptation (Agriculture and food security, farming and horticulture, livestock and poultry, fishery) by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		sources in order to increase ecological capacity						
		Promotion of food regime and proportionating it to environmental capacity and climate change impacts	*	*	*	*	A2	MHME
	Reviewing technical, educational, and research programs to increase adaptive capacity	Identifying required capacities for proportionate researches, planning, and implementation of adaptation policies			*	*	1	MOJA
		Adapting relevant academic courses to climate change, sustainable development, food security				*	1	MOSRT
		to incorporate traditional and scientific knowledge to develop adaptive technologies and increase efficiency			*	*	1	MOJA
		Developing technical capacity of sub sector experts on climate				*	1	MOJA

Table (6.5): Adaptation (Agriculture and food security, farming and horticulture, livestock and poultry, fishery) by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		change impacts						
Increasing international relations	Developing agricultural trade and trans boundary/extra-territorial	Reviewing export and import of agricultural products with respect to water value; cooperation in the field of experiences exchanges and technology transfer	*		*	*	1	MOJA
Adaptation based planning for farming and horticulture	Soil adaptive management	Preparing soil conservation plan with respect to CC impacts			*	*	1	MOJA
		Reviewing macro plan of soil fertility with the priority of damaged and vulnerable regions			*		1	MOJA
		Monitoring soil salinity plan			*		2	MOJA
		Strengthening water tables			*	*	2	Ministry of Education
		Developing vegetation cover adaptable to climate change			*		2	MOJA
	Developing suitable agricultural water management	Improving agricultural water use and reduction of water loss			*	*	1	MOJA
		Promoting reuse of recycled water and treated waste water			*		1	MOE

Table (6.5): Adaptation (Agriculture and food security, farming and horticulture, livestock and poultry, fishery) by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		in agricultural activities						
		Proportionate agricultural activities to hydrological unit capacity			*	*	1	MOJA
	Organizing climate-driven farming and horticulture R&D	Investigation on farming and horticulture plants breeding to produce resistant plants to warm weather and less water			*	*	2	MOJA
		Cultivating halophyte plants (farming and horticulture) in arid and saline areas.				*	2	MOJA
		Improving farming and horticulture products with vulnerable areas priority			*		2	MOJA
		Changing cropping pattern to the one adaptable to climate change impacts		*	*	*	1	MOJA
		Promoting greenhouse farming			*	*	2	MOJA

Table (6.5): Adaptation (Agriculture and food security, farming and horticulture, livestock and poultry, fishery) by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
Adaptation based policy making and capacity development	Modifying macro policies of agricultural water proportionate to the climatic capacity	Preparing preventive and incentive policies for agriculture water	*	*			1	MOJA
		Reviewing permit issuance criteria to harvest ground and underground water for agricultural activities			*		1	MOE
		Supporting the establishment of water specialized NGOs[3] and local water market		*			1	MOE
		Developing virtual water trade		*	*		1	MOE
Conservation and development of capacity of traditional animal husbandry based on carrying capacity	Completing protective measures for indigenous livestock vulnerable races	Developing basic and applied research and technologies for breeding in order to protect genetic resources, efficiency increase, propagation of large and small livestock, poultry, and bees				*	2	MOJA
		Supervision on the import of live			*		1	MOJA

Table (6.5): Adaptation (Agriculture and food security, farming and horticulture, livestock and poultry, fishery) by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		livestock and preventing breeding of indigenous and non-indigenous animals.						
		Reviewing biosafety laws in relation to import and use of GMO agricultural products	*				1	MOJA
	Livestock and poultry breeding	Replacing low efficiency species with indigenous and breeding that are more adaptive to CC impacts				*	1	MOJA
		Livestock breeding to increase fertility, more efficiency of fodder consumption, and less dependence on rangelands			*		2	MOJA
Increase of productivity in livestock and poultry production	Balancing the number of livestock and rangelands capacity	Review of grazing license criteria according to changing climate and rangelands capacity			*		1	MOJA
		Review of grazing in degraded rangelands,			*	*	1	MOJA

