CLIMATE CHANGE

INITIAL NATIONAL COMMUNICATION

December 2010

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SYRIAN ARAB REPUBLIC

UNITED NATIONS FRAMEWORK CONVENTION
ON CLIMATE CHANGE (UNFCCC)

Initial National Communication
Of the
SYRIAN ARAB REPUBLIC

Submitted to the
United Nations Framework Convention on Climate Change

Ministry of state for Environment Affairs (MSEA), in collaboration with United Nation Development Program (UNDP) in Syria, and the Global Environmental Facility (GEF).

(INC-SY)

Compiled and Edited by:

Yousef Meslmani, Ph. D.,

National Project Director

International Technical review by the team of the GEF/UNDP/UNEP National Communications Support Programme (NCSP).

For further information and accessing to the report

Ministry of state for Environment Affairs

Yousef Al-Azmeh Square,
P. O. Box: 3773,
Damascus – Syria

Phone: +963-11-2318682 / 2314111
Fax: +963-11-2320885 / 2316921
Cell phone: +963- 933 - 050 500

http://www.gcea.gov.sy
http://www.inc-sy.org

United Nation Development Program
UNDP
Mezzeh, West Villas, Gazawi Str., No. 8,
Damascus – Syria

Phone: +963 -11-6129811
Fax: +963 -11-6114541
Mobile: +963- 933-214615

www.undp.org.sy
www.un.org.sy

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Foreword

The world is facing several controversial environmental constraints, including the Greenhouse phenomenon and climate change, both of which have become a reality and should be dealt with wisely. The importance of climate change has been emphasized in international meetings, among which the 15th Conference of the Parties of the United Nations Framework Convention on Climate Change (COP 15), held in Copenhagen during the period 7-18 December 2009, as a Conference of the Parties of Kyoto Protocol (CMP-5).

Syrian Arab Republic is not a major contributor in the emission of greenhouse gases. However, Syria, like other countries, is affected by the impact of probable global climate change, characterized by modifications in global precipitations and increased sea levels.

Syria recognized the importance and threats related to climate change and hence joined international efforts to combat them, ratifying the UNFCCC as early as 10 December 1995. It signed the Kyoto Protocol on 4 September 2005. Moreover, Syria has been openly realizing the importance of raising awareness on climate change, which would help the implementation of proper measures in order to reduce the possible negative impacts. The UNFCCC of 1992 is one of the recent series of Conventions which most countries have joined to combat this global challenge.

The cause and effects in time and space of climate change constitute an extremely complex topic. There are numerous studies which confirm the influence of Greenhouse gases on the earth's thermal balance and they therefore ascribe a human reason to climate change.

The adoption of a common strategy to reduce emissions of greenhouse gases requires the industrial countries to follow intense changes in energy policy, investment in the development of alternative energy and the introduction of constraints and changes for industries. Developing countries have been caught between environmental and economic expansion, since environmental measures usually bring about an additional cost, delaying industrial development and the achievement of short-term development policy objectives. Given that climate change is one of the factors contributing to the process of desertification, it becomes a particularly important issue in the Mediterranean basin, already marked by the presence of large desert areas where the biosphere's precarious balance is deeply exposed to environmental degradation.

The Enabling Activities for the Preparation of Syria's Initial National Communication to UNFFCCC (INC project) is being implemented by the State Ministry of Environmental Affairs, in collaboration with the Global Environmental Facility (GEF) and United Nation Development Program (UNDP).

The goal of the Initial National Communication on Climate Change Project is to provide support for the Government of Syria in preparing the First Communication Report on Climate Change (for the United Nations Framework Convention on Climate Change), according to a methodology followed by all member countries; and to submit it to the Conference of Parties (COP) of the Convention, in addition to enhancing the national capacity for synergistic implementation of the UN Framework Convention on Climate Change. The project also aims to:

- Identify challenges hindering adaptation to climate change;
- Identify national constraints limiting proper implementation of the activities related to the UN Framework Convention on Climate Change.
- Provide a practical framework to enhance the national capacity for synergistic implementation of the UN Framework Convention on Climate Change.
- Streamline the commitments and obligations entailed in the global environmental management system and convert them into national policies.

The preparation of the First Initial Communication on Climate Change included the following four main themes, in addition to a number of interrelated topics:

1) Identifying national circumstances.
2) An inventory of greenhouse gas emissions.
3) Programs to measure adaptation to climate change.
4) Programs to measure the mitigation (reduction) of greenhouse gas emissions.

All studies were conducted by the project's management, in cooperation with national experts from different stakeholders and under direct supervision from the State Ministry for Environmental Affairs. We hope that this report shall provide a reference and much information for future policy planning and decision making, to researchers on climate change, especially at a national level. Special thanks are due to all those who participated in this important task.

Dr. Kokab Dayeh

Minister of State for Environment Affairs

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Dr. Yousef Meslmani

National Project Director

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* *This report has been approved unanimously by the technical committee, during the Technical Workshop which took place on 12 April 2009, in Samirsmis Hotel, Damascus.*

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LIST OF ACRONYMS

ACSAD	Arab Center for the Study of Arid Zones and Dry Lands
AD	Activity Data
BBOE	Billion Barrel Of Oil
BOD	Biological Oxygen Demand
BGR	Bundesanstalt fuer Geowissenschaften und Rohstoffe
CDM	Clean Development Mechanism
CFL	Compact Fluorescent Lamps
CH4	Methane
CHP	Combined Heat and Power (Co-generation)
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COP	Conference of Parties
CCS	Carbon Capture and Storage
CSC	Cost of Saved Carbon
CSP	Concentrated Solar Power
CVI	Coastal Vulnerability Index
DEF	Default Emission Factor
EF	Emission Factor
ECEP	Energy Conservation and Environmental Protection
ECRI	Environment & Climate Change Research Institute
EES	Energy Efficiency Scenario
ELS	Efficient Lighting System
GCMs	Global Circulation Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Giga gram equal 109 gram
GHG	Greenhouse Gas
GOFI	General Organization for Industrialization
GTZ	German association for technical cooperation
GWP	Global Warming Potential
HFC's	Hydro fluorocarbons
HFO	Heavy Fuel Oil
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ISCCS	Integrated Solar Combined Cycle Systems
KC	Key Categories
LG	Liquid Gas
LULUCF	Land Use, Land-Use Change and Forestry
Mtoe	Million Tons in Oil Equivalent
NC	National Communication
NERC	National Energy Research Centre
NG	Natural Gas
NGGIP	National Greenhouse Gases Inventory Program
NMVOC	Non Methane Volatile Organic Compounds
N2O	Nitrous Oxide
Non-Annex 1	Countries not included in Annex 1 of Kyoto Protocol
NO_X	Nitrogen Oxides
NPD	National Project Director
NRC	National Research Center
O_2	Oxygen
PFC's	Per Fluorocarbons

PV	Photovoltaic
RES	Renewable Energy Scenario
SNC	Second National Communication
SCR	Steam Condensate Recovery
SEI	Stockholm Environment Institute
SF_6	Sulfur Hexafluoride
SHMI	Swedish meteorological hydrological institute
SHW	Solar Hot Water
SLR	Sea Level Rise
SNAP	Support for National Action Plan
Toe	Ton in Oil Equivalent
Tg	Teragram, equivalent to 10^{12} grams
TOR	Term of Reference
Tier 1	Methodology 1: lower level for GHG calculation
TWG	Technical Working Group
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USCSP	United States Country Studies Program
WHR	Waste Heat Recovery
WMO	World Meteorological Organization

LIST OF UNITS

1 Ton of Crude Oil	= 0.995 TOE
1 Ton N.G.	= 1.111 TOE
1 Ton LPG	= 1.125 TOE
1 Ton of Fuel Oil	= 0.972 TOE
1 Ton of Kerosene	=1.086 TOE
1 Ton of Gasoline	= 1.103 TOE
1 Ton of Gas Oil	= 1.066 TOE
1 Ton of Crude Oil	= 7.3 Barrel Crude
1 Ton Coal	= 0.670 TOE
1 kWh (hydro)	= 220 Gr. O.E (1996/97 –1997/98)
1 Barrel equivalent N.G.	= 5000 Cubic feet N.G.
1 Cubic Meter N.G.	= 35.315 Cubic feet
1 Metric Ton	= 1000 kg.
k (kilo)	= 10^3
M (Mega)	= 10^6
G (Giga)	= 10^9
T (Tera)	= 10^{12}

Summary

The phenomenon of greenhouse gases and climate change is one of the most important current controversial challenges at a global level. Climate change is a reality and there is scientific consensus on its origins: it is due to greenhouse gas emissions resulting from man-made causes. The Fourth Report of the Intergovernmental Panel on Climate Change concluded that the past century has witnessed an increase in average global surface temperature by 0.74 C, an increase in the intensity and repetition of heat waves, strong precipitations in most areas, and a rise in sea level by 17 cm. It is expected that by the year 2100 the average global temperature might increase by 3 °C and sea level could rise between 18 and 58 cm.

Climate change is expected to have many strong effective consequences. Recent studies indicated that the phenomenon has caused a decrease in the agricultural production of rice, maize, and wheat by 30, 47 and 20%, respectively in the Middle East and North Africa. Climate change could hamper efforts to reduce child malnutrition in countries of the region; these would need financial investment as high as 241-271 million dollars, to be spent mostly on research to overcome the consequences on food and nutrition alone. Moreover, recent studies have predicted that the Fertile Crescent will lose its current shape due to climate change. Furthermore, the annual discharge of the Euphrates River will decrease significantly (29-73%), as will the Jordan River's stream flow. Such decrease would definitely impede economic growth and create difficulties towards achieving sustainable development in the countries of the region.

Being an arid and semi-arid country, the Syrian Arab Republic (SAR) will be one of the states most affected by the potential impact of climate change. A preliminary assessment reveals nationwide changes in rainfall patterns and fluctuations in temperature during the past five decades. Average annual rainfall has fallen dramatically in the main agricultural areas over the past years. As a result, the country has suffered from a lack of rain and the prolonged effects of drought.

The recurrence of drought, coupled with its increased intensity, has reduced available water supplies and adversely affected the quality of water, thereby aggravating water resources management problems in the country. Most Syrian cities currently have a water supply deficit. Damascus, once an oasis with pure and ample hydrological resources, is today one of the thirstiest cities in the Middle East; this is especially true in the light of continuous looting by Israel of water resources from the occupied Golan heights, resources that could cover about 30% of Damascus' annual needs. Bearing this in mind, a shortage of water supplies will undoubtedly raise concerns about food production and increase the risk of desertification in the country.

With a population of over 20 million, in addition to one million Iraqis and half a million Palestinian refugees, pressure is being exerted on the meager resources and services; economic sectors are highly affected by climate change, leading to a decrease in the ability to achieve balanced socio-economic development and to constrains in its sustainability.

A major shift in long-term annual rainfall patterns and a rise in temperatures are projected over most areas of Syria by the year 2100. This will predominantly have negative impacts on the agricultural sector, which currently employs 25 - 30% of the total workforce and contributes the same percentage of the country's total GDP. The considerable drop in

groundwater levels in many of the country's water basins is of great concern to national authorities, due to its social, economic and political implications.

Climate change will affect land use patterns, accelerate the pace of land degradation, and increase the risks of drought. Heat waves and dust storms, which have become a bitter scourge for residents of the country's eastern region, are on the increase. Rising sea levels are expected to flood Syrian coastal lowlands. Lastly, climate change will have implications on health services, other economic sectors and natural ecosystems.

Based on the abovementioned facts and on preventive principles, Syria has been concerned about issues of climate change and dealing with its causes and consequences, within the framework of global equity and mutual but distinctive responsibilities. Syria's efforts to deal with climate change at the international level are reflected by its participation in negotiations within the context of the United Nations Framework Convention on Climate Change and the Kyoto Protocol; the road map adopted in Bali; the ministerial declaration of the Council of the Arab Ministers responsible for environmental affairs during its 21st meeting; the 2009 negotiations on the 5th Conference of Parties in the UNFCCC; the 5th COP meeting for the implementation of the Kyoto protocol; the stands of the group of 77 and China, the socio-economics of the country and the national interests and developmental priorities:

1. The UNFCCC should provide easy and direct access to means of implementation for adaptation programs in all developing countries, especially those most affected by climate change. It should encourage partnership in the planning and implementation of adaptation measures within the context of an integrated approach. Such an approach must be based on national experience, facilitate the exchange of knowledge and of lessons learned so as to reduce the exposure of most vulnerable groups in society to this problem. It should additionally ensure effective planning and implementation of adaptation programs.

2. The UNFCCC should include a provision of generous financial resources that is new, additional (above the official development assistance) and fixed, to support adaptation activities in developing countries, particularly those under occupation. The upgraded financial donations must be under the form of periodic grant installments, in order to enable parties to effectively implement adaptation measures.

3. Calls for the adoption of national and regional action plans to deal with issues related to climate change including, assessment of potential impacts and development adaptation programs, in which governments have a central role in implementation. The government's action should be done in coordination and cooperation with civil society organizations and the private sector.

Adaptation programs shall focus on the **provision** of the **necessary infrastructure** to **reduce potential risks** induced by climate change, including necessary mechanisms to insure against risks, and shall improve the efficiency of natural resource management systems. Preparation for risks caused by climate change, data provision and exchange of information, capacity building, as well as awareness and partnerships should also be at the core of adaptation programs.

Mitigation

The objectives of reducing GHG emissions should consider the following:

a. The principle of inclusiveness and mutual vulnerability. In this context, ambitious reduction targets are required to limit the dangers of climate change. This requires dealing with all types of emissions, relevant economic sectors, and all sources of absorption (sinks). Any effective policy must be comprehensive and shall balance the benefits and costs of actions taken.

b. The principles of equity and common but differentiated responsibilities and respective capabilities. This implies acknowledgement of historical differences in the contributions of developed and developing countries to global climate change and differences in countries' capacity to tackle its causes and impacts. Hence a balanced approach is required for the distribution of the burden of responsibilities in an explicit and equitable manner. In this regard, developed countries should take the lead in responding with measures, and not overload developing countries with demands. Furthermore, economic mitigation measures should be just and fair and take into account the national circumstances of developing countries.

Within this framework, the following matters should be emphasized:

1. Reductions of global emissions must be calculated on the basis of historical responsibility. All developed countries should be included in reduction commitments and also demonstrate their leadership in reducing emissions of greenhouse gases as a result of their historical, current and direct responsibilities.

2. Developed countries should commit themselves to reduce greenhouse gas emissions by 2050 in order to achieve a minimum level of stability in global climate. Emission reduction commitments for post-Kyoto should be, by 2020, no less than 40% below 1990 levels.

3. Developed countries should meet their national level emission reductions through mutual cooperation or coordination and support the efforts of developing countries in voluntary shift towards a low-carbon economy. Low-carbon development plans need to be based on each country's respective responsibility and capability, and their development should be financially and technologically supported by developed countries.

4. Any reductions in greenhouse gas emissions in developing countries should be voluntary (non-binding). Voluntary initiatives include, among other things, nationally appropriate mitigation, access to adequate financial and technological support and assistance in capacity building from developed countries.

5. Developed countries should provide funding and technological support to developing countries to cover the full incremental cost of measurable, reportable and nationally verifiable and appropriate mitigation / reduction. This must include the costs of monitoring and evaluating progress in mitigation measures for future commitment periods, within an agreed transparent mechanism and time-span. In this context, the quantified obligations of developed countries must be measurable, recordable and verifiable.

6. National action plans may include purely national mitigation procedures and other measures to move to a low-carbon economy, through nationally agreed appropriate

mitigation, enhanced and supported by adequate funding, appropriate technology, and capacity-building from developed countries. These measures may include market measures, increasing the efficiency of energy production and its use, the rationalization of consumption, and the enacting of laws for energy conservation. On the other hand, developed countries should not offset their full obligations as a result of voluntary reductions from developing countries.

7. Developed countries must be responsible for negative impacts resulting from implementation of measures of response. Actions decided must not adversely affect sustainable development in developing countries. Developed countries shall not resort to any form of unilateral action to reduce GHGs emissions; including emissions from maritime and aviation transport.

8. Facilitating access to a Clean Development Mechanism (CDM), and providing funding and capacity building for project proposals prepared and submitted under the CDM. In this context, carbon capture and storage (CCS) projects should be included under the CDM arrangement.

Finance

1. The level of provided finance should depend on the preventive principle and on guaranteeing keeping global warming within safe limits. The total required finance to handle the impacts of climate change should be provided in abundance and suit the level of risk.

2. The implementation of the Convention's obligations requires an effective financial mechanism, to be operated under the guidance of the Conference of the Parties. This mechanism should be transparent and independent, should include equal geographic representation for all parties, allow equal access to finance, and facilitate the flow of financial obligatory contributions from the developed to the developing countries according to the decisions of the Convention.

3. State financial resources should be granted to cover activities of volunteer reduction, technology transfer and capacity building in developing countries. Implementing unilateral adaptive programs and projects also requires abundant financing.

4. Developed countries should provide the financial support required for global and deep assessments of the probable impact of climate change and of the consequences of implementing responsive measures towards developing countries, in order to help those countries identify priorities, implement and upgrade programs of volunteer reduction, adaptation, technology transfer and capacity building.

Technological Transfer

Volunteer adaptation and mitigation measures require technological transfer towards developing countries, easy access to appropriate technologies and the provision of adequate financial resources. The present institutional arrangements for technological transfer and upgrading in developing countries are not sufficient at this stage and the following should be considered:

1. Adoption of an enhanced institutional mechanism (a facility operating under the authority and guidance of the COP), with an agreed work plan, with set targets and time-based activities. This arrangement will address all technological aspects, including required funding, barriers for the transfer of climatically sustainable technologies to developing countries, and issues related to intellectual property rights.

2. Developed countries should commit themselves to facilitating technological transfer, providing funding and assistance in building the capacity of developing countries in order to diversify their economies. This measure would help developing countries to minimize the effects of decisions taken by developed countries when meeting their commitments to the Convention. Access to clean technology is paramount to any agreement, and technological transfer must be facilitated and not linked to unilateral economic sanctions.

3. Work plans for technology should include activities directly aimed at supporting all phases of the technological cycle, including research and development, transfer and dissemination, policies and roles, funding requirements, and supporting measures for implementation.

4. The implementation of technological development policies should meet the national priorities and needs of developing countries

Building Capacity

1. National capacity building should make an effective contribution in achieving the Convention's objectives and enable party countries to have effective participation in operations of the Convention and Protocol. Capacity building is a continuous, gradual and repeated process and should have financial and technical support provided by the developed countries.

2. The process of institutional and technical capacity building should respond to the priorities, needs and national circumstances of each party country. The developing countries should be ready for a process of capacity building, to be able to understand and select the best option. Within this context, it is recommended to establish distinctive regional centers in the field of climate change.

Institutional Arrangements

Any agreed institutional arrangements should follow criteria of transparency, fairness and balanced regional representation. Institutions must work under the authority and guidance of the Conference of Parties to the Convention.

CHAPTER 1

National Circumstances

1.1. Introduction

The phenomenon of climate change is considered today to be one of the most important discussed issues and contemporary challenges; it has aroused much debate and interest at both international and global levels. This attention was shown in many international assemblies, the last of which being the Bali conference for climate change convening 3-14 December 2007: the aim was to launch the practical negotiations concerning climate change, to find the best methods for diluting the emission of gases that cause the greenhouse effect and to reach an agreement all nations would abide by. The related problems of climate change were confronted at the beginning of 2008. and should be effective by 2012, the year of the termination of the current Kyoto Protocol.

Syria cannot be separated from what is happening to the rest of the world. Despite the fact that Syria is not considered a prime contributor in the global emission of gases (greenhouse), it may be affected by the possible consequences of world climate change. These can be clearly perceived in modifications in rainfall and in rising sea levels. Syria, convinced of the importance and seriousness of climate changes, joined international efforts in facing climate change, and endorsed the UNFCCC "United Nations Framework Convention for Climate Change" on December 10th, 1995. Syria has also signed the Kyoto Protocol on 4 September 2005. It has understood the importance of raising awareness to the reality of climate change, which itself is a mover behind creating suitable procedures for a diminution of its possible negatives consequences.

The 1992 UNFCCC convention is considered one of the most recent meetings (COPs) in which different countries have participated so as to confront this collective threat.

The report on National Circumstances is a first step towards the initial national Communication of the Syrian Arab Republic relative to the "United Nations Framework Convention for Climate Change". This report provides a global overview of local circumstances in Syria through the analyses of main economic sectors of activity, which will facilitate the preparation of the following reports estimating the rates of emissions and finding measures for their diminution, as well as adaptive responses. This will enable decision makers to look at detailed data relative to climate indicators, the discrepancies of those indicators through time and the possible impact of climate change at local level as well as on economics, society, and the environment.

Within this framework, the report on National circumstances is based on five main axes:

1- **The first axis:** contains a presentation on the governmental structure of Syria including Central Administration, Local Administration, and the Environmental Institutional Framework in Syria.

2- **The second axis:** includes a presentation on the crucial demographic indicators, i.e. population growth and density and urbanization.

3- **The third axis:** includes a detailed presentation of the natural facts of the Syrian Arab Republic including landscapes, land, water resources…etc.

4- **The fourth axis:** studies the Syria’s climate and the contrasts between regions, in addition to a presentation of the most important climatic phenomena observed, including heat and cold waves. In addition to this, one can find an analysis of actual rainfall, its temporal and spatial trends and changes observed in the climatic system in Syria (including drought and desertification).

5- **The fifth axis:** an integral study of the most important productive sectors of economic activity in Syria and their contribution to GDP including: exports and imports, investment, agriculture, industry, tourism, the labor force, energy, and transport.

This report is based on largely available documentary research on the topic, found in international reports and reliable scientific articles on climate change. Discussions took place with competent experts working in fields related to climate change.

This report depends on the efforts and expertise of an entire multi-disciplinary team; it also bases itself on policies of planning and sustainable development, economic analysis, meteorology and Geographic Information Systems (GIS). This report offers a road map for the other chapters and paves the way for the application of decisional analytic frameworks in order to evaluate adaptive capacity.

1.2. Governmental Structure

The Governmental structure in the Syrian Arab Republic depends on two integral Administrative levels, central and local:

1.2.1. The Central Administration

Composed of:

- **The Judiciary authority**: this is an independent authority; the president of the republic guaranties its autonomy, with the assembly of higher magistrates' assistance.
- **The Legislative authority**: it includes a parliament elected by direct suffrage according to electoral laws. The period of each electoral mandate is limited to four years; the number of MPs is 250. They work on legislation.
- **The Executive**: represented by a prime minister and composed of the president, the prime minister, his deputies and the ministers. This authority takes charge of applying laws and decrees and observes the work of governmental organisms and institutions.

1.2.2. Local Administration

Syria is administratively divided into 14 governorates ("Mohafazat"), each different in terms of surface, resources and population. Each "Mohafaza" is generally divided into districts ("Manatiq"), and each "Mantiqa" is further divided into smaller administrative units called "Nawahi", and each "Nahia" covers a number of villages, many surrounding farms are related to the village, the smallest administrative unit. The "Mohafaza" is headed by a Governor (the "Mohafez"). A "Mantiqa" is headed by a "Moudir el-Mantiqa". A "Nahia" is headed by a "Mudir el-Nahia", and the village is represented by the "Mokhtar", meaning the village headman.

1.2.3. Institutional Framework for the Environment in Syria

The responsibility for dealing with the main environmental issues in Syria lies with the missions of the Ministry of State for Environment Affairs (MSEA). These bear a direct responsibility in providing the legislative framework or the institutional support necessary for any environmental work. The Syrian Arab Republic was the first Arab country to establish such an independent environmental ministry and to incorporate environmental aspects into development planning. In addition, an inter-ministerial body, the Council for the Protection of the Environment, was established with the objective of setting national policy and coordinating environmental activities.
The SMEA is responsible for applying environmental law in all of its aspects, according to the international environmental agreements followed by the Syrian Arab Republic, through national coordination with those agreements and with the Framework Convention for Climate Change. The SMEA contains nine central directorates, and there are 14 environmental directorates in fourteen governorates in charge of implementing and enforcing adopted environmental policies at local level..

1.3. Population Indicators

Social affairs have an important role in the socioeconomic development plans and Syria has gone through important phases in sustainable development.

1.3.1. Population Growth

Syria has witnessed a rapid population growth in the twentieth century. The number of people actually living in Syrian Arab Republic was estimated to 19.172 million in mid-2007. A doubling of the number of people has been recorded once from 1922 to 2006, with an average increase in annual number by 222.82 thousand. The annual population growth rates diverged in the last fifty years to various degrees; in the 1970s, the population growth rate reached 3.35%, whereas it attained 3.3% in 1991-1994.

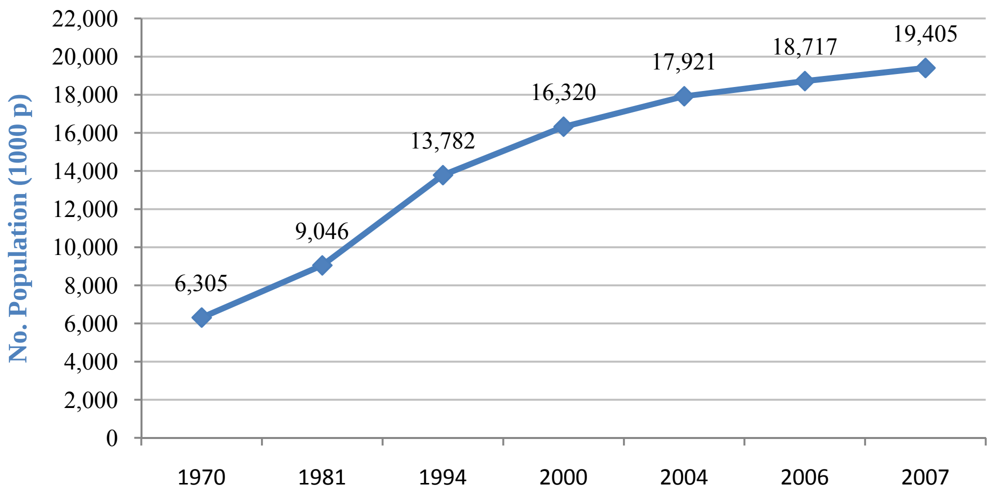


Fig. 1.1 Annual Population Increase in Syria (in thousands of people).
Source: *Statistical Abstract*

In the 1980s and the beginning of the 1990s, there was also an noticeable decline in the population growth rate: this process began with the reduction in the rate of global fertility from 8 children for one women in the 1960s and 1970s to 3.7 children in 2004. Data indicate a tangible reduction in the rate of natural population increase during the 1995-2000 interval, moreover it reached 2.7 from 2000 to 2005 (this figure is continuing to decrease to 2.4).

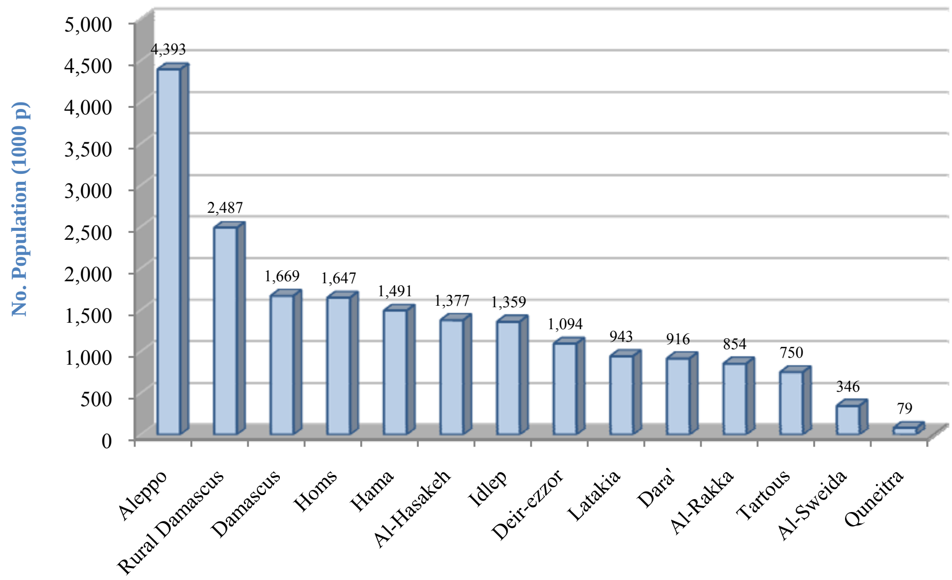


Fig. 1.2 Distribution of Population in Syrian Governorates.

1.3.2. Urbanization

Urbanization percentages increased remarkably at national level; the percentage of urban population increased from 43.5% in the 1970s to 49.8% in the 1990s, reaching 53.5% in 2007. Those percentages differ among governorates varying from 100% in the capital city of Damascus to 0% in the governorate of Quneitra. This increase in the degree of urbanization in Syria was accompanied by a doubling of population figures in the main big cities like Damascus, Greater Damascus, Aleppo, Homs and Lattakia. This led to an increase of indicators of non-sustainable development in Syrian governorates.

1.3.3. Population Density

Population increase was accompanied by a remarkable increase in population density in most governorates between 1970 and 2007: average population density was 34 inhabitants/km^2 in 1970 and increased to 49 inhabitants/km^2 in 1981. This rise continued and a density of 74 inhabitants /km^2 was reached in 1994 and 102 inhabitants/km^2 in 2007. As clarified in figure 1.3, there is a clear disparity in the levels of population density from one governorate to another, since the highest density was noted in the Damascus governorate, with 7,090 inhabitants/km^2 in 1970 and with the very high figure of 13,152 inhabitants/km^2 in Damascus in 2006. By contrast population density declined to 30 inhabitants/km^2 in the Deir-ez-Zor governorate, located on the Euphrates river, the largest source of water in Syria. The governorates of Lattakia and Tartous also registered high densities reaching 383 inhabitants/km^2 in Lattakia, and 376 inhabitants/km^2 in Tartous.

One should emphasize that these population densities are not compatible with available natural resources.

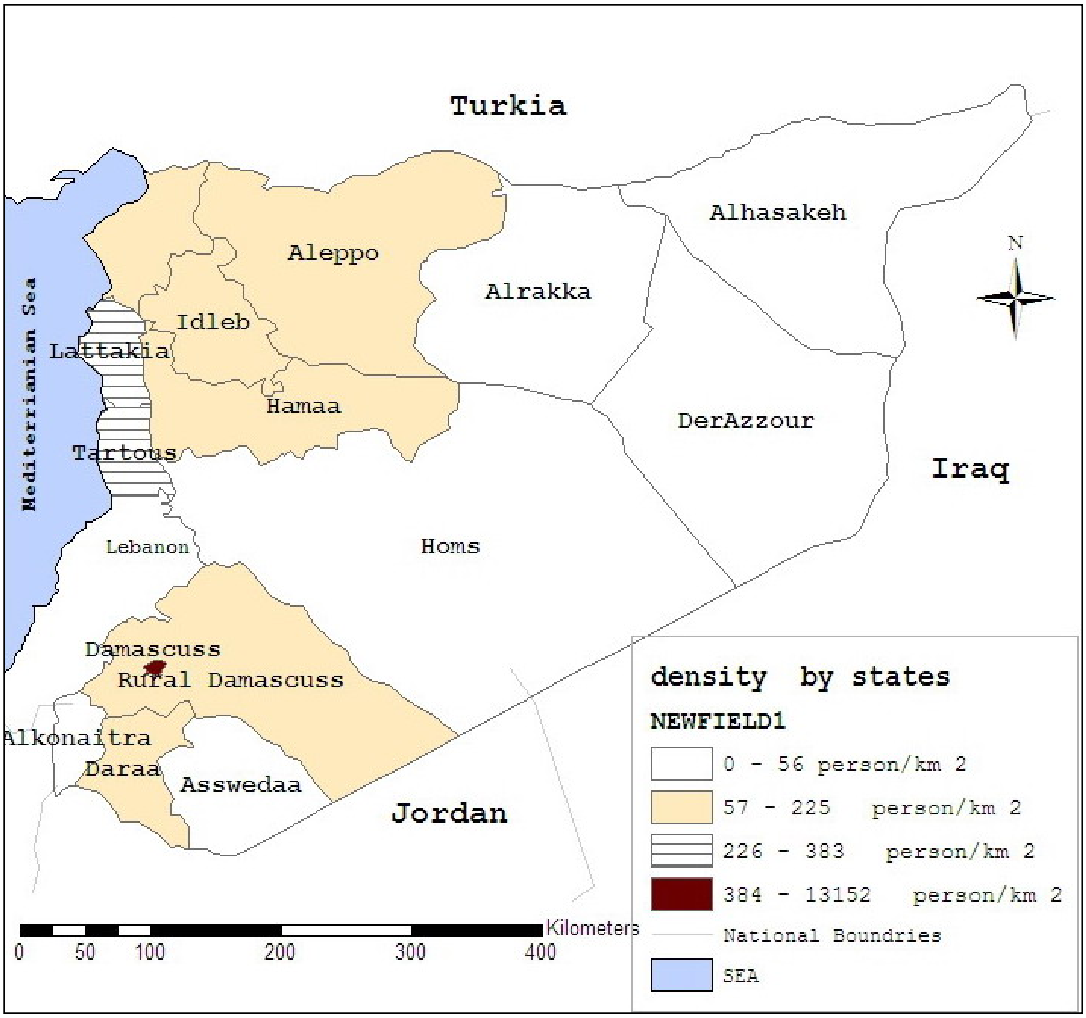


Fig. 1.3 Main Governorates and Population Density in the Syrian Arab Republic

1.4. Facts and Statistics

1.4.1. Syria and its Geographical Location

The Syrian Arab Republic lies in western Asia, on the eastern shores of the Mediterranean Sea between latitudes 32º 19 and 37º 25 degrees north, and longitudes 35º 43´ and 42º 25´ east. Syria is bordered in the north by Turkey, in the east by Iraq, in the south by Jordan and Palestine, and in the west by Lebanon and the Mediterranean.

Fig. 1.4 Geographical Location of Syria.

1.4.2. Mountains and Plains

The Syrian Arab Republic's total area is 18,517,971 hectares, of which 6 million hectares consist of cultivated land, the remainder being steppe and rocky mountains. The Syrian steppe land is suitable for sheep and camel grazing, especially when rainfall is sufficient. Geographically, Syria may be divided into four regions:

- **The coastal region**: it lies between the mountains and the Mediterranean.
- **The mountainous regions**: they run from the north to the south of the country and include all mountains and hills parallel to the Mediterranean Sea.
- **The interior or plains region**: It includes the plains of Damascus, Homs, Hama, Aleppo, Hassakeh and Dera'a. All these plains are situated to the east of the mountainous region.
- **The desert region**: it consists of the desert plains situated in the southeastern part of the country, along the Jordanian and Iraqi borders.[1]

1.4.3. Geology

The geological components with a direct impact on soil structure and agricultural production are:

[1] Statistical abstract 2007, p. 15.

✓ **The newly-formed basaltic Rocks**: they cover the west of the country, in particular the Hawran plain, where the area overlain by this type of nude superficial geology covers over 4,200 Km^2, reducing the area of agricultural land.

✓ **Gypsum rocks**: they overlie soil in the Jazira region and in the northern part of the Syrian Desert.

✓ **Overlying geological sand on the surface**: in particular in the region of the Al-Bishri Mountains, related to wind erosion and the formation of drifting sands.

1.4.4 Land Use

Steppe lands make up most of Syria and have the driest climate, while forests are limited to the coastal ranges. The balance of land use differs from one year to another, depending on annual agricultural production plans, climate conditions, the farmers' response to governmental policies and the market. It is possible to classify land use into four groups, according to figure 1.5:

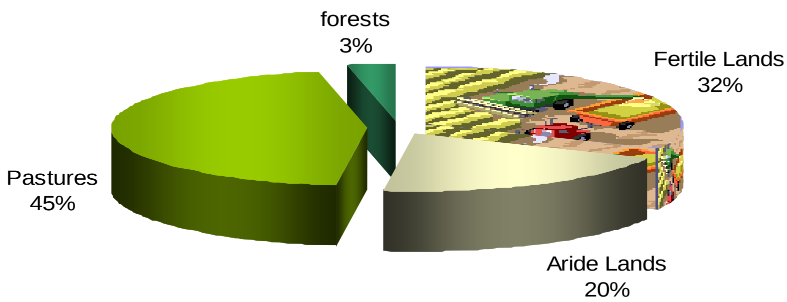


Fig. 1.5 land-use in Syria (Urban areas statistic are not available).[2]

1.4.5. Water Resources

Water resources in Syria are limited. They are not homogeneously distributed in relation to population, which submits these resources to high pressures. According to the Tenth Five-Year Plan, the total of surface and ground water resources was estimated to approximately 15 billion cubic meters, ten of which are surface water and five are groundwater. Table 1-1 gives an overview of surface and ground water resources according to the 2007 study of water balance by the General Commission for Water Resources.

Table 1.1 Average Water Resources in Syria according to the Water Balance in 2007

Hydrologic Basin	Surface Area (km^2)	Surface Inside the calculations of water balance	Average Annual Precipitation	
			mm	Million m3
Barada & Awaj	8630	8630	275	1,691
Orontes	21,634	18,362	415	5,545
Coastal	5,049	5,049	1,147	4,206
Tigris and Habour	21,129	21,129	279	5,937
Euphrates & Aleppo	51,238	51,238	217	10,094
Yarmouk	6,724	5,764	318	1718

[2] MOLAE, UNDP, World Bank, National Environmental Strategy and Action Plan for Syria, 2003, p.19.

Al Badia (the steppe)	70786	70786	141	9910
Total	185180	180958	2752	39101

Source: General Commission for Water Resources.

In spite of the availability of those basins, the average use of total water is around 18 billion cubic meters, with consequently an annual deficit in the water balance of about 3 billiard cubic meters. This deficit clearly appears in the Barada and Al-Awaj drainages, as well as in the Tigris and Habour Basins. This deficit is linked mainly to annual increase in water use in different sectors, far above the renewal rate of water. Syria is therefore categorized as one of the poor countries in water resources, according to the universal classification which considers the limit of water poverty to be 1000 cubic meters per person per year[3]. The water resources in Syria are distributed among seven water basins.

In fact, the acceleration of ground water depletion has been paralleled with the lack of a water-use policy and the non-renewal of ground resources in most regions of the country. This is shown by the decrease of groundwater levels in many areas. The Euphrates, Aleppo-Queiq, Tigris and Habour basins possess a relative surplus of ground water, but available quantities are limited and can hardly satisfy development requirements on a prospective scale. While the coastal basin is blessed with a relatively large surplus, it is not available for general use. Moreover one has to stress the future needs for this region in terms of agricultural development, tourism, and industry. Most water resources in the other basins have been depleted, except that of the Badia (steppe).

The agricultural sector consumes around 90% of water resources, while around 8% are used for drinking purposes and 2% for the industrial sector. The actual calculated amount of water resources per person in Syria is around 1,000 cubic meters a year, and this amount is decreasing with the population growth. The data from the Ministry of Agriculture explains the decrease in the quota of available water per person to a rate inferior to the limit of water deficiency in all years, since it plummeted from 1,015 cubic meters to 747 cubic meters a year, and reached in periods of drought 577 cubic meters a year. The reports indicate that around 1,160 million cubic meters of drinking water were available in 2004, but the main challenge resides in the amount of water lost, varying between 16% and 46%. As shown by statistics, groundwater provided 92% of drinking water in 2004. Average daily water consumption ranged between 60 and 150 liters per person.

The analysis of the quality of water indicates pollution of some sources of surface and groundwater with industrial and wastewater. Despite construction of many sewage networks in many cities and towns, there is considerable lack of water treatment plants. The length of the sewage networks reached approximately 18,300 Km; the percentage of population serviced by sewage networks attained about 95% in urban areas and as low as 46% in rural ones in 2004. The quantity of people serviced by sewage network plants was estimated to be 24% (in 2004)[4].

[3] Tenth Five-Year Plan for economic and social development 2006-2011, Chapter Seven, "Agriculture and Irrigation Sector" p. 337.

[4] Tenth Five-Year Plan for economic and social development 2006-2011, Chapter Seven, "Agriculture and Irrigation Sector".

Water resources are bound to be depleted in most water basins in the near future, since statistics indicate the presence of a water deficit estimated to an annual average of 1,727 million cubic meters; this deficit actually reached 3,125 billion cubic meters, due to the increase in consumption of non-renewable water resources and population increase, economic development, accompanied with diminished, less varied and more unevenly distributed precipitations. The results of this deficit are a depression of groundwater levels, the drying-up of some springs and even the recession of some rivers. (*cf.* 1.5.6. Biodiversity).

1.4.6 Flora and Fauna

A national study of biodiversity revealed the existence of 7,140 plant animal species in Syria inside its diverse ecological systems, these being distinguished by various topographic and climate features, such as coasts, mountains, peaks, arid and humid regions, forests, sea, land and desert.[5] Moreover the study of the natural plant cover makes it clear that Syrian flora contains more than three thousand species of flowering plants (precisely 3,150); the fauna comprises more than 2,500 species.[6]

Flora

The Syrian flora contains 22 species of Ptyeridophytes. These are found in cold and humid regions, and most of these species are threatened by extinction as a result of agricultural expansion. In addition, Syrian flora includes 12 species of Gymnosperms menaced by the diminution of the forest cover as a result of agricultural activity, grazing, fires and population expansion, especially in mountains ranges. There are 3,077 species of flowering plants belonging to the Angiosperm class; these are found in mountainous regions as the Hermon and Anti-Lebanon, the Coastal Range and in mountains of inland Syria). Syria is considered the source of many agricultural subsistence plants such as wheat, barley, lentils, almonds, olives, as well as many medicinal, aromatic and ornamental, plants and trees.

Fauna

The National Strategy for Biodiversity indicates that there are more than 3,000 animal species in Syria, including terrestrial and aquatic animals. Approximately 360 kinds of birds have been registered, of which 143 kinds are migrating stopping in Syria for reproduction. The number of species of threatened migratory birds flying to Syria is 15. There are 124 mammal species, of which 24 are carnivores, 7 insects, 25 bats and 42 rats. As for amphibians and reptiles, the study recorded 127 species, including nine of turtles, 70 of reptiles and 48 of snakes. However, as a consequence of natural habitat destruction, population growth and associated human activities, urban development as well as agricultural expansion, many categories of biological and genetic resources have been depleted.[7]

[5] State Ministry for Environmental Affairs, UNDP, GEF Natural Resources Management - Biodiversity Unit, "Prominent Flora And Fauna Species Of Syria", 2001.

[6] State Ministry for Environmental Affairs, UNDP, GEF, "National Biodiversity Strategy and Action Plan", 2000, p.4.

[7] SMEA, UNDP, World Bank, "National Environmental Strategy and Action Plan of Syria", 2003, p.43.

1.4.7. Forests

Syria is considered a poor country in terms of forests, which cover only 3% of the total land area. Historically documented information shows that Syria was covered with forests and trees extended from the Mediterranean to the limit of Syrian Badia, constituting over 32% of land at the beginning of the last century. The orchards of Damascus are a clear example of a forested area receding from 3,000 hectares to a few hundred hectares. There has also been a decrease in the wooded areas of the Jebel Abdel Aziz, Abou Rajmein, and Balaas mountains, which were in the past ecosystems rich in ecological biodiversity.

The government has realized the importance of forests as important resources and established forested reservations and sanctuaries. The forested areas increased to 253 thousand hectares (with an estimated increase of 100 thousand hectare from the beginning of the 1950s until the end of 2003). The area of protected forests reached about 166,121 hectares by 2005, equivalent to 35% of the total surface of natural and artificial forest. The ministry of agriculture is running a project for forest protection and fire fighting to limit the spread of natural and artificial fires and to prevent the transgression on lands and forested areas.[8]

1.5. Climate

The climate in Syria is Mediterranean, characterized by cold and rainy winters and hot and dry summers. The two main seasons are separated by relatively two short transitional ones: spring and autumn. During winter, temperatures are moderate to cold, though frost can form in mountains during the night. Rain isohyets are between 100 and 1,400 mm/year. In summer, temperatures rise to more than 30 °C in most regions and at times can go above 40 °C. The weather during this season is usually very dry, with a high evaporation level. In winter, Syria is under the influence of two anticyclones whose centres are located in Siberia and in the Mediterranean Sea. In summer however Syria is under the influence of high pressure coming from the Arabian Gulf, the Red Sea and North Africa.

The study of climate shows significant modifications in average annual precipitation during both the winter and autumn seasons. Winter precipitations have decreased during the last five decades in the northern and northeastern zones of Syria. Autumn precipitations, on the other hand, have increased in the northern and central regions. The reasons behind those changes are not well understood.

The same data show that there is a general tendency for lower temperatures during winters, especially in the coastal region and the western sector of inland Syria. The same trend has been observed during springs and autumns. Summer temperatures have been shown to increase in coastal areas.

Table 1-2 shows a few climate statistics from some stations, representing the climate zones in Syria. The standard averages are for 1961–1990.

[8] The status of nutrition and agriculture 2005, Centre of Agricultural Policy.

Table 1.2 Standard Averages of Some Climate Stations in Syria for 1961-1990.

Area	Station Name	Latitude (N)	Longitude (E)	Altitude (m)	Yearly			
					Maximum temperature (°C)	Minimum temperature (°C)	Mean temperature (°C)	Rain (mm)
Coastal Region	Lattakia	35° 36'	35° 46'	9	23	16	19.5	799.2
	Safita	34° 49’	36° 08’	370	22.2	14.5	18.3	1,130.5
	Tartous	34° 52’	35° 53’	5	23.3	15.0	19.1	879.0
Western Inland Syria	Tell Abyad	36° 42’	38° 57’	348	24.8	9.0	16.9	296.7
	Jerablus	36° 49’	38° 00’	351	24.6	10.2	17.4	324.7
	Aleppo	36° 11’	37° 14’	385	23.8	11.0	17.4	330.4
	Almeselmiah	36° 20’	37° 14’	415	23.4	9.5	16.4	332.5
	Idlib	35° 56’	36° 37’	451	22.3	12.6	17.4	505.4
	Hama	35° 07’	36° 24’	305	24.7	10.8	17.7	352.4
	Salamiya	35° 01’	37° 02’	448	24	9.3	16.7	307.6
	Homs	34° 46’	36° 43’	483	22.8	10.7	16.8	435.7
	Damascus, I. A	33° 26’	36° 32’	610	25.0	7.9	16.5	143.7
	Mezzeh	33° 29’	36° 13’	730	24.3	10.3	17.3	204.5
	Kharabo	33° 30’	36° 27’	620	24.7	6.7	15.7	164.0
	Dera'a	32° 36’	36° 07’	543	24.0	10.4	17.2	266.0
South Inland Syria	An-Nabk	34° 01’	36° 44’	1,329	19.2	6.5	12.9	119.6
	Suweida	32° 44	36° 34’	1,015	21.7	9.9	15.8	353.6
Euphrates and Steppe	Palmyra	34° 33	38° 18’	400	25.6	12.2	18.9	136.0
	Deir ez-Zor	35° 17	40° 11’	215	26.6	13.1	19.9	156.3
	Abou Kemal	34° 26’	40° 55’	175	27.5	12.8	20.2	135.0
	Raqqa	35° 54’	38° 59’	246	25.5	11.6	18.5	211.2
	At-Tanf	32° 29’	38° 40’	712	24.8	9.9	17.3	106.6
North-eastern Syria	Qamishli	37° 02’	41° 12’	449	25.1	12.4	18.8	437.0
	Hassake	36° 34’	40° 43’	307	25.7	10.7	18.2	288.8

Source: *Department of Meteorology (Syria).*

1.5.1 Present Situation (Temperature- Relative Humidity-Wind)

The Coastal Area

The coastal area comprises:

- Coastal Plains with altitudes of about 50 –500 m. It is partly hilly (300 –500 m).
- Coastal mountains ("Jibal as-Sahel", 500 –1500 m in elevation).

In general, this area’s climate is moderate, inclined to be dry during summer, relatively cold and rainy during winter in the plains, cold in the mountains and moderate to rainy during transitional seasons.

Temperatures are influenced and moderated by proximity to the sea and by the height of the mountains. The annual average temperature is 18.1 °C on the coastal plain and 15.2 °C in the mountains. The mean maximum temperature in August (the hottest month) is 29.9 °C on the coastal plain and 27.4 °C in the mountains. At some locations in the coastal plains were recorded absolute maximum temperatures of 40.1 – 42 °C.

Winter temperatures are low. The annual mean minimum temperature is 15.4 °C in the coastal plain, and 11.6 °C in the mountains. The mean minimum temperature in January is 8.0 °C on the coastal plain and 4.0 °C in the mountains. Temperatures below zero are normal in these highlands: the recorded absolute minimum temperature was -7.0 °C, but temperatures below zero are rare on the coastal plain, but may sometimes occur for a short while, the absolute minimum temperature ever recorded being -3.4 °C.

In the coastal area relative humidity is high in summer, reaching 73%, and even higher on hot days in the plains. It drops in the mountains by about 8%; its yearly mean is about 67%. Relative humidity (RH) drops to 60% on the plains and increases to about 76% in the mountains during winter. Fog is rare on the plains and its occurrence means that light wind had brought radiation fog.

Northeast to east winds prevail over the coastal plain in winter while southwest to south winds are dominant in other seasons. The annual prevailing wind direction on the coastal plain is southerly. Winds blow from northeast to east over the mountains in winter and are westerly during other seasons, so that the annual prevailing wind direction in the mountains is west. The yearly wind speed is 3.6 m/s on the plains and 3.8 m/s in the mountains.

The Western Inland Area

This area extends east of the coastal mountains and of the borders of Lebanon and Palestine to the west, Jordan to the south. Elevations range from 1000 to 2000 m towards longitude 38° E and reach about 500 m between longitudes 35° N and 37° E. The prevailing climate is dry and hot in summer, cold and rainy in winter and relatively dry during transitional seasons.

Temperatures in this area follow continental norms, with wide daily and seasonal (between summer and winter) ranges. The annual average temperature is 17.4 °C, with a mean maximum temperature in August of 37.7 °C. In the Western inland areas a maximum temperature of 46.3 °C was recorded. Winter temperatures are low; the annual mean minimum temperatures are 11.0 °C and 2.5 °C (in January). Temperatures reach below zero during winter, the recorded absolute minimum temperature being -17.4 °C in the northern part of the area and -13.5 °C in the south.

Relative humidity is high in winter, reaching 75%. It drops in summer to about 49%. Foggy days over the area number 40–60 annually, mostly during December and January.

Local topography plays an important role on prevailing winds, which are western to Northwestern in summer and winter, with increased speed during winter. Wind speed average is 2.9 m/s and on stormy days reaches ≥ 17 m/s (two to ten days annually).

The Mountainous Western Inland Area

This area's topography is more marked than that of other parts of Syria, with higher elevations (of more than 1000 m above sea level). It is bordered by Palestine in the southwest, arid lands (al-Badia) in the east, the Orontes basin in the north and Lebanon in the west. Very cold winters are a feature of this area where snowfall is frequent; summers are dry and moderate, with relatively rainy and cold transitional seasons.

The annual average temperature is 12.8 °C and the mean maximum temperature in August is 30.2 °C. Winter temperatures are low: the annual mean minimum temperature is 5.8 °C and the mean minimum temperature in January is -1.3 °C. Temperatures decrease below zero during all seasons except summer, the recorded absolute minimum temperature being -18.5 °C in winter.

Prevailing winds are western to northwestern in all seasons. The average annual wind speed is 4 m/s, but some mountain ranges opening to the sea have double this average.

The Northeastern Region

This area includes the northeastern parts of Syria, near the 36° N latitude. Turkey borders it to the North and Iraq to the East. The general elevation is about 400 m above sea level and reaches 500–700 m near the Turkish border. Rainy and very cold winters are frequent in this area, with dry moderate to hot summers, and moderate weather with some rain in transitional seasons.

The annual average temperature is 18.6 °C and the mean maximum temperature in July is 40.4 °C. In the northeastern region was recorded an absolute maximum temperature of 49.4 °C. Winter temperatures are low: the annual mean minimum temperature is 11.7 °C and the mean minimum temperature in January is 1.8 °C.

Due to long distances separating the area from sources of humidity and to northern elevations humidity is low, reaching an average of 72% in winter and dropping to about 29% in summer. The annual fog days in the area are less than ten during winter.

Prevailing winds are northwestern in summer (from May to August) and northeastern in other seasons. The average annual wind speed is 2.9 m/s, but it increases to 3.8 m/s in summer.

Arid Lands and the Steppe (Al-Badiah)

This area includes the southeastern part of Syria. It reaches the longitude 38° E to the east, the latitude 36° N in the south and extends eastward to the Iraqi border and southward to Jordan. It is hilly with elevations of about 500–1000 m above sea level. The steppe possesses a continental, hot and dry climate in summer and relatively warm winters with very cold nights, as well as dry transitional seasons.

The annual average temperature is 19.9 °C and the mean maximum temperature in July is 39.7 °C. In the area was recorded an absolute maximum temperature of 49.0 °C. Winter temperatures are low; the annual mean minimum temperature is 13.0 °C, the mean minimum temperature in January is 2.5 °C. It decreases to less than zero during winter and the beginning of spring, the absolute minimum temperature recorded being -11.5 °C.

Relative humidity is low, reaching an average of 71% in winter and dropping in summer to about 31%. Fog forms over some parts of the region, but does not last beyond a few days or hours a year.

Prevailing winds are northern to northwestern in summer, and western and eastern to northeastern in other seasons. The average wind speed is 3.3 m/s.

1.5.2. Recorded Temperatures

In the past fifty years a change in average temperatures has been recorded. Average temperatures were higher than normal ones recorded during the years 1959–1969. This was followed by a relatively cold period (1970 –1994). The standard deviations in temperatures have since then tended to decrease, with increases in temperatures during 1995-2000. Temperatures have apparently been increasing abnormally between 2000 and 2005. The rise in temperatures during the period 1955–2005 was around 0.6 °C, (±0.16 °C). Figure 1.6 shows annual temperature deviations from the standard average for stations representative of climate areas in Syria, during the years 1955–2005. The vertical axes represents mean temperature deviations for each year from the standard average, for the interval 1961–1990, the horizontal axes represents the observed years of temperatures, the bars represent each year's deviation from the standard average. The bottom line represents the general direction of temperature deviations. The black line represents the average trend for each period of five years.

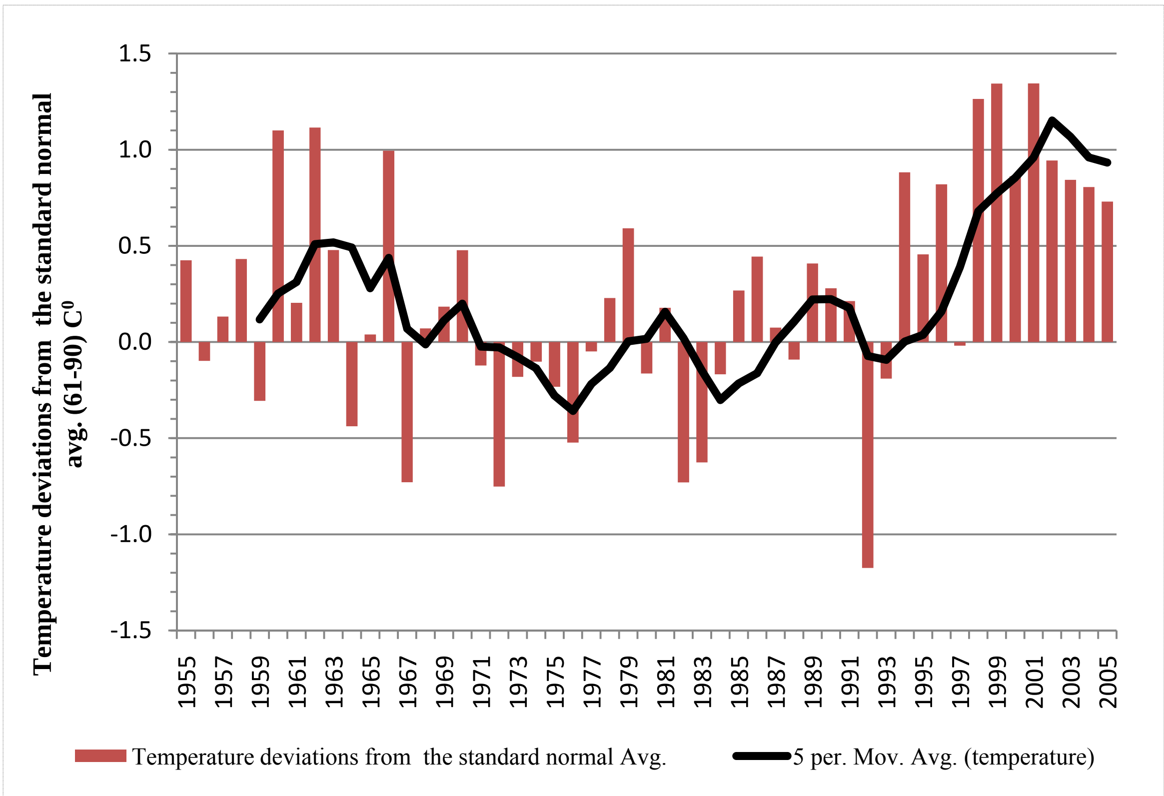


Fig. 1.6 Mean Annual Temperature Deviations from the Standard Average for Stations Representative of Syria's Climate Zones during the Years 1955–2005

Heat Waves

Syria is exposed to heat waves during summer and spring, when temperatures increase by about 5 °C above monthly average. These waves may be divided into: moderate heat waves where the temperature increases by 5-7 °C, and severe waves when the increase reaches 8-10 °C above average. It is known that these waves influence general health: there is a relationship between heat waves and the number of deaths per day during the same period.

Cold Freezing Waves

Syria is exposed to cold waves, especially during winter and occasionally during transitional seasons, when temperatures decrease to zero or below. The number of frost occurrences differs from year to year. Radiation frost occurs during spring. Frost waves occurred in 1950, 1985, 2004, and 2008.

1.5.3. Precipitations and Evaporation

Many factors affect the quantity and distribution of annual, seasonal and monthly precipitations in Syria. Precipitations increase at the foot of western mountains and exceed 1,000 mm *p.a.* (per annum) as a result of proximity to the sea and to topography. They diminish to less than 100 mm in the southeastern corner of Syria (Al-Badia). The wet season starts in September in the coastal area and lasts until the end of May. Table 1.3 shows the annual precipitation average for some stations in Syria.

The average of total precipitations in the coastal plain is about 800 mm *per annum* (p.a.), more than 1,200 mm *p.a.* (per annum) in the mountains, about 300-500 mm p.a. in western inland and northeastern areas, above 600 mm in the Golan heights and the western part of the inland mountains, about 100-250 mm and less in the steppe (al-Badia), and 200-250 mm in its marginal zone (transition into dry farming areas). In general, precipitations are associated with thunderstorms during the winter and transitional seasons; the maximum number of days with thunderstorms is in spring, less in autumn and these are rare in August. Snow falls over the coastal mountains, the western inland range, and the northeastern areas, and sometimes a little in most areas of the arid steppe, lasting only a few hours.

Table 1.3 Annual Standard Precipitation Average and Annual Precipitation Amount for Wet and Dry Years for Some Stations in Syria.

Area		Station	Dry Year	Precipitation Amount in Dry Years	Wet year	Precipitation Amount in Wet Years	Precipitation Standard Average 1961 - 1990
Coastal Regions	Plains	Lattakia	1990	356.4	1961	1164.4 mm	799.2 mm
		Tartous	1990	365.4	1963	1364.4 mm	879.0 mm
	Mountains	Safita	1990	513.6	2003	1821.6 mm	1130.5 mm
Inland Western Region	Western Region	Dera‘a	1999	94.0	1971	418.7 mm	266.4 mm
		Qunaitra	-	-	-	-	775.0 mm
		Mezzeh	1989	68.5	1953	408.8 mm	204.5 mm
		Sirghaya	-	-	-	-	549.0 mm
		Damascus Airport	1999	33.3	1979	283.5 mm	144.3 mm

		Kharabo	1995	49.1	1953	307.7 mm	164.0 mm
		Homs	1999	190.0	1967	758.9 mm	435.7 mm
		Hama	1960	126.8	1988	606.0 mm	352.4 mm
		Salamiya	1952	83.1	1967	538.7 mm	307.6 mm
		Jerablus	1973	156.2	1996	545.0 mm	324.7 mm
		Aleppo	1999	91.9	1954	598.5 mm	331.0 mm
		Idlib	1990	254.4	1997	802.2 mm	505.7 mm
		Tell Abyad	1999	77.7	1967	490.8 mm	296.7 mm
		Meselmia	1990	156.8	1968	547.5 mm	332.5 mm
	Mountains	Sweidah	1999	109.2	1967	578.3 mm	358.2 mm
		An-Nebk	1999	34.6	1954	230.0 mm	119.6 mm
Arid Steppe (Al-badia)		At-Tanf	1958	19.4	1961	290.4 mm	106.6 mm
		Palmyra	1999	20.2	1974	285.5 mm	136.0 mm
		Raqqa	1999	41.2	1988	369.7 mm	211.2 mm
		Deir ez-Zor	1999	41.3	1974	300.1 mm	156.3 mm
		Abou Kemal	1960	45.1	1974	322.6 mm	135.2 mm
Northeastern Region		Qamishli	1947	149.6	1963	728.3 mm	437.0 mm
		Hassake	1973	95.5	1963	508.3 mm	288.8 mm

The Difference and Variability of Precipitations in Syria as a Result of both Time and Place

The annual average of precipitations in Syria (300 mm) is low when compared with the world's average (720 mm). Syria may be divided into five agro-climate settlement zones:

- Zone I: Receives an average of rainfall of more than 350 mm. It consists of two sub-zones. The first receives more than 600 mm annually and is where yields of rainfed crops are certain for all the years.
- Zone II: Receives 250-350 mm of precipitations annually. Main crops are wheat, barley and other summer crops. This zone occupies 13.3% of the country's area.
- Zone III: Receives 250 mm precipitation annually. This amount of rainfall is certain for more than 50% of monitored years i.e. 1-2 of 3 years, and production is then secure. Mainly grain crops are grown in this zone has, but legumes can also be harvested. This zone makes up 7.11 % of the country's total area.
- Zone IV (Marginal zone): Receives 200-250 mm of precipitations annually. This amount of rainfall is certain for more than 50% of monitored years. However only barley can be grown, yet the land can be used as permanent pasture. This zone makes up 9.91 % of Syria's total area.

- Zone V: The steppe, which spreads over 55. 1% of the total area of the country and receives less than 200 mm of precipitations annually. These lands are not suitable for rainfed cultivation.

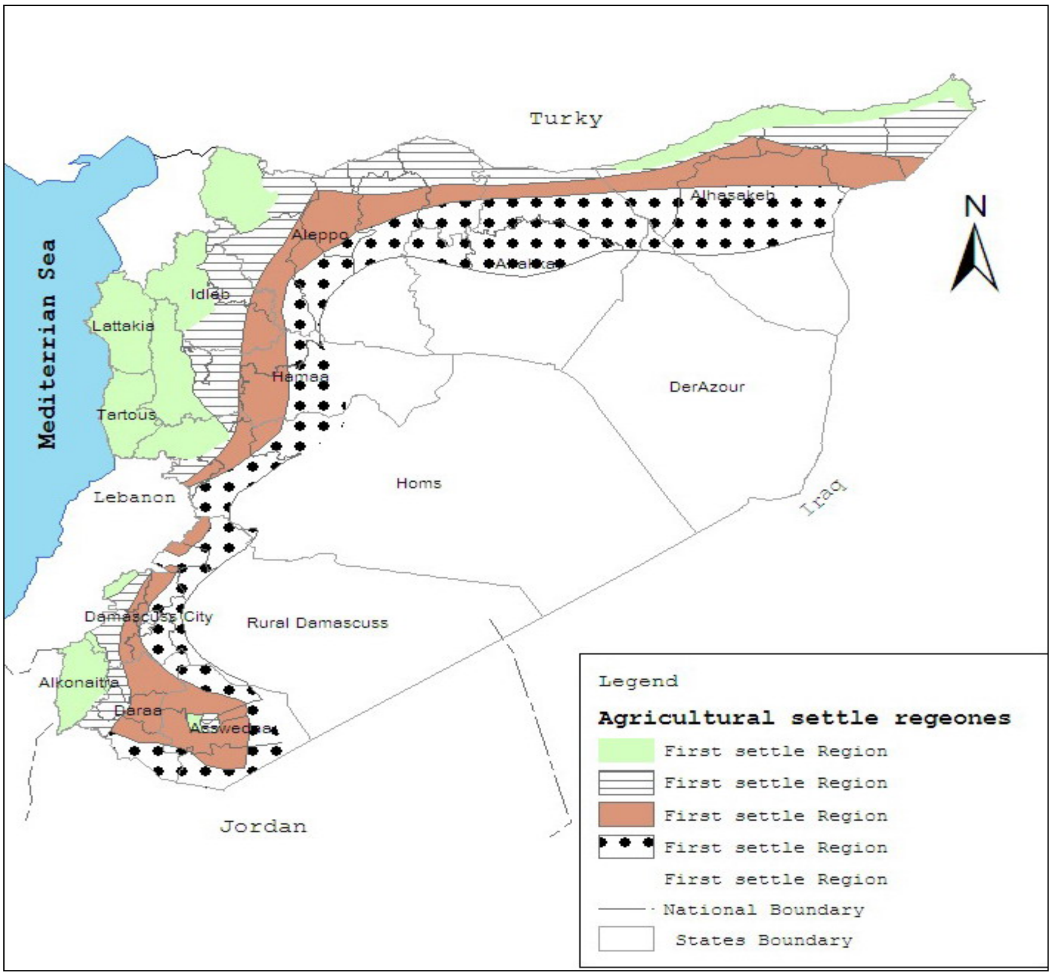


Fig. 1.7 Agricultural Settlement Zones.
Source: *Central Bureau of Statistics, "statistical abstract2007"*

Differences in Precipitations in Syria according to Location

The western, northwestern and furthest northeastern areas receive the largest quantity of rainfall in Syria. On the other hand the southeastern parts of the country are classified as semi-desert. In Table 1-4 the important role of a station's location can be recognized.

Differences in Precipitations in Syria according to Time

This means the difference and variation of precipitations between years and seasons. Amount and distribution of precipitations have a direct impact on agricultural production.

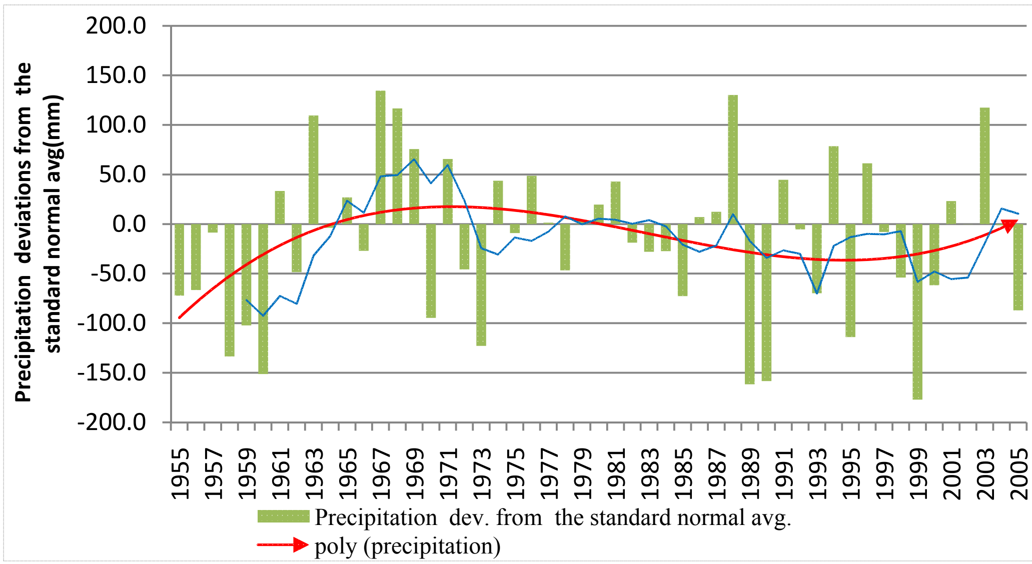


Fig. 1.8 Deviation of Yearly Precipitation Averages from the Standard Normal Average of some Stations Representing Different Areas of Syria.

Table 1.4 Amount of Precipitations for Some Seasons (mm)

Area	Standard Normal Average of Yearly Precipitations 1961-1990	Yearly Precipitations in a Dry Season 1959-1960	Yearly Precipitations in a Wet Season 1987-1988
Aleppo	331	183 mm	506 mm
Hassake	288.8	158 mm	530 mm
Deir ez-Zor	156.0	80 mm	272 mm
Dera'a	266.4	94 mm	306 mm

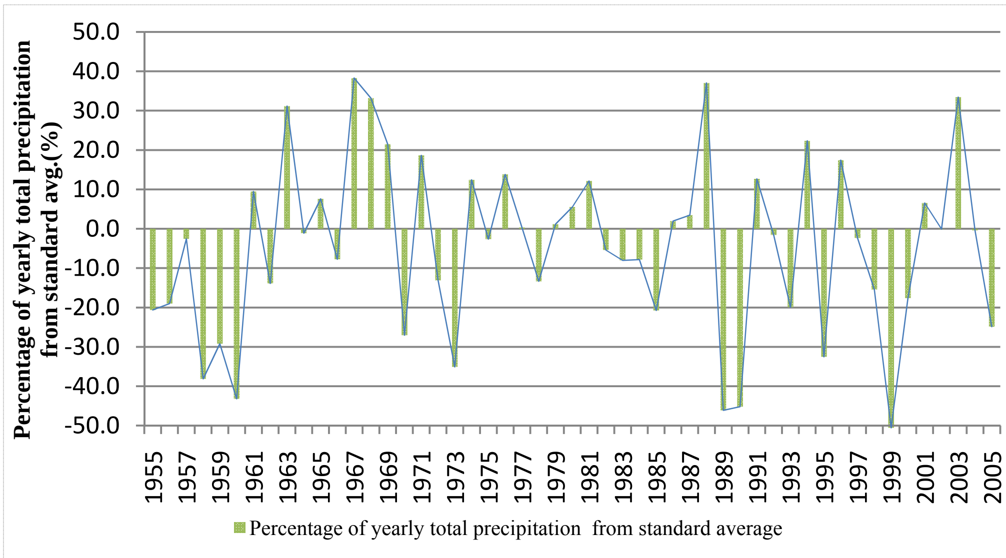


Fig. 1.9 Percentage of Total Annual Precipitations - Deviations from Standard Average 1955-2005.

Evaporation

Syria is characterized by low relative humidity and high temperatures, especially in the eastern area. This increases evapo-transpiration from surface water. Evaporation from surface water along the coast is about 750-1000 mm/year. This average increases eastward to more than 2000 mm/year. Evaporation is about 1200 mm/year on the coast and more than 2600 mm/year in the eastern area.

The Negative Effects of Differences in Precipitation in Syria

Effects of Heavy Rains

Syria is exposed from year to year and from one month to another to very heavy rains exceeding sometimes 50 mm/hour, causing floods with severe damage to humans, livestock, agriculture and resulting in soil degradation. For instance, 31-10-1937 was a major disaster, due to very heavy rain with very strong thunderstorms: very substantial floods in the northeast of Damascus were responsible for the deaths of about 1000 people.[9]

1.5.4. Observed Variables of the Climate System in Syria

Drought (Precipitation Deficiency)

Drought is a complex phenomenon in its effects and results, and is considered one of the main challenges affecting Syria's development. The effects of drought have been observed in different measures in all agricultural, economic and social activities. The United Nations Convention on Desertification Control explained that drought is a natural event happening when annual precipitations are notably less than average, causing unstable hydrology, affecting product recourse or land resource systems. Receiving 68.5% of its available water resources from precipitations, Syria is a drought-prone country, considering other climate characteristics.

The cultivated area in Syria totaled 59,496.16 km^2 in 2006, about 32.17% of the total area. Most (75%) of cultivated lands are non-irrigated and depend on rain. Precipitations are very important for surface water, rivers, reservoirs, all of which are the main resource of irrigation. The agricultural season of 1998–1999 was very dry; non-irrigated crops were severely affected and agriculture went through its worst dry wave in the last 20 years (Table 1-5).

Table 1.5 Percentage of Actual Yields to Estimated Planned Yields

Percentage of Actual Yields to Estimated Yields 1998-1999	Coastal Area >350	Inland Area 250−350	Grazing Area < 250
Wheat	40%	22%	10%
Barley	56%	47%	12%
Lentils	42%	32%	8%

Table 1.6 shows the normal average of Non-irrigated wheat production is usually about 1609 Kg/Hectare (in the year 1987-1988), while the wheat production was decreased to 432 Kg/Hectare (37%) of the total average in the next year 1988-1989 (dry season).

9 Al-Effandi, "British magazine", volume 44, 1948, p. 31.

Table 1.6 Comparison of Different Yields between Years

Agro. Seasons	Average of Precipitations in mm (30 Stations)	Wheat Kg/Hectare		Barley Kg/hectare
		Non-irrigated	Irrigated	
1987-1988	537.8	1,609	2,903	1,385
1988-1989	266.4	432	2,473	94
1989-1990	203.7	1,083	3,338	310

Desertification

Desertification is defined as soil degradation and the absence or decrease of biological or economic production in affected areas. This happens as a result of land misuse or because of actions detrimental to the environment. Desertification threatens large areas of Syria. The main reasons of desertification are:

- ✓ Water erosion
- ✓ Wind erosion
- ✓ Moving sand hills
- ✓ Salinity
- ✓ Soil pollution
- ✓ Intensive agricultural production
- ✓ Irrational land use
- ✓ Over-exploitation of water resources
- ✓ Degradation of plant cover.

1.6. Economic Indicators

Developmental indicators and statistics issued by the Central Bureau of Statistics reflect the process of economic development recorded in Syria during the last years. They reflect the application of an economical reform program and the gradual and deliberate transfer to a social market economy adapted to the economical and social characteristics of Syria. The year 2000, constituted a major starting point towards modernizing and developing the national economy, in terms of adopting the economic, administrative and social reform on the one hand, and the issuing of several laws and decrees on the other. Present economic policies in Syria seek to reactivate the national economy and change its traditional structure to newly accessible and developed economic fields.

Economic growth rate averaged 5.4% during the period between the 1970s and 2003. It gradually decreased from 9.1% in the 1970s to 0.98% during 1980s, 8.45% and 2.37% during 1990-1996 and 1997-2003, respectively.10 The reason for increased growth rates in the 1970s can be attributed to higher international oil prices, in addition to the huge Arab assistance given to Syria by oil-producing Arab countries in the aftermath of the October 1973 war. While the reasons for decreased growth rates in 1980s were attributed to many external factors, including less assistance from Gulf countries and lower international oil prices, followed by the slowdown in money transfers by Syrian manpower and lesser job

[10] State Planning Commission, "Syrian Total Economy Analysis" Damascus 2005, p. 14.

opportunities in Gulf countries. To these factors must be added the embargo imposed on Syria during the second half of 1980s.

The increase in growth rates between 1990 and 1996 was attributed to the optimistic atmosphere in the region and to the economic open-market policies giving the private sector an opportunity for investment. To this should be added the beginnings of light oil production in Syria. Economic recession was the salient feature of the 1997-2000 period, due to a slump in private investment, the unavailability of a proper investment climate on the one hand and, on the other, applied financial and monetary policies (such as a freeze on salaries and wages), decreased investment expenditure, restrictions on loans and continually high interest rates.

During the period between 2001 and 2003 weak public establishment performance in tandem with a decrease in investment was recorded; in addition most of public expenditure was directed towards replacement and renewal and towards investments not leading to direct results on economical growth in the short term (such as expenditure in health and education). In spite of improvements shown by economical growth rates for 2004-2006, the general trend still shows a decrease, as substantial problems in the economic growth resources remain in spite of apparent improvements in financial investment and operations. These are still below required levels to realize sustained growth rates. In addition, the qualitative aspect is still suffering from problems shown by the limited gains of capital and productivity of other remaining production factors. Hence the profits from the economic development process are still not evenly distributed.

Moreover the Syrian economy is still depending on the extractive industry (oil) and on agriculture and is gradually moving towards a dependence on the financial sector, i.e. insurance and real estate. In addition there is a marked decrease in the importance of transformational industries, electricity and water. In other words, the Syrian economy's dependence is still on revenue sectors more than on human performance. (cf. 1.7.1. Overall Local Production)

Overall local production growth rate in 2000 resulted in an inflation of fixed prices by 8.60% and 5% in 2004 – 2005 – 2006 respectively. The reason for the increased growth rate in 2004 was attributed partly to the huge decrease in overall local production in 2003; i.e. growth rate was 1.1% only during that year, due to the circumstances prevailing in the region (the Anglo-American invasion of Iraq and its consequences). Overall local production therefore recorded an average growth of 6% for the period from 2004 to 2006 and this somehow partly reflects the reforms methodological outcomes adopted by the Syrian government on the macro-level since the millennium's beginning. The government supported and subsidized many policies and procedures in various sectors, especially in the services, funds, insurance and real estate and this was reflected in rising private investment, an increase in consumption and substantial non-oil exports. In 2005 the private sector's share reached 52% of the national economy's total capital, i.e. 157 billion Syrian pounds; it rose to 54% in 2006 (170 billion Syrian pounds). Private consumption also reached 24.3% in 2005 and increased to 26.1% in 2006. On the other hand, Syrian non-oil exports increased from 362 million US dollars in 2000 to 510 million US dollars in 2005.[11]

1.6.1. Structural Composition of Overall Local Production

[11] Gerard Duchene - Osama Noujoum "Syrian Economic Trends Bulletin", First Edition, November 2007, ISMF, p. 46.

Extractive industry (oil, phosphates…) and agriculture form the primary sectors of overall local production, since their contribution in 2000 fixed prices reached 46% in 2003 as opposed to 41% in 1990. The structural composition of overall local production in Syria can be illustrated by 2000 fixed prices (as seen on figure 1.10).

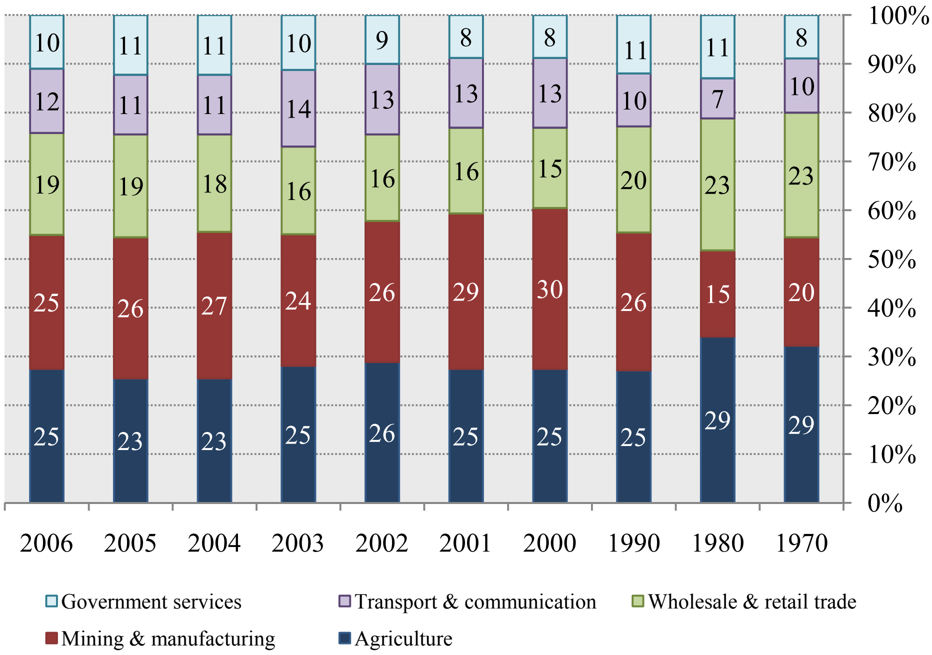


Fig. 1.10 Structural Composition of Overall Local Production in Syria according to Fixed Prices of 2000.
Sources: *The chart was established by using 2007statistics, p. 534-535.*

In fact, the dominance of the agricultural sector on the largest percentage in overall local production explains the different growth rates from one year to another. In effect the difference in agricultural production is due mainly to rains and is often influenced by climate conditions. Additionally the reason for the lower contribution of extractive industries is attributed to a reduction in oil production in general. One can also notice a rising relative importance of the services sector, as a result of new governmental policies which concentrated on increased quantitative expenditure in health, education and public services as from 2001.

1.6.2. Foreign Trade

Syrian exports are limited to a few commodities such as crude oil, which constitutes the most important Syrian product sold outside the country, despite a decrease from 68% in 2000 to 58% in 2005; textiles are the second most important Syrian export, but their share diminished from 6.8% to 5.8% during the 2000-2005 interval. Meat and live animals come third with 3.4%, fruits and vegetables fourth (3%), while raw cotton is fifth with 2.6% (statistics for 2005). Imports to Syria varied compared with its exports, i.e. imports concentrate on metals and their derivatives with 15.5% of imports in 2000 and 13.2% in 2005, followed by equipments and machines (16% and 12.7% of imports during the abovementioned years), while food items are the third main import with 9.5% and means of transport fourth, making up almost 8% of imports.

Decreasing imports can be related to oil derivative imports, representing 17% and 26% of total Syrian imports in respectively 2004 and 2005. This was due to rising oil derivative prices and the increase in the local consumption of these derivatives.

1.6.3. Investment in Syria

Investment projects included in the regulations of law 10 and its amendments[12] consisted of almost 531 projects during 1991-1995. Investment costs exceeded 68 billion Syrian pounds. The transport sector has attracted more than 50% of these projects, with 282 projects and with investments cost amounting to 22.3 billion Syrian pounds, i.e. 32.6% of total costs. The industry sector came second in terms of numbers and first in terms of costs, in the sense that the number of projects in this sector during the aforementioned period reached 238, with a cost exceeding 45 billion Syrian pounds, i.e. 65.9%. The agricultural sector came third with 1.5% of total investment and 1.2% in terms of cost.

Investments included 440 projects with an investment cost of 64 billion Syrian pounds, mostly in the transport and industry sectors during the 1996-2000. The agricultural sector came third in terms of quantity of projects and cost. This situation was similar to that of the period from 2001-2006, with authorized investment reaching 2,684 projects, with a total cost exceeding 941 billion Syrian pounds. There were 1,651 transport sector projects (i.e. 61.5% of total investment) and the investment cost amounted to 64.7 billion Syrian pounds, (i.e. 6.8%). The number of projects in the industry sector was 920 with an investment cost of 672.8 billion Syrian pounds (i.e. 71% in terms of cost). Moreover, the agricultural sector came third with 3.5% in terms of project numbers and 2.9% in terms of cost.

There were 62 foreign direct investment companies in Syria in 2005 and capital accumulation reached 160.6 billion Syrian pounds in 2005. Direct foreign investments constituted 8.07% of overall local production to the national economy (in terms of market price in 2003 and 10.8% in 2005). These investments constituted almost 37% of the national economy's total capital formation in 2003 and it increased to 53% in 2005. These investments were concentrated in transformational industries, finance and agricultural sectors. The food sector came last, due to procedures allowing foreign investment to enter the industry and banking sectors and to encouragements in establishing private banks.

1.6.4. Agriculture

The agricultural sector is one of the most important in the Syrian economy, due to its contribution to overall local production and since it concerns the bulk of the work force and provides food for the population as well as other requirements (manufacturing and export). The average contribution of the agricultural sector to local overall production and with 2000 fixed prices reached 29% between 1970 and 1980, 25% from 1990 to 2005 and 27% in 2007. The percentage of the work force belonging to this sector reached 28.5% in 1999, 17.1% in 2004, 20.1% and 19.5% in 2005-2006.[13]

Since the 1980s Syria was able to become self-sufficient and move from being a food importer to an exporting country for some products and agricultural crops, especially strategic ones such as wheat, barley, cotton, vegetables and fruits. Since the 1970s the surplus of agricultural production (wheat, vegetables and fruits) is exported with a focus on relatively advantageous agricultural and industrial non-oil exports, including olive oil, wheat, animal and plants production, textiles and ready-made clothes.

[12] Numbers and percentages were included according to statistics of the investment bureau (Syrian Investment Commission).

[13] Statistics Central Bureau "Statistical Group in 2007", national accounts chapter, pp. 534-535.

Syrian government has made serious efforts to limit the depletion of natural underground water resources by encouraging farmers to use modern irrigation techniques and making them depend on substitute plants to preserve natural resources and prevent chemical pollution. It has recommended organic agriculture instead of fertilizers, leading to production consistent with sustainable development and a clean environment. The agricultural sector's growth rate reached its maximum limits in 2005 (7%, compared to 2.7% in 2003 and 3.2% in 2004). This can be attributed to increased harvests of fruit trees and the existence of new agricultural areas in production, in addition to the use of bio-protection programs. On the other hand, growth in this sector decreased to 2.2% in 2006,[14] due to increased production requirements above the plan's recommendations, due to decreased imports of seeds and the creation of more poultry farms than those planned. The contribution of the agricultural sector in Syria is considered secondary in terms of gas emissions, when compared to other sectors such as energy and transport.

1.6.5. The Energy Sector

The energy sector in Syria is represented by oil and its derivatives, gas and electricity. This sector is strategic due to its importance for the Syrian economy: it constituted in the 1980s 20% of total overall local production and increased to 26% and 28% in 1990-1995, and reached 27%, 26% and 25% in 2004, 2005 and 2006, respectively.

In fact, oil exports (crude oil and oil derivatives) constituted almost 65% of government income in foreign currency in recent years, and in terms of value oil and its derivatives reached 70% in 2005 of total exports; its national share reached almost 75% in export value. Moreover, this sector contributes also almost 45% of the state treasury funds, under the form of income tax and surpluses. These contributions are related to international oil prices and administrative pricing of derivatives.[15] This situation shows a close connection between the Syrian economy and oil production, exports and their impact on international prices. Due to increased demand on diesel and the need to import huge quantities because of high prices, the contribution of crude oil in the foreign currency balance is bound to decrease significantly.

[14] State Planning Commission. "Analysis of the Macro-Economic Status ", 2003-2006

[15] All numbers and percentages are taken from "an analysis of the *status quo* of the energy sector in 2000-2005, State Planning Commission".

The Oil and Gas Sectors

Oil and gas are considered at present main energy sources in Syria. Geological reserves of all types are estimated to more than 24 billion barrels for oil and 705 billion m^3 of gas. The oil and gas sectors play a vital role in the Syrian economy as they constitute alone one-fifth of local total production; however, this vital role is at present threatened by the availability of oil resources, impeding future self-sufficiency: crude oil production is in effect decreasing.

In fact, the sale of local production of oil and gas has gone up from 355 billion Syrian pounds in 2000 to 500 billion Syrian pounds in 2005. This was a result of fluctuations in oil prices and production. Similarly overall local production in the oil and gas sectors, from 222 billion Syrian pounds to 240 billion Syrian pounds, during the same period has increased. In terms of quantity, oil production reached 25.64 million tons in 2000 and 29.6 million tons in 2005, while its share in national exports decreased from 10 million tons in 2000 to 8.2 million tons in 2005. With the continued slump in production this quantity is bound to decrease.

For gas, surpluses that could be produced are estimated to almost 357 billion m^3. Gas production has developed significantly since 1996, as production has increased from 1.3 billion m^3 to 9.6 billion m^3 at present. The gas sector has witnessed great developments during the last decade: many factories and treatment facilities for natural gas have been created. Moreover a huge network to transport gas from production sites to places of consumption was established. Gas use in generating electrical power has considerably expanded: the quantity of electrical power generated through gas has reached almost 40% of total generated electrical power in 2005.

The Electricity Sector

The electricity sector plays an important role in the Syrian economy, besides its contribution to creating local production and providing direct and indirect job opportunities. This sector meets the Syria's needs in electricity, whether for economic production, commercial activities, the services sector or for home use. Therefore, it contributes to answer social and economical development requirements. Electrical power in Syria is produced in many different ways, including water dams, electro-thermal turbines, gas and steam turbines, installed circuits operated by fuel or natural gas. The total installed capacity of electricity generation system reached about 7,159 MW in 2005 (of which about 6,008 MW was available), while the demand on peak load increased to about 6,000 MW. Besides, the demand in electricity increased by an average of 7.8% during the period 1999-2005.

Providing primary energy resources is one of the most important challenges in Syria. This is due to increased demand on oil and gas resources. The increase reached almost 4.7% per year, concomitant with a gradual decrease in the production of oil. This increase leads to loss of income resulting from the export of oil at present and the necessity to pay the import value of oil derivatives to meet the requirements of electric energy and operate factories. The per capita primary energy consumption in Syria amounts to 1.3 toe/cap, compared to the international average of 1.77 toe/cap (see 1.7.7. The Industrial Sector).

Syria’s industry has developed and undergone modifications, leading to the creation of electronic and chemical industries, as well as an automobile assemblage factories. The contribution of the industrial and mining sectors has varied in total local production, from 20% in 1970 and 15% in 1980, increasing to 26% in 1990-1994, reaching 30% in 2000 and

26% in 2004. It then decreased in 2005–2006. However, the transformational industry sector has achieved a growth of 1.7% in 2005, a much higher figure than that of 2003-2004.[16] This has been attributed to growth in agricultural production, considered as part of the total input in this activity. Also important were support industries and small projects, but the transformational industry sector in Syria could not, during the last three decades, achieve impressive and effective contributions in the country's total production.

1.6.6. The Transport Sector

The transport sector in Syria comes fourth in terms of contributing to overall local production, since it reached 10% in 1970-1990, 13% in 2000-2003, 14% and 15% in 2004-2005.[17] Overall local production in the transport sector reached 103.5 million Syrian pounds in 2005, including 14.3 million Syrian pounds from the public sector and 89.2 million Syrian pounds from the private sector. Moreover the amount of planes taking off from and landing in Syrian airports reached 43,318 in 2006 and 40,383 in 2005, a high figure compared to 31,575 in 2000 and 12,354 in 1985. The number of passengers flying was 2,045,899 in 2000; it increased to 2,835,866 in 2004, reaching 3,485,615 passengers in 2006. On the other hand, the quantity of discharged and loaded goods in the ports of Tartous and Lattakia reached 6,158 thousand discharged tons in 1981 and increased to 5,083 thousand tons in 1994. The quantity discharged in Tartous and Lattakia went up exponentially to 129.9 thousand and 16,651 thousand tons in 2004-2006, while loaded goods during the same years reached 1,472, 1,416, 2,908 and 4,100 thousand tons in both ports.

Rail transport of passengers and goods has increased from 1,680 thousand passengers in 1981 to 1,971 thousand in 1994. It reached 2,303 thousand passengers in 2004 and 2,148 thousand in 2006. Loaded goods increased from 2,881 thousand tons in 1981 to 4,040 thousand tons in 1994. The quantity of these goods increased to 7,232 thousand tons in 2004, reaching 8,752 thousand in 2006. Ships entering and departing Syrian ports of Tartous, Lattakia, Banyas and Arwad were 2,576 in number in 1985, 3,433 in 1994, 7,235 in 2004 and 8,856 in 2006.

The transport and communications sector achieved growth rates of 11.2%, 15.8%, 26.8% and 9.5% in the years 2003, 2004, 2005 and 2006. The reason for this growth in 2005 was attributed to new navigation, air, marine and land lines, improved relations with neighboring countries and tourism. The tenth five-year plan's aims in the transport sector were: increasing the contribution of both the state and the private sector, bringing foreign investment in the transport sector and providing high quality and low cost transport services to encourage transit movement and enhance tourism.

1.6.7. The Tourism Sector

The value of total local production in the tourism sector increased from 12.3 billion Syrian pounds in 2000 to 30.7 in 2006. The sector annually grew by 16.4% in the period between 2000 and 2006. Cumulative investment in hotels and restaurants reached 111.1 billion Syrian pounds in 2000 and increased to 186.1 billion Syrian pounds in 2006, i.e. an average growth of 8.9% during the period of study. One should also note that the value of

[16] State Planning Commission "Analysis of the Macroeconomic Status ", 2003-2006.

[17] Central Bureau of Statistics "Statistical Group in 2007", National Accounts chapter, pp. 534-535.

public sector investments in hotels and restaurants remained stable during this period, reaching 13.1 billion Syrian pounds, while the value of the private sector investments in both activities was of almost 98 billion Syrian pounds in 2000, with an increase to almost 173 billion Syrian pounds in 2006.[18]

1.6.8. Manpower

The agricultural, commercial and services sectors have attracted most of the work force, because of government interest and its policies encouraging the agricultural sector and of the development and growth in both services and trade. The percentage of those who work in the agricultural sector reached 30.3% in 2002 and 19.5% in 2006. The services sector comprised 21% and 26.9% of the active population in the same years. The trade sector comprised 13.7% and 15.6% of the active population in the same years.[19]

Moreover Syria had a work force of 4,859,948 people in 2006: 27.8% were in the public sector, 71.7% in the private one and 0.5% in other sectors. The improved educational background of manpower in Syria should also be emphasized. In 2006 the workforce in Syria included people with the following educational backgrounds: 59.6% were elementary certificate holders, 14.5% had gone to preparatory and vocational schools, 9.7% to secondary schools, 8.7% to intermediate schools, and 7.2% to universities and other institutions of higher education. Manpower in Syria includes, however, unemployed people (121,000 in 1985, which represents 4.7% of the active population); unemployment increased to 206,000 people, i.e. 6%. The number of unemployed reached 290,000 in 1994, i.e. 7.4%; 469,000 in 2000, 548,000 in 2003 and 432,200 in 2006 - 9.5%, 10.7% and 8.1% respectively.[20]

1.6.9. The Handling of Waste

The quantity of municipal waste transported to disposal sites was estimated at around 5,000 tons daily: 90-100% of municipal solid waste was collected in urban areas and 6.4% in rural areas. The study clarified that Syria produced between 3.5-5.5 million tons/daily of municipal solid waste. This was in accordance with the 2002 estimates or equivalent to 10,000-15,000 tons/daily, which reflects a growth in percentage of between 2.5 and 3.5% annually.[21]

Industrial solid waste was removed thanks to means available in municipalities, but as for waste from agricultural activities, the country suffered from the accumulation of around 530 tons of damaged destructive or non-desirable materials. The daily average of municipal waste was estimated to be between 0.4 and 0.8 kg/person/day, with an average of 0.5 kg/person/day. However, in the rural areas, the quantity of waste was thought to be around 0.2-0.3 kg/person/day; nevertheless burning and fires are commonplace. The percentage of recycling and consummation of waste is low, but organic waste is given to farm animals or set aside for compost production at home. The amount of waste collection diverges in Syria. Recent initiatives show an improvement in collecting in some areas. The

[18] State Planning Commission "Analysis of the Status Quo of the Tourism Sector in Syria" and all numbers and percentages.

[19] Syrian Statistical group of 2004, page 90, and 2006, page 89.

[20] Syrian Statistical group of 2001, page 82-83, 2007 page 86-87.

[21] State Ministry for Environmental Affairs, UNDP, the World Bank, " National Environmental Action Plan for the Syrian Arab Republic", 2003, p. 48.

overwhelming majority of collected waste is disposed at open air dumps located in the outskirts of towns; this waste is covered from time to time by soil or is buried, which is the cheapest form of disposal. Most pollution comes from seepage. Except for Deir ez-Zor, no lead was isolated by a hermetic layer at the bottom in order to ensure the protection of natural soils from pollution. Research carried out on some lead in Lattakia, Tartous and Qamishli show the extent of groundwater pollution in those areas.

The burning of waste in the open is quite common in Syria. The negatives effects of open waste dumps are mainly visible in surface pollution and in that of wells, the consequence of seepage which often contains heavy metals like mercury, chrome, nickel, lead, cadmium, copper, and zinc. Most of the lead forms an additional risk because of emissions of gases such as methane, carbon dioxide, complex organic volatile emissions, which are all greenhouse gases contributing effectively to climate change.

CHAPTER 2

Inventory of GHG Emissions

2.1. Introduction

Decision 17/COP8 of the 8th Conference of Parties belonging to UNFCCC states that: "Countries are obliged to communicate every year about their emissions of greenhouse gases (GHG) and their consequences". Countries from non-Annex 1 parties must deliver estimates of their emissions of CO_2, CH_4 and N_2O gases and of their sinks. They are encouraged to present information about HFCs, PFCs and SF_6.