Table (6.5): Adaptation (Agriculture and food security, farming and horticulture, livestock and poultry, fishery) by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		rehabilitation of the pastures with palatable plants through participatory approach						
		Examining the potential production of industrial and non-industrial livestock and poultry to determine import strategy of their food			*	*	1	MOJA
	Sustainable provision of livestock and poultry feed with emphasis on water efficiency and adaptation	Introducing species with lower water requirement in rangelands				*	1	MOJA
		Cultivating halophyte plants in saline and marginal lands			*	*	1	MOJA
		Investigate on change of livestock and poultry pattern and their nutrition according to climate change impacts				*	1	MOJA
Ecosystem management of aquatic reserves of the country	Rehabilitation, Conservation, and wise use of aquaculture	Sustainable and adaptable use of aquaculture resources with			*	*	1	MOJA

Table (6.5): Adaptation (Agriculture and food security, farming and horticulture, livestock and poultry, fishery) by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
	resources	respect to spatial, temporal, and tools prohibitions regarding climate change impacts						
		Rehabilitation of valuable resources and sensitive, valuable, endangered marine ecosystems			*	*	1	MOJA
		Investigate on new methods of endangered aquatic artificial propagation				*	1	MOJA
	Managing rehabilitation and conservation of marine ecosystems and coral reefs	To review rehabilitation and conservation standards of aquatic ecosystems with respect to climate change effects	*				1	DOE
		Identifying sensitive fisheries and vulnerable regions under the effect of climate change and reviewing protected areas management			*	*	1	DOE
		Conserve				*	1	DOE

Table (6.5): Adaptation (Agriculture and food security, farming and horticulture, livestock and poultry, fishery) by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		endangered and vulnerable resources from climate change impacts						
		To conserve and improve capacity of aquatic ecosystems and coral reefs				*	1	DOE
Aquatic management	to introduce adaptable species	Nurture and proliferate resistant aquaculture to salinity and less water			*	*	1	MOJA
		Probing the new emerging and re-emerging diseases related to climate change impacts on aquatic			*	*	1	MOJA
	Management of Aquatic based product	Developing modern technology to reuse water				*	2	MOJA

6.5.3. Natural Resources and Biodiversity

Iran is a rich country in natural resources and biodiversity. However, due to unsustainable lifestyle, its natural assets are undergoing erosive processes. The number of fauna and flora which are listed in the endangered and threatened lists has been rising. Despite the inclusion of the biodiversity conservation in development plans since 2005, economic and infrastructure projects are still the first priority in decision makings. Although, there is a National Biodiversity Strategy and Action Plan, approved by the government a decade ago, its implementation is very slow so that it cannot keep up with the required conservation standards. Many of the proposed actions are adaptation oriented.

To summarize the report, some of the prepared policies and action (Farsi version) are reflected in the following matrix. Like the previous section, details of the Action Plan, phase two, will be specified after the approval of the phase 1 by the government. (Table 6.6)

Table (6.6): Natural Resources and Biodiversity Adaptation by General Policy, Strategy, and Executive Policy

Table (6.6): Natural Resources and Biodiversity Adaptation by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/ Adaptation priority (1,2,3)	Responsible Ministry/ Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
Climate oriented rural and regional development	Promoting complementary and alternative livelihood in rural areas	Developing compatible alternative and complementary livelihoods with climate to reduce adverse impacts of unsustainable use of resources and prevent migration;			*	*	1	Presidency Office
		Promoting participatory livelihood in line with the environment conservation in 30% of natural areas and protected areas;			*	*	2/1	Presidency Office
	Review of regional development plans and eco-tourism	Review of regional development plans and eco-tourism			*	*	1	PBO

Table (6.6): Natural Resources and Biodiversity Adaptation by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/ Adaptation priority (1,2,3)	Responsible Ministry/ Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
	documents	documents based on bio-capacity and adaptation						
Establishment of climate compatible management system	Completing studies and assessments, Review of policies and laws	To review industrial and population site selection criteria				*	1	DOE
		preparing guidelines to estimate sectoral damages;				2	2	DOE
		promoting inter-sectoral cooperation			*	*	A 1	PBO
		To review fauna and flora conservation laws and regulations			*	*	1	DOE
	Improving bio-resources conservation	To review natural resources conservation based on climate change vulnerability, creating biodiversity database;			*	*	1	MOJA
	Completing national environmental M&E system	M&E system to monitor flora (forests, rangelands…) fauna, changes due to climate			*	*	1	MOJA