The First GHG inventory for Syria presents emissions of authorized GHG according to COP directives. It also gives an idea on emissions of non-direct GHG such as CO and NMVOC. It also provides statistics on emissions of SO_x. This inventory is essential for carrying out reduction policies and evaluating their results. The GHG inventory also gives information on main sectors of the economy, such as energy, agriculture, industry, transport and waste, which enables dealing with other environmental issues. It also provides data on economic and social development which assist in planning and management.

The GHG inventory considered the year 1994 as benchmark year for calculation, as recommended by COP. The calculations were carried out for the years between 1994 and 2005, in order to evaluate trends and time series of GHG emissions. They were presented within the context of economic and social progress taking place in the country. The calculations can provide a sound basis for evaluating reduction policies and measures. They can also provide a useful tool for developing future scenarios.

2.1.1. Special Institutional Arrangements Concerning the GHG Inventory

The GHG inventory team was established by hiring a team leader and four experts in the fields of energy, industry, agriculture and waste. Each expert was allocated a number of trainees from the Ministry of state for Environment Affairs, Ministry of Electricity, Ministry Of Industry and Ministry of Agriculture and Agrarian Reform. The trainees worked under the supervision of the expert and focused on collecting data and carrying out calculations. Each expert's work was reviewed by the team leader. Four workshops were held to train the trainees on the GHG inventory.

2.1.2. Preparation of GHG Inventory

Data were obtained mainly from the Central Bureau of Statistics and on each sector from the relevant ministries. Information on the energy sector came from the Ministry of Petroleum and Mineral Resources, the Ministry of Electricity, the Ministry of Industry, the Ministry of Transport, the Ministry of Agriculture and of Agrarian Reform and the Ministry of Local Administration. Data for the agricultural sector was collected from the Ministry of Agriculture and Agrarian Reform. Data on waste and municipal and industrial sewage was obtained from the Ministry of Housing, the Ministry of Industry and the Ministry of Local Administration. Information relevant to the industrial sector was obtained from the Ministry of Industry, the Ministry of Economics and the Ministry of Finance. Sector experts were provided with official letters from the State Ministry of the Environment to facilitate their missions.

Great difficulties were encountered, however, in obtaining data, especially since climate change was new to officials working in these sectors. There was a paucity of statistics and information in the energy sector since energy balances for the years 2000-2004 were not available. The same was true for data on HFCs, PFCs and SF_6 consumption in the industrial sector. Data was converted to the form usable by IPCC Guidelines, and local conversion factors were used in some cases such as the calorific values of fuel products. In other cases, factors were chosen from the 1996 guidelines for countries with similar circumstances. Detailed data are presented in tables in the sector reports.

2.1.3. Methodologies and Sources of Data

According to decision 17 / COP8 "Non- Annex 1 countries should prepare the first national INC communication of data about climate change". It should include a GHG inventory. This inventory should adhere to the IPCC 1996 Revised Guidelines established by NGGIP. These Guidelines were followed for all sectors. The GHG inventory included CO_2, CH_4, and N_2O gases. The study used Tier 1 methodology, although it was adjusted in certain cases to suit better local or national circumstances i.e. Tier 2. Default emission factors (DEF) from the Guidelines were used in most cases for similar circumstances. Activity data (AD) were taken from the Central Bureau of Statistics. Other statistics and data were collected from the relevant sources such as the Ministry of Industry, the Ministry of Agriculture and Agrarian Reform, the Ministry of Petroleum and Mineral Resources, the Ministry of Electricity, the Ministry of Housing, the Ministry of Local Administration, the State Ministry of Environment and the International World Energy Agency (IEA). The computer program based on IPCC revised 1996 Guidelines and provided by NGGIP was used for calculations. Moreover, worksheets of the 1996 Guidelines were used. Finally, the relevant tables in the Guidelines were used for reporting.

2.1.4. Key Categories (KC)

Key categories were not analyzed quantitatively because this was the first time in Syria that GHG inventory was carried out. Therefore a qualitative analysis applied to Syria on the key categories in the IPCC 1996 Guidelines. In general most categories in the energy sector were key ones because of the significance of burning fossil fuel and the rapid increase in demand for energy. This also included fumes from the oil industry since Syria is a gas and oil producing and exporting country. Moreover, agricultural enteric fermentation, the fermentation of animal manure and the fertilization of land are key categories. The emissions and sinks from land uses Forests and trees are important key categories in Land Use and Land Use Change and Forest sector (LULUCF).

Solid waste disposal is a key category because of the increase in waste volume caused by large population growth and the lack of suitable waste disposal methods enabling the recovery of methane. Emissions from domestic waste water have increased in quantity because of the construction of waste water treatment units in big cities in Syria over the recent years. Emissions from industrial waste water plants were not significant because of the small scale of industry in Syria compared to industrialized countries and the lack of waste water treatment facilities in industry or their closure for technical reasons. Nevertheless emissions from waste are in general small compared to those of the energy and even the agricultural sector. Cement manufacturing plants and lime production are significant categories contributing to CO_2 emissions; so are the chemical and the metal industries.

2.2. Trends in GHG Emissions

This chapter describes the results of the GHG inventory compilation for the years 1994-2005.

2.2.1. Total Emissions

Total GHG emissions from Syria (excluding the LUCF sector) increased from 52.66 T g CO_2 eq in 1994 to 79.07 T g in the year 2005, as shown by figure 2.1. Total emissions increased steadily from 1994 to 2005 due to: population growth, which averaged 2.5% yearly, steady rise in the standard of living and increased consumption, the growth of economic development (averaging 4 -7 % yearly) and emigration from the countryside to the cities. Nevertheless emissions from energy sources increased more rapidly from 38 T g in 1994 to 58 T g in 2005. This increase was due to a big growth in electricity demand and in transport, which increased rapidly due to the liberalization of the economy and to the reduction of custom duties in 2003-2005. However emissions per unit of energy plummeted due to higher efficiency of industry and its more automatic character, the import of fuel-efficient modern cars and the transfer from fossil fuel oil to natural gas for electricity generation.

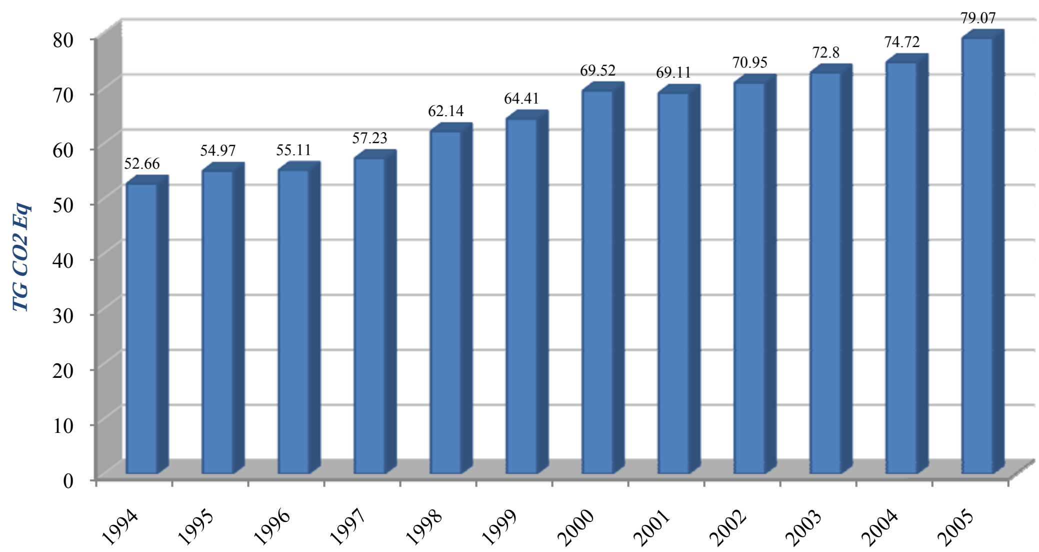


Fig. 2.1 Total Emissions of GHG from 1994 to 2005

2.2.2. Total Emissions by Gas

Figure 2.2 shows the share of each GHG in total emissions. It is clear that the share of CO_2 is the highest: it increased from 68% in 1994 to 74% in 2005, due to the increase in the use of oil and gas for energy (since most CO_2 comes from burning fossil fuels in the energy sector). The share of CH_4 decreased from 18% in 1994 to 13% in 2005, while the share of N_2O decreased from 14% in to 13% during the same period. This could be explained by the high increase in the share of GHG released from electricity generation in total emissions.

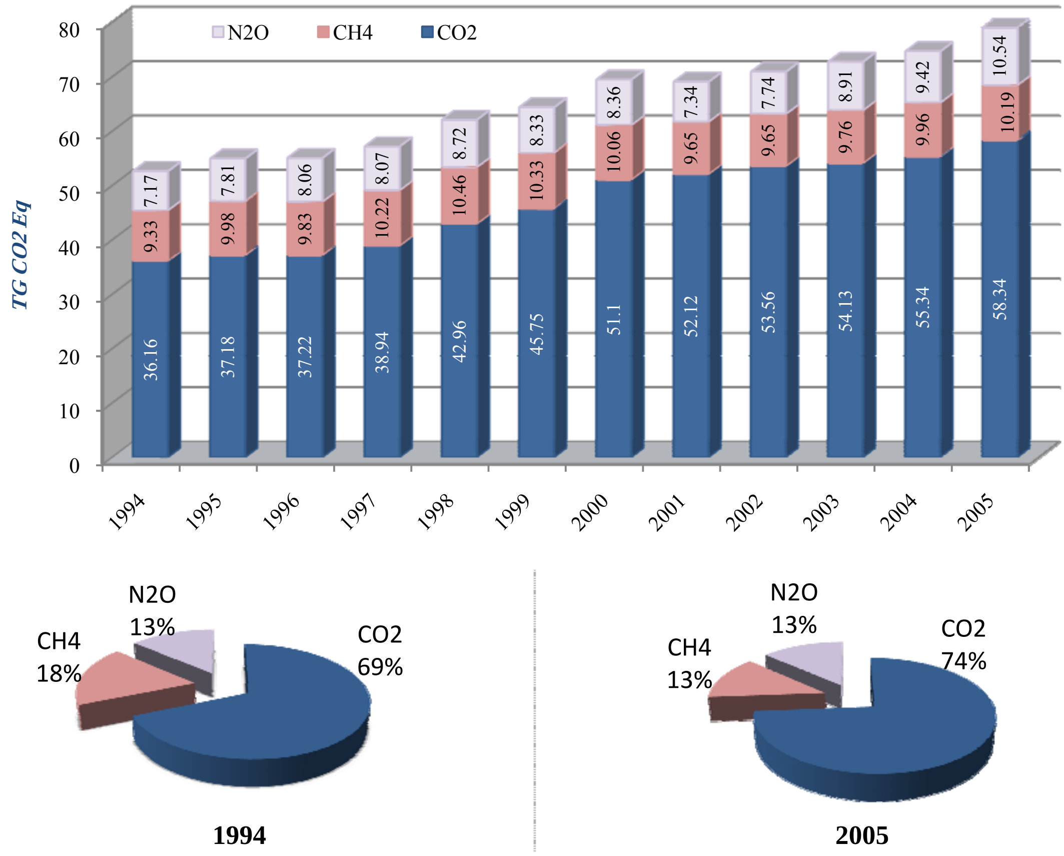


Fig.2.2 Share of each GHG Gas from Total Emissions from 1994 to 2005

2.2.3. Total Emissions by Sector

The share of GHG emissions in key sectors like energy, agriculture (except LUCF), industry and waste are presented in Figure 2.3, which shows that the energy sector is the largest contributor with 72% in 1994 and 73% in 2005. The total emissions of GHG from the energy sector increased from 38.23 k ton/year in 1994 to 58.35 k ton/year in 2005 .Emissions of GHG in agriculture sector increased from 9.47 K ton/year in 1994 to 13.93 k ton/year in 2005. Agriculture's share has remained constant at 18% and likewise that of waste at 5%; industry's share decreased slightly from 5% in 1994 to 4% in 2005. This means that the energy sector has grown the fastest, followed by agriculture and to a lesser extent waste, while the growth of industry has been less substantial.

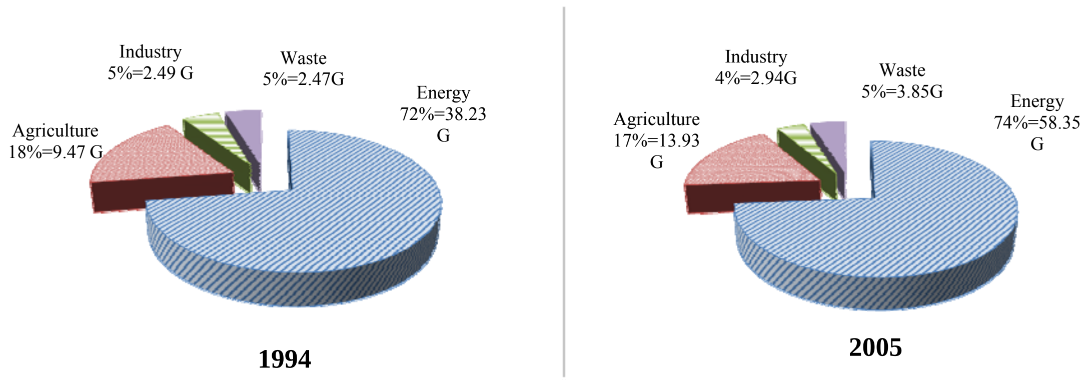


Fig. 2.3 GHG Emissions by Sector in CO_2 eq for the Years 1994 and 2005

Figure 2.4 also shows emissions of GHG for the years 1994-2005 according to sector. It is clear that emissions from the energy sector have risen steadily and fast, while agriculture's share has remained constant; the same can be said of the waste sector, while industry's contribution has slightly increased from 2.49 k ton/year in 1994 to 2.94 k ton/year in 2005 . This slight increase is translated to a decrease in the share of industry in total GHG emissions from 5% to in 1994 to 4% in 2005 as shown in Fig 2.3.

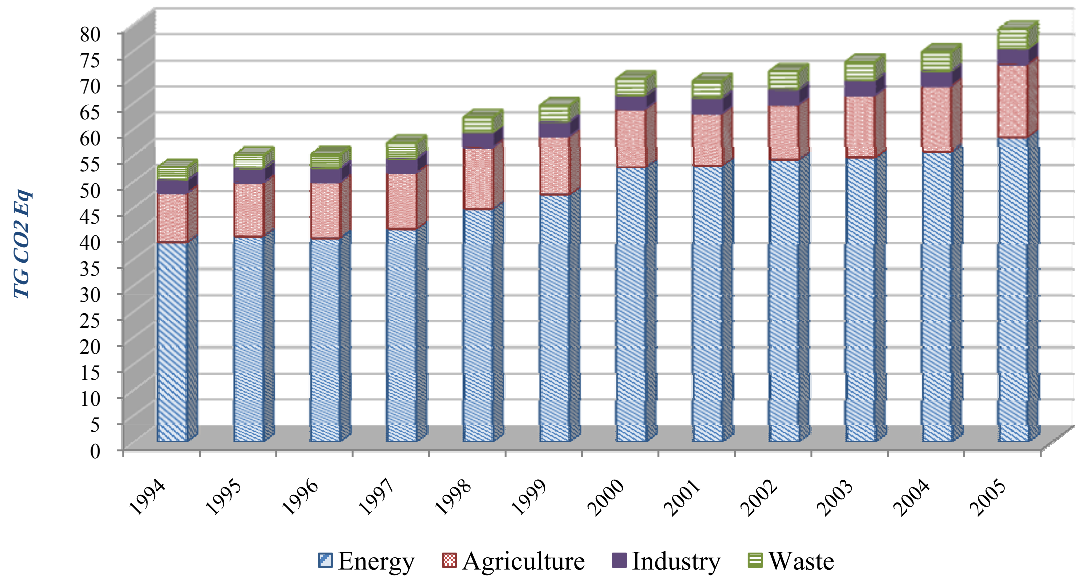


Fig. 2.4 GHG Emissions according to Sector from 1994 to 2005

Table 2.1 presents a comparison of emissions from different countries. Per capita emissions of equivalent CO_2 are around 4.0 ton in Syria for the year 2005 (without taking LUCF into account). It is obvious that emissions per capita in Syria are much less than those of the European Union, 15 or 25 % less than the world average and slightly less than Turkey.[13]

Table 2.1 Indicators of GHG Emissions in Syria and the Rest of the World

Countries	Ton CO_2/ capita Without LULUCF	Tg Co_2 eq Without LULUCF	Ton CO_2/ capita	Tg Co_2 eq
EU-15	10.9	4.180	9.0	3.447
EU-25	11.0	4.925	9.0	4.064
OECD	NA	NA	11.1	12.780
Annex 1	14.7	17.288	12.2	14.289
Non-Annex 1	16.0	13.855	13.4	11.633
World	NA	NA	4.0	24.983
Turkey	4.1	286.3	3.3	231.0
Syria(*)	3.95	79.0	2.85	57.00

(*) The population of Syria is thought to be 20 million.

2.3. Overview of Emissions

2.3.1. Total Emissions

In the year 2005 the share of CO_2 was the largest of GHG emissions in Syria. It reached 74%, while the contribution of CH_4 was 13% and that of N_2O 13% CO_2 eq. Table 2.2 gives the total emissions for 1994 according to each GHG. Table 2.3 shows total emissions of GHG in TG CO_2 eq in four sectors; energy, agriculture, industry and waste.

Table 2.2 Total GHG Emissions by each Gas for 1994

Gas	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
CO_2	36.16	37.18	37.22	38.94	42.96	45.75	51.10	52.12	53.56	54.13	55.34	58.34
CH_4	9.33	9.98	9.83	10.22	10.46	10.33	10.06	9.65	9.65	9.76	9.96	10.19
N_2O	7.17	7.81	8.06	8.07	8.72	8.33	8.36	7.34	7.74	8.91	9.42	10.54

Table 2.3 Total GHG Emissions by Sector for 1994

Sector	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Energy	38.23	39.40	39.06	40.82	44.65	47.40	52.66	52.96	54.13	54.54	55.60	58.35
Agriculture	9.47	10.32	10.70	10.78	11.72	11.04	11.04	9.85	10.38	11.74	12.56	13.93
Industry	2.49	2.71	2.74	2.74	2.81	2.88	2.65	3.04	2.99	2.95	2.86	2.94
Waste	2.47	2.54	2.61	2.88	2.95	3.07	3.16	3.25	3.45	3.57	3.670	3.85

In Syria the majority of GHG gases emitted are CO_2 and originate from the energy sector. This sector caused the emission of 95.137% of all CO_2 gases in 2005.

Electricity generators were responsible for 39% in the same year, while transport represented 22%.

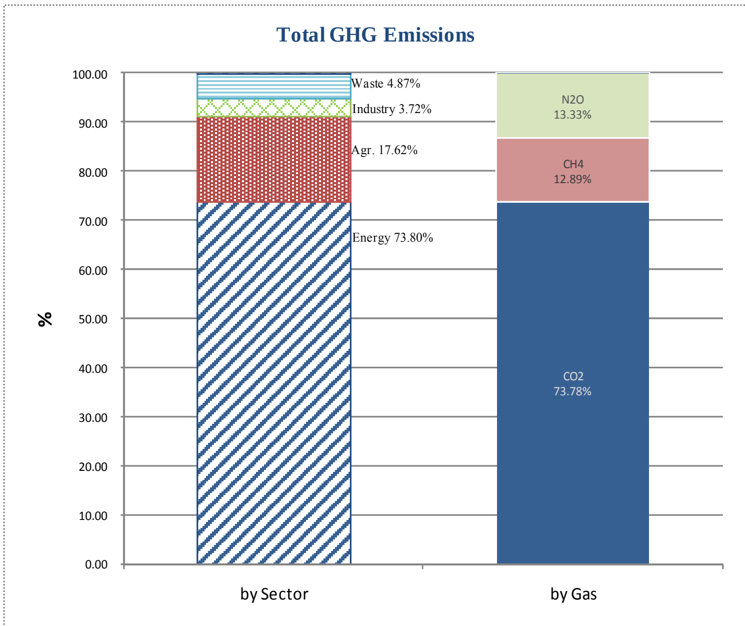


Fig. 2.5 Overview of Total Emissions in 2005 by Gas and Sector

2.3.2. The Energy Sector

Trends in GHG Emissions

Emissions from the energy sector grew steadily from 1994 to 2005, as shown by Figure 2.6. Since the energy balance for the years 2000-2004 was not available, emissions were calculated for these years by using the Reference method only. A comparison was made between the Reference and Sector methods for GHG emissions from the energy sector for the year 2005. It was found that total emissions from the energy sector were 58.35 T g by the sector method and 58.366 T g by the Reference method (after taking into account emissions of CH_4 and N_2O in the Reference method). The difference between both methods was only 0.03%.

Total emissions of GHG in 1994 were estimated to be 38.24 M ton CO_2 eq, with CO_2 representing 89% of total emissions. GHG emissions reached 58.35 M ton CO_2 eq in 2005, with CO_2 constituting 95%. So it achieved an annual growth of 3.9% on average. This growth is less than the growth of demand on primary energy, which increased from 11.7 Mega tons of oil equivalent (Mtoe) to 19.39 (Mtoe) during the same period. Therefore, the emission per capita from the energy sector only decreased from 3.30 ton CO_2 eq /ton equivalent oil to 2.98 ton CO_2 eq /ton during this same period.

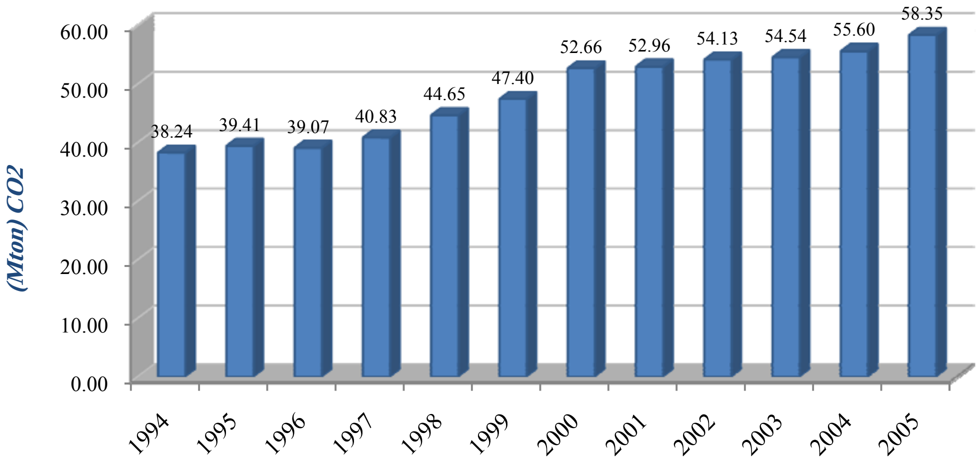


Fig. 2.6 Trends in Total GHG Emissions from the Energy Sector from 1994 to 2005

Emissions of the Energy Sector (by Gas)

Figure 2.7 shows emissions of GHG from the energy sector according to gas. It is quite clear that the share of CO_2 is by far the largest, reaching 89% in 1994 and that CH_4 comes second with 11%, while that of N_2O is negligible. This situation developed due to the increase in oil and gas consumption in electricity generation and transport, as well as energy procurement. The share of CO_2 therefore reached 95% of GHG emissions in 2005, while that of CH_4 was of 4% and N_2O of 1%.

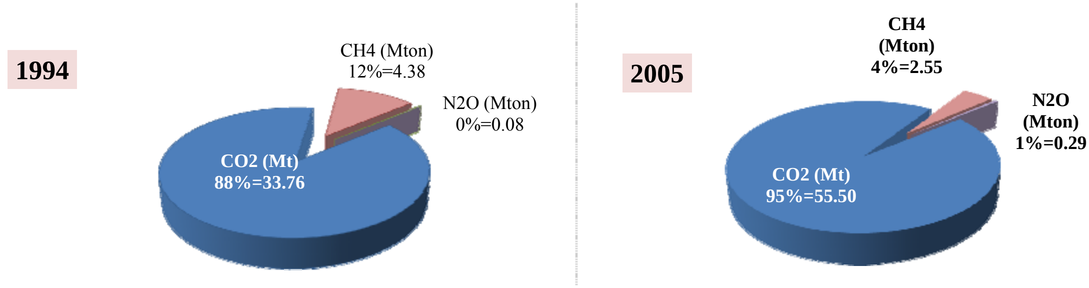
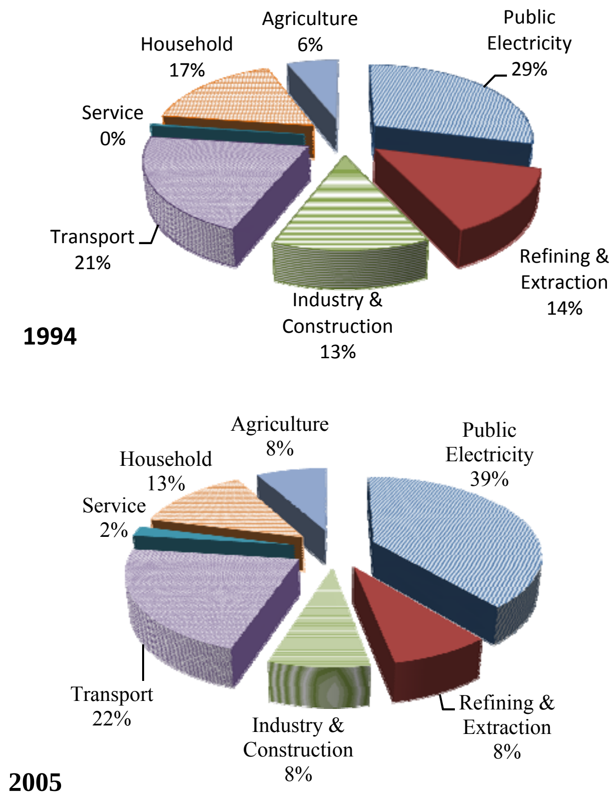


Fig. 2.7. GHG Emissions from the Energy Sector by Gas during the Years 1994 and 2005

Emissions of Energy Sector (by Sector)

Figure 2.8 shows the emissions for the years 1994-2005of GHG in the energy sector for the relevant categories. It is clear that electricity generation is dominant in GHG emissions, with its share increasing from 29% in 1994 to 39% in 2005. This is followed by the transport sector which increased its share from 21% to 22% over the same period. In third position comes the housing sector, with its share diminishing from 17% in 1994 to 14% in 2005. The share of industry and construction has receded from 13% to 8% and the share of oil extraction and industry from 14% to 8% during the same period. The share of electricity generation, transport and oil industry combined, increased from 64% to 77% during the same time gap.



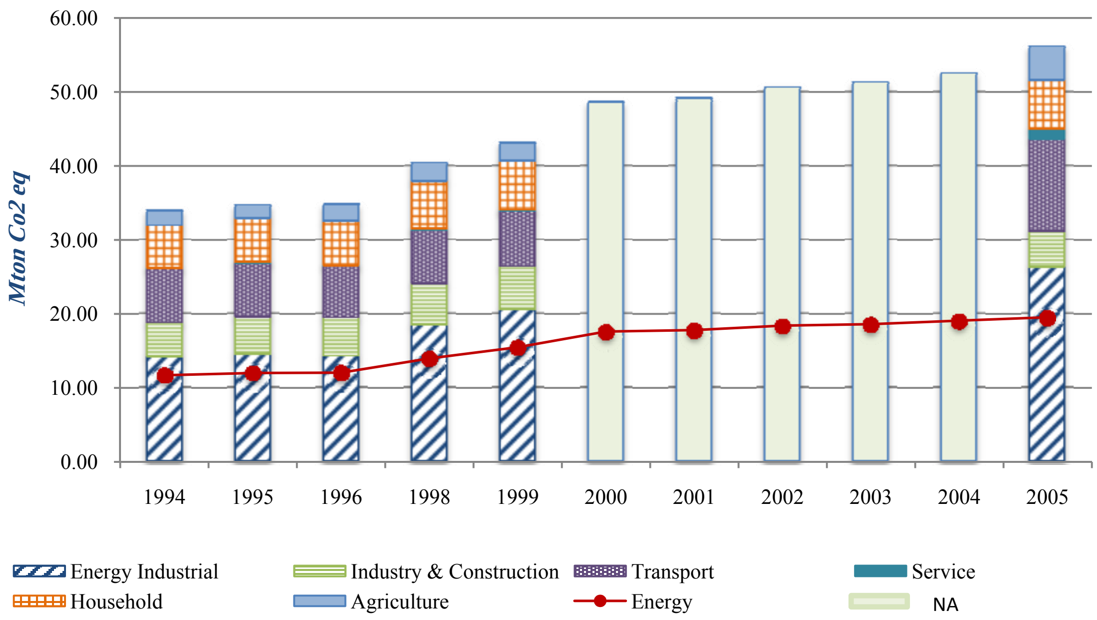


Fig. 2.8 GHG Emissions in the Energy Sector by Activity during the 1994-2005Period

2.3.3. The Industrial Sector

Trends in Total GHG Emissions from Industry

Figure 2.9 shows total emissions of GHG in CO_2 eq from the industrial sector for the years 1994-2005. The curve shows a slight increase in emissions from 1994 to 1999, which reached a peak in 2001 and which then slumped slightly until 2005. This can be explained by fluctuations in production, especially in the cement industry responsible for most emissions from industry.

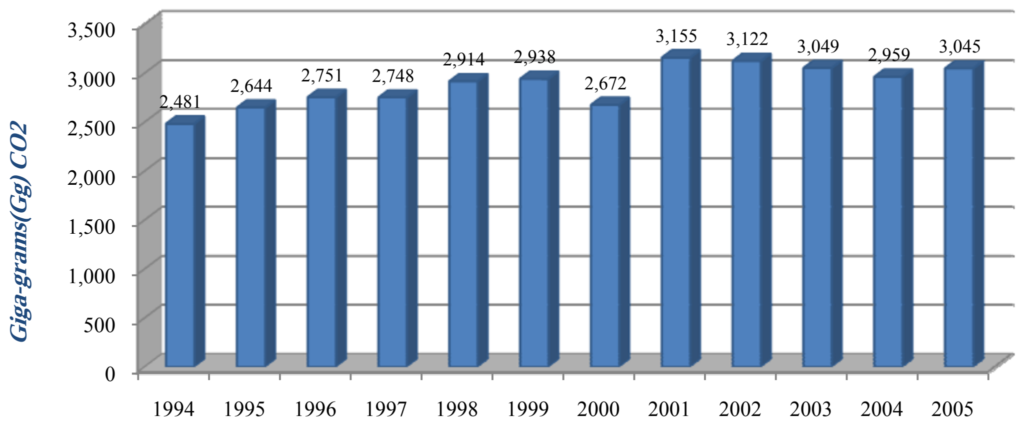


Fig. 2.9 General Trends in GHG Emissions from Industry for the Period 1994-2005

Emissions from Industry (by GHG Gas)

Emissions of the three main GHG gases (CO_2, CH_4 and N_2O) from industry are presented in Figure 2.10. The graph shows that the highest emission from industry is in the form of CO_2, while CH_4 emissions from the petroleum coke industry are negligible, and so are N_2O from agricultural fertilizer production.

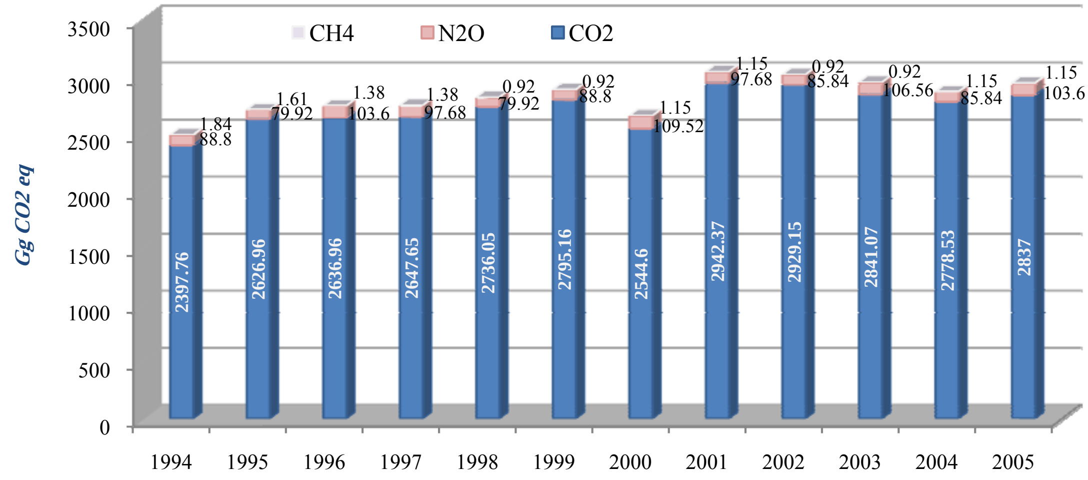
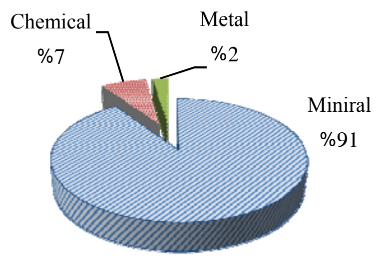


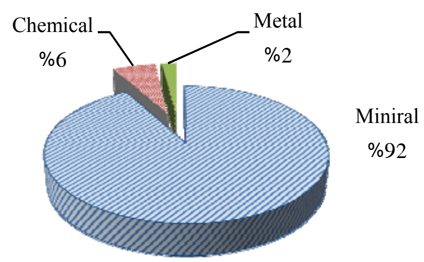
Fig. 2.10 GHG Emissions from Industry, by Gas, from 1994 to 2005

Emissions of GHG from Industry (by Sector)

Figure 2.11 shows industrial emissions of CO_2 gas by sector. It is obvious that the largest share comes from the mineral industry which has increased from 91% in 1994 to 92% in 2005. The largest contribution to the mineral sector comes from the cement industry with 89% of total emissions in 1994 and 91% in 2005. The second contributor (7%) is the fertilizer industry and a small percentage (2%) derives from metal and iron industries.



CO_2 Emissions, 1994



CO_2 Emissions, 2005

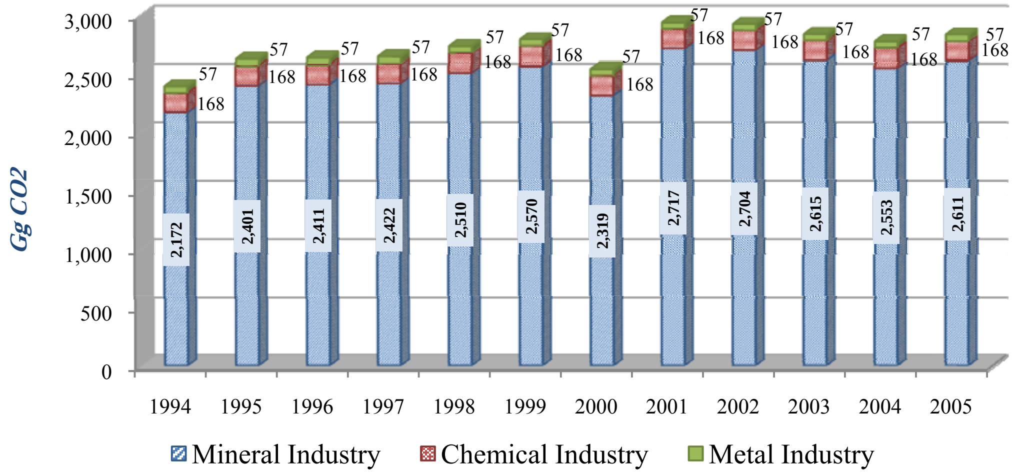


Fig. 2.11 GHG Emissions from Industry by Activity Sector

2.3.4. The Waste Sector

Trends in Total GHG Emissions from the Waste Sector

Figure 2.12 shows that total GHG emissions from the waste sector in CO_2 eq increased steadily during the years between 1994 and 2005. This increase averaged 5% a year during this period. This substantial growth reflects the rapid increase in population (approximately 2.5% during the specified period), the rise in living standards, the expansion of cities and of urban population due to emigration from the countryside and the lack of solid waste treatment facilities to recover CH_4.

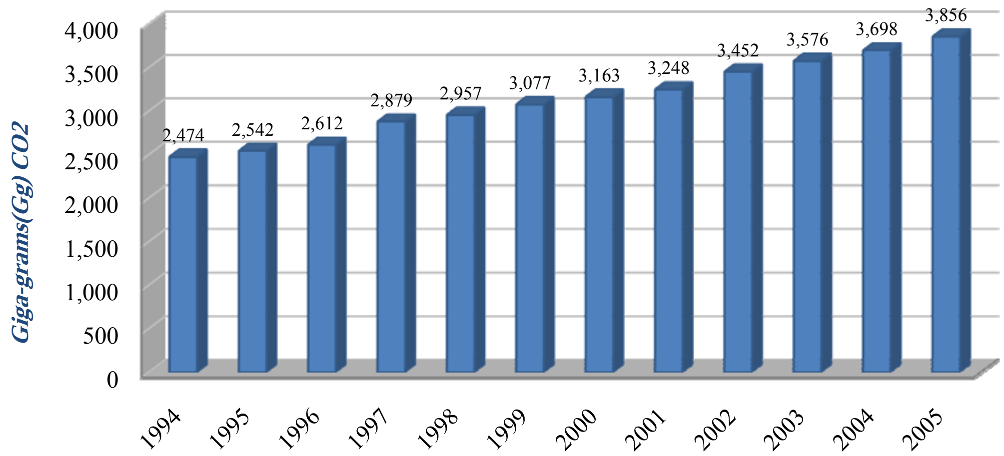


Fig. 2.12 Total GHG Emissions from the Waste Sector in CO_2 eq during the 1994-2005 Period

Emissions of the Waste Sector (by GHG gas)

Figure 2.13 shows emissions from the waste sector in terms of GHG gases. It is clear that the main GHG is CH_4 produced by the fermentation of organic waste, followed by N_2O. The importance of nitrates is due to the fact that most municipal water treatment plants were not operational in 1994.

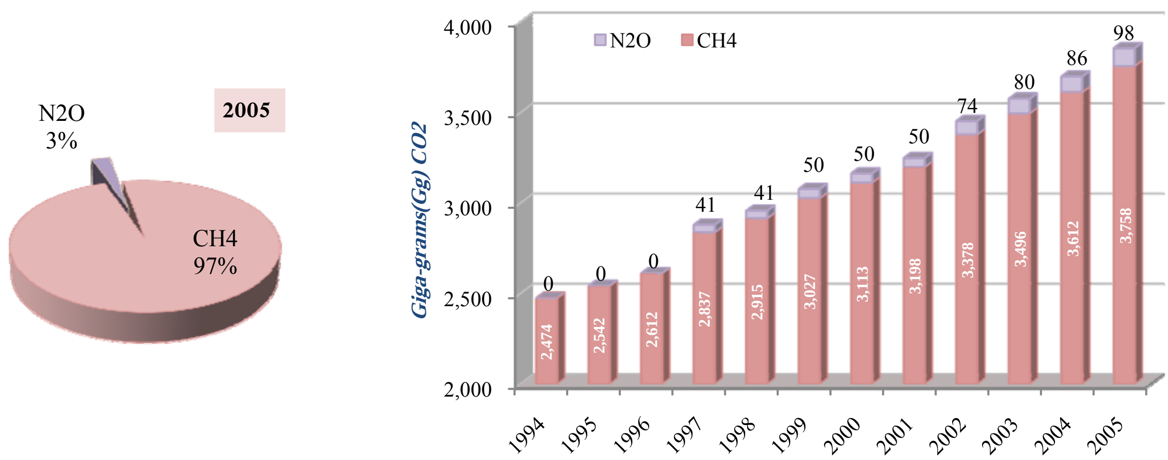
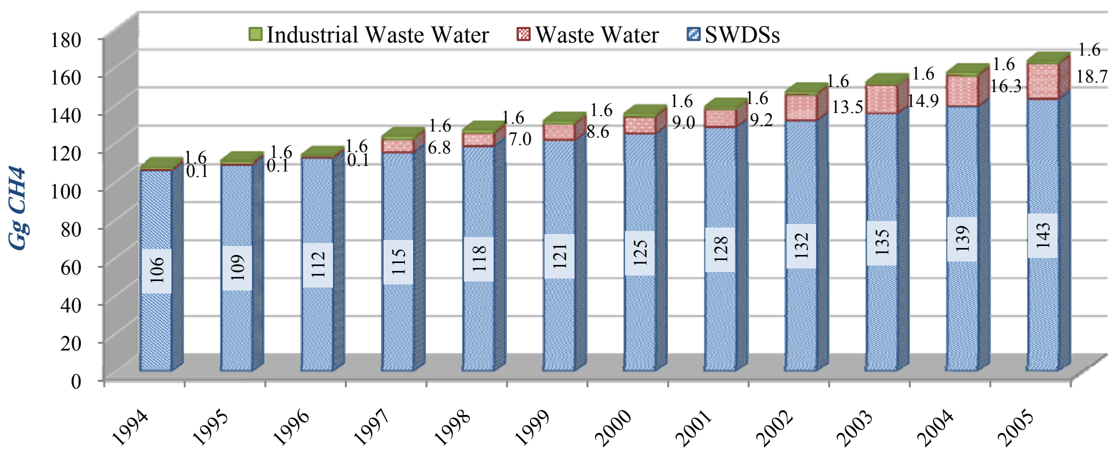


Fig. 2.13 GHG Emissions by Gas from the Waste Sector (in CO_2 eq)

Emission from the Waste (by Sector)

Figure 2.14 shows emissions from the waste sector by sector for the years 1994 – 2005 (essentially methane – CH_4). It is clear that the main producer of GHG is solid waste, followed by municipal sewage water and finally industrial waste water. The figure shows also the distribution of methane emissions in the waste sector for the years 1994 and 2005. It is clear that emissions from solid waste accounted for 88% in 2005, followed by 11% from municipal sewage water and 1% only from industrial waste water. The reason for this is the delay in building municipal water and sewage treatment plants, as well as the lack of water treatment plants in industry or their closure because of technical reasons.



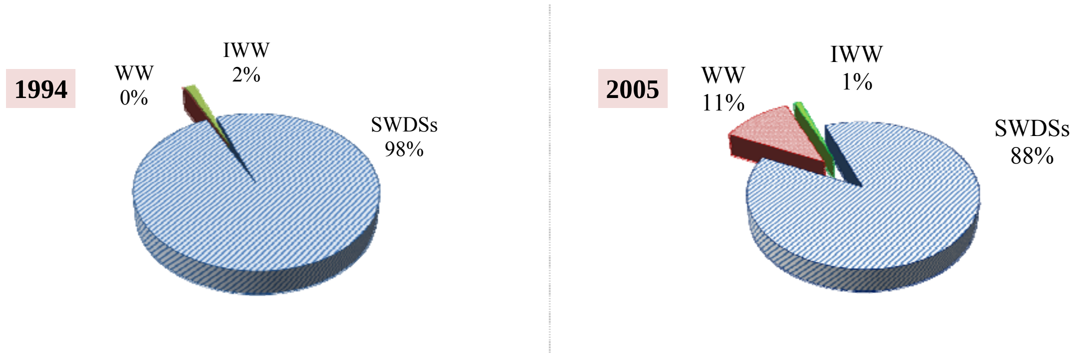


Fig. 2.14 CH_4 Emissions from the Waste Sector (by Sector of Activity) in 1994 and 2005

2.3.5. The Agricultural Sector

Trend in Total Emissions from Agriculture

Figure 2.15 shows the total emissions from agriculture in CO_2 eq, for the years between 1994 and 2005. It appears that emissions increased from 1994 to 1998 and then decreased until 2001, to grow again from 2002 and reach their peak at 14 T g / year in 2005. This could be explained by fluctuations in agricultural production.

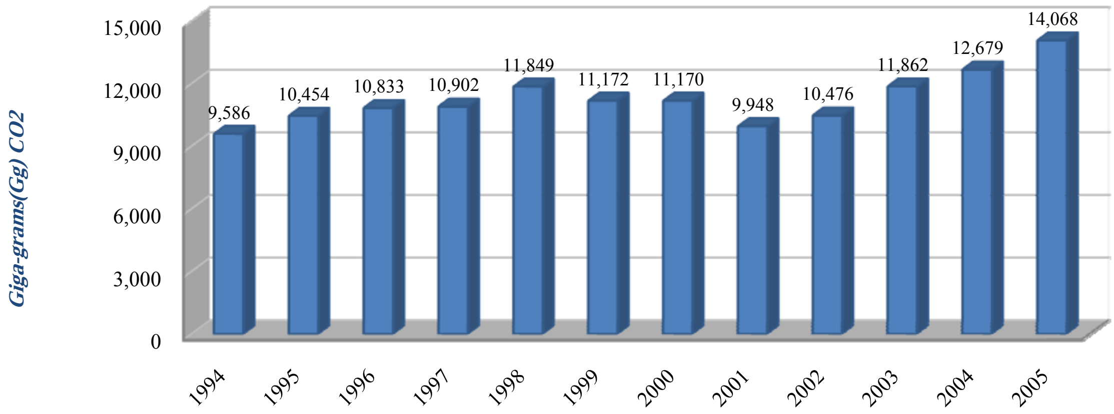


Fig. 2.15 Total GHG Emissions from Agriculture during the 1994-2005 Period

Agricultural Emissions (by Gas)

Figure 2.16 shows emissions of GHG from the agricultural sector for the years 1994 and 2005 (quantities of CH_4 and N_2O only have been measured). It is clear that the share of N_2O in CO_2 eq is higher, varying between 72% and 74%. The major part comes from soil fertilizer, followed by animal waste.

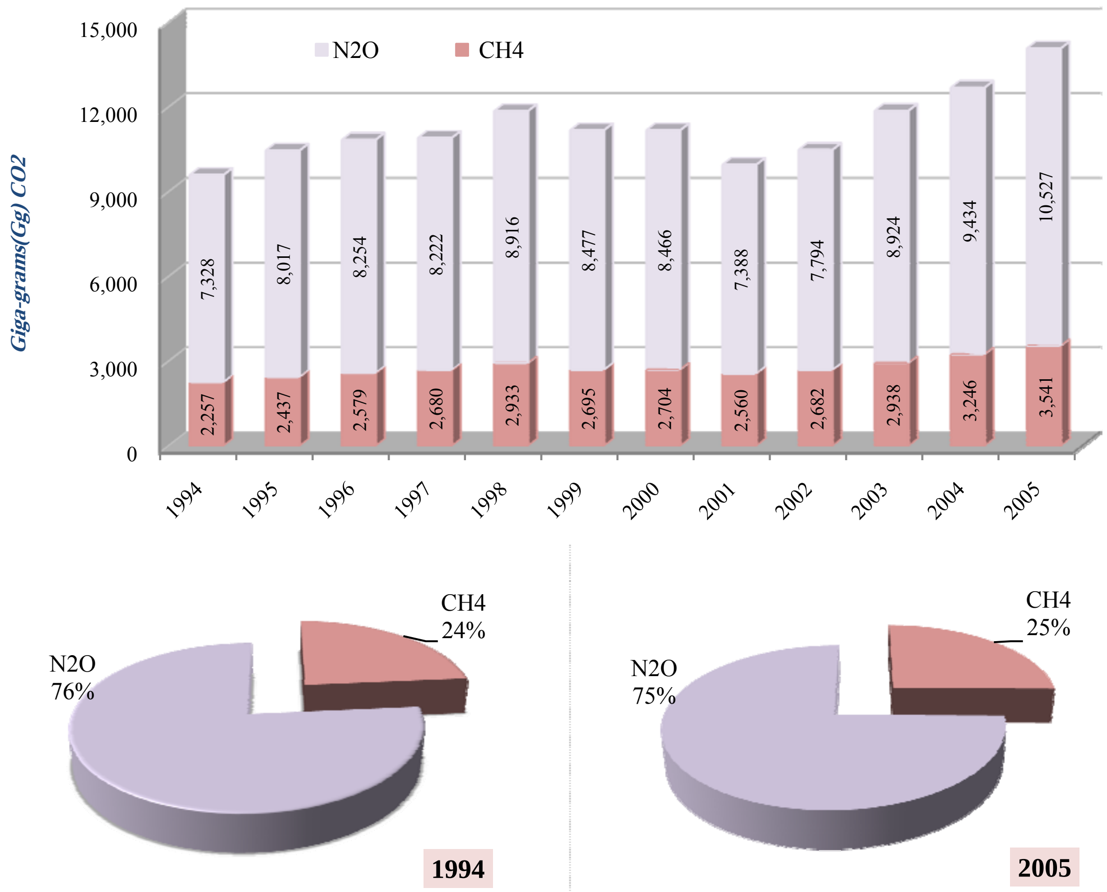


Fig. 2.16 Total GHG Emissions from Agriculture (by Gas)

Agricultural Emissions (by Sector)

Fig. 2.17 presents emissions by sector from agriculture, in CO_2 eq. It is clear that the key category in this sector is N_2O from agricultural fertilizer (72 -74% of the total). CH_4 from the enteric fermentation of animals (22-24% of the total) is the second source of GHG. The percentage of emissions from burning agriculture crop waste after the harvest accounts for a mere 3%, that of animal waste and manure is 1%, while emissions from burning steppe vegetation is negligible.