Table (6.6): Natural Resources and Biodiversity Adaptation by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/ Adaptation priority (1,2,3)	Responsible Ministry/ Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		change; Complete monitoring network of domestic sources of dust storm.						
		Regarding likely environmental damages due to climate change impacts, preparing warning system and environmental risk management				*	2	DOE
	Adaptive integrated ecosystem management	Identifying effective mechanisms to institutionalize sustainable development and wise use of bio-resources			*	*	1	DOE
		establishment of sustainable ecosystem management;			*	*	2	DOE
Establishment of supportive and compensatory system	Adaptation based socioeconomic development plan	Integration of biodiversity conservation in socioeconomic development plans;			*	*	1	PBO

Table (6.6): Natural Resources and Biodiversity Adaptation by General Policy, Strategy, and Executive Policy

General policy	Strategy	Executive policies (aims and manner)					Mitigation/ Adaptation priority (1,2,3)	Responsible Ministry/ Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		formulation of biodiversity spatial plan						
Research, cultural, public education, and training development	Capacity development of the experts	GOs and private sector's decision makers and experts as main target groups			*	*	2/1	PBO
	Public awareness raising	using mass media and formal education to make people aware of the biodiversity importance			*		2	Ministry of Guidance and Islamic culture, I.R.I Broadcasting Organization
	To prepare and implement biodiversity research policy and develop coordination among pertinent agencies	Improving relevant research quality and quantity in a cost effective manner			*	*	1	MSRT
Developing regional and international cooperation	International and regional cooperation	Developing capacity on biodiversity valuation, especially in sensitive and vulnerable areas, and receive technical knowledge on biodiversity rehabilitation			*	*	1	Ministry of Foreign Affair / Pertinent GOs

6.5.4. Health

Recently, a climate change and health committee has been established within the Health Deputy of Ministry of Health and Medical Education.

The national strategy plan for climate change and health prepared with the experts of the national climate change office with corporation of

the committee and it is following for government approval. (Table 6.7)

Table (6.7): Health Adaptation by General Policy, Strategy, and Executive Policy

General Policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
Improving the health system and resilience to mitigate adverse effects of climate change	Vulnerability assessment against climate change effects in health sector	Establishing a national database for recording risk factors and diseases related to climate change and adverse weather conditions			*	*	1	Ministry of Health and Medical Education (MOHME)
		Vulnerability assessments and adaptation against non-communicable, communicable, occupational diseases, air pollution, water and food safety,			*	*	1	MOHME

Table (6.7): Health Adaptation by General Policy, Strategy, and Executive Policy

General Policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		nutrition security related and also against emergencies and extreme events						
		Identifying vulnerable areas affected by effects of climate change gradual and extreme events			*	*	1	MOHME
		Developing early warning systems (EWSs) to reduce the effects of extreme weather events on human health			*		1	MOHME
Enhancing professional knowledge and public culture of adaptation in health sector	Capacity building and adaptation plan development in health sector	Updating rules, standards and operating procedures for organizational capacity building in adaptation	*		*	*	2	PBO
		Codification and implementation of health management adaptation plan against emergencies and also management of non-communicable, communicable,	*		*		1	MOHME

Table (6.7): Health Adaptation by General Policy, Strategy, and Executive Policy

General Policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		occupational diseases, air pollution, water and food safety, nutrition security						
		Codification and application of regulations ,taxes and special incentives related to adaptation	*		*		2	MEAF
		Improving the structure of public and private sector participation in implementing the climate change adaptation plans in the health sector	*		*		2	MOHME
		Improving the M&E system for actions and adaptation related plans in the health sector			*	*	2	MOHME
	Knowledge and awareness promotion	Continuously Upgrading professional skills of human forces in health sector			*	*	2	MOHME
		Promoting the public awareness			*		2	MOHME

Table (6.7): Health Adaptation by General Policy, Strategy, and Executive Policy

General Policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		about communicable and non-communicable diseases affected by climate change						
		Promoting educational programs in schools to enhance public knowledge about the effects of climate change	*		*		3	Ministry of Education
		Training workers specially the workers who work in outdoor and warm condition.			*	*	2	MOHME
		Enhancing the basic knowledge about climate change and sustainable development with social and economic considerations in curriculums of universities	*			*	3	MSRT and MOHME
	Promoting research and technical-executive programs	Developing the research programs, technology transfer and knowledge documentation to assess climate change macro				*	**2**	MOHME

Table (6.7): Health Adaptation by General Policy, Strategy, and Executive Policy

General Policy	Strategy	Executive policies (aims and manner)					Mitigation/Adaptation priority (1,2,3)	Responsible Ministry/Organization
		Aims	Modification of laws and regulations	New laws and regulations	Controlling measures	Preventive measures		
		impacts on public health and adaptation to this phenomenon.						
Development of regional and international cooperation	Enhancement of benefit from professional regional and international cooperation in health sector	Development of regional and international cooperation in order to increase the effectiveness of adaptation actions and improve technical capacity of national experts	*		*	*	2	MOHME

6.6. Monitoring and Evaluation (M&E) System

Regarding the obligations of the I.R. Iran under the Climate Change Convention and the new structure of strategy and Action Plan, an active Monitoring & Evaluation system is required. After the approval of the report by the government, details will be determined. The reason for it is nature of phase 2. Upon the approval of the second phase, all GOs are bound to identify their actions in view of their location, time of construction, budget and manufacturing issues. Preparation of transparent and articulated guidelines is of great importance for those who are supposed to report activities, which ultimately leads to emission reduction/adaptation. On the other hand, Climate Change Project lacks the capacity to handle such an extensive work. It seems that outsourcing is the best solution. It can be more productive when the results of the implementation and goal indicators are collected in a GIS environment. The following points are some of the main specifications of it:

- It is a participatory M&E,
- Provincial universities, NGOs, and experts are the evaluators,
- Short term training can increase quality of M&E,
- Reporting forms will be prepared collectively,
- Best practices will be used for replication.

Abbreviations

AD	Activity Data
ADCP	Acoustic Doppler Current Profiler
AEs	Anode Effects
AMSS	Automatic Message Switching System
AOGCM	Atmosphere-Ocean General Circulation Model
AR4	Fourth Assessment Report
AR5	Fifth Assessment Report
ASAP	Automated Shipboard Aerological Program
ASCII	American Standard Code for Information Interchange
ASMERC	Atmospheric Science and Meteorological Research Centre
AWOS	Automated Weather Observing System
AWS	Automatic Weather Station
BAU	Business As Usual
BOD	Biochemical Oxygen Demand
BOF	Basic Oxygen Furnace
BTU	British Thermal Unit
C&I	Criteria and Indicators
C_2F_6	Hexafluoroethane
Ca	Calcium
Ca^{++}	Calcium Ion
CAO	Civil Aviation Organization
CBS	Commission for Basic Systems
CCHF	Crimean-Congo Hemorrhagic Fever
CCHP	Combined Cooling, Heat and Power
CCS	Carbon Capture and Storage
CDD	Consecutive Dry Day
CDM	Clean Development Mechanism
CF_4	Tetrafluoromethane
Cg XVI	Sixteenth World Meteorological Congress
CH_4	Methane
CHP	Combined Heat & Power
CL	Cutaneous Leishmaniasis