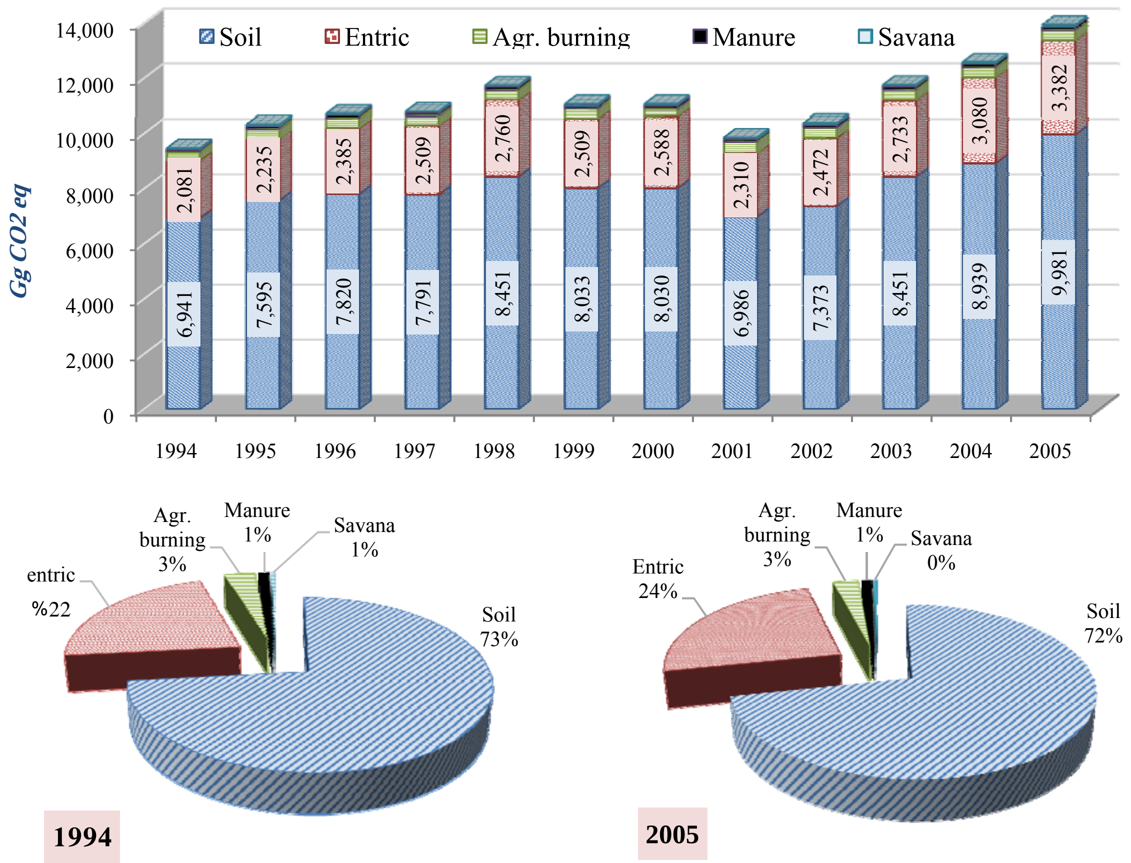


Fig. 2.17 GHG Emissions from Agriculture (by Sector)

2.3.6. Emissions of GHG from Land Use and Forestry

Emissions of GHG (by Gas)

Figure 2.18 shows emissions by GHG from land use and the forestry sector (LUCF). It is obvious that emissions of CO_2 are by far the highest, while those of CH_4 and N_2O are negligible.

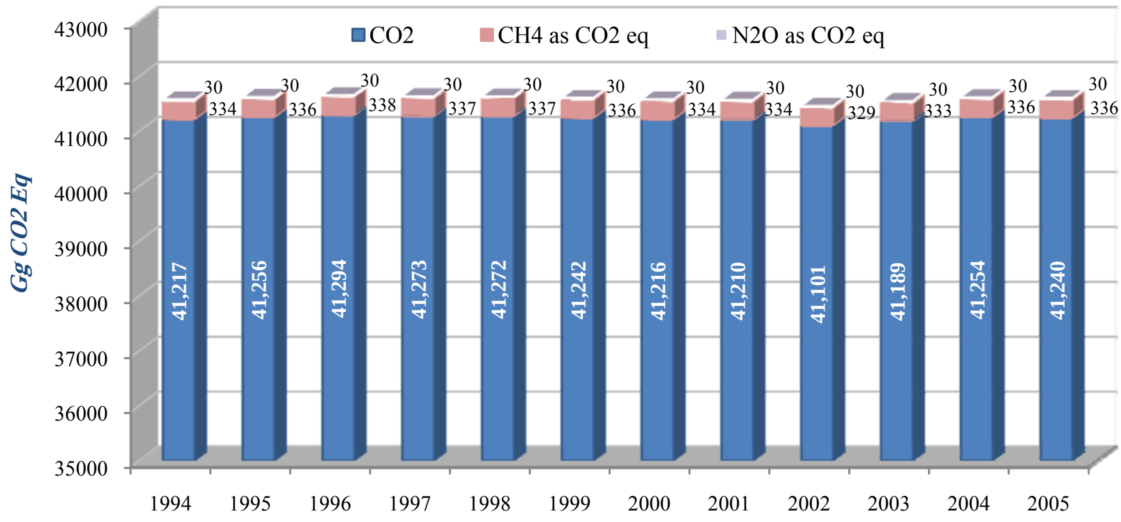


Fig. 2.18 GHG Emissions from LUCF (by Gas)

GHG Emissions and absorption of GHG (by Sector)

Figure 2.19 shows emissions for the year 1994 by sector of GHG and its sinks (absorption) by the LUCF sector. It is clear that emissions are less than the absorption of GHG by natural factors (sinks). The main factor of absorption (sinks) comes from forests and trees, followed to a much lesser extent by deserted land. Emissions were highest from fires in forests, followed by those from mineral soils and finally emissions from in-field burning.

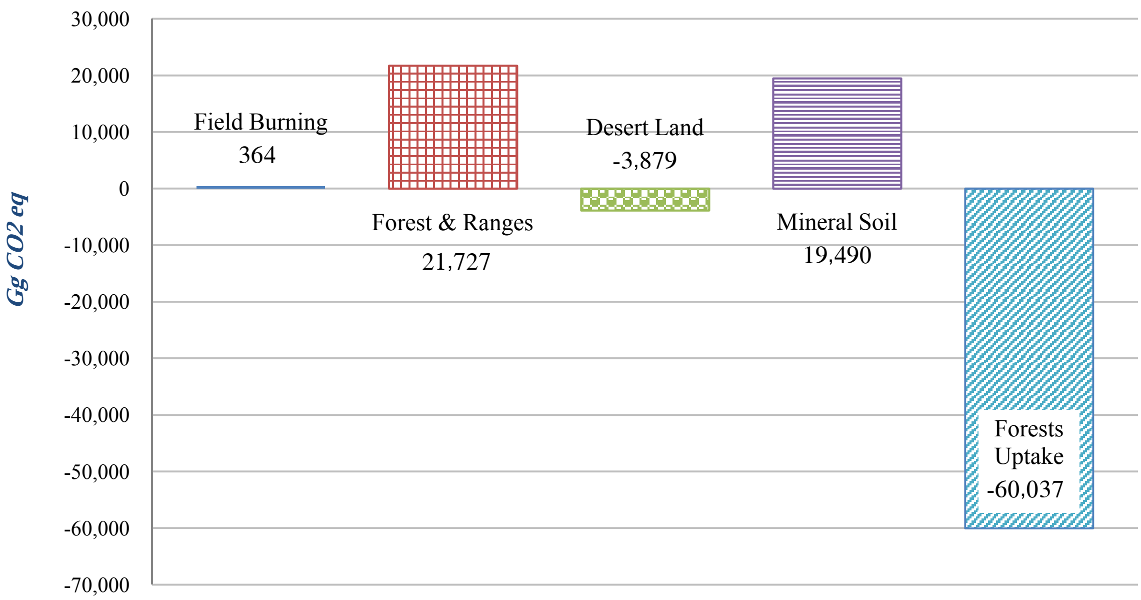


Fig. 2.19 GHG Emissions and Absorption (Sinks) /Retention by LUCF in 1994

Figure 2.20 shows results of GHG emissions and absorption by LUCF from 1994 to 2005.

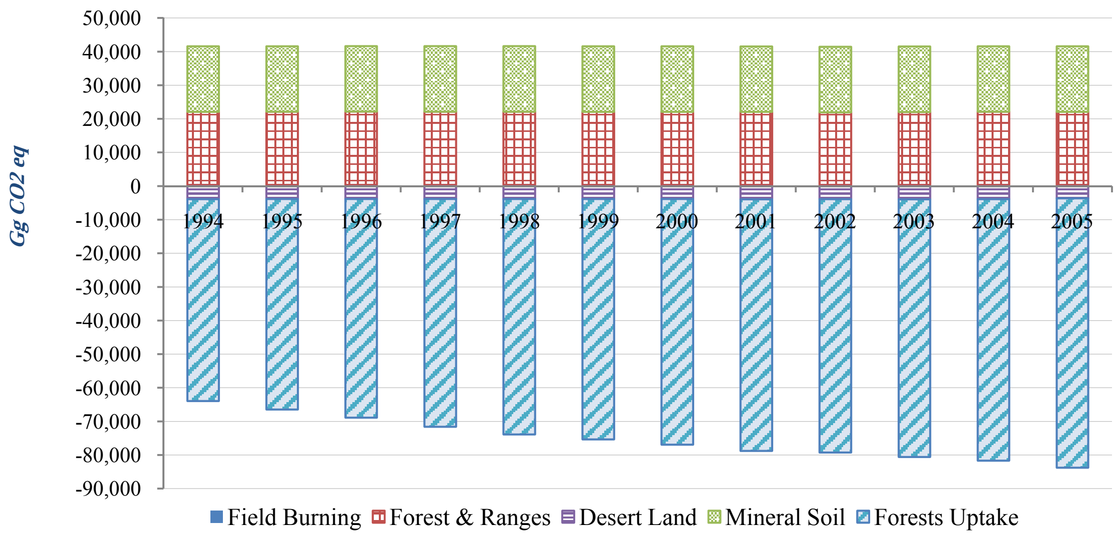


Fig. 2.20 Emissions and Absorption of GHG by LUCF in the 1994-2005 Period

Trends of Emissions of GHG Precursors and SO_2

Emissions of NMVOC, CO, SO_2 and NO_x from the industry sector were calculated according to IPCC 1996 Revised Guidelines. Figure 2.21 shows the total emissions of these gases. Most emissions are in the form of NMVOC which come from the food and drinks industry, followed by asphalt used on roads and to cover roofs. SOx gases come next (mainly from the cement industry). It is worth mentioning that SOx is not a GHG or a precursor, but a polluting agent.

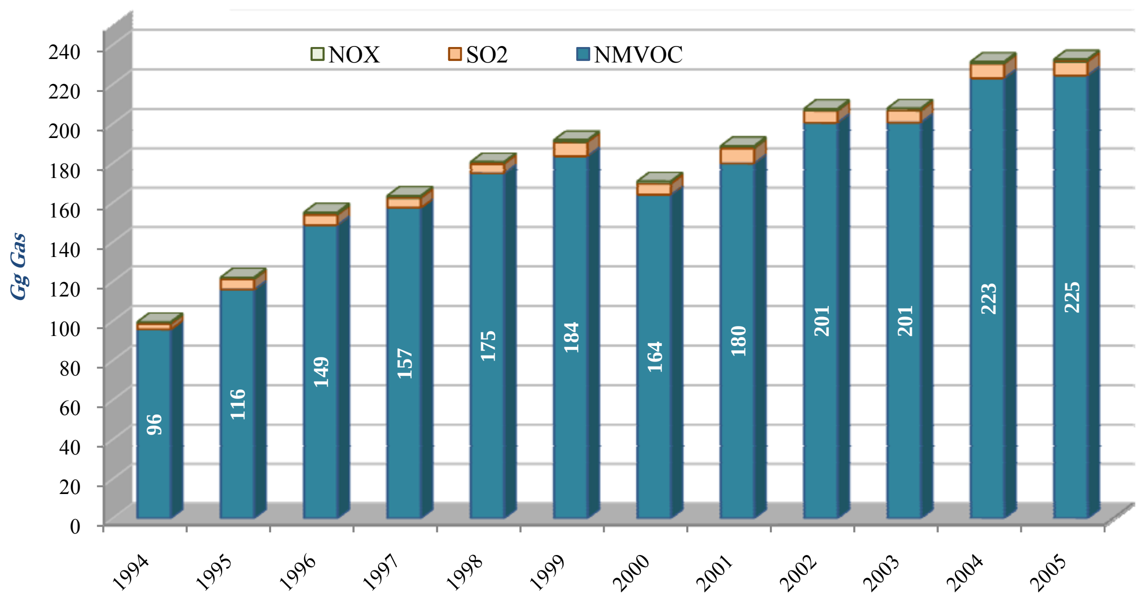


Fig. 2.21 Emissions of NMVOC, Sox (Sulfates) and NOx (Nitrates) from Industry

Emissions of CO originating from the LUCF sector are shown in Figure 2.22. CO is a precursor of CO_2. The share from forests is nearly constant, while that from agriculture is increasing slightly through the years.

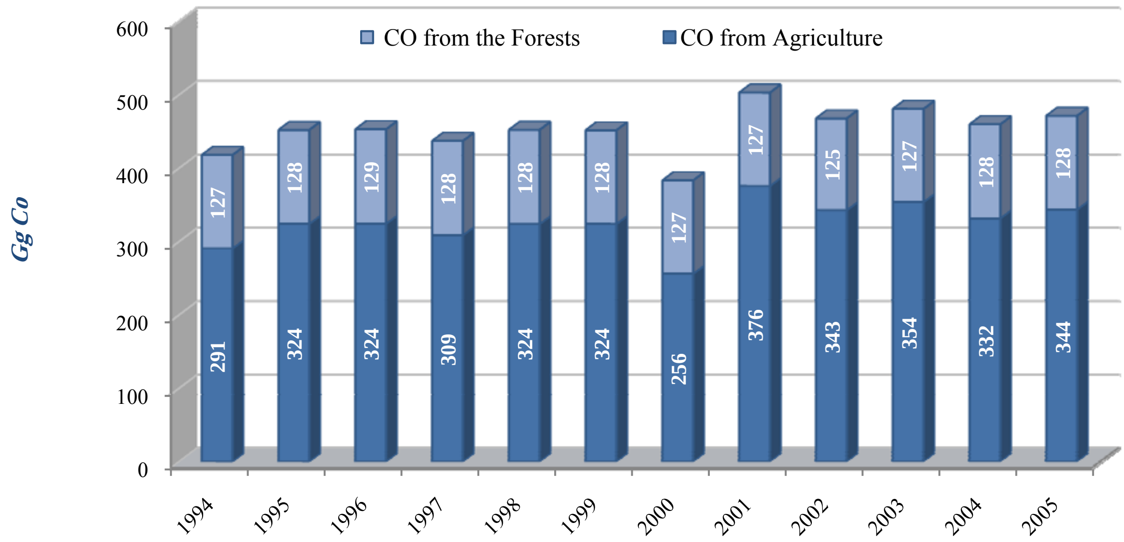


Fig. 2.22 Emissions of CO by LUCF

2.4. General Issues and Scope for Development

2.4.1. Quality Control

Since this report is the first national communication for Syria that followed the methodologies and instructions of the IPCC, and due to the absence of institutions dealing with the GHG inventory, there was in general a lack of data or a deficiency in the quality of data. This was especially true for the energy sector, with the lack of an energy balance for the years 2000-2004. This made it necessary to calculate GHG emissions from the energy sector for these years by using the Reference method only. There was a lack of data from the industrial sector concerning other GHGs such as SF_6, HFCs and PFCs. Another problem in industry is related to the lack of data from the private sector: there is for instance a paucity on lime production. In the waste sector there was also a lack of quality data on municipal waste water plants, and more specifically on industrial waste water stations.

2.4.2. Uncertainties

Uncertainty is inevitable in the GHG inventory compilation, this for many reasons. Data were obtained from the Central Bureau of Statistics and the concerned ministries. There was uncertainty relating to these data due to inaccuracies and their availability from more than one source. There were many instances of lack of data and of conversion and emission factors. This made it necessary to use default emission factors (DEF) from IPCC Guidelines, many of these not local. There was moreover a degree of uncertainty related to them. In several cases, local conversion factors, when available, were used for better estimations (such as the calorific values of oil products used in Syria). Also Tier 1 was used, adding another source of uncertainty.

2.4.3. Use of Complex Methodologies

Tier 1 in the IPCC Revised 1996 Guidelines was applied. This was recommended by COP for non-annex 1 countries and for the first national communication (INC). In this work the gaps were recognized. It will be possible in the second national communication to avoid these gaps and to use a mixture of Tier 1 and Tier 2, which depends on more accurate data and local emission factors.

2.4.4. The Training of a GHG Inventory Group

During the process of the GHG inventory compilation linked to the first national communication, a group of trainees from the State Ministry of Environment met together and gained experience. During the workshops other trainees from the concerned ministries joined in. These trained personnel could later form the basis of a permanent unit in charge of preparing inventories for the following years and for the second national communication. Further training could be needed both locally and externally.

CHAPTER 3

Vulnerability Assessment and Adaptive Measures to Climate Change

3.1. Introduction

This chapter describes the vulnerability to climate change (CC) of major sectors in Syria. Special attention is devoted to illustrate trends in CC, climate predictions, the vulnerability of water resources, of agriculture, energy, and of the public health sector to such changes. Other issues like the effect of the possible rise in sea levels (SLR), the vulnerability of forest and rangeland sectors, as well as biodiversity, are similarly addressed. Sector adaptation measures are proposed. Socio-economic aspects of climate change were collected, based on sector vulnerability results.

The indirect effects of climate change are of a broad nature and require detailed and comprehensive surveys. The figures presented regarding simulated climate change, the vulnerability assessment of various sectors and associated socio-economic impacts, are therefore solely indicative and must be used with extreme caution.

3.2. Trends in Climate and Projections

3.2.1. Trends in Climate

A 52-year record (1955 - 2006) from 30 selected synoptic stations was used to assess the long term climate variations and trends in the country. The selection of these stations was based mainly on the length and continuity of their meteorological records. Recorded data consisted of the monthly mean values of surface air temperature and total rainfall. Trends in extreme daytime temperatures and precipitation indexes were examined from 1965 to 2006 at thirteen stations covering the climate district. The set of data was analyzed for outliers (anomalies), and those identified as outliers to a present threshold value were considered. Finally, the time series analysis for non-climate events possibly taking place during the life of station, and the detection and adjustment of such events within homogeneous trends in the time series, were carried out following a procedure developed by Hanssen-Baure and Foreland (1994).

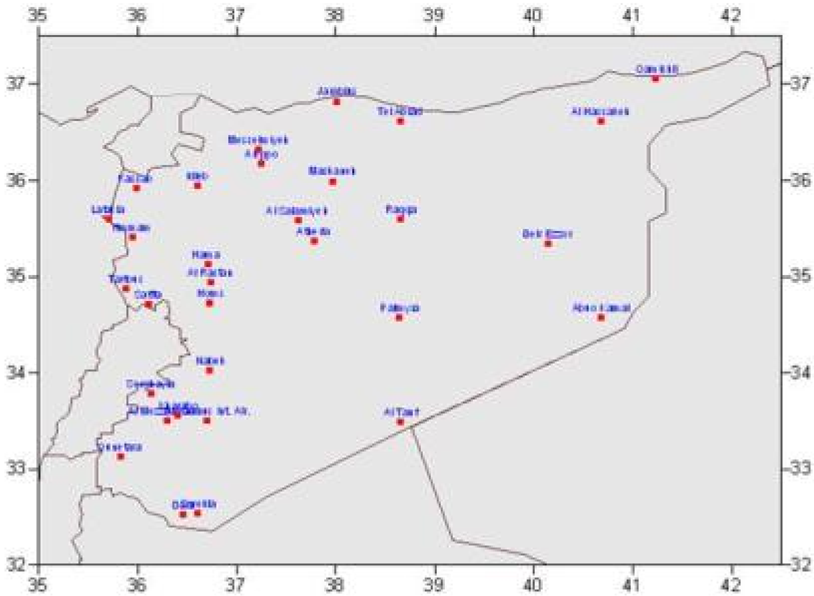


Fig. 3.1 Distribution of Weather Stations used in the Trend Analysis.

Selected parameters to describe general climate characteristics during the baseline scenario were surface air temperature, precipitations, winter maximum and minimum surface air temperature, as well as summer maximum and minimum surface air temperature. Average annual and seasonal values of these three parameters were analyzed and displayed in a series of symbol maps. Figure 3.1 above outlines these stations.

Precipitations

Precipitation Trends

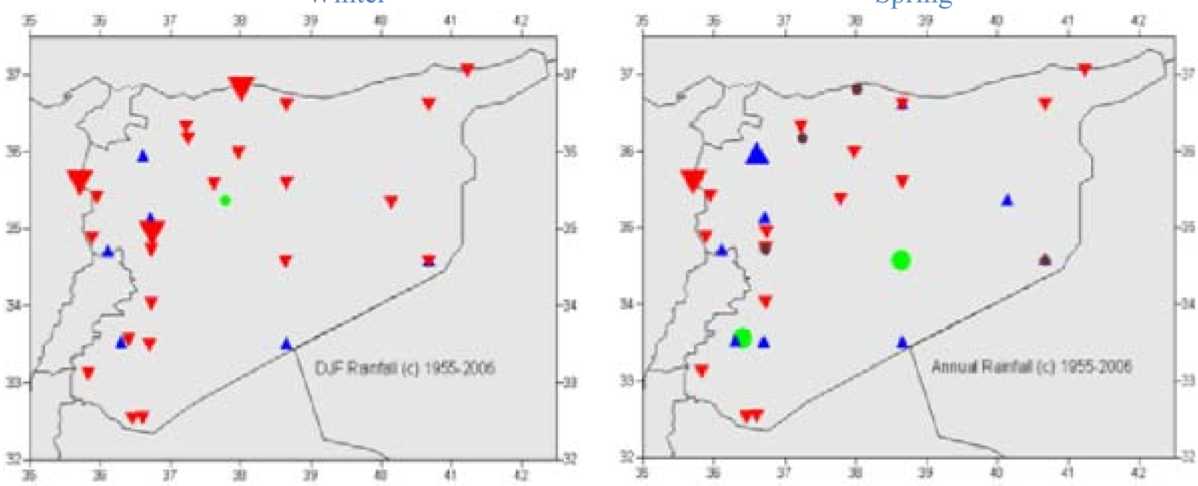
Due to a number of difficulties (quality of data, length of records, precipitation variability) involved in developing signals of climate change in terms of changing precipitations, extreme care must be taken in interpreting the significance of long term trends in precipitations.

Generally speaking, the Mann-Kendall trend test showed a coherent area of significant change in precipitations during both the winter and autumn seasons. Winter precipitations in the northern and northeastern zones of Syria showed signs of decrease in the last five decades. By contrast, autumn precipitations increased at stations lying mostly in the northern zone of central Syria. The reasons behind these changes are not well understood. Further investigation is needed to define causes of this increase. Moreover few stations statistically showed significant changes in winter and autumn precipitations. Figure 3.2 shows the results of the Mann-Kendall trend test for the annual precipitations and for those of three seasons in the country.

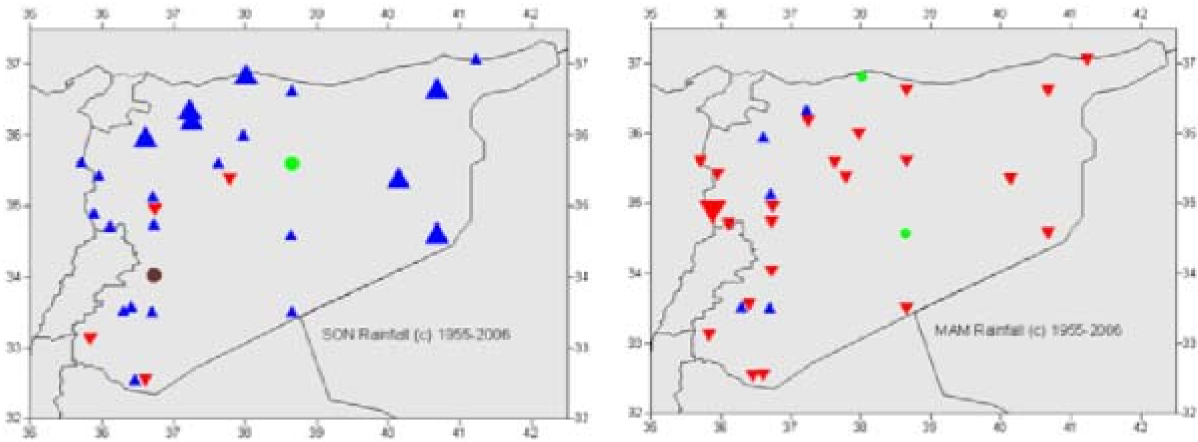
Precipitation Extremes: Events and Indices

The analysis of the precipitation indices of extreme events showed a slight, not really significant, decrease in the number of days with precipitations (≥ 25 mm), in average precipitation intensity (PRCP ≥1.0mm/day), in maximum precipitations during specific days and in the national average of annual precipitation anomalies during wet days.

Winter Spring



Autumn Annual



● denotes no trend ▲ significant increase ▲ insignificant increase
▼ significant decrease ▼ insignificant decrease and ●insignificant increase and decreases

Fig. 3.2 Seasonal and Annual Precipitation Trends for the 1955-2006 Period

Surface Air Temperature

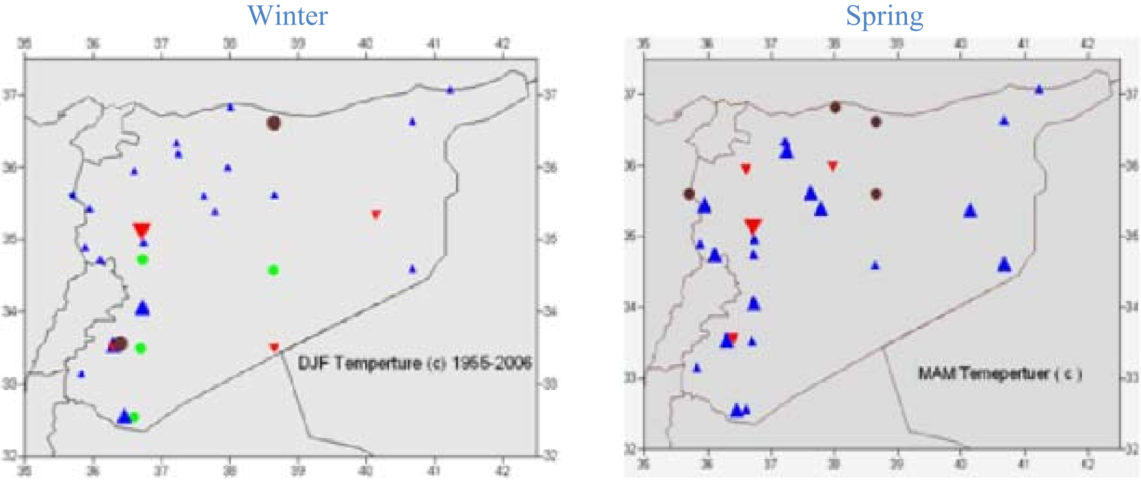
Surface Temperature Trends

The result of the Mann-Kendall trend analysis applied to seasonal and annual average surface air temperature series between 1955 and 2006 showed a widespread increase in summer temperature at all stations in the country, with a prominent increase in the coastal and western regions. By contrast, winter temperatures in the country appeared to generally decrease. This decrease was mostly noticeable at coastal stations, prominently in spring and autumn.

Surface Temperature: Extremes Events and Indices

The analysis of temperature indices of extreme events showed a significant tendency to increase in terms of annual maximum of daily maximum and minimum temperatures, annual minimum of daily maximum surface air temperature, annual minimum of daily minimum surface air temperature, the number of tropical nights, and the number of summer days. The latter denotes an increase in the number of warmer days and nights during the year. Nevertheless, a significant trend showing the decrease of cool nights and days, in the diurnal temperatures range, was also observed (Figure 3.3).

Winter Spring



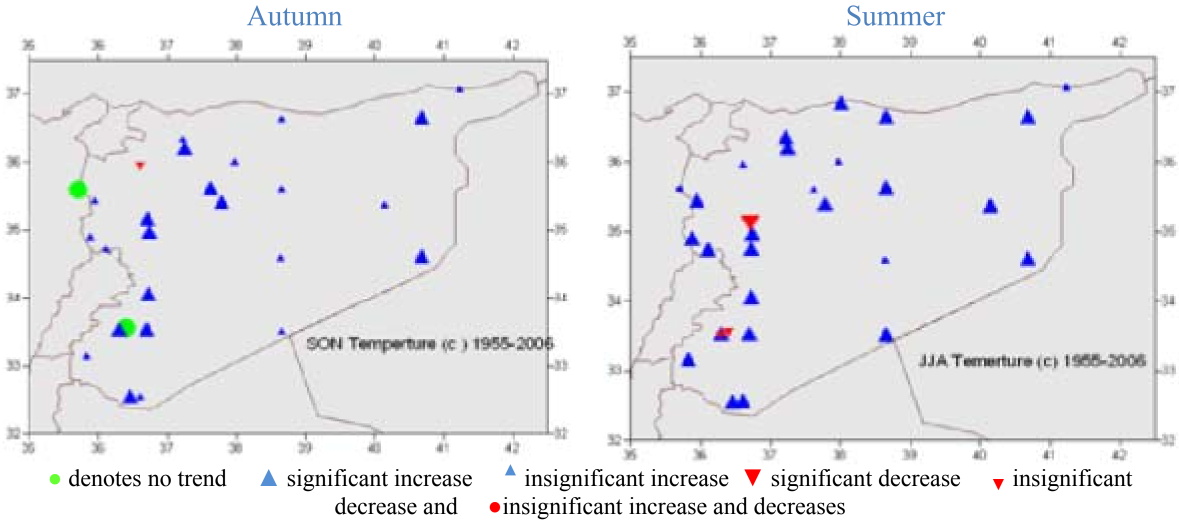


Fig. 3.3 Mann-Kendall Trend Analysis applied to Seasonal Average Annual Temperature Series between 1955 and 2006

3.2.2. Climate Projections

Climate Change Scenarios

Climate change scenarios were developed to predict changes in temperature and precipitation values in 2041 and 2100, using two different models. The Model for the Assessment of Greenhouse Gases Induced Climate Change (MAGICC version 4.1, September 2003), coupled with a Climate Scenario Generator (SCENGEN), was used for the 2041 prediction, while predicted data acquired by the use of global models were retrieved from the IPCC data base for 2041 -2100. Of the 17 GCM models, three models (CCSR96, IAP-97 and MRI-96) were found to very closely simulate climate trends for Syria (Figure 3.4).

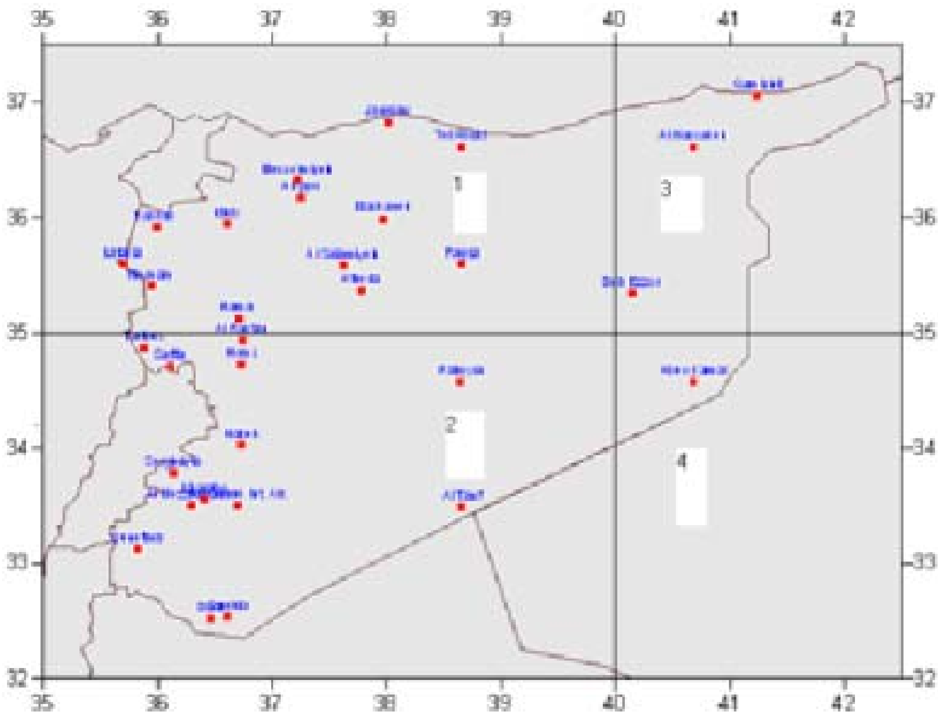


Fig. 3.4 The Four Grids Covering Syria.

The following are the main results of climate predictions:

✓ Average warming in Syria for the year 2041 will be higher than the global average for both reference and policy scenarios.

✓ The greatest increase (2.0-2.1°C) will occur in the north-west and the southeast (cells 1 and 4), while the most moderate increase (1.0-1.2°C) will occur all over the country.

✓ The highest increase in precipitations will occur in summer and autumn in all regions.

The results of running a combination of these models for reference (P50) and policy (WRE-350) emission scenarios are tabulated and shown in table 3.1 for each of the cells of the grid.

Table 3.1 Changes in Seasonal and Annual Mean Temperatures (°C) and Precipitation (%) from CCSR96, IAP_97 and MRI_96 Scenarios for the year 2041.

Zone / Emission Scenario		1		2		3		4	
		35 – 40 N		30 – 35 N		35 – 40 N		30 – 35 N	
		35 – 40 E		35 - 40 E		40 – 45 E		40 – 45 E	
		C	P	C	P	C	P	C	P
Winter	Policy*	1.0	-13.3	1.1	-16.2	1.0	-10.3	1.2	-13.6
	Reference**	1.1	-14.4	1.2	-17.5	1.1	-11.1	1.3	-14.7
Spring	Policy	1.4	-3.3	1.4	-10.2	1.5	-8.9	1.5	-13.1
	Reference	1.5	-3.6	1.5	-11.0	1.6	-9.7	1.6	-14.2
Summer	Policy	1.9	-4.0	2.0	79.3	1.9	-6.3	1.9	62.5
	Reference	2.1	-4.3	2.1	85.7	2.1	-6.8	2.0	67.5
Autumn	Policy	1.5	-1.3	1.5	14.9	1.6	-0.7	1.6	7.3
	Reference	1.6	-1.4	1.6	16.1	1.7	-.08	1.6	7.9
Annual	Policy	1.4	-9.7	1.5	-8.0	1.5	-9.1	1.5	-9.9
	Reference	1.6	-10.5	1.6	-8.6	1.6	-9.8	1.6	-10.7

*Policy scenario (WRE 350) Global-mean dt: 0.81 (°C)
**Reference scenario (P 50%) Global-mean dt: 1.1(°C) C: temperature, P: rainfall

The results of the MRI_96 were used to predict precipitation data for the country in 2041, using the average rate of change deduced from the model. Data are displayed in table 3.2.

Table 3.2 Calculated Average Annual Rainfall for Meteorological Stations in Syria for the Year 2041, Using Model MRI_96.

Station	Average of 1961-1990 (mm)	Rate of Change (%)	Average Change (mm)	Average for 2041 (mm)
Lattakia	802.0	-5.4	- 43.3	758.7
Hammam	852.9	-5.4	- 46.1	806.8
Safita	1,130.9	-5.1	- 57.7	1073.2
Tartous	872.4	-5.1	- 44.5	827.9
Tel Abyad	287.3	-5.4	- 15.5	271.8

Jerablus	324.0	-5.4	- 17.5	306.5
Aleppo	329.5	-5.4	- 17.8	311.7
Ath-Thawra	186.6	-5.4	- 10.1	176.5
Meslemieh	330.8	-5.4	- 17.9	312.9
Idlib	504.5	-5.4	- 27.2	477.3
Hama	348.5	-5.4	- 18.8	329.7
Salamiya	305.3	-5.1	- 15.6	289.7
Al-Rastan	380.5	-5.1	- 19.4	361.1
Homs	433.4	-5.1	- 22.1	411.3
Damascus Int. Air Port	142.2	-5.1	- 7.3	134.9
Mezzeh Airfield Damascus	200.3	-5.1	- 10.2	190.1
Kharabo	161.6	-5.1	- 8.2	153.4
Dera‘a	265.6	-5.1	- 13.5	252.1
Nebek	120.1	-5.1	- 6.1	114.0
Sirghaya	572.4	-5.1	- 29.2	543.2
Quneitra	610.2	-5.1	- 31.1	579.1
Sweida	357.7	-5.1	- 18.2	339.5
Palmyra	134.2	-5.1	- 6.8	127.4
Meskene	228.7	-5.4	- 12.3	216.4
Deir ez-Zor	157.2	-6.2	- 9.7	147.5
Abou Kamal	133.7	-5.0	- 6.7	127.0
Raqqa	210.5	-5.4	- 11.4	199.1
At-Tanf	105.0	-5.1	- 5.4	99.6
Qamishli	435.1	-6.2	- 27.0	408.1
Hassakeh	285.8	-6.2	- 17.7	268.1

The A2 and B2 climate scenario models were used to simulate changes in temperature and precipitations for 2010-2100, with reference to baseline record values of the 1961-1990 time span. The results of these predictions are shown in the following sections.

Precipitations (the A2 Scenario)

Seasonal changes in precipitations, as predicted by the Hadley Model for the years 2010-2039, 2040-2069 and 2070-2099, using the A2 scenario, are presented in table 3.3. More details are highlighted in figures in the following sections.

Table 3.3 Seasonal and Annual Precipitation Variability (in mm) for the Years 2010-2039, 2040-2069 and 2070-2099, compared to Normal Average (1961-1990).

Years	Winter	Spring	Summer	Autumn	Annual
2010-2039	3.0 : -12.0	3.0 : -8.0	4.0 : -4.0	-4.0 : -16.0	**-2.0 : -40.0**
2040-2069	-6.0 : -22.0	-3.0 : -22.0	4.0 : -6.0	-4.0 : -28.0	**-20.0 : -60.0**
2070-2099	-16.0 : -34.0	-6.0 : -38.0	14.0 : -12.0	-6.0 : -40.0	**-6.0 -34.0**

A2 Scenario (2010-2039)

The results of A2 scenario application for the period of 2010-2039 indicate that the southern regions will experience an increase in winter precipitations by an average of 3 mm, while precipitations are expected to decrease in the northeastern and northwestern regions by as much as 12 mm. In the central and coastal regions, a decrease of 10 mm rainfall is expected. During spring, there will be a diminution in precipitations in the northern and northeastern district by 8 mm. In both western and inland areas, precipitations are expected to rise by 3 mm. During summer, a 4 mm increase in precipitations is expected along the coast and the southern regions, while a decrease in precipitations is imagined for the northeastern region. In autumn, an overall decrease in total precipitations in most of the country is predicted. In general, the Mann-Kendall trend test showed a coherent area of significant change in precipitations during both winter and autumn seasons. Winter precipitations in the northern and northeastern zones of Syria showed signs of decrease in the last five decades. Annual changes in precipitations for the period are shown on figure 3.5.

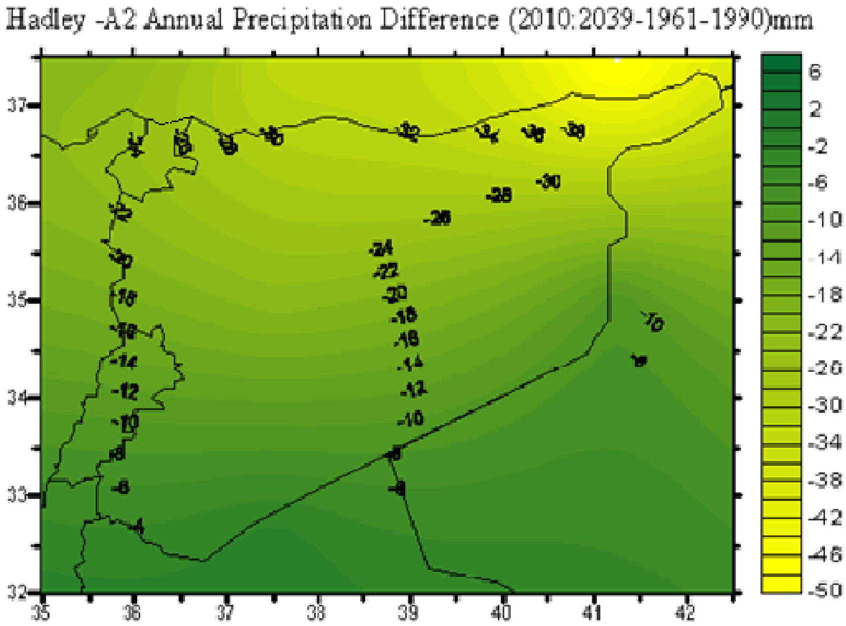


Fig. 3.5 Changes in Annual Precipitations for 2010-2039 (A2 Scenario – Hadley Model - CM3)

A2 Scenario (2040-2069)

The results of the A2 scenario application for the period of 2040-2069 indicate that winter and spring precipitations are expected to decrease by 6-22 mm and 3-22 mm respectively. Nevertheless summer precipitations will increase by 2 mm in the coastal area and the southern part of the country, while a decrease of 3 mm is expected in the northeastern corner. In autumn, an overall decrease in total precipitations in the most of the country is expected. Figure 3.6 depicts annual precipitation changes for the period.

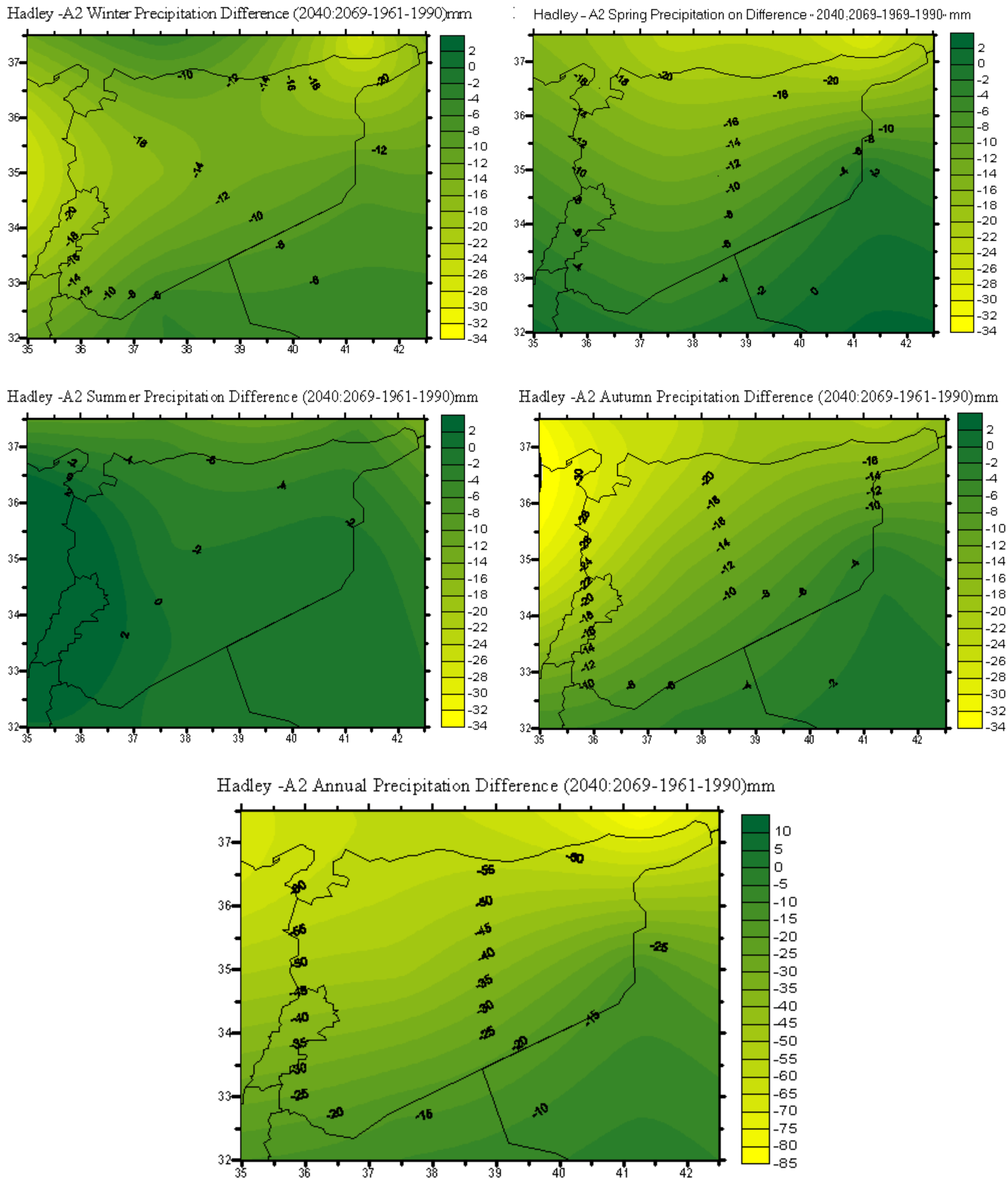


Fig. 3.6 Changes in Seasonal and Annual Precipitations in 2040-2069 (A2 scenario – Hadley Model-CM3)

A2 Scenario (2070-2099)

The results of the A2 scenario application for the period of 2070-2099 indicate that winter and spring precipitations are expected to decrease by 16-34 mm and 6-38 mm respectively. Nevertheless a 14 mm increase in summer precipitations is expected in the coastal region and in the southern part of the country, whereas a 12 mm decrease is forecasted for the northeastern regions. In autumn, an overall decrease in precipitations in most of the country is predicted.

Annual precipitation changes for the period are shown on figure 3.7.

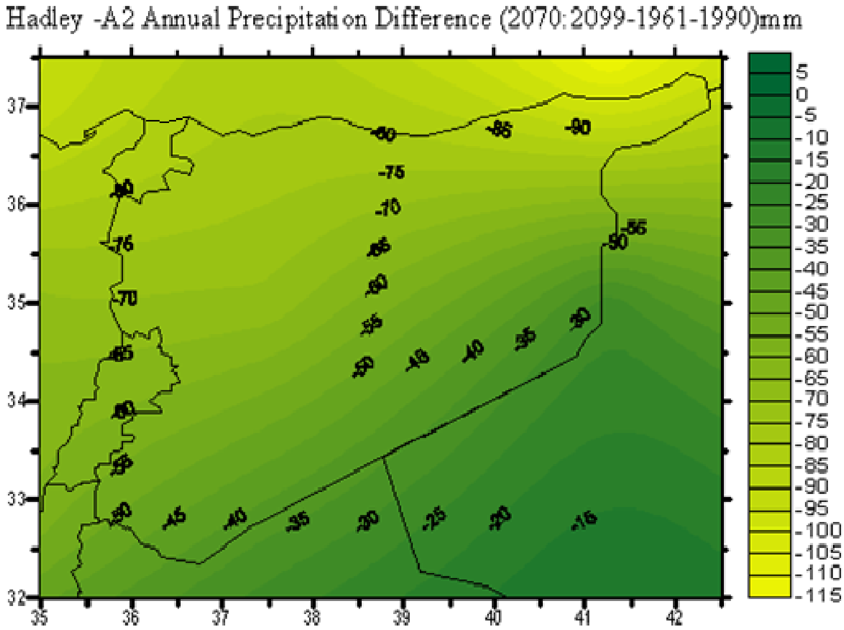


Fig. 3.7 Changes in Annual Precipitations for 2070-2099 (A2 scenario – Hadley Model-CM3

Changes in Precipitation (the B2 Scenario)

Seasonal changes in precipitations, as predicted by the Hadley Model for the years 2010-2039, 2040-2069 and 2070-2099, using the B2 scenario, are presented in table 3.4. More details are highlighted in the figures of the following sections.