Cl^-	Cloride Ion
CMA	China Meteorological Administration
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2 eq.	CO_2 equivalent
CO_3^{---}	Carbonate
COD	Chemical Oxygen Demand
CSC	Cost of Saved Carbon
CSR	Cruise Summary Reports
CTD	Conductivity Temperature Depth
DGPS	Differential Global Positioning System
DOC	Degradable Organic Carbon
DOE	Department of Environment
DVB	Digital Video Broadcasting
DVB-S2	Digital Video Broadcasting - Satellite - Second Generation
DWD	The Deutscher Wetterdienst (German weather forecasting service)
EAF	Electric Arc Furnace
EC	Executive Committee
ECMWF	European Centre for Medium-range Weather Forecasting
ECO	Economic Cooperation Organization
EEZ	Exclusive Economic Zones
EF	Emission Factor
EM/RC55/R.8	Eastern Mediterranean Regional Committee issued a Regional Committee Resolution
ENSO	El Niño–Southern Oscillation
ERC	Emission Reduction Contribution
FAO	United Nations Food and Agriculture Organization
FOD	First Order Decay
FRWO	Forest, Range and Watershed Management Organization
FTP	File Transfer Protocol
FYDP	Five-Year Development Plan
GAW	Global Atomosphere Watch
GCM	General Circulation Model

GCOS	Global Climate Observation System
GCRMN	Global Coral Reef Monitoring Network
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GISC	Global Information System Centers
GLOSS	Global Sea Level Observing System
GNP	Gross National Product
GO	Governmental Organization
GOES	Geostationary Operational Environmental Satellite
GOOS	Global Ocean Observing System
GPS	Global Positioning System
GSI	Geological Survey of Iran
GSN	Global Surface Network
GTS	Global Telecommunication System
GUAN	Global Upper-air Network
GWP	Global Warming Potential
HCO_3^-	Bicarbonate
HDI	Human Development Index
HFC_{134a}	Tetrafluoroethane
HFCs	Hydrofluorocarbons
HQ	Headquarter
I. R. Iran	Islamic Republic of Iran
IBTrACS	International Best Track Archive for Climate Stewardship
ICARDA	International Center for Agricultural Research in the Dry Areas
ICZM	Integrated Coastal Zone Management
IEA	International Energy Agency
IFO	Iranian Fisheries Organization
IIES	Institute for International Economic Studies
IMIDRO	Iranian Mines & Mining Industries Development & Renovation Organization
IMO	International Maritime Organization
IMT	Ministry of Industry, Mine, and Trade
INC	Initial National Communication

INCOD	Iranian National Center for Ocean Data
INDC	Intended National Determined Contribution
INIOAS	Iranian National Institute for Oceanography and Atmospheric Science
INSO	Iranian National Standardization Organization
IOC	Intergovernmental Oceanographic Commission
IODE	International Oceanographic Data and Information Exchange
IOGOOS	The Indian Ocean Global Ocean Observing System
IPCC	Intergovernmental Panel on Climate Change
IPMO	Iranian Ports and Maritime Organization
IPPU	Industrial Processes and Product Use
IPsec	Internet Protocol Security
IRIB	Islamic Republic of Iran Broadcasting
IRIMO	Islamic Republic of Iran Meteorological Organization
IRIMSAT	A DVB-S2 satellite broadcasting service operated by the Islamic Republic of Iran
IRIR	Islamic Republic of Iran Railway
IRR	Iranian Rial
ISA	Iranian Space Agency
IVR	Interactive Voice Response
JCOMM	Joint Technical Commission for Oceanography and Marine Meteorology
JMA	Japan Meteorological Agency
KP	Kyoto Protocol
LARS-WG	Lars Weather Generator (A Stochastic Weather Generator for Use in Climate Impact Studies)
LEAP	Long-range Energy Alternative Planning Systems
LFG	Landfill Gas
LPG	Liquefied Petroleum Gas
LULUCF	Land Use, Land-Use Change and Forestry
M&E	Monitoring and Evaluation
MCF	Methane Correction Factor
MEAF	Ministry of Economic Affairs and Finance
MF	Météo-France

MFG	Meteosat First Generation
MFI	Meteo France International
Mg	Magnesium
Mg^{++}	Magnesium Ion
MIMT	Ministry of Industry, Mine and Trade
MIT	Mitigation
MITD	Modernization and Information Technology Development Project
MOE	Ministry of Energy
MOHME	Ministry of Health and Medical Education
MOI	Ministry of Interior
MOJ	Ministry of Justice
MOJA	Ministry of Jihad-e-Agriculture
MOP	Ministry of Petroleum
MPO	Management and Planning Organization
MRICGCM	Meteorological Research Institute Coupled Atmosphere-Ocean General Circulation Model
MRUD	Ministry of Roads and Urban Development
MSG	Meteosat Second Generation
MSRT	Ministry of Science, Research, and Technology
MSW	Municipal Solid Waste
MTSAT	Multifunctional Transport Satellite
N_2O	Nitrous Oxide
Na	Sodium
Na^+	Sodium Ion
NAPA	National Adaptation Programs of Action
NCC	National Cartographic Center
NCCO	National Climate Change Office
NCDC	National Climatic Data Center
NGO	National Geographic Organization
NGOs	Non-Governmental Organizations
NH_3	Ammonia
$NH4^+$	Ammonium
NMVOCs	Non-Methane Volatile Organic Compounds
NO	Nitric Oxide

NO_3^-	Inorganic Nitrate
NO_x	Nitrogen Oxides
NOC	Network Operations Center
NODC	National Oceanographic Data Center
NPP	Net Primary Productivity
O_3	Ozone
OASC	Oceanic & Atmospheric Science Centre
ODB	Observational Database
OH^-	Hydroxyl Ion
OTEC	Ocean Thermal Energy Conversion
P	Precipitation
PBO	Plan and Budget Organization
PFCs	Perfluorocarbons
PG-GOOS	Persian Gulf & Gulf of Oman Oceanographic Study
PHC	Primary Health Care
PM	Particulate Matter
PMO	Ports and Maritime Organization
PRECIS	Providing Regional Climates for Impacts Studies
PSO	Port and Shipping Organization
QFE	Atmospheric Pressure (Q) at Field Elevation
QFF	Atmospheric Pressure Converted to Mean Sea Level Elevation
QNH	Atmospheric Pressure (Q) at Nautical Height
R & D	Research & Development
RBCN	Regional Basic Climatology Network
RBR	Radiation Belt Remediation
RBSN	Regional Basic Synoptic Network
RCM	Recording Current Meter
RE	Renewable Energy
REGCM	Regional Climate Model system
RES	Reference Energy System
ROPME	Regional Organization for the Protection of the Marine Environment
RTC	Regional Training Centre
RTH	Regional Telecommunication Hub

SDSM	Statistical Downscaling Model
SF_6	Sulfurhexafluoride
SFM	Sustainable Forest Management
SNC	Second National Communication
SO_2	Sulfur Dioxide
SO_4	Sulfate
SO_4^{++}	Sulfate Ion
SOOP	Ships of Opportunity Program
SPI	Standardized Precipitation Index
SRES	Special Report on Emission Scenario
SST	Sea Surface Temperature
SWDS	Solid Waste Disposal Site
T	Temperature
T_{ave}	Average Temperature
T_{max}	Maximum Temperature
T_{min}	Minimum Temperature
TCC	Tokyo Climate Center
TCP/IP	Transmission Control Protocol/Internet Protocol
TNC	Third National Communication
TSP	Total Suspended Particulate
UKMO	United Kingdom Met Office
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USD	United States Dollar
USSR	Union of Soviet Socialist Republics
UV	Ultraviolet
V & A	Vulnerability and Adaptation
VL	Visceral Leishmaniasis
VOS	Volunteer Observing Ships

VPN	Virtual Private Network
VSAT	Very Small Aperture Terminal
WAN	Wide Area Network
WHO	World Health Organization
WHR	Waste Heat Recovery
WIS	WMO Information System
WMO	World Meteorological Organization
WOUDC	World Ozone and Ultraviolet Radiation Data Center
WTR	Wave and Tide Recorder
WWEC	Worldwide Energy Conference

Units

µg	Microgram
°C	Degree Centigrade
2005 USD	2005 United States Dollar
bcm	Billion Cubic Meters
cm	Centimeter
Gg	Gigagram
h	Hour
ha	Hectare
IRR	Iranian Rial
kbps	Kilobits Per Second
kg	Kilogram
Km	Kilometer
Km^2	Square Kilometer
kw	Kilowatt
lit	Liter
m	Meter
m^2	Square Meter
m^3	Cubic Meters
mboe	Million Barrels of Oil Equivalent
Mbps	Megabits Per Second
MCM	Million Cubic Meter
Mg	Megagram
mm	Millimeter
Mt	Milion Ton
MW	Megawatt
yr	Year