Table 3.4 Seasonal and Annual Precipitation Variability (in mm) for the Years 2039, 2069 and 2099 in Relation to Normal Average (1961-1990).

Years	Winter	Spring	Summer	Autumn	Annual
2010-2039	4.0 : -6.0	4.0 : -10.0	8.0 : -8.0	-4.0 : -20.0	**-8.0 : -44.0**
2040-2069	-11.0 : -18.0	7.0 : -7.0	9.0 : -5.0	-3.0 : -17.0	**-8.0 : -49.0**
2070-2099	-12.0 : -18.0	-6.0 : -28.0	10.0 : -12.0	-2.0 : -28.0	**-25.0 : -75.0**

B2 Scenario (2010-2039)

The B2 scenario application for the period of 2010-2039 indicates mixed results, with respectively an expected decrease in some areas and an increase by 6 mm and 4 mm in winter precipitations. Moreover decrease of up to 10 mm and a 4 mm increase in precipitations is expected for spring. During summer, an 8 mm increase in precipitations is forecasted in the coastal area and the country’s southern region, while an 8 mm decrease is expected in the northeastern region. In autumn, an overall decrease (up to 20 mm) in total precipitations in most of the country is imagined.

Annual precipitation changes for the period are shown on figure 3.8.

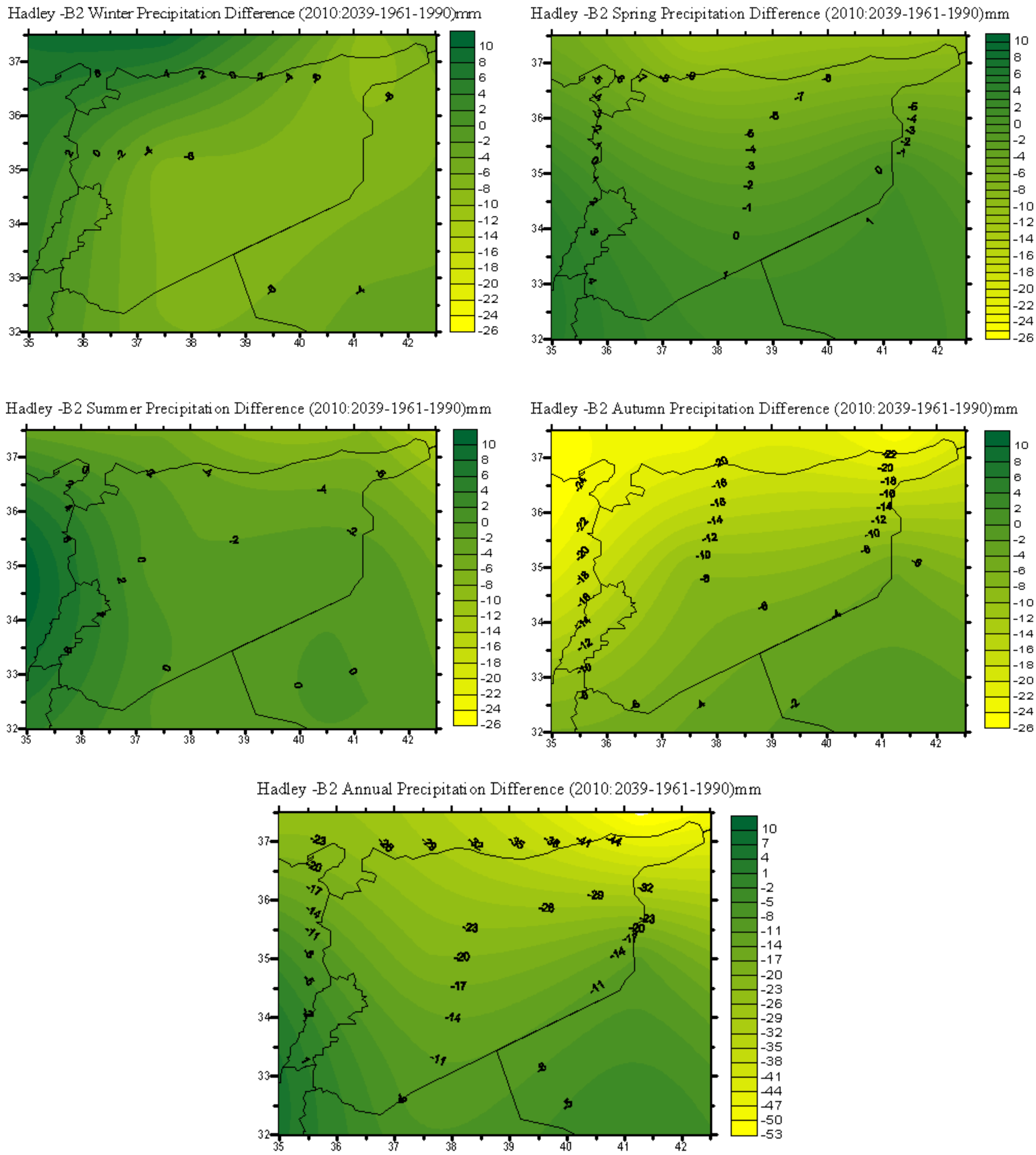


Fig. 3.8 Seasonal and Annual Precipitations Changes in 2010-2039 (B2 Scenario – Hadley Model - CM3)

B2 Scenario (2040-2069)

The B2 scenario application for the years 2040-2069 indicates that winter precipitations are expected to decrease by 6-18 mm. A decrease and an increase of 7 mm are however forecasted during the spring season. During summer, a 9 mm increase in precipitations is expected. This would affect the western coast and the southern regions, contrasting with a 5 mm expected decrease in precipitations in the northeastern districts. In autumn, an overall decrease in precipitations in most of the country is imagined. Annual precipitations changes for the period are shown on figure 3.9.

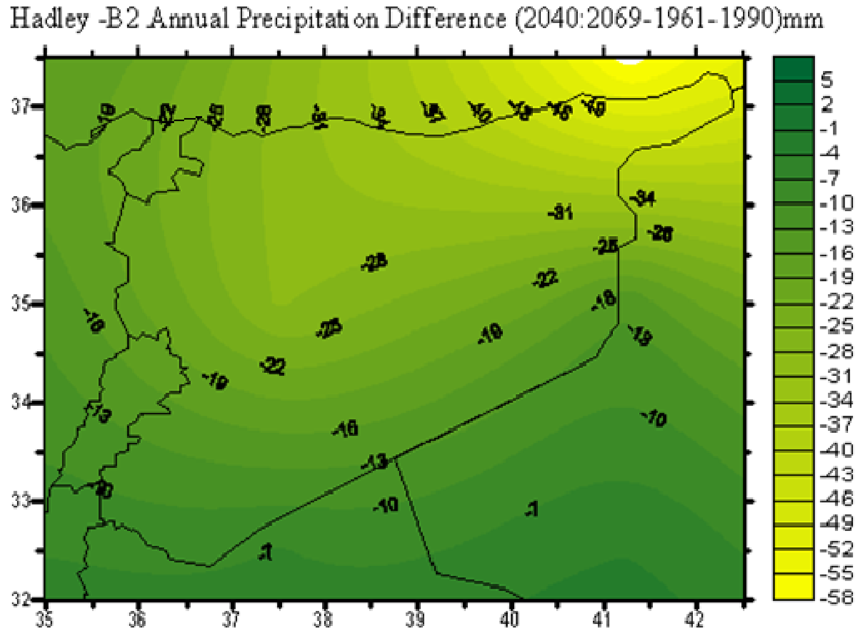


Fig.3.9 Changes in Annual Precipitations in 2040-2069 (B2 Scenario-Hadley Model-

B2 Scenario (2070-2099)

The B2 scenario application for the years of 2070-2099 indicates that winter and spring precipitations are expected to decrease by 12-18 mm and 6-28 mm respectively.

However a 10 mm increase in precipitations is expected in summer, affecting the western coastal region and the southern districts. Yet a 12 mm decrease in summer precipitation is predicted for the northeastern districts. In autumn, an overall decrease in total precipitations in most parts of the country is forecasted. Annual changes in precipitations for the period are shown by figure 3.10.

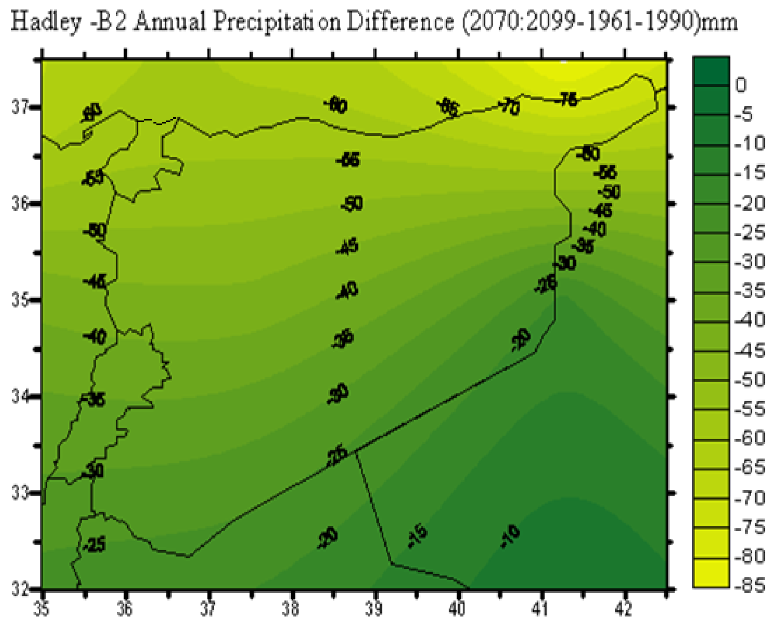


Fig. 3.10 Changes in Annual Precipitation in 2070-2099 compared to the 1961-1990 Period (B2 Scenario– Hadley Model - CM3)

Temperature

Table 3.5 shows the seasonal and annual dry air temperature variation (°C) for the years 2010-2039, 2040-2069 and 2070-2099, as compared to the normal averages of 1960-1990

Table 3.5 Seasonal and Annual Dry Air Temperature Variations for the Years 2039, 2069 and 2099,Compared to Normal Averages from the Years 1961-1990

Years	Winter	Spring	Summer	Autumn	Annual
2010-2039	0.8-1.0	0.7-1.1	1.2-1.9	1.1-1.7	**0.9-1.4**
2040-2069	1.8-2.2	1.8-2.6	2.6-4.4	2.2-3.0	**2.1-3.0**
2070-2099	3.3-4.1	3.3-4.7	4.4-7.0	3.9-5.0	**3.8-5.2**

Changes in Temperature (the A2 Scenario)

A2 Scenario (2010-2039)

Predictions reveal that an increase of 0.7 °C in minimum seasonal temperature is expected for spring, while a maximum increase of 1.9 °C is to take place in summer. In winter, temperature changes are expected to vary from a minimum of 0.8 °C in coastal areas to a maximum of 1.0 °C in the east, southeast and northeastern part of the country. In spring, an overall increase of 0.7-1.1°C is expected for the western and eastern regions, respectively. Furthermore, a similar increasing trend of 1.2-1.9 °C is expected in the southwest and the northeastern regions. In autumn, an increase of 1.1 °C and 1.7 °C is forecasted for the western and northeastern regions. Annual temperature changes for the period are shown in figure 3.11.

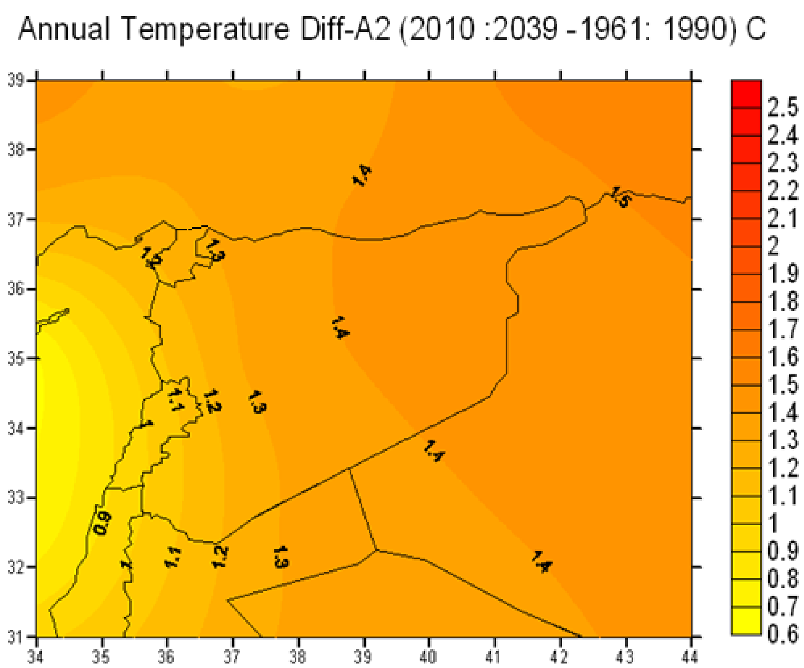


Fig. 3.11 Changes in Annual temperature in 2010-2039 (A2 scenario-Hadley Model - CM3)

A2 Scenario (2040-2069)

The scenario predicts an increase in minimum seasonal temperatures by as much as 1.8 °C in winter and spring, while a maximum increase of 4.4 °C is expected in summer. In winter, temperature changes vary from a minimum of 1.8 °C in the Southwest to a maximum value of 2.2 °C in northeastern Syria. In spring, an increasing trend of 1.8°C - 2.6 °C is expected in western, central and northern Syria. In summer, a trend increasing from Southwest (2.6 °C) to Northeast (4.4 °C) is expected. In autumn, another from Southwest (2.2 °C) to Northeast (3.0 °C) is forecasted. Annual temperature changes for the period are shown in figure 3.12.

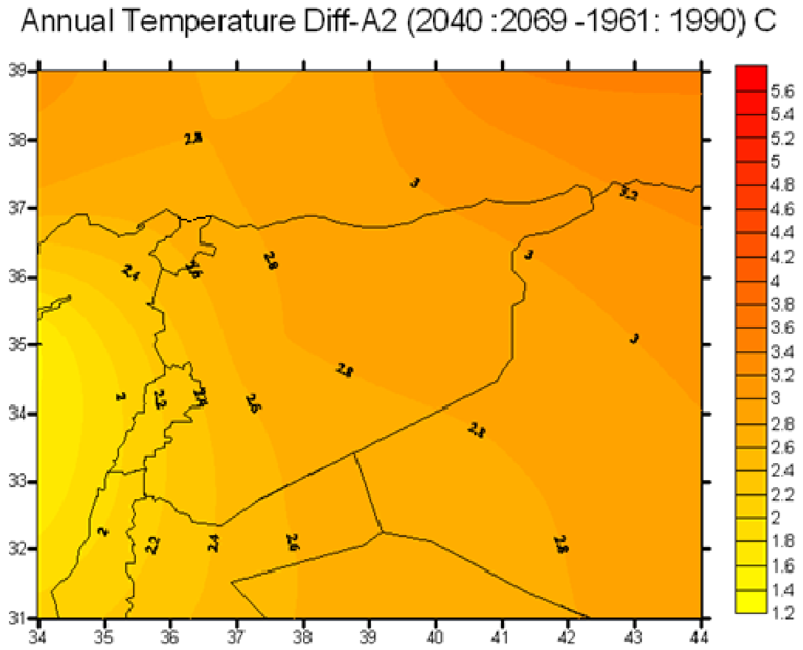


Fig. 3.12 Changes in Annual Temperature in 2040-2069 (A2 Scenario - Hadley Model - CM3)

A2 Scenario (2069-2099)

Spatial variations on a seasonal basis, as foreseen by the scenario for the years 2070-2099, show an expected increase in minimum seasonal temperatures by 3.3 °C in winter and spring; a maximum increase of 7.0 °C is nevertheless expected in summer. In winter, temperature increases vary from a minimum of 3.3 °C in the western part of the country to a maximum of 4.1 °C in eastern parts of Syria. In spring, a trend to increase spreading from the western corner (3.3 °C) to central and north Syria (4.7 °C) is likely. Similar trends of 4.4 °C in the Southwest and 7.0 °C in the Northeast are possible. In autumn, a trend for temperatures to increase from the Southwest (3.9 °C) to the Northeast (5.0°C) is forecasted. Annual temperature changes for the period are shown in figure 3.13.

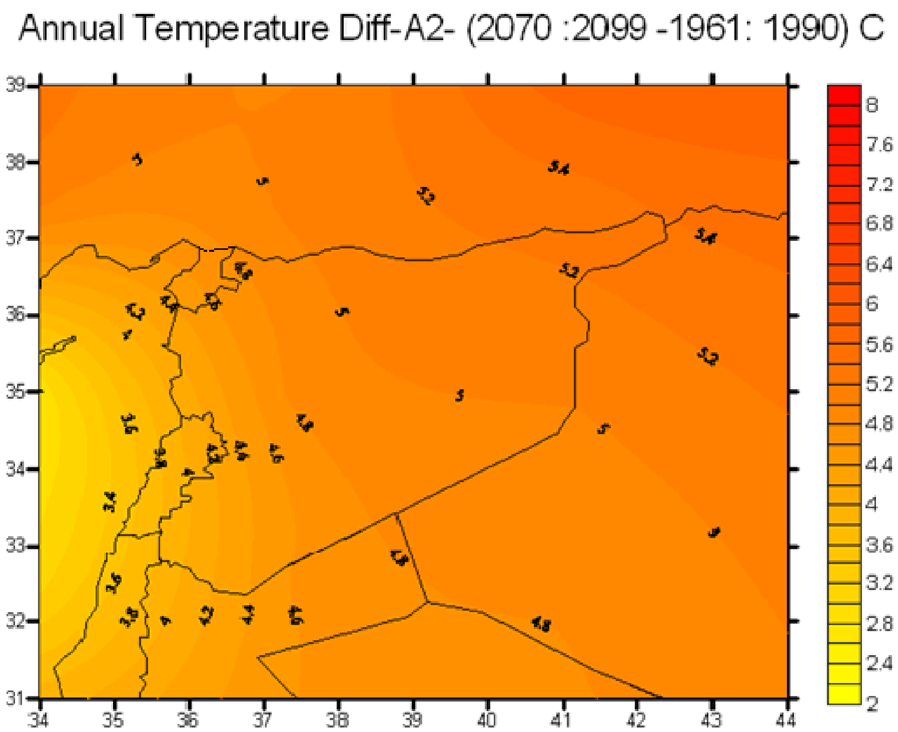


Fig. 3.13 Changes in Seasonal Temperatures in 2070-2099 (A2 scenario – Hadley Model - CM3)

Changes in Temperature (the B2 Scenario)

Changes in temperature at various periods, as predicted by the Hadley model for the B2 scenario, are shown in table 3.6.

Table 3.6 Seasonal and Annual Dry Air Temperature Variability in 2010-2039, 2040-2069, 2070-2099 compared to Normal Averages (1961-1990), from the Model HADCM3.

Years	Winter	Spring	Summer	Autumn	Annual
2010-2039	1.0-1.3	0.8-1.2	1.1-2.5	1.2-1.8	**1.1-1.7**
2040-2069	1.5-1.9	1.1-1.8	2.1-3.6	1.7-2.1	**1.6-2.4**
2070-2099	2.5-2.8	2.4-3.2	3.4-5.1	3.0-3.6	**2.8-3.8**

B2 Scenario (2010-2039)

In this scenario established for the period 2010-2039, a 0.8 °C increase in minimum seasonal temperature is expected for spring, while a maximum increase of 2.5 °C is forecasted for summer. In winter, temperature changes are to vary from a minimum of 1.0 °C in the southwestern regions of the country to a maximum value of 1.3 °C in northeast Syria. In spring, a trend showing an increase of 0.8-1.2 °C from the western regions to central and north Syria is expected. Similar trends of 1.1-2.5 °C in summer are expected for the southwestern and northeastern regions. In autumn, a trend revealing a gradient from southwestern (1.2 °C) to northeastern Syria (1.8 °C) is foreseen. Annual temperature variations for the period are shown in figure 3.14.

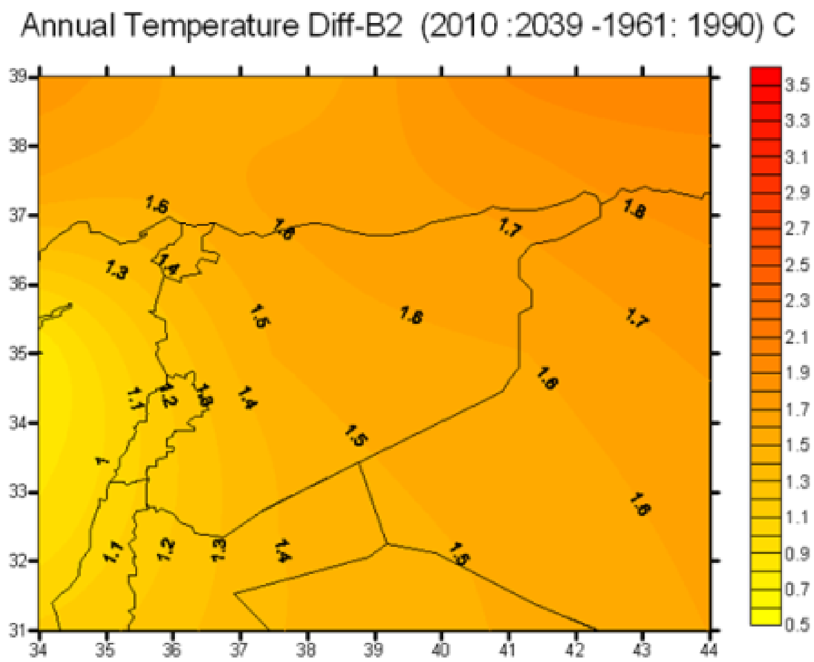


Fig. 3.14 Changes in Annual Temperature in 2010-2039 (B2 Scenario – Hadley Model - CM3)

B2 Scenario (2040-2069)

An increase of 1.1 °C in spring minimum seasonal temperature is expected, while a maximum increase of 3.6 °C is forecasted for summers. In winter, temperature increases are to vary from a minimum of 1.5 °C in the Southwest to a maximum of 1.9 °C in northeast Syria. In spring, a trend showing increases of 1.1°C in western Syria to 1.8 °C in the Central and Northern regions is plausible. In summer, a trend revealing increases of 2.1 °C in the Southwest to 3.6 °C in the Northeast region is foreseen. Finally autumn temperatures will rise by 1.7 °C in the Southwest to 2.1 °C in the northeastern parts of the country. Annual temperature changes for the period are shown on figure 3.15.

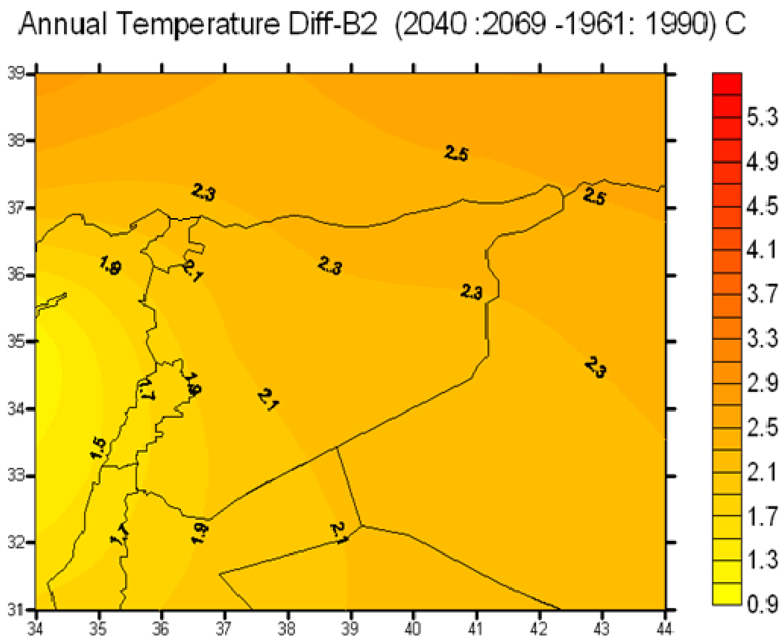


Fig. 3.15 Changes Annual Temperature in 2040-2070 (B2 Scenario – Hadley Model - CM3)

B2 Scenario (2069-2099)

During this period, a 2.4 °C minimum seasonal temperature increase is expected in spring, while a maximum increase of 5.1 °C is predicted for the summer. In winter, temperature rises will vary from a minimum of 2.5 °C on the Southwest region to a maximum of 2.8 °C in northeastern Syria. Similarly a trend revealing an increase of 2.4 °C in the western region to 3.2 °C in central and northern Syria is expected for spring. Furthermore, a trend showing an increase of 3.4 °C in the Southwest to 5.1 °C in the northeastern region is expected for the autumn season. In summer, similar increases by as much as 3 °C in the Southwestern region to 3.6 °C in the Northeastern region are expected. Annual temperature changes for the period are shown in figure 3.16.

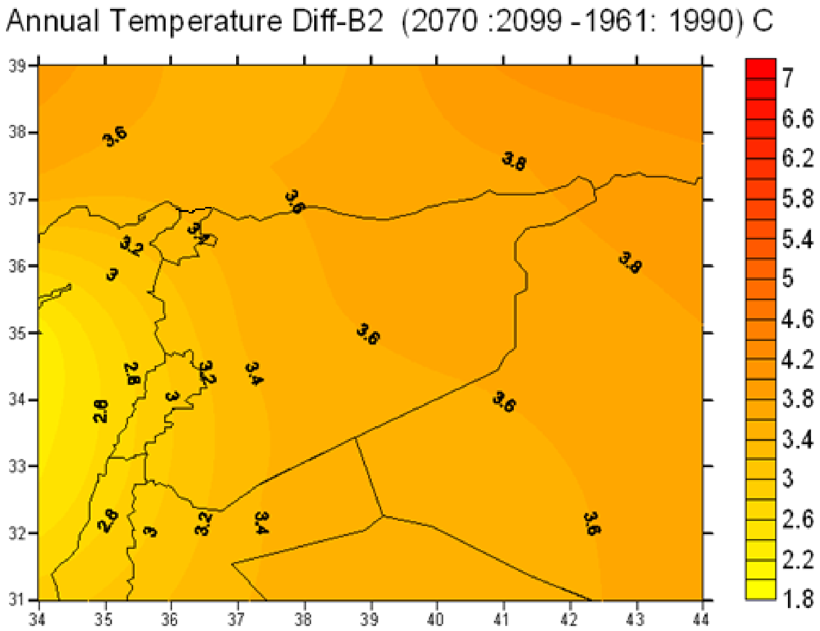


Fig. 3.16 Changes in Annual Temperature in the 2070-2099 Period (B2 scenario – Hadley Model-CM3)

3.3. Impact Assessment and Adaptation Measures

3.3.1. Water Resources

Overview

Syria by and large is an arid or semi-arid country. The prevalence of an arid and semi-arid climate has a direct link to the country's available and renewable water resources, largely dependent on rain water. The average annual per capita share of water amounts to slightly over 1000 m^3, a low figure compared to 7500 m^3 at global level. The per capita share of water is expected to worsen in the future: it might drop to 500 m^3 in 2025. Water availability is currently under heavy and increasing pressure, due to persistent drought, population growth and the irrational use of hydrological resources.

Groundwater is a crucial source of water in arid environments. Its importance increases considerably during droughts. With few exceptions, most of the groundwater basins in Syria are experiencing water deficits. Recent studies projected a change of groundwater recharge of more than -30% between the present-day (1961 to 1990) and the 2050s (2041 to 2070) (Döll and Flörke, 2005).

The overall water deficit in the country is growing. In the years 2001-2002, the average deficit was 16% above that of the years between 1992 and 2000 (Abed Rabouh, 2007). Water deficit, estimated at 651 mcm/y for the period 1995-2005, is expected to increase to 2077 mcm/y in 2026-2027, solely because of population growth and increasing development (Kayal, 2007).

The Impact of Climate Change

A change in current climate conditions is likely to bring about significant changes in precipitation and temperature patterns (see above section). These changes are likely to put more pressure on water resources, thus exacerbating the current situation, unless adaptation measures are seriously considered in the planning and management of these precious resources.

The impact of climate change on water resources, reflected in an overall decrease in precipitations and increased temperature, was assessed thanks to two different case studies. The first dealt with the Euphrates River as a major source of surface water in the country. The second was an analysis of the Zabadani sub-basin and the Fijeh spring, two revealing examples relevant to the study of the impact of climate change on ground water resources.

Case Study (1): The Euphrates River

The climate change projection for the upper Euphrates and Tigris watershed areas shows that major reductions in water from melted snow might affect these two rivers' stream flow. The reduction might reach to 100 mm in snow water equivalent (Onol and Semazzi, 2006). The model-derived climate sensitivity of the Euphrates River discharge shows that a 25% decrease in precipitations heightens or lowers the discharge profile of the river, while keeping its hydrographic shape unchanged (Smith *et al*. 2000). This prediction means that the annual discharge rises to 40,655 mcm or drops to 15,751 mcm (in comparison with a reference value of 27,048 mcm). This is a 50% rise and a 42% drop respectively, nearly twice the imposed percentage change in precipitations. Regional modeling studies predicted a reduction of nearly 40-50 mm in the upper Euphrates and Tigris basins, i.e. a decrease of about 7% of average rainfall. Such reductions are expected to result in drops of about 11% in Euphrates river discharge (Figure 3.17) (Evans, 2008). Other studies predict a reduction of approximately 10-25% in river runoff in the upper Euphrates and Tigris basins by 2070 compared to the average flow of the year 2000 (Lenher *et al.*, 2001 and EEA, 2004).

Any imposed change in temperature nevertheless alters the shape and magnitude of Euphrates discharge. Warming of approximately 5 degrees significantly increases evapo-transpiration, therefore lowering the discharge curve dramatically (and dropping the annual discharge from 27,048 mcm to 16,329 mcm (~60%)). Warming also eliminates the spring peak by preventing the overwinter storage of water in perennial mountain snow and glaciers. A 100 mm reduction in snow water equivalent in the Euphrates headwaters will lead to reduced flows in late summer, when water is scarce and demand is higher. Similar sensitivities to temperature change were observed in the Upper Tigris.

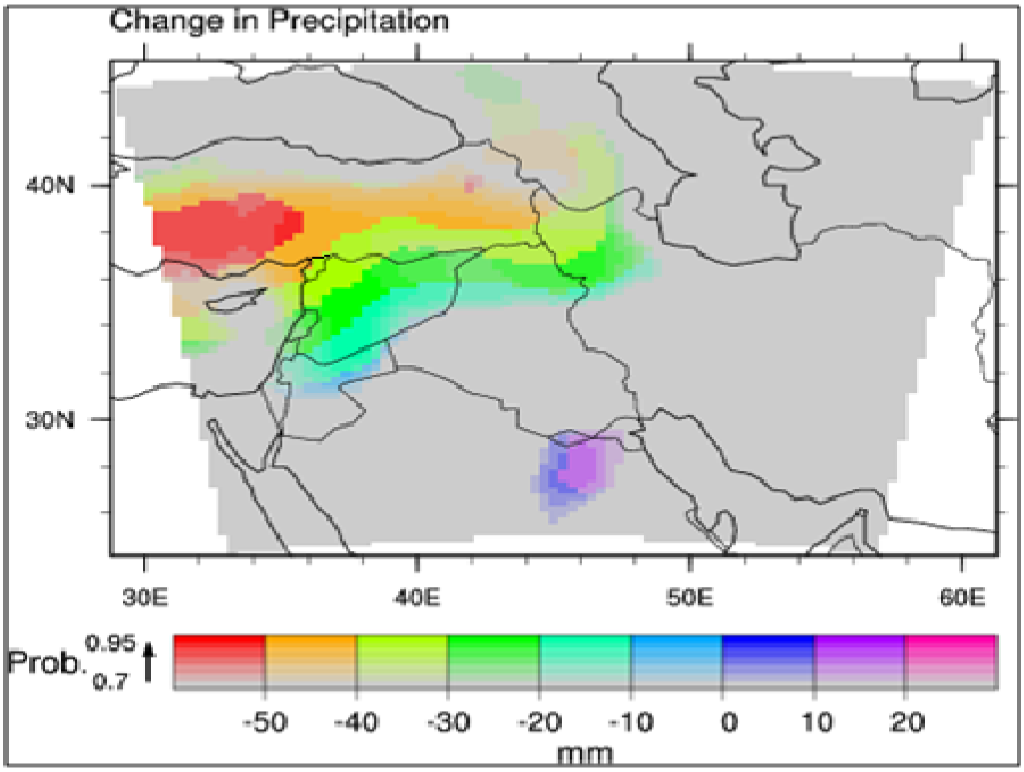


Fig. 3.17 Probability of Changes in Precipitations by Amount (hue) and Significance (sat).

Syria obtains 36% of its renewable annual water resources from the Euphrates River. Hence reductions in flow discharge will affect several sectors relying on water derived from Euphrates river flow. The large irrigation projects on the river basin will be most vulnerable to such changes, in terms of quantity and quality of irrigation water, thereby affecting cropping area and yield. Additionally reducing snow melt flowing through dams will decrease stored water, negatively affecting the potential generation of hydropower. Furthermore, the decline in water level in the Tigris and Euphrates will diminish the surface of irrigated areas by 1.5 ha/yr, which represents an annual loss of one million tons of agricultural products, evaluated at 20 million S.P. (U.S. $ ~ 425,000)[22].

Case Study (2): The Zabadani Sub-Basin

Located in the Anti-Lebanon Mountains, the Zabadani Sub-Basin receives 700 mm of annual rainfall. The sub-basin covers 140 km² and is drained by the only perennial stream of the region, the Barada River (its source lying at 1095 m a.s.l., see figure 3.18). The Karstic Barada spring constitutes an important resource of drinking water for Damascus. Additionally there is already competition for spring water among municipal drinking water suppliers, as well as between the agricultural and tourism sectors. In dry years the Barada spring (average discharge 3.8 m³/s) ceases completely to flow during summer months, worsening such conflicts.

The Decision Support System (DS) developed by the Arab Center for the Study of Arid Zones and Dry Lands (ACSAD) in Syria, *Bundesanstalt fuer Geowissenschaften und Rohstoffe* (BGR) and Stockholm Environment Institute (SEI) was utilized to explore the

[22] In the future national communications it is highly recommended to consider the importance of water stored under the form of snow for the nation's agriculture in additional to the impact of temperature and precipitation changes on snow amounts.

impact of climate change on groundwater levels by using dynamic linkages between the calibrated groundwater mathematical model (MODFLOW2000, United States Geological Survey) and the Water Evaluation and Planning Model (WEAP21, Stockholm Environmental Institute) (Al-Sibai *et al.*, 2008).

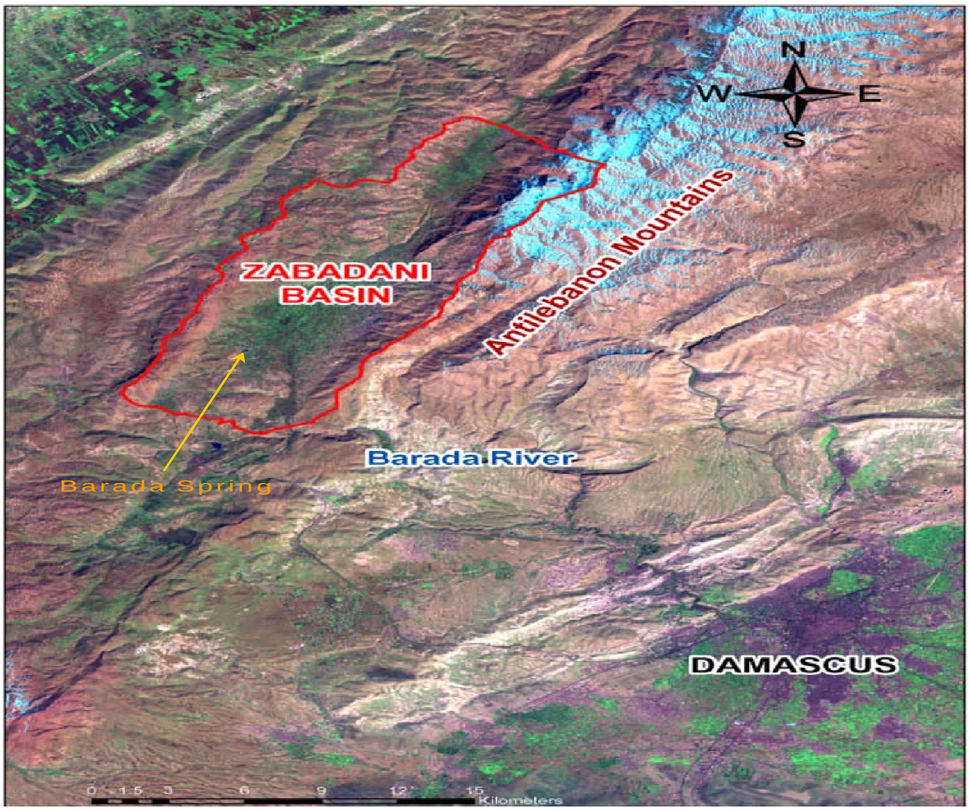


Fig. 3.18 The Zabadani Sub-Basin

The impact of climate change on the Barada's spring discharge was further studied using the calibrated model "Streamflow Simulator 2007". Simulation results showed that a decrease in 2040 of 5.1% in annual rainfall [(23)], accompanied by the same pattern of rainfall and pumping rate of the year 2006-2007, would result in a continuous decrease in spring discharge, a gradual disappearance of the low flow period of the spring, and a restriction of spring discharges mainly at peak times. The model expected by 2039 a decrease of 37% in annual discharge (Figure 3.19).

[23] Vulnerability Assessment and Adaptation Measures of Water Resources: Modeling; (2009). Meslmani Y. and Al-Sibai M.; (INC-SY_V&A_Water Model); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.

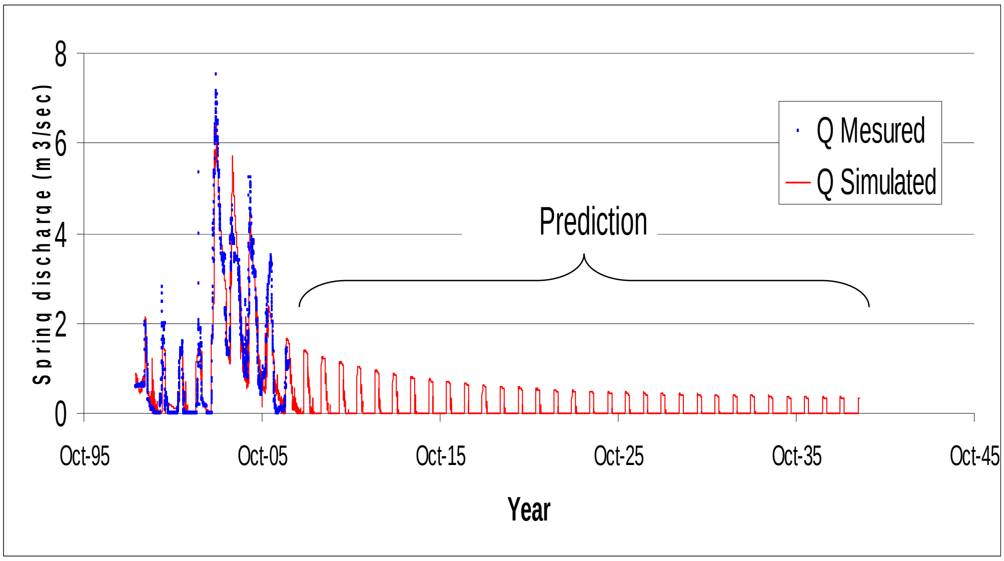


Fig. 3.19 Simulated Daily Spring Discharge after 2007

The socio-economic and political impact of groundwater decline is of great concern. With the Barada and Awaj basins having the highest quantity of drinking water (24%), the domestic sector living in the basin will be the most vulnerable. Generally speaking, besides the environmental impact of a lowering of ground water level, the lowering of water wells by 20 meters will increase the cost of irrigating crops by 5 billion S.P. This implies deeper agricultural wells and additional costs associated with pumping, for an irrigated total area of 812,921 hectares.

A priority in order to adapt to water scarcity would be reducing people's vulnerability and helping in particular the poor and economically disadvantaged living mainly in rural areas. Any strategy should focus on two main issues: sustaining agricultural production and preserving the environment. This requires making major changes in water management, policies, and water-related infrastructure.

Adaptation

The predicted impact of climate change on water resources could be harnessed by measures guided by the philosophy and methodology of integrated water resources management. The following bullets are suggested as possible adaptation measures:

- Preparing a national water master plan within the framework of integrated water resources management, as well as integrating into the plan water policies and strategies related to water use.

- Strengthening the institutional and technical capacity of water related agencies to ensure systematic collection, processing and exchange of data and information, and enhancing better coordination and cooperation between various water stakeholders.

- Enforcing laws and regulations. These include spring protection zones, well drilling permissions, drilling supervision and specifications, protection of groundwater recharge zones, groundwater pumping schemes, protection of groundwater and surface from pollution, and finally water resources development.

- Improving irrigation efficiency by reducing water demand for irrigation through changes in the cropping calendar, crop mix, irrigation method and area planted.
- Improving rain collection techniques.
- Rationalizing water use and applying water saving measures.
- Rehabilitating existing dams as well as improving water basin infrastructure for increased water storage capacity.
- Strengthening existing observation networks (metrological, surface and ground water).
- Capacity-building to integrate climate change adaptation strategies into sector and cross-sector development plans.

3.3.2. Agricultural Production

Overview

Syria's economy has traditionally been dominated by the agricultural sector, which employs 25-30% of the total workforce and contributes about 25-30% of the country's GDP (Statistical Abstract, 2004). Nearly 70% of the cropped area (5,523,356 ha) in the country depends on rainfall (Statistical abstract, 2005). Consequently, variations in the amounts and timing of rainfall can immediately cause substantial shifts in areas planted, productivity and yields in most of the major agro-ecological zones in the country.

The expected increase in temperature and decline in rainfall will have an impact on the crop water supply-demand relationship, on crop water use efficiency, on the reduction of the growing season and decreases in water availability. This depends by itself on the extent of changes in the form of precipitations and the timing of its events.

By and large, the two most important crops in the country are wheat and cotton. Wheat is considered as the crucial staple and strategic crop in Syrian agriculture (NAPC, 2002). It occupies 34% of the cropping area in the country, and 55% of this production is coming from irrigated farming (Statistical Abstract, 2005). Furthermore wheat is planted on 70% of the irrigated land devoted to strategic crops. The crop is of paramount importance for food security of the country because it is the main source of protein.

Moreover raw cotton is by far the country's single most important agricultural export. It is planted on 25% of irrigated land devoted to strategic crops. It accounts for 29.5% of agricultural export value and 13.8% of agricultural trade volume (NAPC, 2002). In addition, it is the largest employer of labor within the agricultural sector. Almost all the cotton is grown on irrigated land, largely in the northeastern part of the country (the Jezira).

The olive tree constitutes the most important fruit tree in Syria. The country was ranked as the world's sixth olive oil producer in 2005 (IOOC, 2006). In 2006, the area planted by olive tree was 564,938 hectares in surface and production reached 1,200,000 tons of olives (Statistical Abstract, 2006).

Impact of Climate Change

The likelihood of an impact from climate change on wheat and cotton production was assessed in the Hassakeh governorate, since this region is the main agricultural one in terms of wheat and cotton production. Yet Aleppo governorate was also selected to assess the effects of climate change on olive tree production, since the governorate contributes 23 % of olive oil production.

CROPWAT is an irrigation management model developed by the FAO Land and Water Management Division. It is used to evaluate crop water requirements and irrigation needs (Smith, 1992). The model was utilized to assess the effect of climate change on wheat (irrigated and rainfed), cotton, and olive tree water use and yields.

The results should be used as a mere indication of the effects of climate change on agricultural crops, due to: inherent deficiencies in the model itself, the assumption that nutrients are not limiting, and because the effects of warming on length of growing season were not taken into consideration. The following sections highlight the results.

Impact on Irrigated Wheat

Using the CROPWAT model fitted with the current climatic conditions, it was estimated that the wheat water requirements (ETm) are 563 mm annually. However, actual crop water use is estimated at 402 mm. Consequently the difference between actual and potential evapo-transpiration is 161 mm. This indicates that wheat grows with a water deficit under the current crop management system and the diminution in yields due to this stress is about 30% (Table 3.7).

Table 3.7 Actual Water Use for (in mm) Wheat under Current Climatic Conditions

ETo (mm)	ETc (mm)	Ky[1]	Ya[2] t/ha	Ym[3] t/ha	Ks	ETc_{actual} (mm)	Yield reduction (%)
613	563	1.00	3.5	5.0	0.7	402	30

ETc: Crop evapotranspiration
ETo: Reference evapotranspiration
Ks: Water stress coefficient
ETm: Crop water requirements
Kc: Crop coefficient
Ya: actual yield
Ym: maximum/potential yield
Ky : yield response factor.

[1] Irrigation and Drainage Paper No. 33 (Doorenbos and Kassam, 1979)
[2] Average of yields during15 years in the Hassakeh governorate
[3] from Irrigation and Drainage Paper No. 33 (Doorenbos and Kassam, 1979) and local data

The predicted changes in temperature and precipitations for the B2 scenario – Hadley Model-CM3 for the period 2070 to 2100 for Hassakeh governorate was used in the CROPWAT model to calculate crop water use for potential optimum production under climate change conditions. The findings revealed that an increase in atmospheric temperature and a decrease in precipitations could lead to increased wheat crop requirements, from 563 to 617 mm. This means an increase of 9.6% in water use for irrigated wheat, compared with crop water use under current conditions. If no additional irrigation water is added to compensate for this increase in water demand, crop production will be reduced by 15.7 % (from 3.5 to 2.95 ton/ha, table 3.8).

Table 3.8 Actual Water Use (in mm) for Irrigated Wheat under Conditions of Climate Change

ETo (mm)	ETc (mm)	Ky	Ya t/ha	Ym t/ha
670	614	1.00	2.95	5.0

Impact on Rainfed Wheat

Crop productivity under rainfed conditions largely reflects rainfall conditions. Rainfed wheat productivity in the Hassakeh governorate ranges between 280 kg/ha to 2377 kg /ha for rainfall between 95 to 530 mm (taking into account some years of total crop failure). A drastic change in climate will therefore adversely affect rainfed wheat production (Figure 3.20).

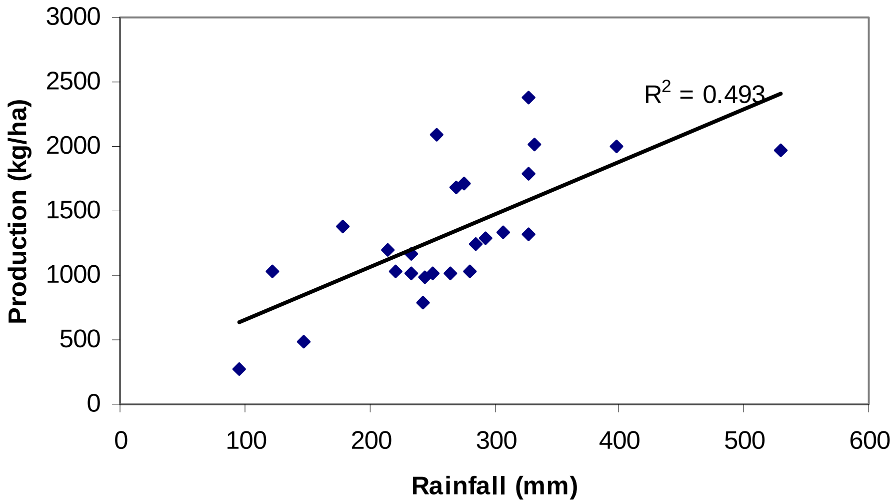


Fig. 3.20 The Relationship between Rainfall and Rainfed Wheat Production in the Hassakeh Governorate

Following the previous methodology, the potential crop water requirements for rainfed wheat were calculated: these are 428 mm. Actual crop water requirements for rainfed wheat are of 203 mm. This means a loss of yields by 52.5%, if compared to production under optimum conditions (table 3.9).