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TNC-Contributors

In preparing Iran's Third National Communication under the Climate Change Enabling Activity Project in Iran, many individuals and organization have contributed, a list of which is given below along with their roles:

A. Project Management

- Prof. M. Soltanieh (Sharif University of Technology; Project Manager, From 2012 to 2013)
- Dr. M. Nasseri (University of Tehran; Project Manager, From 2013 to 2017)
- Mr. M. S. Ahadi (National Climate Change Office; Project Assistant)
- Dr. A. Massah Bavani (University of Tehran, Coordinator for Vulnerability and Adaptation Assessment, Climate Modeling and GCOS)
- Mr. H. Eshraghi (National Climate Change Office, Coordinator for Mitigation Poilicy Assessment and Greenhouse Gas Emission Inventory)

B. UNDP/GEF Coordination

- Mr. M. Kamyab (Head of Energy, Environment and Disaster Management Cluster, UNDP Country Office in Tehran)
- Dr. A. Nazaridoust (Head of Programme and Assistant Resident Representative, UNDP Country Office in Tehran)
- Ms. L. Shajii (Programme Officer, UNDP Country Office in Tehran)
- Ms. S. Bakhshalian (Programme Officer, UNDP Country Office in Tehran)
- Ms. Y. Khodabandehlou (Programme Officer, UNDP Country Office in Tehran)
- Ms. S. Koochaki (Programme Officer, UNDP Country Office in Tehran)

C. Working Groups

I) Energy

- Dr. M. Sadeghi Shahdani (School of Economic Science, Head of Group in Mitigation Polices Assessment)
- Dr. N. Rahimi (Ministry of Energy; Head of Group in GHG's Emission Inventory)
- Dr. N. Kargari (Ministry of Energy, GHG's Emission Inventory)
- Mr. R. Goodarzi (Ministry of Energy, GHG's Emission Inventory)

II) Industrial Processes

- Ms. F. Lotfi (National Climate Change Office, Head of Group in GHG's Emission Inventory)
- Mr. S. Minapour (National Climate Change Office, Head of Group in Mitigation Polices Assessment)

III) Agriculture, Biodiversity and Land Use Change & Forestry

- Dr. M. Jafari (Research Institute for Forest and Rangelands, Head of Group in Inventory, Mitigation and Vulnerability and Adaptation Assessment in Forest and Rangeland)

- Dr. F. Khorsandi (Islamic Azad University, Head of Group in Vulnerability and Adaptation Assessment in Agriculture)
- Mr. R. Shahifar (Iran Fisheries Organization, Vulnerability and Adaptation Assessment in Agriculture)
- Ms. L. Sarabian (Ministry of Agriculture, Vulnerability and Adaptation Assessment in Agriculture)
- Mr. A. Dehghan (Ministry of Agriculture; Head of Agriculture Group in Inventory and Mitigation Asssessment)
- Mr. M.R. Khosravi (Head of Group for Vulnerability Asssessment in Biodiversity)
- Mr. M. Tohidifar (Expert of Biodiversity and Natural Resources)

IV) Climate Modeling and GCOS

- Mr. A. Kamal (University of Tehran, Climate Modeling)
- Ms. F. Rahimzadeh (Atmospheric Science and Meteorological Reserch Center, Meteorological Organization of Iran, Head of GCOS Working Group)
- Mr. M. Khoshkam (Meteorological Organization of Iran)
- Dr. H. Fahmi (Ministry of Energy)
- Dr. S. H. Rahmati (Islamic Azad University of Tehran, Science and Research Branch)
- Mr. A. Dehghan (Ministry of Agriculture)
- Dr. A. Naderi-e-bani (National Center for Oceanography, Ministry of Science, Research and Technology)
- Mr. A. Ansari Amoli (Iranian Space Agency)
- Mr. F. Rahimi (Iranian Space Agency)

V) Waste

- Dr. M. Safa (Iran's Municipality and Rural Management Organization, Ministry of Interrior Affairs, Head of Group for Mitigation Assessment)
- Ms. L. Ghafghazi (University of Tehran, Head of Group for Inventory Assessment)

VI) Coastal Zone

- Dr. H. Alizadeh Lahijani (National Center for Oceanography, Ministry of Science, Research and Technology; Head of Group)
- Dr. A. Naderi-e-bani (National Center for Oceanography, Ministry of Science, Research and Technology)

VII) Water Resources

- Dr. H. Fahmi (Water Resource Research Center, Ministry of Energy; Head of Group in Vulnerabiity and Adaptation Assessment)

VIII) Health

- Dr. E. Ahmadnejhad (Environmental and Occupational Heath Center, Ministry of Health and Medical Education; Head of Group)

IX) National Circumstances and National Action Plan

- Mr. H. Farahanirad (Management and Planning Organization, Head of Working Group)
- Ms. M. Maghsoudi (National Climate Change Office, Department of Environment)
- Ms. N. Babaei (National Climate Change Office, Department of Environment)

X) Reaserch, Education and Public Awareness

- Dr. A. Massah Bavani (University of Tehran, Head of Group for Climate Change Research and Education)
- Ms. M. Sadeghi Hariri (National Climate Change Office, Head of Working Geoup on Public Awareness)
- Ms. A. Shahni Danesh (National Climate Change Office, Public Awareness Expert)

XI) Technologhy Needs Assessment

- (Vice- Presidency for Science and Technology, Presidency of the Islamic Republic of Iran)

XII) Coordination Group and Supporters

- Ms. M. Saraydarchi (National Climate Change Office)

XIII) Ecotourism

- Dr. M.R. Saeidabadi (University of Tehran)
- Dr. A. Sadatfar (Research and Technology Institute of Plant Production (RTIPP); Shahid Bahonar University of Kerman)
- Ms. N. Ahmadi (Expert of Environment)

XIV) Economy

- Dr. S.S. Hoseini (University of Tehran, Head of National Development Fund of Iran)
- Dr. M.R. Nazari (Environmental Sciences Research Institute, Shahid Beheshti University)

D. Editors

- Mr. Mehrdad Mohammadi
- Ms. A. Shahni Danesh
- Ms. M. Sadeghi Hariri
- Ms. N. Babaei

E. Steering Committee

- Department of Environment; Head
- Ministry of Foreign Affairs
- Ministry of Petroleum
- Ministry of Energy, Electricity and Energy Affairs
- Ministry of Energy, Water Affairs
- Ministry of Industries, Mines and Trade
- Ministry of Agriculture
- Meteorological Organization of Iran
- Iranian National Center for Oceanography
- Ministry of Health and Medical Education
- Ministry of Economic Affairs and Finance
- University of Tehran

- Forests, Range and Watershed Management Organization
- Management and Planning Organization
- Organization of the Petroleum Exporting Countries (OPEC), Ministry of Petroleum.
- Institute of Research and Planning in Higher Education, Ministry of Education
- Deputy for Housing and Construction, Ministry of Roads and Urban Development
- Islamic Azad University
- Iranian Society of Environmentalists (IRSEN)

F. Ministries, Organizations and Institutions

I) Iranian

- Ministry of Foreign Affairs
- Ministry of Petroleum (Bureau for Health,Safety and Environment(HSE), Planning and OPEC Affairs)
- Ministry of Energy (Water Resources Research Center, Deputy for Electricity and Energy)
- Ministry of Agriculture (Forestry and Rangeland Organization and the Office of Sustainable Development)
- Ministry of Industries, Mines and Trade (Health, Safety, Environment and Energy Office)
- Ministry of Health and Medical Education (Center of Environment and Health)
- Management and Planning Organization
- Institute for International Energy Studies (IIES)
- Meteorological Organization of Iran (Atmospheric Science and Meteorological Research Center and National Center for Climatology)
- Iranian National Center for Oceanography (INCO)
- Statistical Center of Iran

II) International

- United Nations Development Programme (UNDP Country Office in Iran)
- Global Environment Facility (GEF)
- National Communications Support Programme (NCSP)