Table 3.9 Actual Water Use for Rainfed Wheat under Current Climate Conditions

ETo (mm)	ETc (mm)	Ky1	Ya2 t/ha	Ym3 t/ha	Ks	Etc actual (mm)	Yield reduction (%)
494.3	428.4	1.05	1.40	2.95	0.475	203	52.5

[1] *Irrigation and Drainage Paper No. 33 (Doorenbos and Kassam, 1979)*
[2] *Average of yields during 15 years in the Hassakeh governorate*
[3] *From local data*

Under the climate change scenario, crop water requirements for rainfed wheat would climb to 469 mm. This is equivalent to an increase of 9.6 % in crop water demand, reducing yields by 21%, unless water is added (Table 3.10).

Table 3.10 Actual Water Use for Rainfed Wheat under Current Climate Conditions

ETo (mm)	ETc (mm)	Ky	Ya t/ha	Ym t/ha
541.1	469	1.05	1.1	2.95

The decline in crop production due to climate change will result in a decrease in the value of plant production by as much as 7.8%. This decline will affect food security in the long run. It is very difficult to predict the economic outcome for such an impact. However, the consequences of the severe drought of 1998/1999, which caused a loss of 21.6 billion S.P. (current prices) can be used as an indicative figure for such an impact.

Impact on Cotton

By following the above-mentioned methodology, it was found that crop water requirements for cotton are 1169 mm. The difference between required water and actual allocated hydrological resources (982 mm) reduces yields by 20% (table 3.11).

Table 3.11 Actual Water Use for Cotton under Current Climate Conditions

ETo (mm)	ETc (mm)	Ky[1]	Ya[2] t/ha	Ym[3] t/ha	Ks	Etc actual (mm)	Yield reduction (%)
1,307	1,169	0.8	4.0	5.0	0.84	982	20

[1] Irrigation and Drainage Paper No. 33 (FAO 1979)
[2] Average of Yields during 15 years in the Hassakeh governorate
[3] from Irrigation and Drainage Paper No. 33 (FAO 1979) and local data

Under the climate change scenario, crop water requirements for cotton (ETc) would increase from 1169 mm to 1287 mm (10.1%). If no additional irrigation water is added to compensate for this increase in demand, the crop production will be reduced by 7.5 % (Table 3.12).

Table 3.12 Actual Water Use for Cotton under Current Climate Conditions

ETo (mm)	ET crop (mm)	Ky	Ya t/ha	Ym t/ha
1,415	1,287	0.85	3.7	5.0

Impact on Olive Tree Production

By using the abovementioned methodology, the team found that crop water requirements for olive trees (ETc) are 858 mm (table 3.13).

Table 3.13 Actual Water Use for Olive Cultivation under Current Climate Conditions.

Parameter	ETo (mm)	ETc (mm)	Ky[1]	Ya[2] Kg/tree	ETc_{actual} (mm)
Irrigated	1,446	858	1.1	17.5	463

[1] From calibration of local data
[2] Average of yields during 15 years in the Aleppo governorate

Under the climate change scenario, crop water requirements for olive tree (ETc) would increase from 858 to 945 mm (10.2%). If no additional irrigation water is added to compensate for this rise in water needs, the production for irrigated olive will diminish by 17 % (Table 3.14).

Table 3.14 Actual Water Use and Yields for Olive Tree Cultivation under Conditions of Climate Change

Parameter	ETo (mm)	ETc (mm)	Ya* Kg/tree	ETc_{actual} (mm)
Irrigated	1,588	945	14.5	437

*Yields calculated using CROPWAT

Adaptation

The present level of adaptation to climate risks in the agricultural sector is limited to calls for using irrigation water efficiently through a national program, restricting cropping areas, demands for new farming practices, and lately establishing a farmer support fund. Adaptation measures in the agricultural sector must be pursued with a strategic vision in accordance with the value and importance of the agricultural sector's contribution to the national economy and to food security of the country. Future strategies for adapting to climate change in the agricultural sector may involve the following measures:

- Reviewing agricultural policies and strategies regarding agricultural crops, in relation to CC.
- Developing and implementing easily accessible drought forecast and drought monitoring information systems, in order to improve drought preparedness within the national plan to mitigate the effects of drought.
- Developing agricultural research and extension services. Changing crop practices (optimum sowing date, heat-tolerant cultivars, water rationing and increasing planting density).
- Developing agricultural research and extension services. Changing crop practices (optimum sowing date, heat-tolerant cultivars, water rationing and increasing planting density).
- Modernizing water irrigation practices and improving irrigation management.
- Increasing rain effectiveness by applying conservation farming, water harvesting and storage structures.

3.3.3. Natural Ecosystems

Forests

The total area of Syria occupied by forests exceeds half a million hectares, i.e. 2.71 % of the country's total area. Nearly 53.56% of these forests are manmade. 99% of forests are state owned and managed by the forestry service. They are managed according to general guidelines and broad goals, but there is an absence of clear policy. The forestry bureau is limited in its resources, insufficient in capacity and inefficient in coordinating inter-agency forest related activities.

Forest clearance, wildfires and quarrying are the main pressures causing current woodland degradation in Syria. Pressures from these activities (especially fires) have increased in the last twenty years. Hence intensifying agents of forest disturbance will increase the latter's vulnerability to climate change and jeopardize their ecosystems.

Impact of Climate Change

Although no quantification of the effects of climate change on forest vegetation has been done, it is generally accepted that such effects may take temporal and spatial forms. The recession of climax forests is quite possible under the destructive agents of change, which in turn reflects a temporal shift in forest vegetation. Moreover a decrease in precipitations and an increase in temperatures might cause spatial "upward shift" for some plant species of the forest vegetation zones of mountainous areas. A 200-meter upward shift was reported in Lebanon and Turkey. If this happens in Syria, this may change vegetation association, as change may affect community composition in the first place. Actually the scarcity and disappearance of some species from certain mountain zones has been reported by some Syrian researchers.

Brutia pine forests, which constitute 27.5% of the natural forested area, are the most vulnerable to climate change resulting from possible increase in the frequency, intensity and extent of fires. The effects will be stronger with the increasing frequency of drought and the prevalence of longer and warmer summer days. This is evident when one observes that larger forested areas have been lost to fires during the past years: for instance, a single forest fire in late December 2004 caused a reduction by nearly 0.4 % of the total forested area in the country.

Manmade forests, constituting more than 53% percent of country's forests, are vulnerable to climate change: most of these forests are planted in areas of low rainfall in the interior of the country (marginal forests). Moreover, the severity of insect attacks and diseases are expected to increase due to a more favorable climate for the spread of ailing agents.

Finally water shortage will become a major constraint for increasing the forested surface and even maintaining it, since scarce water is to be diverted to other uses. Hence reforestation work, stretching species beyond their natural distribution limits, will be limited to the species' natural habitat.

Adaptation

With a stocking capacity of nearly 16 million tons of carbon and an annual absorption of 1.6 tons of atmospheric CO_2 per year, Syrian forests play a major role as a carbon sink, contributing to curbing CO_2 emissions. To strengthen and maximize this role, the following measures are suggested:

- The adoption and execution of a formal forest policy for forest development and conservation.
- The strengthening of the forestry bureau's activities now directed towards a more focused protection of existing forests against wildfires and other destructive agents.
- The rehabilitation of burnt and degraded forests, in order to increase their capacity to absorb carbon.
- The establishment of a network of functional protected areas, in order to ensure the conservation of the country's most valuable forest ecosystems.
- Capacity building at institutional and staff levels.

Marginal steppe and Grazing Zones

Syria's marginal steppe zones (the Badia) constitute 55.1% of the country's total area. The vegetation of the Badia is fragile, due to limited rainfall, periods of cold temperature, frequent drought spells, land tenure and the current prevailing grazing patterns. Productivity in these regions is low and varies, depending mainly on rainfall, soil and site conditions. The main cause of degradation and desertification in marginal lands is land tenure, which leads to communal grazing rights, over- and early grazing, fuel wood collection, and floodplain ploughing.

Frequent droughts are common in the Syrian marginal arid zones and their impact is immense. For instance the 1989/1999 drought caused a loss of 38.7 million S.P. in sheep alone (1999 prices). Moreover the total loss in hay was estimated at 0.8-1 million tons, i.e. 10 billion S.P. (current prices).

Impact of Climate Change

Climate change will augment the existing problems of desertification, water shortages and low forage productivity. Moreover, it will introduce new threats to herders and livestock owners' wellbeing, rangeland ecosystem services and national economy. On the other hand, land degradation and desertification affects availability of crop residue fodder during the drought periods.

Adaptation

Despite some of the shortcomings in rangeland management, there is great potential for improving the Badia vegetation and enhancing its resilience to climate change. The following measures need to be strengthened:

- Effective implementation of set of drought management strategies including setting an effective feed reserve policy.
- Supporting the use of renewable energy in rangeland development, Solar Power Plants, solar panels, wind farms investments.
- Expansion of plantation programs of drought-tolerant native and exotic species.
- Expanding programs for fighting desertification.
- Solving issues relating to land user rights for the local communities.
- Diversification of sources of income for Bedouin population.

Biodiversity

In general, biodiversity in Syria is under pressure due to population growth and the unwise use of biodiversity-related resources. The number of threatened species in the country totals 68 of the various animal taxonomic groups (IUCN 2008). Seven of these species are listed as critically threatened, whereas 26 are considered endangered and 35 vulnerable (IUCN 2008).

Impact of Climate Change

Climate change may add additional pressure on already stressed ecosystems and species, thus augmenting threats to their survival and possible extinction. Moreover increasing demand for irrigation water has lowered the groundwater table in most of the country's basins. This in turn has a negative impact on swamps and other wetlands, since these ecosystems may dry up and affect the survival of water-dependent species. A further rise in sea water temperature might also increase the rate of the Mediterranean sea's "tropicalization", contributing to the problematic arrival of invasive species along the Syrian coast.

Adaptation

The following are possible measures of adaptation to reduce the impact of climate change on biodiversity:

- Updating a national biodiversity strategy and plan of action.
- Integrating a biodiversity strategy and plan of action within a national climate change plans and programs.
- Promoting conservation measures and the sustainable use of biodiversity components.
- Formulating a long-term research initiative on the status of species and their adaptability to changing environments.
- Promoting public awareness, emphasizing the importance of biodiversity and the probable impact of climate change.

Land Degradation and Desertification

Overview

More than 70% of arid lands in Syria are highly vulnerable to degradation. Another 23% (semi-arid lands) are vulnerable, but to a lesser degree. The danger caused by different forms of land use, however, varies between and within categories, according to their localization in the country's different agro-climatic zones. The main forms of land degradation include: wind erosion (affecting 9 % of the country's land surface), water erosion (6%), sand encroachments (2 %), and salinization (0.1%).

In the last twenty years substantial changes in land use have affected Syria (see figure 3.21). These changes were brought about by drought and land mismanagement. For instance the expansion of agricultural production has not been accompanied by an appropriate use of technology, by effective agricultural policies, sustainable farming systems, or by planned urban development, resulting in a degradation of land resources.

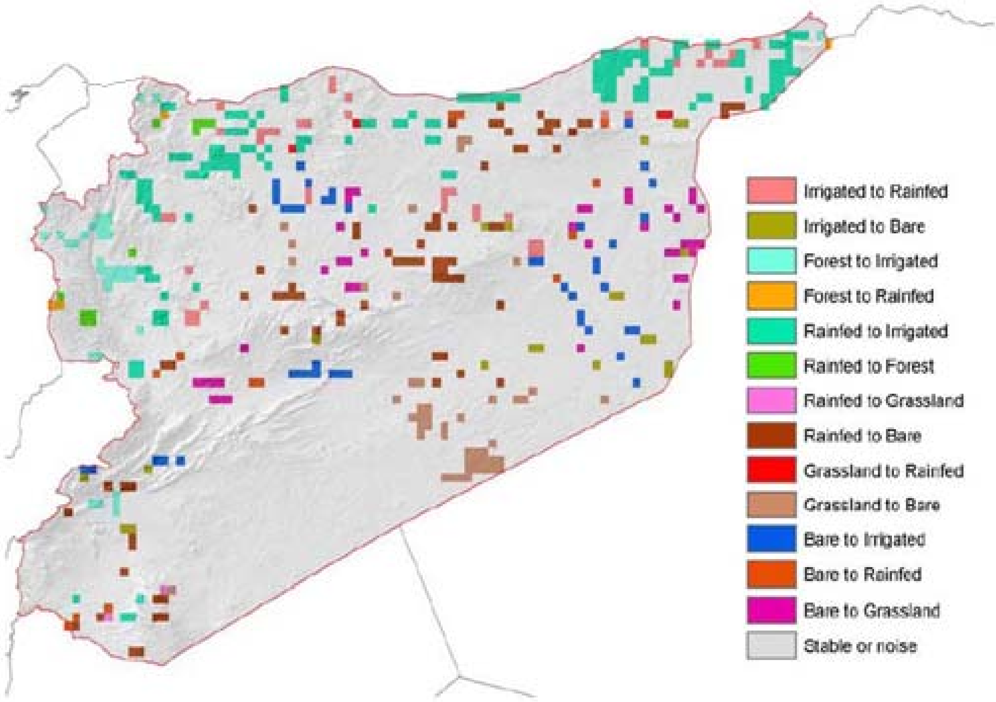


Fig. 3.21 Changes in Land Use/Land Cover in Syria between 1982 and 1999 (Celis, *et al*., 2007)

Impact of Climate Change

Climate change will affect land use patterns and accelerate the pace of land degradation. Proper land use policies and appropriate farming systems must be devised and applied in the most dynamic ways to hamper this effect. The challenge lying ahead is to sustain and optimize the use of natural resources in order to improve agricultural production and people's livelihoods.

Adaptation

Great opportunities exist in Syria to overcome land resource degradation and to increase food production. The following suggestions are adaptation measures:

- Setting proper land use policies and strategies to manage land resources and reduce the effects of climate change.
- Mobilizing and mainstreaming resources to protect the natural base of resources.
- Adopting and applying integrated management techniques, multi- and inter-disciplinary (and participatory) approaches when assessing and managing scarce land resources.
- Applying and disseminating conservation agriculture.
- Modernizing farm management and applying proper techniques and technologies in the production process.
- Supporting research activities and extension services.
- Facilitating the exchange of information and of experience between researchers, extension services and farmers.

3.3.4. The Rise in Sea Level (RSL)

Overview

The coastal region forms only about 2% of the total area of the country, but in this area resides more than 11% of the total population. Moreover, the region contributes more than 12% to GDP (MOLA 2007). The coastal area is the food basket of the country, especially when it comes to greenhouse cultivation and fruit orchards (CBS 2006). In addition the area contributes to nearly, 38% of national cement production and 50% of national oil refining. Cement plants and refineries are located on the very shoreline (Figure 3.22) (Ibrahim 2003).

The rise in sea level might adversely affect a number of the coastal zone's physical, ecological, biological, and socioeconomic characteristics, already under stress. The following sections highlight the methodological assessment and consequences of a rise in sea level.

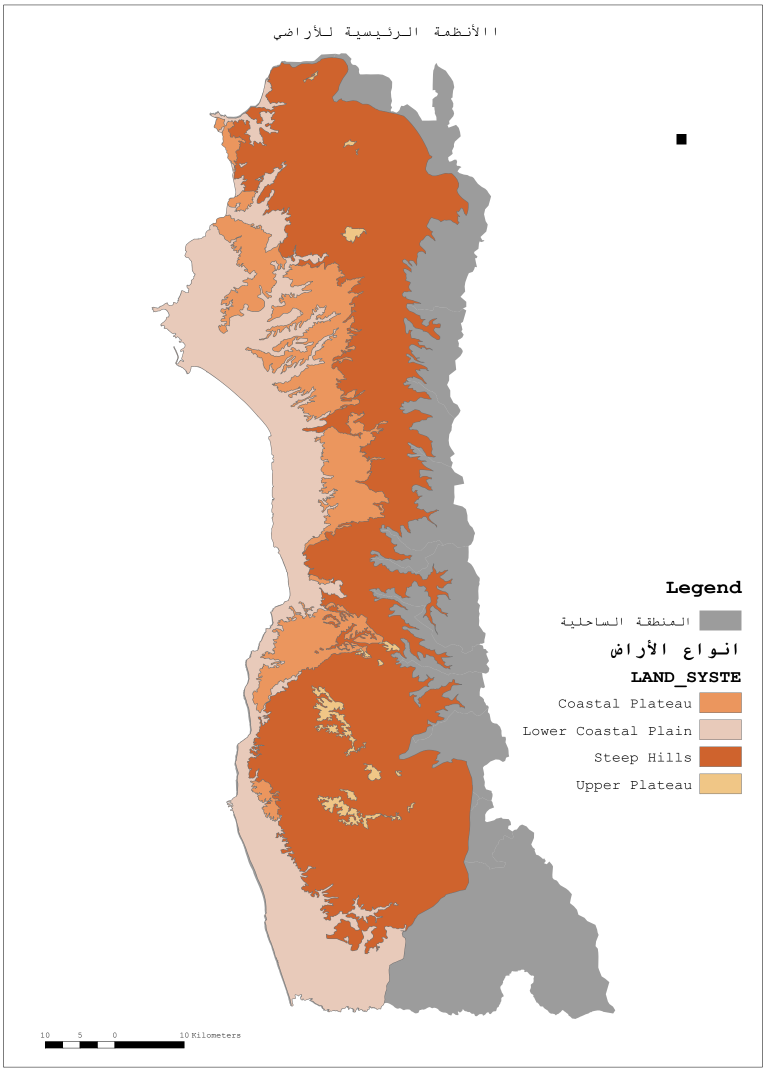


Fig. 3.22 Geomorphological Divisions of the Coastal Region (GORS 2006)

Scenarios for the Rise in Sea Level (RSL)

In order to assess the possible impact of RSL on coastal areas, a digital elevation model for the entire coastal zone (DEM) was built using the ArcGIS software. The spatial resolution of the DEM was 10 m and its vertical accuracy was between 5 and 10 m, the DEM in this case being of rather low accuracy (see Figure 3.23). The land use/cover map developed by the GORS project, visually interpreting Multispectral Landsat Satellite images with a FAO legend, was used for overlay and risk assessment. Additionally a one-meter spatial resolution IKONOS image taken in 2006 and covering the entire area was used for the visual interpretation of coastal geomorphology. Multi-temporal satellite images acquired by the Landsat satellite enabled an estimate of shoreline erosion.

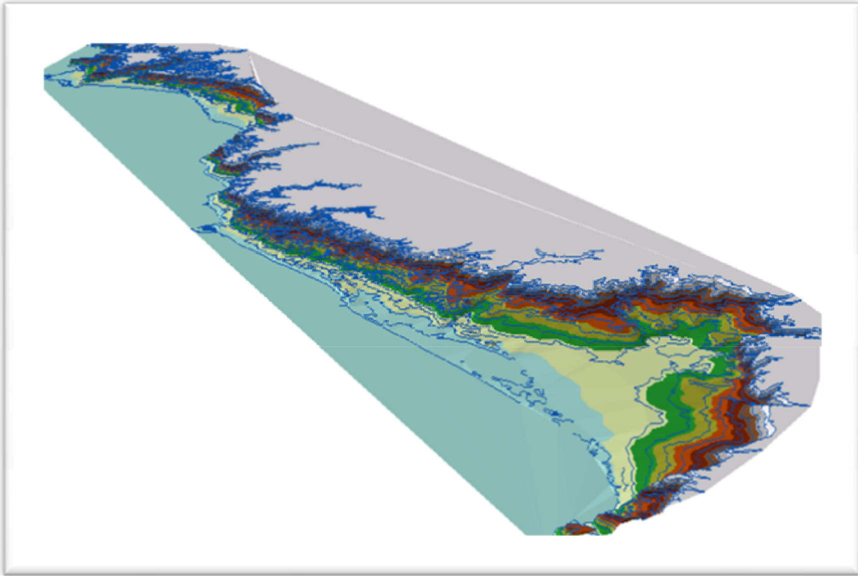


Fig. 3.23 DEM of the Syrian Coast

Six scenarios for a rise in sea level (RSL) ranging from very low to extreme risk were developed (see table 3.15). A coastal vulnerability index (CVI) was adopted from literature such as (Gornitz, et al. 1994)[24] and (Shaw, et al. 1998)[25]. The CVI is defined as (CVI = $\sqrt{\frac{a \times b \times c \times d \times e \times f}{6}}$) where a is the geomorphology, b the coastal slope, c the projected sea-level rise, d defines the shoreline erosion and accretion rate, e the mean tide range, and f the mean wave height. The index allows the six variables to be related in a quantifiable manner expressing the relative vulnerability of the coast to physical changes due to a rise in sea level[(26)].

24 Gornitz, V. M., Daniels, R. C., White, T. W., and Birdwell, K. R., 1994, The development of a coastal risk assessment database: Vulnerability to sea-level rise in the U.S. southeast: Journal of Coastal Research, Special Issue No. 12, p. 327-338.

25 Shaw, J., Taylor, R.B., Forbes, D.L., Ruz, M.H., and Solomon, S., 1998, Sensitivity of the Canadian Coast to Sea-Level Rise:Geological Survey of Canada Bulletin 505, 114 p.

26 *The CVI equation adopted in this project is being adopted and used worldwide in researches and projects. The geology is omitted from the equation, however its impact is not neglected at all since geology is used in the assessment of erosion and accretion rates.*

Impact of a Rise in Sea Level (RSL)

The results of these scenarios indicate that different segments of the coastline are vulnerable to a rise in sea level, as a consequence of expected climate change. This rise would have an impact on beaches, urban settings, and agricultural zones. Moreover additional problems may arise due to salt-water intrusion and increase in water and soil salinity.

Nevertheless the socioeconomic impact of a RSL on coastal lowlands would vary, depending on the flood levels, the degree of land use and development activities. The likely inundated sea shore area varies between 17.56 km^2 in a very low risk scenario to 118.90 km^2 in an extreme risk scenario (Tables 3.15 and 3.16). Coastal vulnerability indices are shown in six maps presented in the annex[27]; one should note that the three first scenarios represent the most likely one to materialize these are based on the IPCC's reports namely (IPCC AR4, 2007), whereas the last three incorporates estimates of extreme weather condtions and/or based on pessimistic scenarios developed along the Mediterranean basin.

Table 3.15 Inundated Areas in 2100 according to Various Scenarios of a Rise in Sea Level

Scenario	Trend (cm/yr)	Variation 2000-2100 (cm)	Inundated area (km^2)
Very low	0.6	60	17.56
Low risk	0.9	90	20.27
Moderate risk	1.3	130	23.89
Intermediate risk	1.9	1.9	27.57
High risk	2.5	250	30.35
Extreme risk	>5	500 up to 750	118.90

Table 3.16 Categories of Coastal Vulnerability Index and Effect

Class Risk	Description	Length (km)	Total Length (%)
1	Very low	2.74	1.5
2	Low	40.31	22.0
3	Moderate	74.72	40.8
4	High	29.48	16.1
5	Very high	35.75	19.5
Total		**183.00**	**100.0**

Possible physical impacts of a RSL include: (1) inundation and displacement of lowlands and wetlands, (2) increased salinity of coastal aquifers, (3) increased coastal erosion, and (4) increased coastal flooding and damage. One could thus infer that the most vulnerable coastal areas are: flat and low-lying coastal plains (sandy and rocky areas within an elevation of 0–1 m MSL), deltas and estuaries in the coastal plain and sandy shores characterized by a gentle sloping beach face.

Applying the extreme risk scenario shows that nearly 3.8% of coastal populations will be affected by a rise in sea level. The impact of this rise on major land use as a consequence of flooding is illustrated in figure 3.24.

27 Syrian Sea Level Rise Vulnerability Assessment 2000-2100 (GIS), (2009). Meslmani, Y., and Faour, G., (INC-SY_V&A_Syrian Sea Level Rise); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.

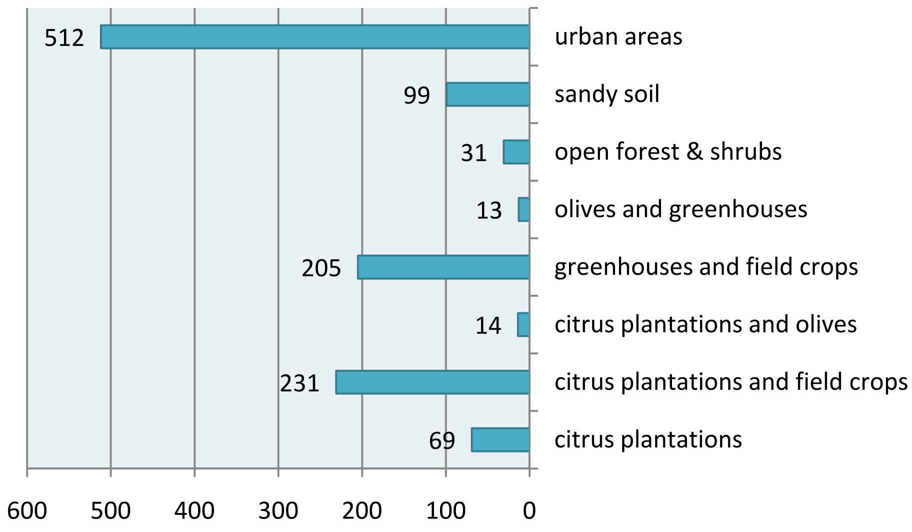


Fig. 3.24 Impact of RSL on Land Use/Cover (ha) [27]

It is very difficult to precisely evaluate the socioeconomic impact of a rise in sea level on local communities in affected areas, because of different sources of stress associated with RSL on these communities and the complexity of the problem itself. However, based on land use categories in the affected areas, a rough examination of economic losses as a result of RSL alone, the amount reaches 50 billion Syrian pounds. This figure represents direct average economic losses resulting from permanent disappearance of 4,108 hectares of agricultural and forested areas, 450 hectares of beach and 1,090 hectares of urban area. However these losses may go down to 10 billion S.P. in case of a RSL of 0.6 m and may reach 84 billion S.P. if the extreme RSL scenario is justified.

Nearly 2,000 agricultural families (and another 4,000 in the case of the extreme scenario) will be in danger of losing their economic subsistence and their dwellings. This signals the possibility of family migration to new areas, putting more pressure on the latter. Table 3.17 shows possible economic losses due to a rise in sea level of 2.5-3 m.

Table 3.17 Possible Economic Losses due to a RSL of 2.5-3m along the Syrian Coast.

Scenario	Total economic loss (in millions of S.P.)
Citrus plantations	13,205
Olives	432
Greenhouses	8,303
Crops (vegetable and field crops)	15,023
Forest	191
Sandy soil	1,800
Urban areas	10,900
Total	49,854

Table 3.18 Impacts of SLR on Landuse /Cover .

Scenario	Very low risk: 0.6m	Extreme risk: 5-7.5m
Land cover	**Area in sq Km**	**Area in sq Km**
Citrus and other plantations	3.14	37.51
Forest	0.41	2.21
Olives	0.19	1.51
Greenhouses and field crops	2.05	33.63
Sandy soil	0.99	7.98
Urban areas	5.12	16.73

Adaptation

Since adaptation is the only option to address the threat of sea level rise, hence, a series of hard and soft adaptation measures may be considered to counter the RSL threat. However a framework to incorporate policies which handle cross-cutting issues and measures per sector must be devised. The following suggestions may be considered:

- Assessing present pressure impact and the possible impact of climate change on coastal systems (RSL, wind, temperature increase, geology)
- Mapping institutions related to coastal activities and assessing their capacity
- Scrutinizing adaptation measures, including engineering and non-engineering options
- Formulating a framework that incorporates integrated coastal zone management (ICZM), disaster management (DM), and research as vital cross-cutting adaptation options, with measures by sector to alleviate the potential threat of climate change on coastal areas.
- Capacity building of related institutions
- Increasing public awareness of risks posed by SLR[28]

3.3.5. Energy

Overview

The Syrian energy system is characterized by low per capita energy consumption and a dependency on fossil fuels. Primary energy consumption per capita in Syria is 1.3 Toe (ton of oil equivalent). This is a low figure when compared to 1.77 toe of the world's average and 2.64 Toe of the Middle East (IEA statistics, www.iea.org). The primary energy supply in 2005 approximately reached 24.9 MToe; the power generation sector consumed alone about 37% of this amount. Total final energy consumption amounted to 15.2 MToe. The transport sector's (Trans) share was also high (26%), followed by households (HH) (24%) and industry (20%). Consumption by agriculture (Ag), construction (Cons), mining (Min) and the service sector (Serv) amounted to 11%, 7%, 7%, 5% respectively (figure 3.25). Final consumption of energy by fuel type is distributed in the following way: 72.1 % as oil derivatives, 10.3 % as natural gas, 2.8 % as traditional fuel, and 15% was transformed into electricity .

28 more accurate DEM should be considered in the second national communication (SNC).

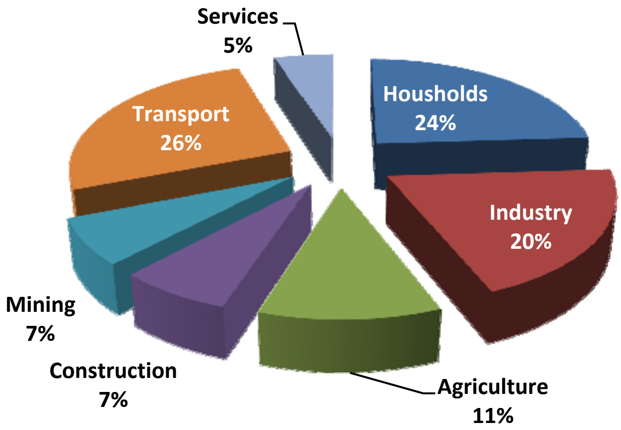


Fig. 3.25 Final Energy Consumption by Sector in 2005

Present energy conversion technologies rely mainly upon combustion of fossil fuels. During combustion carbon and hydrogen from fossil fuels are converted mainly into carbon dioxide (CO_2) and water (H_2O), releasing as heat the fuel's chemical energy. This heat is generally either used directly, but more often for generating electricity or for transport. This sector includes two main combustion-related activities, namely stationary combustion and transport. Stationary combustion is responsible for about 70% of greenhouse gas emissions from the energy sector.[29] Stationary combustion practically includes all energy-consuming activities, except those of the transport sector (in addition to petrochemicals and fertilizers). About half of stationary combustion emissions are associated with combustion in energy industries, essentially power plants and refineries. The energy industry forms a part of this category: energy extraction, production and transformation, which includes power generation and petroleum refineries; manufacturing industries and construction: activities like iron and steel production, chemical manufacturing, paper, food industries, beverages and tobacco, and other sectors such as commerce and residential construction. Mobile combustion devoted to transport (road and other traffic) causes about one quarter of the emissions in the energy sector [IPCC, 2006].

Total overall electricity generation in 2005 amounted to 34.9 TWh, whereas total final electricity consumption was 27 TWh (i.e. about 76.82 % of total generated electricity). Total installed capacity and the structure of Syrian electricity's generation system in the year 2005 are shown on figures 3.26 and 3.27.

[29] 2006 IPCC Guidelines for a National Greenhouse Inventory.

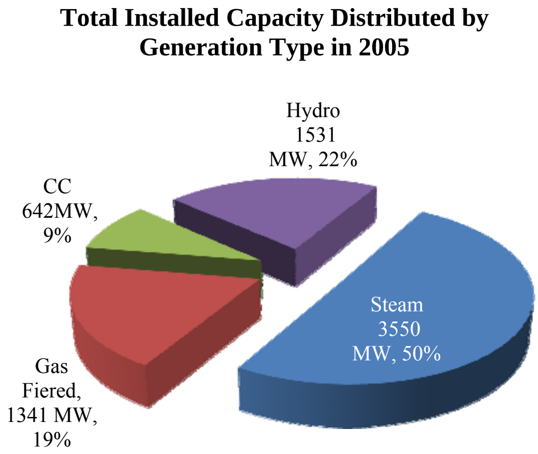


Fig. 3.26 Total Installed Capacity by Type of Electricity Generation

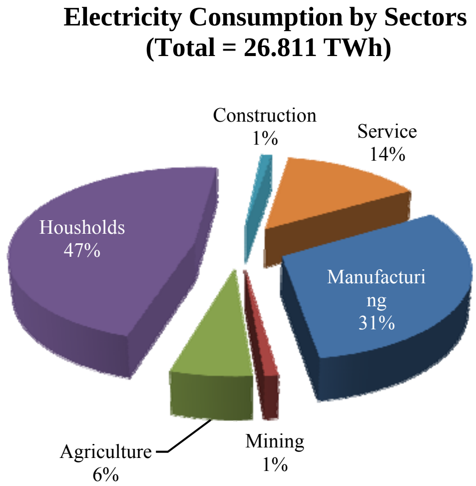


Fig. 3.27 Electricity Consumption by Sector

Impact of Climate Change

The power sector (generating electricity)'s consumption during the year 2005 was about 4,152 Ktons of fuel oil and 3,727 Mm^3 of natural gas, which amounted to 78% and 68% of the total consumed fuel oil and natural gas (FEB, 2005). It is worth mentioning that the CO_2 emissions originating from the generation of electricity amounted to ca. 40% of the energy sector's total CO_2 emissions.

Due to the comprehensive nature of the impact of climate change on different socio-economic activities, it is most likely that all consumption sectors could be affected. This includes the housing sector, transport, agriculture and industry. Electricity generation, water and agriculture seem to be the most sensitive sectors to climate change. The housing sector will suffer the most under the new conditions, whereas the most sensitive segments of society would be low-income households[30].

The ever-increasing scarcity of water will affect power production, as the amount of water required for the cooling process becomes limited. Nevertheless water is needed in many cases in electricity for pumping, transport and distribution. Moreover a rise in the price of electricity could limit water availability for various sectors of consumption.

In order to evaluate the impact of adaptation measures in future energy supply policies on GHG emissions, two energy supply scenarios were chosen. These scenarios were: a business-as-usual reference scenario and an alternative one based on the enforcement of sharing renewable resources.

[30] *The demand of electricity generation will be increase, during the heat waves consecution and period, since the air conditioning in households use will be increase too.*

Adaptation

To deal with expected future climate change, various development trends are applicable. However the feasibility of the assumed development trends should be evaluated while bearing in mind energy indicators for sustainable development. The social (easy access to and affordability of energy services), economic, environmental and institutional implications should be adequately studied. This means that a future energy supply strategy should assure adequate, reliable and efficient energy services to all segments of society at affordable costs, compatible with local conditions and in an environmentally safe manner. According to these requirements, the Syrian energy sector possesses great potential to deal with expected climate change. The coping capacity of this sector will depend on conservation measures and efficiency improvement (shifting to modern alternatives) with the aim of reducing the dependency on fossil fuels. Its share amounts presently to more than 95% of total primary energy in Syria. The coping capacity of the energy sub-sectors can be classified as follows:

- The power sector: the potential of this main sub-sector depends on:
  - Efficiency improvements, for instance shifting to combined cycle power plants,
  - Substituting fuel oil with natural gas,
  - Reducing illegal consumption in electricity distribution,
  - Increasing the share of renewable energy and electricity from nuclear plants.
- The transport sector: improvements could be made by:
  - Shifting to modern form of public transportation like the Metro,
  - Shifting to trains for transporting freight,
  - Replacing old cars by new, more efficient alternatives, including modern hybrid cars (in the distant future)
- Industries:
  - Improving the efficiency of industrial processes, mainly in the application of heat,
  - Rehabilitating and modernizing energy consuming industries like the production of cement.
- Agriculture:
  - Improvements could be made in water pumping,
  - Adopting innovative ways of measuring water demand management,
  - New machines for agriculture,
  - Reducing the share of water intensive agricultures like cotton cultivation (due to both, high energy and water requirements).
- Housing:
  - Conservation measures in all residential backgrounds (changes in behavior),
  - Development of alternative heating devices,
  - Increasing the share of solar energy for water and residential heating,
  - Increased insulation in buildings,
  - Improving the efficiency of air conditioners and refrigerators.

The coping capacity to climate change of the energy sector is reflected by its ability to undergo required restructuration, technological change and improvements. The choice of clean technologies (renewable energy or nuclear power and through the use of improved devices in other sub-sectors) should be a clear one. The ability to restructure the energy sector, presently apparently obsolete, is a realistic and promising option, even if the burdens are of a financial and structural nature. Recent results, an outcome of the new national energy supply strategy, indicate that both windmills and nuclear plants are promising alternatives for Syria's future energy supply [Hainoun et al, 2008]. However, the increased share of renewable energy (coming mainly from the wind) requires significantly higher installed capacity – due to the low availability factor of renewable energy-.The results of evaluations show that replacing one capacity unit of fossil fired by renewable sources of energy results in a factor of more than 2.

To alleviate the impact of climate change on the energy sector, various policies and adaptation measures can be assessed. The feasibility of imposed policies and measures should be evaluated on the basis of cost and time efficiency: the lower the cost and faster the impact (i.e. reducing GHG emissions and alleviating their impact), the more favorable the measure. Thus following measures can be considered for Syria:

- Encouraging renewable sources of energy and nuclear power;
- Conservation measures: both behavior (related to energy consumption) and technical;
- Encouraging the introduction of clean technologies in all energy conversion processes;
- Introducing mitigation (reduction) techniques (for instance the capture CO_2 and its storage);
- Removing subsidies on fuel will reduce total consumption, due to the reduction of individual consumption and technologically-triggered improvements;
- Imposing limits on CO_2 emissions (taxes and fines).

To evaluate the impact of adaptation measures on a future energy supply policy relevant to GHG emissions, two different energy supply scenarios can be developed (to be discussed below - see chapter on energy reduction).

3.3.6. Public Health

Overview

People of Syria are relatively enjoying good public health status. Within the last three decades infant mortality rate, mortality rate for children under five, and maternal mortality rate have declined steadily, while life expectancy at birth has increased. This reflects the efforts of health authorities in the country to raise public health standard and maintain it on government agenda[31].

Impact of Climate Change

Quantifying the full impact of climate change on public health is extremely difficult. It is nevertheless well established that known diseases may extend their range due to warming, floods and other weather-related phenomena deriving from climate change. The paragraphs below cite two cases relating to the possible effect of climate change on the country's public health.

Leishmaniosis (the Aleppo boil) has been endemic in Syria since the ninetieth century and is found in all regions of the country. Due to climate change, Leishmaniosis might flourish

[31] Vulnerability Assessment and Possible Adaptation Measures of Health Sector (2009). Meslmani Y., Murtada S., Jafari R. and Al Tawil A.; (INC-SY_V&A_Health); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.

as a result of rodent (vector) population outbreaks, themselves favored by of the expansion of drought-tolerant foraging species (*Anabasis articulate*) and the decline of natural predators (hawks). Moreover additional factors like the urban expansion into these rodents' habitats could augment the risk of disease spread.

Another problem is malaria. Syria is relatively free of local strains of malaria; nevertheless the World Health Organization (WHO) classified border areas with Iraq and Turkey as malarial high risk areas. The possible re-emergence of malaria due to climate change is likely, especially with the existence of predisposing factors: the occurrence of floods or the breakdown of dams, leading to the formation of swampy areas ad marshes.

It is clear that climate change has a negative impact on factors determining health, namely water, air and food. It is therefore indirectly influencing human health when these determinants are affected. Moreover climate change possesses a direct impact on the environment itself, since it increases health hazards. For instance, lower quantities of water and a lower quality standard leads to an increase in waterborne diseases. Additionally the incidence of floods, heat waves, droughts and dust storms directly influence public health. This direct impact might express itself in higher weather-related mortality, affecting the most vulnerable groups in society (i.e. the poor, elderly and chronically sick). Generally speaking, in the eventuality of climate change, as water becomes scarce and food productivity declines, current difficulties and problems related to water and food will increase and new challenges will emerge.

Some local predisposing factors may accentuate the impacts of climate change. These include: the concentration of population in big cities, leading to increased pressures and competition for services, and increasing air pollution from energy and transport. Moreover adaptation has its limits (the prevention of direct and indirect health hazards) from a technical, logistical, and physiological viewpoint. For instance, there is a clear negative relationship between waterborne diseases and the amount of water per person. As water quantity and quality deteriorate, the incidence of diarrhea, typhoid fever, and waterborne diseases, already existing in some governorates, becomes higher. Any significant decrease in the national water budget would therefore directly affect the amount of water per person, consequently causing serious health concerns.

Adaptation

The health system needs to be prepared to manage the new risks to public health and the possible emergence of new diseases. A lax support health program poses the greatest threat to effectively fighting aliments and death caused by climate change. Adaptation of public health can include the following strategies and measures:

- Securing minimum household water requirements to maintain health.
- Intensifying water pollution control activities and ensuring safe reuse of wastewater
- Maintaining acceptable standards of medical services.
- Promoting health education and community awareness.
- Devising strategy for national disasters and management plans to deal with prospective hazards.
- Upgrading and validating routinely collected health records through national information systems.

- Involving all national parties working in the health service and making them join a program aimed at developing strategies to confront changes in infectious disease patterns caused by climate change.
- Upgrading ongoing prevention programs relating to climate-related diseases.
- Capacity building for institutions and staff working in health sector.

3.4. Adaptation Framework: The Way Forward

The reduction of precipitations and the elevation of temperatures will be the two main visible consequences of climate change in Syria. Presently drought, heat waves and dust storms are the major environmental hazards associated with climate variability. These phenomena are expected to intensify because of climate change. The consequences of these modifications will be immense and will pose significant challenges to planners and managers unless adequate measures are taken. Direct effects on water resources and on agricultural production will be felt, since these represent the sectors most vulnerable to climate change. Other sectors will be directly or indirectly affected.

A sound scientific assessment and a better understanding of climate change's impact and associated risks are the first step towards formulating an adaptation policy and measures. This requires capacity building for the scientific assessment of vulnerable sectors and ecosystems, as well as the provision of financial resources to implement this task. Following this stage, based on the country's socio-economic and political environment, proper adaptation policies can be drawn and mechanisms for integrating them into national plans can be devised.

Generally speaking, adapting to climate change requires a package of responses that include adjustments at various levels, from community to national level. This means changes in the behavior of individuals and adjustments in how business is carried out. The general aim of adaptation is to promote the resilience of natural ecosystems in order to cope with climate change and to set a series of planned actions to enable other sectors to gradually adjust to new outcomes.

Adaptation processes require the formulation of national programs of action. By defining short, medium and long term priorities, such programs should aim at promoting sustainable development in all sectors and be based on the country's preexisting coping capacity. Moreover the participatory approach and integration measures for all sectors within a clearly defined national policy embracing these programs are prerequisites for the success of proposed measures. The following items are some considerations for policies that should be taken into account when devising adaptation strategies and responses to reduce the impact of climate change:

- Providing an environment for legal and institutional changes to set the adaptation process into motion. This entails updating laws and making institutional reforms in the decision making process and for work mechanisms.
- Adaptation capacity differs from sector to sector. One should therefore strengthen the capacity of all sectors to enable coping with climate change. This is a priority and should be embedded within the adaptation strategy.
- Adaptation options, at sector or cross-sector level, must be assessed and validated against the country's set of socio-economic and environmental indicators.

- Financial resources are vital elements for developing comprehensive adaptation measures and incorporating these within national policy. They are essential for any implementation of measures.

An adaptation Action Plan: the policy framework

Adaptation to climate change in Syria requires adopting a series of mixed strategies and measures. The following paragraphs identify the most necessary actions at policy level:

National Policy Initiatives

A national policy initiative must be developed to incorporate adaptation in vulnerable sectors into national development plans. Through this initiative, a national based mechanism for ranking risks and prioritizing actions can be set by making special institutional arrangements and motivating the effective participation of various stakeholders. The national policy initiative should facilitate the horizontal and vertical integration of sector policies carried out by the various agencies, and be able to reach out for international assistance. Major elements of national policy include: facilitating the access to information and motivating public awareness, reviewing plans for adaptation, setting criteria for measuring achievements and the implementation of the latter.

Ecosystem Protection Initiatives

Water and land resources are under continuous pressure and require urgent responses. Devising an integrated program for the protection of ecosystems to ensure their sustainability should be a priority action in the country. Effective programs for the protection and sustainable use of these resources must be developed and implemented, with the full responsibility and participation of stakeholders.

In this context, the following programs and projects are the country's priority:

- Strengthening the climate monitoring network and the management of data on climate.
- Ensuring the integrated management of water resources.
- Developing agricultural technologies.
- Ensuring the integrated management of land resources.
- Diversifying sources of income and enhancing the capacity of the Badia's community residents.
- Reinforcing the conservation of elements of biodiversity and their sustainable use.
- Ensuring the integrated management of the coastal zone.
- Strengthening information systems for health and other relevant sectors.
- Developing and deploying technologies using renewable sources of energy.
- Raising public awareness and good environmental behavior of citizens.

CHAPTER 4

Reducing GHG Emissions

4.1. Introduction

In this part of the study the following main issues in Syria have been reviewed: Energy Status in Syria; Oil, Gas and Oil products; Syria's Power Generation; the transport sector including measures to reduce GHGs from this sector; the building sector including proposed actions to reduce GHGs emissions from household sector, proposed clean development mechanism projects in the domestic sector, and economic impact of the use of solar water heating systems; Syria's industrial sector including emissions from industrial processing, & emissions from energy consumption in industry; the Syria's agricultural sector and the Syria's waste sector including the solid waste, waste water & sewage , and Industrial waste water.

4.2. Energy Status of Syria

This part reviews the energy status of Syria, where primary energy consumption reached 19.6 million tons of oil equivalent (Mtoe) in 2005, and the final energy consumption reached 15.2 Mtoe in the same year.

According to statistics from the International Energy Agency (IEA), per capita primary energy consumption in Syria amounted to 1.3 toe, low when compared to an average of 1.77 toe per capita in the rest of the world and 2.64 toe per capita in the Middle East. While per capita electricity consumption was in the same year 1,317 KWh/capita/year (again a low figure when compared to the world average of 2,516 kWh/capita/year and the 2,881 KWh/capita/year of the Middle East's average). The total amount of Syrian carbon dioxide emissions was in 2005 3.2 tons CO_2/capita, equal to the world average, yet once more a low figure when compared to the 6.51 tons of CO_2/capita in the Middle East.

Table 4.1 Secondary Consumption in 2005 byType of Fuel Type

	%	Amount Million tom eq
Diesel	31.7%	6,725.8
Oil	6.8%	1,440.3
Heavy oil	24.9%	5,276.8
LG	4.8%	1,010.1
NG	20.5%	4,353.8
Asphalt	3.2%	676.5
Heavy derivatives	2.0%	419.3
Hydro. and wind	4.1%	869.8
Coal	2.0%	420.3
CSP	0.0%	1.9
Total	**%100**	**21.2**

Liquid Gas (LG), Natural Gas (NG), Concentrated Solar Power (CSP)

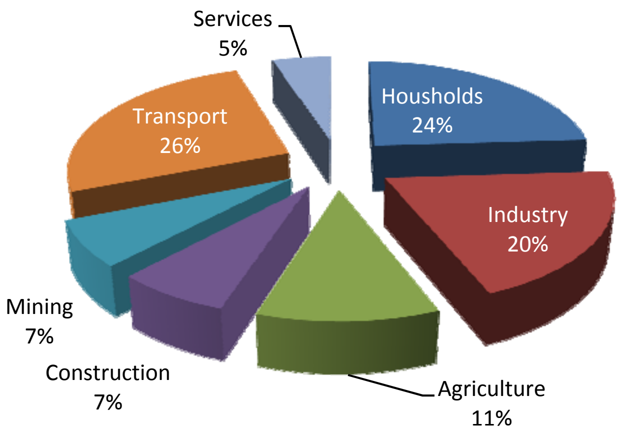


Fig. 4.1 Final Energy Consumption by Sector of Activity in 2005

4.3. Oil, Gas and Oil Products in Syria

This part reviews the status of oil, gas and oil products in Syria. The following has been reviewed for this study: oil and gas production and consumption, working companies in this sector, the transfer of crude oil and gas, the storage and distribution of oil products and the status of the petroleum refining industry. The report reviews the potentials for reducing GHGs emissions in the oil and gas sector. This can be done by applying a number of measures, including those mentioned in the following paragraphs.

Mitigation through Energy Efficiency

Oil and gas companies in Syria have taken many steps to use energy in a more efficient way. Natural gas which used to be burnt in flares, as it is not economically to recover, is used by Gas Turbines to generate electricity localy in oil & gas fields, as well as old turbines & old electrical equipment have been replaced by new ones. There are still many areas in the oil and gas sector where energy can be preserved: the burning process can be controlled, scaling on walls of boilers, ovens and heat tubes can be reduced, waste heat from flue gases can be used and equipment can be better insulated.

Daily oil production in 2009 was 380,000 b /d, 10% used for energy consumption in the oil and gas sector, (i.e. 38,000 b/d). By using the abovementioned energy conservation measures, 10% of energy consumed can be saved (3,800 b/d, i.e. 188.704 Kt oil/year), and consequently the reduction of GHG emissions by 553 Kton CO_2/year could be achieved.

Mitigation through a Shift to Cleaner Fuels

In the 1990s Syria made great efforts to switch from fuel oil to natural gas for electricity generation. Many power stations like Gander were built using natural gas only, while old plants such as Banias and-Mhardeh were converted so as to operate with fuel oil as well as natural gas. The Ammonia Production Fertilizer Company in Homs switched from naphta to natural gas. This switch was facilitated by the Ministry of Petroleum, which built factories to recover gas by-products and treat them instead of burning them in flares. This was also possible because of the discovery of new natural gas fields.

The quantity of oil consumed in the oil and gas sectors equals 38,000 b/day. If 50% of this quantity is replaced by natural gas (i.e. 19,000 b/day, which is equal 946.112 toe/year), reductions in GHG emissions will be as high as 694 K tons of CO_2/year.

Mitigation through the Recovery of Gas Flares

The amount of gas burnt in flares decreased by 72%, from 3,420,000 m^3/d in 2003 to 952,000 m^3/d in 2005. The Kharta field was connected to NG pipes in order to recover 200000 m^3/d. The quantity of gas burnt in flares decreased to 452,000 m^3/d and the percentage reduced by 78%. The quantities of gas still burnt in flares are estimated at 215,000 m^3/d in six gas plants. All of these were not connected to the gaspipes of treating plant because the distance is more than 70 km.

It is assumed that recovering 100000 m^3/d burnt in flares will mitigates 369.7 t CO_2 / day and 134.5 kton CO_2 / year

Mitigation through the Maintenance of Pipes and the Prevention of Leakage

The number of leaks in the Syrian Petroleum Company SPC was 464 (oil) and 16 (gas) in 2004. In that same year, the total quantity of oil leaked was 3755 b (512 tons), equal to 17.5 leaked units per million of units produced. In 2005 a clear improvement took place: the number of oil leaks and the quantity of oil leaked diminished. The number of leaks dropped to 416 and the total quantity leaked was 2 925 b (345 tons). The ratio went down to 16.79 units leaked per 1 million of units produced. The measures taken to limit leaks were: to increase the regular maintenance at sites, the use of modern supersonic equipment to detect leaks and the injection of anti-corrosion chemicals in pipelines.

From the inventory report (energy section), fugitive gases equal 105 Kt of CH_4/year. This is equal to 105 * 25 = 2625 Kt of CO_2 yearly.

One can suppose that better maintenance will prevent 25% of gases leakages. GHG mitigation thanks to the maintenance of pipelines equals 656 Kt of CO_2 yearly.

Mitigation by Storage of CO_2 in Oil Fields and trough the Enhancement of Oil Production

This is done by injecting CO_2 in semi-depleted oil fields. Oil is pushed by mixed or unmixed displacement, which leads to its flow towards the surface. It is possible to produce 10-15% more oil in the field through this method. The operation requires injecting a quantity of 140-280 m^3 of CO_2 in order to produce 1 barrel of crude oil.

The Clean Development Mechanism (CDM)

The Kyoto Protocol established the Clean Development Mechanism (CDM). Industrial countries finance gas reduction projects in developing countries and the reduction of emissions from these projects is counted as part of the obligations of industrialized countries. The aims of the Kyoto Protocol include:

- To help Non–Annex 1 parties to achieve sustainable development and participate in the final objective of the agreement.

- To help parties in Annex 1 to comply with their obligations (limiting emissions and reducing their quantities).

In the gas and oil sector it is possible to benefit from CDM by doing the following:

- Limiting the burning of gas in flares.
- Producing clean fuel.
- Preserving energy in oil refining and gas liquefaction,
- Storing of carbon dioxide or using it for the enhanced recovery (ER) of oil..

4.4. Syria's Power Generation Sector

Syria's power generation sector plays a key role in GHGs emissions. The installed capacity reached 7,160 MW, with a peak load of 6,008 MW. Electrical energy generated amounted to 34.8 TWh and final electrical energy consumption in 2005 was 26.8 TWh.

The growth of demand for electrical energy has led to the increasing demand for fossil fuels, leading to a greater reliance on thermal power plants consuming fuel and gas. This has increased the amount of fuel used in the production of electricity, from 3 million toe in 1994 to 6.9 million toe in 2007. In addition GHG emissions grew in the electricity sector, from about 9 million tons of CO_2 in 1994 to nearly 24 million tons of the same gas in 2007, an average growth rate of 8%. In 2005 GHG emissions from power generation amounted to more than 40% of the country's GHG total.

The shift to natural gas instead of fuel oil in power plants may limit significantly the annual growth rate of emissions. However the specific emission rate of carbon dioxide per KWh generated went up from 740 grams CO_2/KWh in 1994 to 668 g CO_2/KWh in 1998, and then to 690 g CO2 / kWh in 2007.

The measures taken for reducing GHG emissions in the electricity sector were exposed by adopting a mitigation scenario applicable in the power generation system's future expansion plans. The mitigation scenario depends on the following actions:

- Improving the technical level of plants by increasing efficiency and performance and increasing the load coefficient.
- Shifting from heavy fuel oil to natural gas.
- Improving efficiency through greater reliance on combined cycles in power plants. Increasing the contribution of clean technologies through greater reliance on renewable energies and nuclear energy.
- Reduction of technical losses and illegal consumption in the distribution subsector.

Table 4.2 presents generated electricity, installed capacity and the type and amount of fuel required according to the reduction and the reference scenarios, for the years 2005 and 2030.

Table 4.2 Generated Electricity, Capacity Installed and Fuel required for the Reference and Mitigation Scenarios

	Reference scenario		(The mitigation scenario) Emissions reduction	
	2005	2030	2005	2030
Electricity generated (TWh)	34.14	148.4	34.14	143
Installed capacity (MW)	6,200	29,600	6,200	32,600
Fuel required (million toe)	7	30	7	23
Natural gas	42%	24.6%	42%	45.8%
Heavy fuel oil	58%	65.2%	58%	17.7%
Nuclear fuel		9.7%		12.5%
Diesel		0.5%		1
Liquefied gas				11%
Coal				12.0%

Options adopted by 2030 in the emissions mitigation scenario are wind turbines, solar photovoltaic and solar concentrators, in addition to nuclear energy. This would take place in the following way:

- Hydropower with a 200 MW generating capacity
- Wind farms producing up to 2000 MW
- The introduction of photovoltaic power plants producing up to 2000 MW
- Solar power concentrators of up to 1000 megawatts
- An increase in the contribution of natural gas in electricity generation processes
- The introduction of LNG power plants & coal as from 2020
- The introduction of two new nuclear plants of 1600 MW capacity after 2020

The capacity share of renewable sources of energy other than hydropower would reach 15.3% and 5% of energy would be produced by nuclear plants. Reduction goals would be reached by 2030.

Figure 4.2 shows installed capacity development between 2005 and 2030

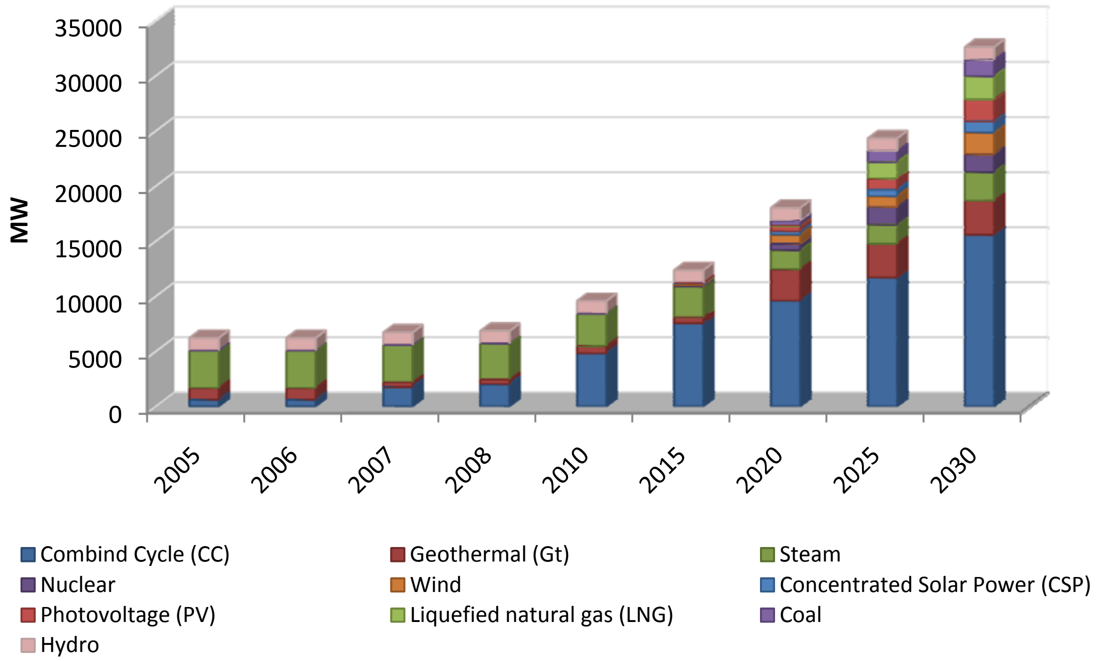


Fig. 4.2 Development of Installed Capacity during the 2005-2030 Interval

While figure 4.3 presents electricity production in 2030 by comparing the reference scenario to the emissions mitigation scenario:

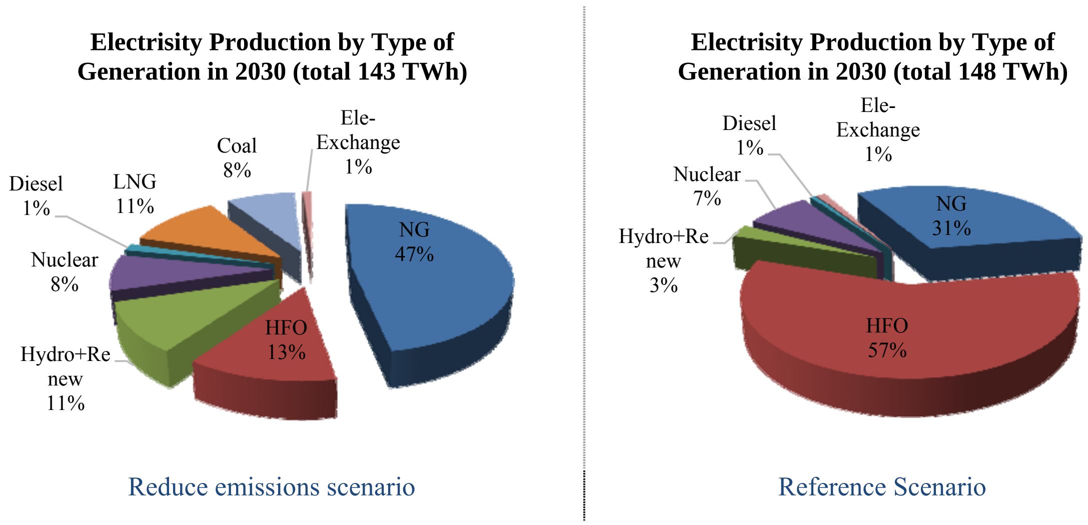


Fig. 4.3 Electricity produced in 2030 by Type of fuel: Comparison of Two Scenarios. (NG=natural gas, HFO=heavy fuel oil)

Figure 4.4 shows the decline of GHG emissions in the mitigation scenario when compared to the reference scenario:

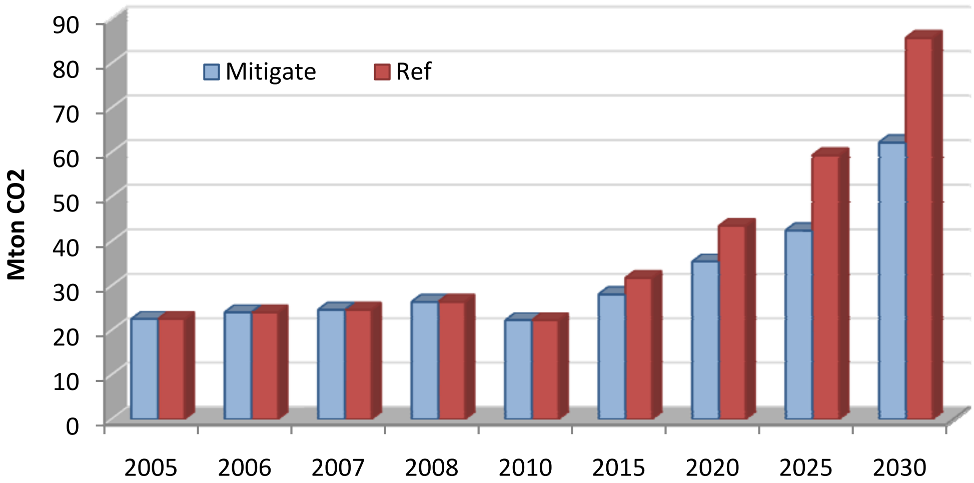


Fig. 4.4 Comparing GHG Emissions in the Reduction and the Reference Scenarios

The amount of CO_2 emissions in the reference scenario would grow from about 24.6 million tons CO_2 in 2007 to nearly 86 million tons of CO_2 in 2030. In comparison, 62 million tons of CO_2 would be produced in 2030 if one applies the reduction scenario; this means that adopted measures in the mitigation scenario, by increasing the share of environmentally-friendly technologies as well as reducing losses in electricity transmission and distribution system, would lead to a reduction of 24 million tons of CO_2 in 2030.

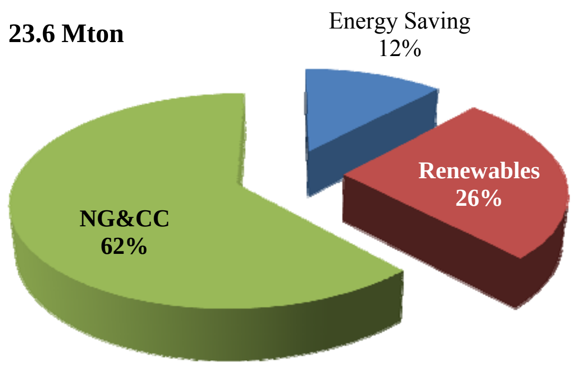


Fig. 4.5 Expected Reduction according to the Reference Scenario of 2030

The figure shows that the impact of mitigation will appear by 2015 and will reduce power generation sector emissions in 2030 to about 27% of the country's total emissions. Renewable energies will contribute 11% in the mitigation scenario, (and only 3% in the reference scenario).

4.5. The Transport Sector in Syria

This sector is one of the basic ones of the Syrian national economy. Fuel consumption in this sector was recorded by measuring the impact of energy intensity in goe/ton Km in the case of cargo and in goe/passenger/km in the case of passenger transport. Passenger transport was recorded, as well as the impact of vehicle speed on fuel consumption and therefore on the amount of emissions. The distribution of energy consumption in the transport sector is as follows:

Table 4.3 Distribution of Energy consumed by the Transport Sector

Energy consumption in passenger transport between cities	624.9 (Ktoe)
Passenger transport in cities	1,208.7 (Ktoe)
Cargo	1,805.8 (Ktoe)
International transport	574.7 (Ktoe)
Total energy consumption in the transport sector	4,214.3 (Ktoe)

In the transport sector fuel is consumed as gasoline, kerosene for aircraft and gasoil (diesel).

Figure 4.6 shows the evolution of fuel consumption and GHG emissions in the transport sector during the 1994-2005 intervals.

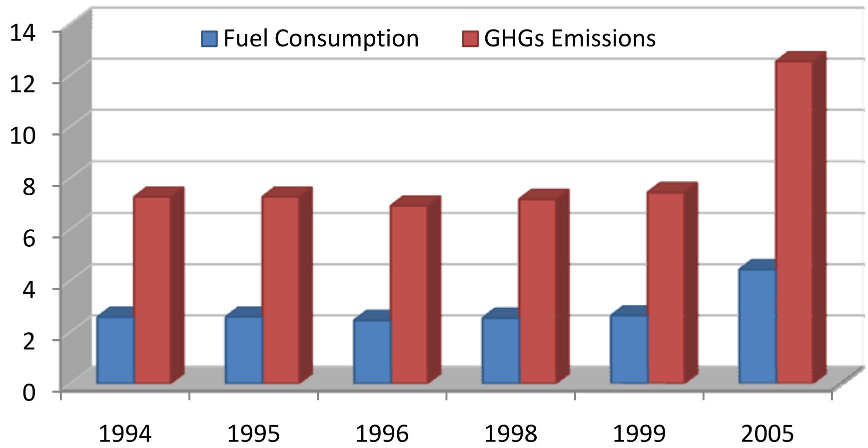


Fig. 4.6 Evolution of Fuel and GHG Emissions in the Transport Sector during the 1994- 2005 Period

If one takes into account the evolution of final energy demand in Syria, the amount of GHG emissions in the transport sector was:

- 7.5 million tons of CO_2 equivalent in 1994
- 10 million tons of CO_2 equivalent in 2000
- 12.5 million tons of CO_2 equivalent in 2005
- The quantity of CO_2 equivalent in 2010 is expected to be 15.5 million tons

It should be noted that the transport sector contributes 22% of total CO_2 emissions, 10.2% of total methane (CH_4) emissions, and 15.4% of total nitrogen gas (N_2O) emissions.

Measures to Reduce GHG Emissions from the Transport Sector

A - Technical options for improving fuel consumption efficiency

- Improving current engines. CO_2 emissions could thus be reduced by anything between 12% and 25%
- Repetition Shifting from gasoline to natural gas.
- Using hybrid and electric cars. In this way CO_2 emissions could be reduced by 10% - 30%
- Using auto-fuel cells. Emissions could likewise be reduced by 75% -100%
- Improving technological performance in cars. Emissions could in this way be reduced by 8%
- Using alternative fuels, which would reduce emissions by up to 100%

The emissions in cities constitute 30% of the total. Those of rural areas cities are 70% of total emissions from the transport sector. This is shown in table 4.4:

Table 4.4 Emissions by the Transport Sector in Cities and Outside Cities

Statement	2020 Million tons CO_2	2030 Million tons CO_2
Total emissions	21	26.5
Emissions in cities	6.3	7.95
Emissions of road transport in cities	6.05	7.63
Emissions outside cities	14.7	18.55
Emissions of road transport outside cities	14.11	17.8

Table 4.5 shows that the reduction of GHG emissions in 2020 and 2030, through the application of measures improving the efficiency of road transport. These measures are divided into technical and administrative procedures.

Table 4.5 Emissions of Greenhouse Gases in 2020 and 2030

Proposed Measure	Reduction of Emissions Ktons CO_2 eq		Reduction of Emissions Ratio %	
	2020	2030	2020	2030
Fleet innovation	1,411	2,670	10	15
Other administrative procedures and Organizational planning	1,411	2,670	10	15
Road maintenance and improvement	1,411	2,670	10	15
Total	4,233	8,010	30	45

Measures to Improve and Develop Transport and Traffic Systems in Cities

The following can be put forward in order to partly eliminate problems linked to traffic and transport in cities:

- Developing the organizational structure of the transport sector in cities

- Developing transport systems
- Developing transit systems

Measures to Reduce the Demand on Transport and to Modify its Peak

These include:

- The payment of various bills
- The consolidation and installment of fees and tolls on vehicles
- Shifting the starting and ending time of working hours for the different institutions and working sectors.
- The simplification of administrative procedures in the institutions by using new communication technique (internet, email,…).

The Control of the Technical Condition of Vehicles, the Improvement of the Efficiency of Driving and Fuel Specifications

Table 4.6 presents the effects of the reduction of GHG emissions by applying the following proposed actions:

Table 4.6 GHG Reduction of Emissions by the Application of Proposed Actions

Proposed action	Mitigation rate%		Mitigation quantity Ktons CO2	
	2020	2030	2020	2030
Development of the organizational structure of the transport sector in cities	10	15	605	1,145
Development of transport systems	10	15	605	1,145
Development of transit systems	5	10	303	763
Measures to reduce the demand for transport and shifting the times of peak	5	10	303	763
Controlling the technical condition of vehicles	3	5	181	356
Improving fuel specifications	3	5	181	356
Total	36	60	2,178	4,579

The Reduction of Emissions by Shifting to Rail Transport

Table 4.7 presents the effects of reducing GHG emissions by increasing the share of rail transport to 26% and reducing that of road transport, by the rehabilitation of the existing railway network, the repair of existing locomotives and the purchase of new ones.

Table 4.7 Reduction of GHG Emissions by developing Rail Transport

Proposed action	GHG emission reduction rate %		Reduction of GHG emissions (Kt of CO_2 equivalent)	
	2020	2030	2020	2030
Increase of the share of rail transport to 26%	5	3	705	423
Electrification of some existing lines	5	10	20	52
Rehabilitation of the existing network and locomotives	5	5	20	26
Purchase of new locomotives	5	5	20	26
Administrative, planning measures	5	5	20	26
Total	**20**	**25**	**785**	**553**

Table 4.8 shows the total amount of GHG reductions in the transport sector through the application of all proposed actions in 2020 and 2030:

Table 4.8 Reduction of GHG Emissions in the Transport Sector in the Years 2020 and 2030

Actions and projects	**GHG emission reduction rate %**		**GHG emissions mitigation (Kt of CO_2 equivalent)**	
	2020	**2030**	**2020**	**2030**
Improvement and development of vehicles and the use of bio-fuels (ethanol, biodiesel)	34.2	68.4	2,069	5,220
Updating the fleet of vehicles, road maintenance and improvement of standards, improved administrative and organizational procedures	30	45	4,233	8,010
Development and improvement of transportation systems in cities	36	60	2,178	4,579
Development of the rail transport system and increase of its share to 26%, starting from 2020 (in parallel to a reduced reliance on road transport)	30	35	785	553
Total			9,265	18,362

The implementation of proposed actions would reduce GHG emissions by 9,265 Kt CO_2 (44%) in 2020 and by 18,362 Kt CO_2 (69.3%) in 2030.

4.6 The Building Sector in Syria

In 2005, the number of houses in Syria was 3.479 million. That of occupied houses was 3.0914. The energy intensity in the household sector was approximately 11.6 Kgoe./m^2. In the same year total energy consumption in the domestic sector amounted to 3.589 million toe, 20% of which consumed for cooking purposes, 40% for domestic heating, 19% for water heating and 19% for lighting and electrical equipment. The intensity of energy consumption in the services sector was about 14 Kgoe/m^2/year. Total energy consumption in the services sector was 855 Ktoe, 24% of which was used by restaurants, hotels and shops, 37% by communications and storage, 22% by prayer houses and 17% by other services. In 2005 total energy consumption in both the domestic and service sectors was 4.444 million tons of oil equivalent (Mtoe).

The total number of houses in Syria in 2004 was 3,368 million; in 2007 it was 3.740 million houses, which reflects an annual increase of 124,000. Population increased from 17.921 million to 19.041 million during the same period. One can conclude that there is a home for every 4 people. One can assume a constant rate of growth up to the year 2030 (the expected population will therefore be 31.470 million and the number of expected houses 7.9 million). The number of houses at the beginning of 2010 was approximately 4 million; the projected increase in housing between 2010 and 2030 would be 3.9 million. Energy consumption per household was equal to 1 toe/year in 2005; assuming a constant consumption rate per house, households will use 7.9 million toe by 2030.

4.6.1 Proposed Actions to Reduce GHG Emissions in the Household Sector

A - Solar Water Heating Systems:

The total number of houses was 3.5 million in 2005. Household energy consumption for water heating, according to the study of the National Energy Committee (NEC), was 192 Kgoe/year and, according to the estimation of the National Energy Research Center, (NERC) 232 Kgoe/year. The predicted total number of houses will be 7.9 million in 2030. If a quarter of these houses are equipped with solar water heaters (SWH), energy saved would be 379 Ktoe. This would lead to a reduction of GHG emissions of 1137 KtCO_2; these figures would be 458 Ktoe and 1374 KtCO_2 according to the same NERC study.

Nevertheless if 50% of houses are equipped with solar water heaters (SWH), the amount of energy saved, according to the NEC study, will be 758 Ktoe. This will lead to a reduction of GHG emissions of 2,274 KtCO_2, while according to the NERC study the quantity of energy saved will be 916 Ktoe: this would lead to a reduction of GHG emissions of 2,748 Kt CO_2.

Moreover if 4,000 solar water heating systems (producing 2500 liters of hot water a day each) were installed in the services sector, this would reduce energy consumption in 2030 by 12 Ktoe and GHG emissions by 36 Kt CO_2.

B – Photovoltaic (PV) Energy

In order to provide buildings in rural or remote areas with solar PV systems, 15 megawatts peak (PV) systems should be installed by 2030. Energy consumption would be therefore reduced by 2.5 Ktoe, leading to a reduction of GHG emissions by 7.5 KtCO_2.

C –The Thermal Insulation of Buildings:

The estimated number of houses built during the period 2010-2030 is 3.9 million (at a rate of 195,000 per year). Energy savings achieved in each house would be 745 liters of diesel/year for domestic heating and 2933 KWh/year for air conditioning. This would lead to an annual energy saving rate of 1375 Kgoe/year. The number of houses to be thermally insulated in the next twenty years can be classified according to three scenarios: table 4.9 shows the effect of light, medium and high energy savings in 2030:

Table 4.9 Houses insulated by 2030 according to the various Scenarios

Scenario	Diesel oil (in 10^6 liters)	Electricity (GWh)	Number of Insulated Flats in 2030
1. Weak	149	587	200,000
2. Medium	447	1,760	600,000
3. High	745	2,933	1,000,000

Energy savings according to scenarios and source of energy are presented in table 4.10.

Table 4.10 Energy Saved by Using Thermal Insulation in Houses in 2030

Scenario	Unit	Diesel oil	Electricity	Total
1. Weak	Ktoe	128	147	**275**
	%	47%	53%	**100%**
2. Medium	Ktoe	384	440	**824**
	%	47%	53%	**100%**
3. High	ktoe	641	733	**1,374**
	%	47%	53%	**100%**

D- Reflective Roofs for Buildings

Increasing solar reflection of the building roofs reduces their solar heat gain, lowers temperatures and decreases outflow of thermal infrared radiation into the atmosphere. Most existing flat roofs are dark and reflect only 10 to 20% of sunlight. Resurfacing conventional dark roofs with a cool white material with a long-term solar reflection of 0.60 or more will increase solar reflection by at least 40%. Retrofitting 100 m^2 of roof can reflect 40% of solar radiation and thus can reduce 4 tons of CO_2 GHG emissions. If 1% of roofs on new buildings to be built by the year 2030 (equal to 3.9 million houses) are painted in white, this could save 8.63 Ktoe of energy consumed and reduce 25 Kt of CO_2 GHG emissions.

E- Using Efficient Lighting

Lighting in households consumes 20% to 25% of total electricity in Syria. Fluorescent lamps are most commonly used. However incandescent lamps are still utilized despite the widespread availability of energy-saving lamps. Table 4.11 presents proposed measures for improving lighting systems in households, as well as in the commercial, service and industrial sectors. The table presents the resulting electric energy savings in 2030.

Table 4.11 Measures for Improving Lighting Systems in different Sectors in 2030

No.	Measures	Savings in 2030 (GWh)
1	High-efficiency lighting in the religious and industrial sectors	477.3
2	CFL and high-efficiency tube lamps in households applications	377.1
3	High-efficiency lighting in commercial and government applications	374.6
4	High-efficiency street lighting measures	249.3
	Total	**1,478.3**

Thus improving the energy efficiency of lighting in the households and in the service and industrial sectors could save up to 1,478.3 GWh of electrical energy, the equivalent of 369.6 Ktoe. This implies a reduction of 1,110 Kt of CO_2 in 2030.

F- Using Efficient Electrical Appliances in Households

According to a study made by the National Energy Research Center, 2% of total electrical energy production in Syria in 2004 could be saved if the use of efficient refrigerators in households with an annual electricity consumption of 600 kWh per refrigerator and per year (instead of 744 kWh/ refrigerator/year) becomes widespread. The study estimates the proportion of houses in Damascus equipped with air conditioning systems to be about 40%, and 28% in Rural Damascus. Table 4.12 presents proposed measures and electrical energy savings in 2030.

Table 4.12 Improving Energy Efficiency of Electrical Appliances and Quantity of Energy Saved

No.	Measures	Savings in 2030 (GWh)
1	High-efficiency air Conditioners in residential areas	197.3
2	High-efficiency refrigerators in residential areas	82.1
3	High-efficiency air conditioners in medium and large commercial areas	76.8
4	High-efficiency water heaters and water heater controllers in residential areas	75.4
5	High-efficiency motors for water and wastewater pumping	71.9
6	High-efficiency air conditioners and load control in small commercial areas	58.4
7	High-efficiency air conditioners and load control in government sector	11.2
	Total	**573.1 GWh** **143.3 ktoe**

Total prospective savings in 2030 as a result of solar water heating systems and energy efficiency measures are estimated to be 1,183 Ktoe, equal to 6.0% of secondary energy consumed in Syria in 2005 (19.6 Mtoe), and to 7.75% of final energy consumed in 2005 (15.25 Mtoe). This corresponds to 2.45% (55.12 Mtoe) of final energy consumed in Syria in 2030.

As a result, the reduction in CO_2 emissions in 2030 will amount to 1734.5 Kt of CO_2. This represents 3% of GHG of 2005 emissions (58,350 Kt of CO_2).

4.6.2 Proposed Clean Development Mechanism (CDM) Projects in the Domestic Sector

The following projects could be proposed as CDM projects:

1. Energy efficiency improvement and solar water heating systems for the Youth Residential Project, a project which includes the construction of 50,000 houses distributed in all of Syria's governorates.
2. The improvement of energy efficiency and of solar water heating systems in the Damascus suburbs of Dummar and Qudsaya. These are residential areas of more than 10,000 houses.
3. SA project on solar water heaters in residential buildings.

Interested parties from governmental and private sectors should study the possibilities of benefitting from CDM in order to implement these projects by 2012.

4.6.3 The Economic Impact of the Solar Heating of Water

A study of the cost of water heating from different sources is necessary to assess achieved economic feasibility of solar energy use. It is clear that:

1. The cheapest way is to heat water by gas,
2. The cost of heating water with electricity is cheaper than with diesel (due to the poor results of the *Khazanat* heating devices in bathrooms),
3. Reducing the price of a liter of diesel to 18 Syrian pounds and raising the price of a gas cylinder to 400 Syrian pounds will make the cost of water heating with diesel and gas similar to that of electricity,
4. The cost of solar water heating is currently cheaper than any other means, but it needs various facilities in order to overcome the initial cost.

4.7 The Industrial Sector in Syria

Industry is one of the important sources of GHG emissions. These emissions derive from the industrial process or from use of energy. Industries emitted many different kinds of gases: the main ones in terms of presence and quantity are carbon dioxide (CO_2), nitrogen dioxide (NO_2) and methane (CH_4), in addition of other specific gases low in quantity but with a dramatic effect on climate change.

4.7.1 The Syrian Industrial Sector

Syrian industry belongs to eight establishments from three sectors: public, private and joint ventures. The Ministry of Industry is the party responsible for heavy and transformation industries related to the public sector. All industrial establishments consume energy and are the main emitters of GHG: CO_2, NO_2, CH_4. Cement, chemical industries and engineering are the three main emitters of these GHG.

4.7.2 Emissions from Industrial Processing

The most important industries emitting GHG gases in Syria are cement (carbon dioxide), then the chemical industry (which involves petroleum coke, nitrogen acid, soda ash use). Petroleum coke emits methane; nitrogen acid emits nitrogen dioxide and the use of soda ash results in the emission of carbon dioxide. The third most important contributing industry is metal scrap fusion, which releases carbon dioxide. Figure 4.7 illustrates the variation in emissions expressed in carbon dioxide from each industry during the period 1994-2005. Total emissions have increased as a result of industrial development (particularly from chemical industries). It is clear that the cement industry has the lion's share (85%) of total industrial emissions, followed by the chemical (17%) and engineering (3%) industries.

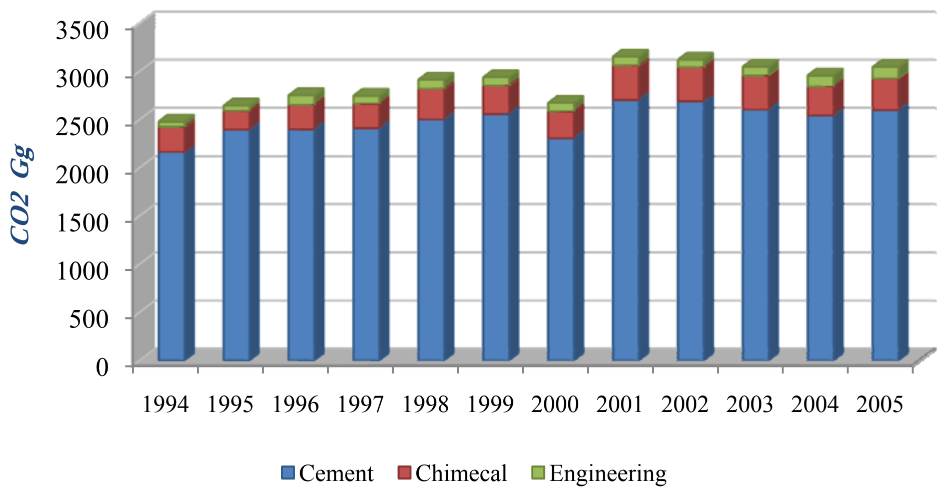


Fig. 4.7 Modifications in Emissions (as Carbon Dioxide) between 1994 and 2005

4.7.3 Emissions from the Consumption of Energy in Industry

Figure 4.8 illustrates energy consumption classified according different types of industry during the period 1994-2005. Cement utilities consume the highest ratio (66%) of total energy, followed by sugar (13%), chemicals (11%), textiles (5%), foodstuffs (4%) and finally engineering (2%).

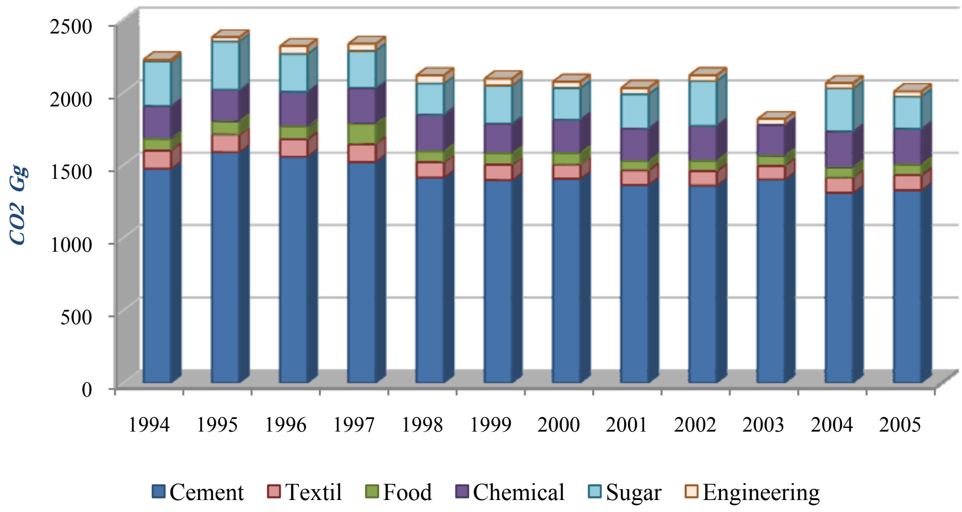


Fig. 4.8 Energy Consumed by Various Industries

This study shows that the largest source of emissions in industry derives from fuel oil consumption - about 97, 86, 81, 52, and 34% for cement and sugar industries, chemicals, textiles, foodstuffs and finally engineering. Total energy emissions are decreasing due to use of natural gas instead of fuel.

4.7.4 Total Emissions in Industry

Figure 4.9 presents that total emissions in the industry in both the production process and energy consumption and distribution. It is clear that cement is still the largest source of emission, followed by chemical sugar, engineering, textile and the production of foodstuffs.

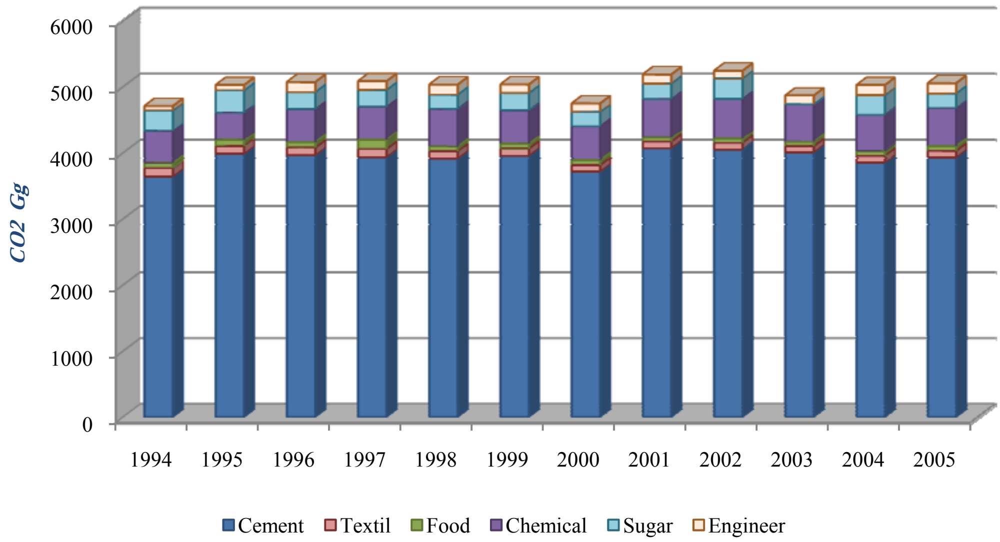


Fig. 4.9 Total of Emissions in Industry (both Processing and Energy)

Figure 4.10 shows that total industrial emissions deriving from the use of energy decreased between 1994 and 2005, since natural gas has been substituting fuel oil in certain industries. Nevertheless total industrial emissions have tended to increase because of the industrial development in the last few years of many sectors like chemicals, engineering and the sugar and food industries.

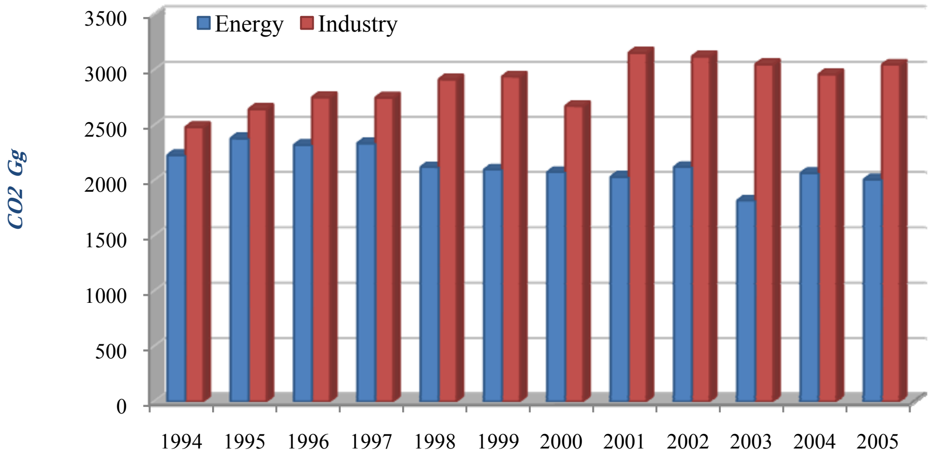


Fig. 4.10 Total of Industrial Emissions between 1994 and 2005.

Process emissions constitute about 55-62% of total industrial emissions. The distribution of emissions is the following: cement and engineering industries (65%), chemicals (55%). Processing emissions thus take a share larger than that of energy: reduction procedures should be available to decrease processing industrial emissions.

The Reduction of Emissions

The energy balance shows that industry consumed about 4 M tons in Oil Equivalent (Mtoe) i.e. 18% of total energy consumed (22,895 Million toe) in 2008. Moreover total emissions from industry can be divided into two groups: 60% of the emissions belong to industry processing and 40% is energy consumed by industry. It is very important to reduce emissions in both areas and apply measures to both processing and energy consumption. However applying reduction measures in energy consumption is much easier and more options are available than there are for production and processing, and processing emissions are limited by quantity and production methods. There are many thermal and electrical devices that decrease emissions by 25%. These are available at moderate cost, especially in the cement and textile industries and the payback period lasts between one and ten months. The average of fuel saved because of the implementation of reduction measures is estimated at about 11% of total annual energy consumption: approximately 400,000 toe (equivalent to 1.2 Million tons of CO_2) would thus annually be saved.

Future Insights in the Reduction of Industrial Emissions

The annual expected average increase of consumed energy would be about 6% at the end of 2030, when the consumption of energy carriers would reach 17.8 Mtoe. Still, applying available energy saving measures, energy savings would amount to 11% of total consumption of energy in industry (saving about 2 Mtoe, about 6 Mtons of CO_2).

4.8 The Agricultural Sector in Syria

All agricultural production would increase to satisfy the rising demand for various commodities. By 2030, principal expected developments in agriculture will include: expanding the surface of cultivated lands; increasing the number of green houses, of forested areas, the number of tractors, of combine harvesters and of fishing boats; increasing production of poultry and of stored agricultural products; using nitrogen fertilizers; augmenting the quantity of farm animals, from 54.5 million in 2006 to 125 million in 2030; reducing the surface of the steppe.

Energy Use Developments in the Agricultural sector in 2007 and Expectations for 2030

Developments in the agricultural sector in Syria will mean more energy used (from 1.65 ton Diesel in 2007 to 2.15 ton Diesel in 2030 (figure 4.11). Cultivation and other work by tractor account for the major part, which is equal to 64% of total use in 2007 and 52% in 2030.

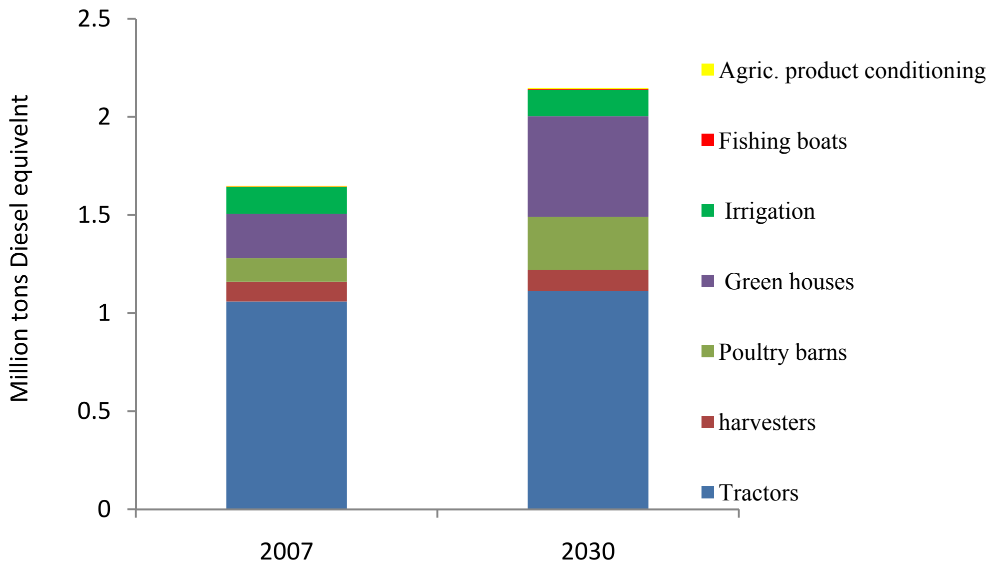


Fig. 4.11 Energy used by Agriculture in Syria in 2007 and 2030

GHG Emissions in the Agricultural sector in Syria and Expectations for 2030

The year 2006 was a basis for comparison of developments in GHG emissions in the Syrian agricultural sector because there was no comprehensive data available for the previous year(s).

GHG emissions in 2006 were estimated to be 63,156 Gg CO_2 eq and are expected to increase by 29% to 81,410 Gg CO_2 e in 2030 (with no consideration to the mitigation effects brought by government actions).

The mismanagement of land through burning and converting forest and rangeland into cultivation, the quantity and depth of fields, inappropriate crop rotation and application of fertilizer, fallowing and burning crop residues and grasslands are the main causes of GHG emissions in the agricultural sector. Its contribution to total GHG emissions in 2006 was around 87%, whereas the contribution of energy use was 7% and the remainder (6%) was caused by farm animals. GHG emissions from land management, however, are bound to reach 66,787 Gg CO_2 e in 2030. Emissions from the use of energy will also increase to 6,187 Gg CO_2 e and those caused by farm animals will reach 8,436 Gg CO_2 e.

Measures to Reduce Carbon and Nitrogen Emissions in the Agricultural Sector

Measures are implemented to reduce GHG emissions from land management and energy use in agricultural activities by preventing the combustion of crop residues and grasslands, by improving irrigation methods, disseminating modern irrigation techniques and using biogas technology. These measures lead to:

- Reduce the expected GHG emissions in 2030 by 4,894 Gg CO_2 e.
- Increase biogas production until 2030 with the rising number of farm animals and its contribution to GHG reduction will be 3,319 Gg CO_2 e. A further increase of 118 Gg CO_2 e in its contribution can be achieved by disseminating its production by herders and inhabitants of the steppe.
- Reduce GHG emissions by applying Conservation Agriculture (CA) to cropland and lessening the use of energy by an equivalent of 2,198 Gg CO_2e in 2030 (a reduction of 2,042 Gg CO_2 e was effective in 2006).
- Extend CA to forest management, will imply the reforestation of burnt woodlands, the diminution of emissions from ongoing wood burning and a reduction in the conversion of cropland (in order to reach 42,328 Gg CO_2 e).The use of CA will also restrain the use of fertilizers, increase soil organic matter and cut water runoff by 90%.
- Also introducing animal production in the farming system within the application of CA will reduce in organic fertilizer use by 13.7 tons N/year from the waste dropped on the soil grazing forage crops.

Applicable Scenarios to mitigate Carbon and Nitrogen Emissions in agricultural sector

The development of the agricultural sector in Syria between 2006 and 2030 might follow any of the following three scenarios:

1. The continuous application of present procedures, including biogas production, will reduce emissions by 4,894 Gg CO_2e,
2. The adoption of CA and its application to arable lands, including animal husbandry, will reduce emissions by 7,092 Gg CO_2e (minimum scenario),
3. The adoption of CA to arable lands, forests and steppe and marginal areas will reduce emissions by 49,538 Gg CO_2e (maximum scenario). Scenarios 2 and 3 would further diminish GHG emissions by reducing the use of inorganic fertilizers by more than 13.7 tons of nitrogen per year, improving soil fertility and increasing the percentage of organic matter in the soil.

Procedures to Increase Carbon Storage in Syria's Agricultural sector

Stored carbon in forests in 2006 was 170,438 Gg CO_2 and is expected to increase by 43% in 2030. The Carbon balance show that net retention and storage, emissions and reductions of carbon in 2006 was 107,282 Gg CO_2. This will increase to 168,058 Gg CO_2 in 2030. Carbon storage and retention, however, could be optimized by expanding the area of tree plantations and by increasing the proportion of conifers. The rehabilitation of degraded marginal zones and steppes will double at least their capacity to retain Carbon. Conservation agriculture could additionally increase carbon retention by 74%.

Table 4.13. Balance of Emission, Retention, and Diminution of GHG in the Agricultural Sector in 2006 and Expectations for 2030, based on Current Procedures

Agriculture Activities	2006	2030	
	Emissions (+) and Retention (-) Gg CO_{2e}	Reduction of Emissions Gg CO_{2e}	Increases from 2006 Emissions (+) and Retention (-) Gg CO_{2e}
Cultivating and fertilizing land	+ 11,178.6	0	+ 11715.4
Burning and converting forest and marginal land for crop production	+ 343,42	0	0
Burning grasslands	+ 227.6	-227.6	0
Burning crop residues	+ 322,1	-1322	0
Land management sum total	**+ 55,071.2**	**-1549.6**	**+ 11,715.4**
Farm animals	+ 3,490	0	+ 4,945.9
Agricultural activities sum total	**+ 58,561.2**	**-1549.6**	**+ 16661.3**
Energy	+ 4,595	-25.1[5]	1592.2+
Carbon emissions sum total	**+ 63156.2**	0	**+ 18253.5**
Use of biogases	0	-3318.7 [6]	0
(-) Reduction sum total	0	**-4893.4**	0
Net reduction (-) and emission (+)	**+ 63156.2**	**+ 13360.1**	
Forest (C) retention[4]	**- 170438.1**	**- 74136.0**	
Net reduction (-) retention (-) and emission (+)	**-107281.9**	**- 60775.9**	

[6] *The value is due to reducing 2,588 Gg CO_2e from energy emissions and the rest from ones produced by animals. Tables and sections are in the full report.*

Climate and Environmental Impact

The optimized management of marginal zones, of the steppe, forests and cultivated lands would increase water conservation, carbon retention and enable substantial reduction of GHG. Consequently relative humidity would improve and the severity of hot, cold and dry spells would be milder. This would also reduce ground water contamination and protect biodiversity.

Economic Impact

Reducing the use of energy and inorganic fertilizers in agriculture, increasing water availability for crops by improving soil water storage and reducing surface water runoff and irrigation needs for crops will diminish costs of production. Farmers' income will rise steadily, commodity prices will decrease and production will become more affordable to wider segments of society, improving the nutrition and health of the country's inhabitants.

Production of biogas from farm animals in farms and rangeland as an energy source would also reduce the cost of used energy which contributes to farmers' and herders' income, and may reduce meat prices. This may increase accessibility of meat to greater number of people, which would also improve their daily diet and health conditions.

Increasing forested areas and rehabilitating degraded sites in forests will provide sustainable investment opportunities in the exploitation of medicinal and aromatic plants. Bee rearing will also be positively affected and will offer employment opportunities, improving the locals' income.

The rehabilitation of forests and marginal areas will also protect soils from erosion and reduce the effects of flash floods as well as their adverse impact on farmers' fields and the service infrastructure.

Obstacles and Suggestions

The main obstacles against sustainable agricultural development and the optimization of agricultural production in Syria are: the lack of expertise, insufficient funding, one-sided approaches in solving problems and issues, centralized governance and the weak understanding of the environment's role of as a domain for all human life and activities, the basis of human survival.

These obstacles could be overcome by adopting the following suggestions:

1. Adopting all procedures and actions needed to enforce laws, measures and plans endorsed by the government in order to protect the environment and develop natural resources,
2. Immediate and intensive actions for capacity building and developing expertise in environmental protection and the enhancement of natural resources,
3. Immediate and intensive actions for capacity building and developing expertise in developing agricultural systems in a way suiting the different environmental zones in Syria, particularly the application of concepts of a Conservation Agriculture System which includes the integration of animal raising into the farming system,
4. Immediate reduction of the number and depth of cultivars and the expansion of Conservation Agriculture in Syria,
5. Rehabilitating and protecting burnt areas in forests, forbidding wood collection in forests or at least regulating its use through a plan that secures the sustainability of woodlands and the diversity of the plant cover; developing forest resources that provide direct income to the people (medicinal and aromatic plants, fruits and leaves, honey), and finally increasing annual forest replanting and augmenting the proportion of fast growing trees,
6. Developing and disseminating the production and use of biogas from farm animal manure in the countryside and stock raising zones,

7. Expanding rehabilitated degraded grazing areas, forbidding early grazing and regulating it,
8. Activating the role of science, allocating required resources for research and studies to improve and increase soil biomass, and introducing or developing more drought-resistant and more productive plant varieties to be used in grazing lands, forests, and for crops.

4.9 Syria's Waste Sector

The GHG emissions inventory report shows that emissions from the waste sector have increased over the years as a result of population growth and rising standards of living. Table 4.14 shows the amount of organic material produced by solid waste. Biogases result from the leavening of organic material present in domestic solid waste. The generated biogases contain approximately 60% of methane gas, characterized by a relatively high thermal index of c. 6,500 kcal/m^3. Biogases can be obtained from the decomposition of waste rich in organics at disposal and landfill sites.

Table 4.14 Organic Material in the Final Disposal Sites between 1994 and 2008

Years	Urban population	Waste Rate per capita	Solid Waste (kg/day)	Organic material ratio	Total organic waste (kg/day)
1994	9,091,800	0.5	4,545,900	0.57	2,591,163
2000	10,714,800	0.5	5,357,400	0.57	3,053,718
2002	11,318,400	0.5	5,659,200	0.57	3,225,744
2004	11,955,600	0.5	5,977,800	0.57	3,407,346
2006	12,502,945	0.5	6,251,473	0.57	3,563,339
2008	13,083,313	0.5	6,541,657	0.57	3,728,744

To reduce such emissions, the following measures are proposed:

4.9.1 Solid Waste

- Implementing a National Strategic plan for solid waste treatment,
- Using anaerobic digestion techniques (Biogas Technology) for waste treatment and utilizing produced biogas for electrical energy production,
- Reducing waste production,
- Encouraging national awareness for an optimal handling of waste,
- Encouraging the production of domestic fertilizers,
- Developing waste collection procedures

4.9.2 Wastewater and Sewage

Organic materials constitute about 40-60% of the composition of sludge resulting from wastewater treatment in which methane emissions are produced. These emissions can be reduced by the construction of wastewater treatment plants, using anaerobic digestion techniques (biogas digesters) and taking advantage of the resulting methane for electrical energy generation.

4.9.3 Industrial Wastewater

Industrial wastewater problems resulting from industrial activities appear where organic materials contained in the industrial wastewater are the main source of methane gas emissions. To reduce these, the following measures are recommended:

- Establishing treatment plants for industrial wastewater in industrial areas and using produced methane for electrical energy generation.
- Separating industrial wastewater from the residual water in industrial facilities and small factories. This wastewater is to be treated in central treatment plants.

4.9.4 Reduction by the Implementation of the Proposed Mitigation Measures

Emissions from the anaerobic decomposition of solid waste in landfills vary between 10% and 23% of the total quantity of methane gas released in the atmosphere. Domestic and industrial wastewater are responsible for the release of an additional 10% of methane. The accumulation of methane produced solid waste is expected to be around 1,623.87Gg of CH_4, equal to 40,597.5 Gg CO_2 eq released during the period 2010-2030.

In the case of the domestic landfill concept as an option for treating solid wastes and recovering methane gas as methodology to reduce the GHGs emissions, considering that every ton of waste produces theoretically 300-1500 m^3 of biogas annually, assuming that biogas production varies between 25% and 50%. In the case of the biological treatment of organic solid waste, the production and collection of methane gas varies between 30% and 50% with an average of 40%. It is expected in this case that the accumulation of methane production from solid waste would be around 1713.99Gg and 42849.75 Gg CO2 eq during the period 2010-2030, as it is shown in table (4.15)

Table 4.15 Expected Production from Solid Waste and Reduction of Methane between 2009 and 2030

Year	CH_4 produced Gg	CH_4 reduced Gg	Year	CH_4 produced Gg	CH_4 reduced Gg
2009	157.86	63.15	2020	198.69	79.48
2010	161.57	64.63	2021	202.40	80.69
2011	165.28	66.12	2022	206.11	82.45
2012	168.99	67.60	2023	209.82	83.93
2013	172.70	69.08	2024	213.54	85.42
2014	176.42	70.57	2025	217.25	86.90
2015	180.13	72.06	2026	220.96	88.39
2016	183.84	73.54	2027	224.67	89.87
2017	187.55	75.02	2028	228.38	91.36
2018	191.26	76.56	2029	232.10	92.84
2019	194.98	78.00	2030	235.81	94.33

Biological treatment is taking place in domestic and industrial wastewater treatment plants. These also collect biogases and thus contribute to reducing emissions of greenhouse gases from industrial wastewater, by 10% . Efficient production and collection of methane gas could be as high as approximately 25%.

4.10 Obstacles and Difficulties in the Implementation of Emission Reductions

A - Obstacles and Difficulties in Residential, Commercial and Service Sectors:

- Lack of awareness of tenants of buildings and ignorance of technologies improving energy efficiency through the use of solar energy
- Absence of building codes or specifications for energy performance. A thermal insulation code is the first step in devising a special code for buildings,
- High prices of energy-saving products, tools and equipment,
- Lack of expertise, of designers and of contractors proficient in improving energy efficiency in buildings,
- Need for skilled development in renewable energy technologies and energy efficiency improvement,

Despite the restructuring of energy prices, these are still not encouraging for the widespread use of renewable energy and energy efficiency improvement technologies.

The following solutions are suggested to overcome constraints:

1. The adoption of a general database on the energy sector,
2. The adoption of a program for training, rehabilitation, and employee awareness in the fields of renewable energy and energy efficiency improvement,
3. Periodical revision of the rates of energy carriers and the taking into account of the advantages of renewable energy investment and energy efficiency,
4. Awareness of decision-makers at different levels,
5. Design, implementation, monitoring and evaluation of pilot projects in renewable energy.

B - Obstacles and Difficulties in the Industrial Sector

Emission reduction constraints are technological, economic, political, cultural, social, behavioral and institutional in nature. Difficulties in reducing emissions in the industrial sector include: lack of information, of investment and legislation. Nevertheless there are many opportunities for optimizing energy efficiency, renewable energy technology, especially in solar energy and developmental support plans for raising the income level and encouraging research and feasibility studies on the removal of constraints.

4.11 Expected Future GHGs Mitigation Emissions from different Sectors

Sources GHG include combustion processes of the energy sector and non-combustion processing in industry, agriculture, waste management, forestry and others sectors. The activities responsible for GHG emissions in the energy sector comprise energy industries (extractive, productive and energy conversion for the generation of electricity and petroleum refineries), industry, construction, transportation and other varied sectors which include commercial, housing and agricultural combustion processes.

In the framework of evaluating the future strategy to reduce GHG emissions, various measures have been proposed according to sectors of emission. The paragraph below summarizes and evaluates the adopted reduction measures according to instruments, impact and effectiveness. More focus is given in evaluating implications of the proposed reduction measures in various sectors, in particular those related to GHG emissions from the production and consumption of electricity. This results from the fact that reductive measures are adopted for both demand and supply, as opposed to GHG reductions, which are achieved on the supply side, where electricity is produced using certain fuel admixture.

4.11.1 Expected future GHGs mitigation emission from the Energy Industry

The energy industry comprises: oil and gas extraction, oil refining and the generation of electricity.

Production of Oil, Natural Gas (NG) and Oil Products:

In this sub-sector, the following mitigation measures are proposed:

❖ Mitigation by energy conservation :

Different measures are proposed: the renewal or replacement of machinery and equipment, improvements in the management of industrial processes, such as better control of burning processes, tank insulation, limitations on the scaling on furnace walls, boilers and heat exchanging tubes and regular programmed maintenance. Additional measures are to be introduced: the recovery of heat from flue gases, the use flue of gases in producing steam for different thermal applications.

Potential annual GHG emission reductions for 2009 are estimated to around 553 Kt CO_2. However to plan future GHG reductions, GHG amounts are to be linked to the expected official annual growth rate of oil production (officials estimate an average annual growth rate of - 2.8% for oil production during the period 2010-2025).

❖ Reduction by switching to cleaner fuels (natural gas instead of oil)

Potential annual GHG emission reductions thanks to this measure are estimated in 2009 to reach 694 Kt CO_2. Taking into account tendencies towards saturation of this measure, expected future projections of GHG reductions are linked to the annual growth rate of natural gas production (officials predict an average annual growth rate of 11% for the period 2010-2016 and - 4% after that).

❖ Reduction by maintenance of pipes and prevent leakage

Potential annual GHG emission reductions thanks to this measure are estimated to reach 656 Kt CO_2 in 2009. Future GHG reductions are dependent on the expected official average annual growth rate of oil and natural gas in Syria.

❖ Reduction by the recovery of flared gases

Potential annual GHG emission reductions thanks to this measure are estimated to 135 Kt CO_2 in 2009. Future GHG reductions are related to expected official annual growth rate of NG in Syria.

Due to the fact that the abovementioned potential estimates of GHG reductions need a certain time to be diffused, it was assumed that initial GHG reduction in 2010 would reach only 20% of estimated annual potential (about 0.4 Mt CO_2 eq). Moreover full implementation will be achieved by 2015, when GHG reductions will amount to 2 Mt CO_2 eq. This amount will remain steady until 2020 and then follow proposed annual growth rates.

The Generation of Electric Power

Proposed GHG reduction measures in the power sector comprise: energy saving (power plant efficiency improvements and the reduction of electric grid losses), clean generation technologies using an increased share of NG and combined cycle generation, and finally the choice of renewable and nuclear options. Proposed reduction measures were evaluated by developing two different electric expansion plans. The first is based on the Reference Scenario (RS) that reflects baseline development. The second is an alternative expansion scenario, the so-called Mitigation Scenario (MS), that focuses on introducing the abovementioned policies (energy saving and clean technologies) that help in reducing GHG emissions.

4.11.2 Expected future GHGs mitigation emission from the Transport Sector

GHG reductions should be achieved in this sector by a set of reduction measures related to passenger and freight transport. This includes the improvement of existing engines, the shift from gasoline to diesel, the introduction of hybrid fuel cell vehicles and the use of alternative fuels, in addition to improvement in the efficiency of urban transport and the control of the technical performance of vehicles. Railways should be encouraged to constitute of 26% total road transport by 2020.

Since future estimates of GHG reduction were given for the years 2020 and 2030, expected developments during the years in between were interpolated using average annual growth for the period 2020-2030, which amounted to approximately 7%. For the period 2010-2020, an annual growth rate equal to that of energy consumption in the transport sector in the reference scenario (NECS, 2010) was adopted. Expected reductions for 2010 were assumed to be 1.4 Mt CO_2 eq, equal to expected reductions resulting from the modernization of vehicles (this measure has been successfully implemented in the last 5 years).

4.11.3 Expected future GHGs mitigation emission from the Building Sector (Households and Services)

So as to reduce GHG emissions in this sector, a set of measures were adopted and expected GHG reductions were estimated for the year 2030.

- Increasing the share of solar water heating: expected GHG reductions in 2030 are estimated to 2.8 Mt CO_2 eq;

- Introducing effective thermal insulation of residential buildings. For this measure the high scenario expects a GHG reduction of about 3.8 Mt CO_2 eq resulting from saving of diesel and electricity;[32]
- Use of efficient lighting. This measure is expected to diminish emissions by about 0.9 Mt CO_2 eq in 2030.
- Use of energy-efficient household equipments. This measure is expected to diminish emissions by approximately 0.34 Mt CO_2 eq in 2030.

In the calculations of incremental GHG reductions, expected GHG reductions in 2010 are assumed to be 5% of those of 2030.

4.11.4 Expected future GHGs mitigation emission from the Industrial Sector

Adopted reduction measures in this sector consist mainly in saving energy, efficiency improvements in all combustion processes, in addition to selected improvements in industrial processes. Estimated results indicate that main reductions will arise from combustion processes, whereas industrial processes will have limited potential. GHG reductions in 2030 are expected to reach 6 Mt CO_2, a high figure when compared to 1.6 and 3 Mt CO_2 in 2010 and 2020 respectively.

4.11.5Expected future GHGs mitigation emission from the Agricultural Sector

GHG emissions in this sector are the result of fossil fuel combustion, land use and animal breeding. Adopted GHG reduction measures in this sector show that diminutions of emissions in 2030 will amount to 5 Mt CO_2 eq.

4.11.6 Expected future GHGs mitigation emission from the Waste Sector

GHG emissions in the waste sector arise from the accumulation of biogas (mainly methane) after fermentation of municipal and industrial waste, in addition to sewage treatment. Proposed reduction measures in the waste sector include: collecting gases from sanitary landfills where municipal solid waste is discarded; the treatment of solid organic waste and the use of methane in electricity generation; the reduction of waste production; finally incentives for the domestic production of fertilizer. Expected GHG reductions are estimated to respectively 1.3 and 2 MT CO_2 eq in 2010 and 2030.

Table 1 summarizes achieved total reductions of GHG emissions for the period 2010-2030, in all sectors. It is expected that estimated reductions of 5.4 Mt CO_2 eq in 2010 will increase following an average annual growth rate of 13% and reaching approximately 64 Mt CO_2 eq in 2030. Figure 1 shows the distribution by sector of expected GHG reductions in 2030. Results indicate that the power sector will achieve the most substantial share (about 37%) followed by the transport sector (29%) and the construction sector (12%).

[32] Saved diesel is estimated to 0.64 Mtoe and electricity to 2.9 TWh. For GHG calculations, emission factors 2.8 Mt CO_2/Mtoe for diesel and 0.6 Mt-CO2/TWh for electricity (according to the GEH grid emission factor estimation) were used.

Table 4.16 Expected Development of Possible GHG Reductions by Sector of Emission (Mt CO_2 eq)

Sector	2005	2010	2015	2020	2025	2030
Electricity	0.00	0.03	3.68	8.05	16.88	23.52
Oil and Gas Extraction	0.00	0.40	2.04	2.04	1.75	1.50
Industry	0.00	0.30	0.64	1.36	2.88	6.00
Transport	0.00	1.40	3.60	9.27	13.04	18.36
Construction	0.00	0.38	0.81	1.72	3.65	7.77
Agriculture	0.00	0.25	0.52	1.11	2.36	4.90
Waste	0.00	1.34	1.51	1.66	1.83	1.97
Total	0.00	4.10	12.80	25.19	42.39	64.03

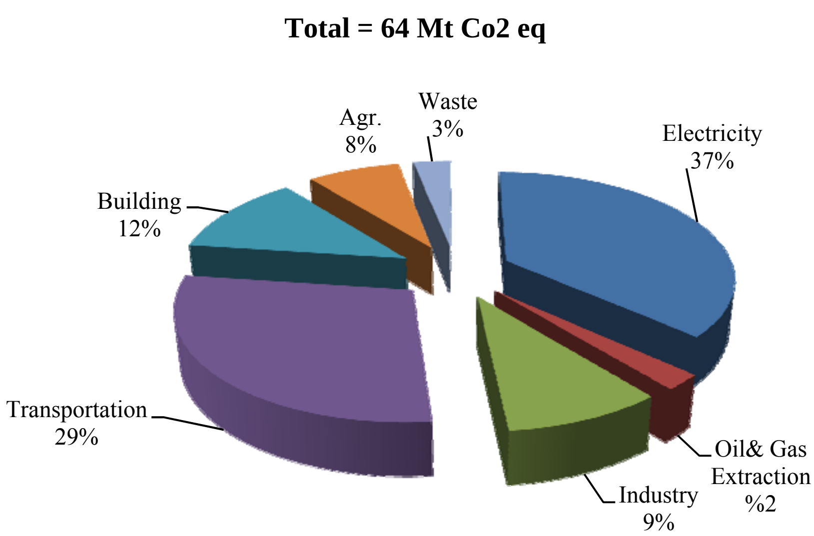


Fig. 4.12 Distribution in 2030 of Possible GHG Reductions by Emission Sector

PUBLIC AWARENESS, EDUCATION AND CAPACITY BUILDING

This chapter provides information considered relevant to the achievement of the objectives of the UNFCCC. In the context of addressing climate change at the national level, the following information is considered; education, training, public awareness, capacity-building and steps taken to integrate climate change into relevant policies and research and studies.

5.1 PUBLIC AWARENESS

Recently awareness campaigns were carried out during “Enabling Activities for the Preparation of Syria's Initial National Communication to the UNFCCC” project (INC-SY project), implemented at the Ministry of State for Environment Affairs (MSEA) and financed by the government, GEF/UNDP and other donors. These campaigns focused mainly on various environmental issues related to climate change such as forestry and tree planting, energy and water saving, waste minimization and recycling, various painting competitions for children and adults.

Globale Warming and Climate Change Exhibition 2008

Group photo: The State Minister of Environment and the UN Resident Representative (in the middle) after giving awards to the winners

Painting competition, best prize winners 2008

The competition festivals

The exhibitions of Globale Warming and Climate Change, were organized for the second year by the SMEA and UNDP in the cooperation with a number of NGOs and the private sector, held during the World Environmental Day (WED) 2007and 2008.

Workshop on Communicating Climate Change

Group photos: Field training for the Radio and Television environmental reporters, Damascus 2008.

Media trainers from press, radio and television , at the Danish institute in Damascus.

One day public awareness workshop on impacts of climate change on water resources and drought, Deir al-Zour, August 2009. (In the cooperation with UNDP and patronage of the Deir al-Zour governorates)

During the years 2007-2009, the Ministry of State for Environment Affairs (MSEA) and other national parties including Damascus, Aleppo, Homs, Al-Rakka and Deir al-Zour Governorates, and NGOs launched various awareness activities and trainings related to climate change and environmental issues. The awareness activities used several tools and targeted different stakeholders and society groups including universities students. Trainings focused on connecting the well known environmental issues such as water and energy saving with Climate Change, in addition to several tree planting and cleaning awareness campaigns:

- A Workshop on Communicating Climate Change, MSEA and UNDP in cooperation with Danish Institute in Damascus, December, 2008.
- Two documentary movies on climate change impacts and drought was prepared in Arabic, during the INC project.

Furthermore, the local daily newspapers published many articles and specific reports[33] on climate change and other environmental related issues. In addition, several television and radio programs addressing climate change issues were broadcasted.

Reports, articles and various activities can be accessed from the project's first Arabic website www.inc-sy.org related to climate change issues, established during the INC-SY project.

[33] Several articles and about 68 reports related to Climate Change, in English and Arabic, were published in national magazine and newspaper and through *MSEA/UNDP*.

Public awarness Campings 2008-2009

Planting activities, Conservation and Protected Area, Lattakia, 2008.

Volunteer Cleaning activities, Lattakia, May 2008.

Free environmental painting competition for children, during the international volunteer day (IVD) 2008.

5.2 EDUCATION

Schools curricula deal with environmental concepts and national priorities and challenges in general and climate change issues in particular at some grades. However, there is a need to re-evaluate the curricula aiming at better educating the students on climate change and environmental issues. Moreover, in most of the Syrian Universities, there are special departments teaching environmental sciences and issues related to climate change.

5.3 CAPACITY BUILDING

Syria, convinced of the importance and seriousness of climatic changes, and has ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1995, Syria has also signed the Kyoto Protocol on 4 September 2005. The Ministry of State for Environment Affair (MSEA) became the national focal point for climate change issues.

The country started its efforts within the UNFCCC in 2007 with a program supported by the Global Environment Facility (GEF) and managed by the United Nations Development Programme (UNDP) for national capacity building in documenting national emissions of greenhouse gases and preparing Syrian's initial national communication (INC-SY) to the UNFCCC.

In 2005, the Ministry of State for Environment Affair (MSEA) implemented another project entitled "National Capacity Self Assessment for Global Environmental Management (NCSA)". The NCSA was a GEF initiative aiming at assessing the capacity constraints and potentials for implementing the three international environmental conventions on biodiversity, climate change and desertification.

Also, as part of the capacity building efforts, promoting the cleaner production practices is an important and ongoing effort to prevent pollution; reduce the depletion of non-renewable resources; and minimize waste in the production process, and eventually help in climate change mitigation efforts.

Additionally, the Ministry of State for Environment Affair participated in and organized workshops related to Clean Development Mechanism (CDM) aiming at promoting this mechanism as a tool to mitigate climate change on the global level.

INC-SY project held various technical networking meetings and workshops on specific themes with support of (MSEA) including:

- Several training workshops for the GHG team members to provide technical support and to be trained on the GHG inventory according to the IPCC standards and methods, were held in different cities in Syria.

Training workshops 2008-2009

Workshop for launching the GHGs inventory National Report, Aleppo, 2009.

Second national Training workshop on GHGs inventory, Tartous, 2009.

5.4 STEPS TAKEN TO INTEGRATE CLIMATE CHANGE INTO NATIONAL POLICIES

Climate change is probably one of the most complex and challenging problems facing policy makers today. To effectively incorporate climate change issues into national sustainable development agendas, countries need to develop responsive policies and weigh various potential alternatives under conditions of high uncertainty and consequently recommend specific courses of actions considering the country's economic and socio-political realities.

Through reviewing available published national polices and strategies of water and energy, it was clear that the climate change was not directly addressed.

The only other national project in the climate change focal area which was approved in January 1997 with GEF funding of $4.61 million, titled "Supply-Side Efficiency and Energy Conservation and Planning" was implemented through UNDP and cofinanced with $25.1 million by the Ministry of Electricity[34], the national executing agency, $0.505 million by UNDP, and $0.18 million by the Organization of the Petroleum Exporting Countries. To date, this has been the largest project funded by the GEF in Syria and accounts for over a third of total funding thus far[35].

The Ministry of Electricity, in cooperation with the United Nations Department of Economic and Social Affairs, launched a master plan for the development of renewable energy use in 2002; it is currently updating this plan with GTZ assistance. The plan delineates sub plans to be carried out in order to provide a major boost to renewable energy development in Syria.

Recommended program initiatives include specific plans to be taken up for mainstreaming renewable energy in the national energy mix; and research, development, and demonstration projects for technology development.

The National Renewable Energy Master Plan consists of a set of actionable recommendations and proposals for renewable energy systems development and accompanying measures to facilitate this development.

The master plan proposals assume:

- a 10-year implementation period from 2002 to 2011;
- that the development of energy systems contributes to meeting the primary energy demand in the country and would reduce dependence on hydrocarbon sources such as gas-based electricity, gasoline generators, diesel heaters, and butane lamps;
- facilitating measures including the establishment of institutions, the conduct of studies and surveys, and training and capacity-building efforts;
- government commitment resulting in adequate resource allocation and establishment of an enabling institutional framework.

The National Adaptation Plan of Action (NAPA) which was proposed by INC-SY was adapted in the 11^{th} five year plan of the country through the State Planning Commission (SPC).

The NAPA implementation and sustainability aspects were taken into consideration while designing the Plan of Action as well as a proper and effective management and follow-up tools in MSEA and other institutions related to implementing the INC Action Plan.

NAPA is designed on the basis of the following six themes:

1) Develop sustainable institutional coordination mechanisms;
2) Develop clear and systematic integration of the UNFCCC concepts in the national policy and legislation;
3) Sustainable development of agricultural and water resources;

[34] The Syrian government committed funds for converting the combustion processes for two of four power generation units from heavy fuel to natural gas.

[35] GEF Country Portfolio Evaluation: Syria (1994–2008), Global Environmental Facility (GEF), Evaluation Office, Report No. 52, Washington, November 2009.

4) Capacity development, knowledge management, networking, outreach and awareness;

5) Develop means for technology transfer; and

6) Local communities' empowerment and participation

A review of potential evaluation criteria focused on the NAPA Annotated Guidelines as well as for the 10th and 11th -5 year Socio-Economic Development Plans, the National Environmental Policy presented in Copenhagen Conference on Climate Change (December 2009), the National Environmental Action Plan for Conserving Biodiversity, and the National Action Plan for Combating Desertification. Stakeholders were consulted for finalizing the following set of evaluation criteria by which to evaluate each proposed adaptation measure:

- Contribution to sustainable development;
- Livelihood security of local communities;
- Poverty reduction to enhance adaptive capacity;
- Synergy with other multilateral environmental agreements; and
- Cost-effectiveness.

NAPA Includes the following16 projects within the above listed six themes:

1) Development of a sustainable coordination mechanism among institutions implementing the National Adaptation Plan of Action (NAPA);

2) Strengthen the technical capacity of the UNFCCC focal point at the MSEA;

3) Develop a regulatory framework for systematic integration of the concepts of UNFCCC in the national policy and legislation;

4) Development of a policy system for assessing the impact of the economic and trade agreements on the environment;

5) Integrated Agricultural production;

6) Conservation and rational use of water resources including modern irrigation;

7) Develop and implement easily accessible drought forecast and drought monitoring information systems to improve drought preparedness;

8) Development of the investment environment in agriculture and agribusiness;

9) Develop Sustainable Awareness on Adaptation to Climate Change;

10) Establish and Maintain Climate Change Database;

11) Develop agricultural and water research and extension;

12) Development of knowledge management and networking;

13) Development of a technology transfer system and capacity building for energy efficiency and renewable energy;

14) Develop linkages between policy-making and research, and national policies of technology transfer at the regional and international levels;

15) Create environment for renewable energy and develop capacity for rational and efficient uses of energy; and

16) Development and implementation of a comprehensive capacity building and innovation program for community management of natural resources based on traditional knowledge.

There is a range of challenges that could threaten the ultimate implementation of priority adaptation activities identified by the NAPA process. Potential challenges are of various types including technical, economic, financial and institutional in nature at different levels.

A mechanism for implementing, monitoring and evaluating NAPA has been developed.

Stakeholders agreed that further delay in adaptation would significantly increase vulnerability of the other sectors, and/or lead to much higher adaptation costs in the future.

The Ministry of State for Environment Affairs is considering to get high level commitment and endorsement of this action plan to help in having the issue of climate change integrated into the strategies and plans of the relevant main sectors specially water and agriculture.

5.5 RESEARCH AND STUDIES ON CLIMATE CHANGE

Syria, as a developing country, has limited financial resources allocated for research regarding climate change. Only minor research activities and studies have been carried out through funded projects, universities, research centers and the INC-SY project and mainly addressed issues related to climate change and environment areas:

- Climate Changes in Syria: Primary national inventories study for green house gases (GHG), the team leader and reviewer were experts on air pollution and atmospheric physics from national institutions. The project was supported by the Deutsche Gesellschaft für Technische Zusamenarbeit Gmbh (GTZ), and implemented by the Environmental & Scientific Research Centre (ESRC) in 1998.
- National Strategy for Sustainable Development in Syria (NSSD). Implemented by The Fund for Integrated Rural Development of Syria (FIRDOS) in Collaboration with the General Directorate of Environmental Programme affairs in Syria, and supported by United Nation for Environmental Programme / Mediterranean Action Plan (UNEP/MAP), and Global Environment Facility/Small Grant Programme (GEF/SGP).
- Impacts of Climate Change on water sector and adaptation in the MENA region and Syria (2008). Meslmani Y. and Hoff H.; Modernization Programme for the Syrian Water Sector and German Development Cooperation - GTZ, Damascus, Syria. June 2008. (Arabic report).
- Climate Changes and the Mediterranean Environmental and Societal Impacts (2008). Meslmani Y. and Eido M. (INC-SY_V&A_Climate-Changes-and-the-Mediterranean-Ar); June 2008. United Nation Development Programme (UNDP) / GCEA. (Arabic report).
- Environmental Fund for Environmental Protection Programme in urban-industrial sector. Preparation of an Air Quality Monitoring Programme in Damascus, Project of Technical Cooperation between the Syrian Arab Republic and the Federal Republic of Germany, Deutsche Gesellschaft für Technische Zusamenarbeit Gmbh (GTZ). Project Number:96 2268 9-002.00.
- Evaluation of the Environmental state in Syria, national first report (2006). In Collaboration with General Directorate of Environmental affairs in Syria, and supported by United Nation for Environmental Programme (UNEP).
- Project of integrated pollution control in Aleppo (2000). Sub project: "Air Pollution in Aleppo City and surrounding Industrial region". Cooperation Project between the Syrian Arab Republic and the European Union (EU), United Nation of Development Programs (UNDP),and LIFE Program. Project Number: SYR / 97 / G81 / C / 5G / 99.
- Some Trends Related to Air Pollution in Damascus. Meslmani Yousef (2004). Management of Environmental Quality: an International Journal, Vol. 15 No. 4, 2004.
- Clearing the Air, Several factors need to be addressed if Syria is to improve the quality of its Air. Yousef Meslmani (2008). Focus on Environment, SYRIA TODAY, Issue No. 40, August 2008.

- View of Air pollution problem in Damascus. Meslmani Yousef (2002). European-Arabian Conference for the Environment, 10 – 14 October 2002, Rostock, Germany.
- Proposal of Air Quality Program for Damascus City. Meslmani Yousef (2004). International Conference on Atmospheric Pollution, Dubai International Convention Center, 21 –24 February 2004. Dubai – UAE.
- Dust full study in the surrounding area of a cement factory and determination of the major elements of the dust fall using Neutron Activation Analysis, NAA. Meslmani Y. and Al-Oudat M. (2004). Seventh Arab Conference on the peaceful uses of Atomic Energy, 4 – 8 December 2004. Sanaa–Yemen.
- The effects of cement dust on olive trees in the area surrounding Tartous cement factory. Meslmani Y., Al-Aoudat M. (2005). 3rd International Symposium on Air Quality. Management at Urban, Regional and Global Scales, 26 – 30 September 2005, Istanbul– Turkey.
- Review of Air Quality in Syria: 1999-2006. Meslmani Yousef (2006). Environmental Protection Division, Atomic Energy Commission of Syria. AECS-PR/Rss 697; September, 2006.
- Effect of using unleaded gasoline on lead concentration in air, soil and plants in Damascus-Syria; Meslmani Y., Al-Oudat M. (2006). Eighth Arab Conference on the peaceful uses of Atomic Energy. 3 – 7 December 2006, Amman-Jordan.
- Influence of Cement Dust Emission on Olive trees around Tartous cement factory in Syria: A case study for the eastern Mediterranean region. Meslmani Y., Al-Oudat M. (2007). 14th International Symposium on Environmental Pollution and its Impact on Life in the Mediterranean Region with focus on Environment and Health. October 10-14, 2007; Seville - Spain.
- National Greenhouse Gases (GHG) Inventory from the Waste Sector in Syria. The 49th Science Week, Conference on Management of Solid and Liquid Wastes in Syria, Status and Prospects for Development; 09 – 11 November 2009. Al-Baath University, Homs, Syria.

However, more focus is needed on research directed towards implementation of adaptation and mitigation measures.

6.1 INTRODUCTION

INC-SY identified constraints and gaps and related financial, technical and capacity needs which could be summarized as; capacity building to increase the local knowledge base; mobilize financial resources to conduct studies and implement adaptation and mitigation projects; and strengthen the legislative and institutional framework.

6.2 CONSTRAINTS, GAPS AND NEEDS

6.2.1 GHG Inventory Problems and Constraints

Data gaps and lack of data available in the format and quality needed for GHG inventory preparation was one of the main identified problems faced during the preparation of INC.

Data are often available in formats that suit government planning purposes, but do not cover all the information required by the IPCC methodology for inventory. Lack of institutional arrangements for data collection and data sharing exist.

Specific examples for lack of disaggregated data are:

- Unavailability of long term weather data and various difficulties to obtain the available one.
- Unavailability of local emission factors, thus the IPCC default values was used.
- Lack of data in the industrial sector including fuel consumption figures.
- Lack of up-to-date data in the transport sector including types of roads and modes of transportation. In addition, data of local aviation and marine are not available.
- Lack of data for use of energy in the agriculture, forestry and fishing subsectors.
- Lack of IPCC methodology for the solvents sector.
- Unavailability of data in the LULUCF sector of forest and non forest annual growth rates,
- Lack of data on soil types and their carbon content and land use patterns.

Needs to Address the Identified Problems and Constraints

The data system of green house gases inventory aiming at collecting data in the needed quality and format. This system should include institutional arrangements to facilitate data collection and sharing among the various national institutions. Furthermore, this system should include a legislative framework to obligate private sector to report the required data.

Taking the above into consideration, the following strategic actions are proposed/required:

- Conduct studies with regional cooperation aiming at developing regional emission factors.
- Develop the local capacities in using the new guidelines, methodologies, tools and software.

- Conduct surveys, studies and scientific research aiming at developing disaggregated data and emission factors needed for the GHG inventory estimation with special focus on key emission sources and sectors with high uncertainty.
- Secure and mobilize financial resources to address the above mentioned needs.

6.2.2 Mitigation Analysis Problems and Constraints

The main constraints identified with regard to mitigation of climate change are:

- Lack of data in all main sectors.
- Limited expertise in the scenarios models.
- Limited technical expertise in main sectors such as transport, agriculture and others; e.g. green technology, integrated and sustainable urban planning, renewable energy and energy saving technologies.
- Lack of legal and institutional framework to promote energy efficiency and renewable energy options.
- Weak awareness among decision makers on climate change in general and on financial and environmental benefits of CDM.
- Improper enforcement of existing laws related to energy efficiency and renewable energy.

Needs to Address the Identified Problems and Constraints

The following actions are recommended to address the identified constraints with regard to mitigation measures:

- Develop the local capacities in specific areas such as improvement of transport efficiency, assessment of different transport modes and application of transport mitigation methodologies.
- Develop the local capacities in using GHG mitigation methodologies, tools and software.
- Secure and mobilize financial resources to implement GHG mitigation projects especially small scale CDM projects.
- Formulate legal and institutional framework to promote energy efficiency and renewable energy options as well as enforcement of exciting laws through setting bylaws and regulations.
- Raise awareness of decision makers and top management of industrial organizations on the benefits of CDM projects.

6.2.3 Vulnerability and Adaptation Problems and Constraints

Data availability, consistency and transparency were the main identified problems faced during the preparation of climatic scenarios and thematic vulnerability and adaption studies as indicated in the below list;

1 There are missing data in the daily and monthly climatological time series at the majority of national meteorological stations. There is also a problem in water data availability. The quality of the available data is sometimes inappropriate.

2 The existing climatic and water resources monitoring in the country are facing permanent problems in operation, slow modernization of equipment and degardation of the existing monitoring network.

3 Health data on climate sensitive diseases are either limited or not available, e.g. current records are based on disease groups.

4 Lack of regional climatic prediction models and downscaling models, thus, Global Circulation Models (GCMs) were used with high spatial distribution.

5 Lack of well developed methodologies and tools for undertaking vulnerability and adaptation studies especially for health and socioeconomic sectors.

6 Limited local and regional V&A studies to perform comparisons with the studies conducted during the INC preparation and to verify the obtained results.

7 Lack of financial resources to address needs, conduct research and studies, and implement adaptation measures.

8 Socioeconomic data are either unavailable or available in inappropriate form. In general, data of some socioeconomic variables are available at the governorate level and not at cities, towns and villages level.

Needs to Address the Identified Problems and Constraints

The following actions are recommended to address the identified constraints:

1 Enhancing technical capacity for monitoring and data collection, data management and updating of basic data sets, and preparation of basic maps and databases.

2 Capacity building is needed in the area of methodologies, tools and guidelines to conduct V&A studies.

3 Improve meteorological, air quality and water monitoring through modernization of equipment and extension of monitoring networks.

4 Conduct studies and research to assess adverse impacts and vulnerability to climate change in different sectors specially those that were not included in INC, such as the tourism sector. In addition, studies are needed to geographical cover all potentially vulnerable areas of Syria.

5 Secure and mobilize financial resources to conduct studies and implement adaptation measures.

6 In the field of climate and climate change scenarios there is a need to establish regional models and downscaling models.

6.3 Financial resources and technical support for the preparation of national communication and for activities relating to Climate Change

Syrian Arab Republic has limited access to Global Environment Facility (GEF) investment agencies, since Syria does not belong to any of the regional banks with direct GEF access.

Furthermore, Syria is not a member of any of the regional development banks that can implement and manage GEF projects such as the African Development Bank and the Asian Development Bank.

GEF financially supported Syria in executing the following climate change activities:

1 Preparation of the Initial National Communication (INC-SY), executed by the General Commission of Environmental Affairs (GCEA), later became Ministry of State for Environment Affairs (MSEA), 2007-2010.

2 The “Supply-Side Efficiency and Energy Conservation and Planning” project established a target to reduce national energy consumption by 1.83 percent and carbon dioxide (CO_2) emissions by 765.5 tons by 2008. Although no data are available to support this result, the project did introduce efficiency management systems and maintenance management systems which have been replicated at several power generation plants around the country. The project also created the National Energy Research Centre (NERC), an institution within the Ministry of Electricity mandated with researching new alternative energy resources and energy efficiency initiatives; the center also has the capability of conducting energy audits.

3 National Capacity Self Assessment (NCSA) for Global Environmental Management. In the multifocal area, the “National Capacity Self-Assessment (NCSA) for Global Environment agreements” project enabled government institutions to develop new project concepts in biodiversity, land degradation, and climate change, and to coordinate the requirements of the three relevant conventions. The project also provided capacity building for government institutions, and highlighted gaps in existing capacities for determining needs and coordinating priorities in these three thematic areas. NCSA was executed by (MSEA).

4 The Small Grand Program (SGP) has contributed to greenhouse gas (GHG) reduction in Syria through biogas projects which offer good opportunities for communities and NGOs to learn and replicate results in this area.

6.4 TECHNOLOGY TRANSFER

GEF support addressed national priorities in the biodiversity and climate change focal areas; other national priorities have not been addressed.

Technology transfer needs, constraints and gaps have been addressed in one GEF funded projects called: the National Capacity Self Assessment for Global Environmental Management (NCSA). Main constraints and gaps identified at the NCSA project can be summarized as follows:

1- Absence of updating available data bases and low accessibility to information;

2- Weak institutional and technical capacity development for climate change;

3- Lack of appropriate funding for technology transfer and research.

4- Lack of legislative and institutional framework.

5- Routine government procedures and lack of specialized staff in the public sector.

6- Lack of projects, studies and budgets especially in all fields of impacts of climate change in Syria;

7- Limited expertise in modern technology maintenance and spare parts availability.

8- Administrative difficulties at the national and international levels in certain cases, and incompatibility of financial and administrative procedures among international donors and national executing stakeholders;

9- Lack of incentives and high taxation and customs on modern technology.

10- Lack of clear national policies for regional and international technology transfer, and weak linkages between scientific research and policy making;

11- Insufficient information and training courses allocated to emphasize the effectiveness and the feasibilities of different technological options.

12- Weak institutional and legislative framework of regulating accesses to genetic resources and benefits sharing;

13- Special needs to transfer knowledge and experience of the new technologies.

14- Lack of long-term programs for awareness and education on the new concepts of sustainable environment and climate change issues.

1. Abed Rabboh R. (2007). Water demand management in Syria. 3rd Regional Workshop on: Water and Sustainable Development in the Mediterranean Water Demand Management, Progress and Policies. Blue Plan UNEP/MAP, Zaragoza, Spain.
2. ACSAD-BGR Technical Cooperation Project. 2007. Management, Protection and Sustainable Use of Groundwater and Soil Resources; PROJECT REPORT PHASE III, 01.04.2004 – 31.03.2008, Development and Application of a Decision Support System (DSS) for Water Resources Management.
3. Al-Afandi (1984). British magazine, Volume 44, 1948, p. 31.
4. Allen R. G., Pereira L. S., Raes D., Smith M. (1998). Crop Evapotranspiration. Irrigation and Drainage paper 56, FAO, Rome, Italy.
5. Al-Sibai M.; Droubi A.; Abdallah A.; Zahra S.; Obeissi M.; Wolfer J.; Huber M.; Hennings V. and Schelkes K. (2008). Incorporate MODFLOW in a Decision Support System for Water Resources Management, Proceeding of MODFLOW and More international conference, Colorado, USA.
6. Assessing the potential Mitigation of greenhouse gas emissions (GHG) within the industrial sector in Syria (2010). Meslmani Y., Housami N. and Tannous N.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_Mitigation_Industrial opportunities); February 2010.
7. Assessing the potential Mitigation of greenhouse gas emissions (GHG) within the oil and gas production sector in Syria (2010). Meslmani Y. and Kherfan S.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_Mitigation_ Oil & Gas Production) February 2010.
8. Assessing the potential Mitigation of greenhouse gas emissions (GHG) within the Power Generation Sector in Syria (2010). Meslmani Y. and Hainoun A.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_ Mitigation _Power Generation opportunities). February 2010.
9. Assessing the potential Mitigation of greenhouse gas emissions (GHG) by using the renewable energy and energy efficiency (2010). Meslmani Y. and Zein A.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_Mitigation_ Renewable Energy & Energy Efficiency). February 2010.
10. Assessing the potential Mitigation of greenhouse gas emissions (GHG) within the building sector (2010). Meslmani Y. and Zein A.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_Mitigation_ Building opportunities). February 2010.
11. Assessing the potential Mitigation of greenhouse gas emissions (GHG) within the Transportation Sector (2010). Meslmani Y. and Al Shaar M.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_Mitigation_ Transportation opportunities). February 2010.
12. Assess the potential Mitigation of greenhouse gas emissions (GHG) within the Wastes sector (2010). Meslmani Y. and Kabekli R.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_Mitigation_ Wastes opportunities). February 2010.
13. Assessing the potential Mitigation of greenhouse gas emissions (GHG) within the Agriculture sector (2010). Meslmani Y., Asfari A. F. and Daoud M.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_Mitigation_ Agriculture opportunities). February 2010.
14. Beaumont P. (1981). Water resources and their management in the Middle East. In Change and Developments in the Middle East: Essays in Honor of Fisher W.B., Clarke JI, Bowen-Jones H. (eds.), and Methuen: London; 40–72.
15. British Petroleum (2005), "BP Statistical Review of World Energy", London.
16. Building to Implement the UN Conventions on Conserving Biological Diversity, Combating Desertification and Climate Change and Their Synergies in Syria .The Ministry of Local Administration and Environment, the United Nations Development Program and the Global Environmental Fund. Self-Assessment of National Capacity Building Needs in Syria to Manage Global Environmental Issues (NCSA); October 2007. Damascus, Syria.
17. Central Bureau for Statistic (2007). Statistical Abstract. Damascus, Syria.
18. Central Bureau of Statistics, CBS (2008). Agricultural Statistical Abstracts, Damascus.
19. Celis D., De Pauw E. and Geerken R. (2007). Assessment of land cover and land use in Central and West Asia and North Africa (CEWANA). Part 1. Land cover/land use-base year 1993. International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria.

20. Climate-Changes-and-the-Mediterranean-Environmental-and-societal-impacts (2008). Meslmani Y. and Eido M. (2008). (INC-SY_ Climate Changes and the-Mediterranean); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. June 2008. (Arabic report).
21. Darkazalli G. (2005). Policy Strategy and Institutional Development to Introduce Photovoltaic Systems into Syrian Arab Republic. Study funded by UNDP, April 2005.
22. Desertification / Land Use: Vulnerability Assessment in Syria (2009). Meslmani Y., Asfary A. F., Wahbi A., and Shaaban S., (INC-SY_V&A_Desertification); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
23. Doorenbos J. and Kassam A. H. (1979). Yield response to water. Irrigation and Drainage Paper 33. FAO, Rome, Italy.
24. Döll P. and Flörke M. (2005). Global-scale estimating of diffuse groundwater recharge. Frankfurt Hydrology paper 03. Institute of Physical Geography, Frankfurt University.
25. Droubi A., Al-Sibai M., Abdallah A., Zahra S., Obeissi M., Wolfer J., Huber M., Hennings V. & Schelkes K. (2007). A Decision Support System (DSS) for Water Resources Management, Design and Results from a Pilot Study in Syria. Proceeding of Climate Changes and Water Resources in the Middle East and North Africa, ed., Zereine; Springer, Germany.
26. Duchene G. and Noujoum O. (2007). "Syrian Economic Trends Bulletin", first edition, November 2007, ISMF, p. 46.
27. Dust fall study in the surrounding area of a cement factory and determination of the major elements of the dust fall using Neutron Activation Analysis, NAA (2004). Meslmani Y. and Al-Oudat M., Seventh Arab Conference on the peaceful uses of Atomic Energy Sanaa 4 – 8 December 2004. Sanaa – Yemen.
28. EEA. 2004. Impact of climate change, EEA Report No 2/2004. Available at http://reports.eea.eu.int/climate_report_2_2004/en.
29. Effect of using unleaded gasoline on lead concentration in air, soil and plants in Damascus-Syria (2006). Meslmani Y., Al-Aoudat M., Al-Kharfan K. and Al-Shamali K.; Eighth Arab Conference on the peaceful uses of Atomic Energy Amman, 3 – 7 December 2006.
30. El-Hakim M. (2005). Les Aquifers Karstiques de L'Anti-Liban et du Nord de la Plaine de la Bekaa: Caracterisitques, Fonctionnement, Evolution et Modelisation, d'apres L'Exemple du Systeme Karstique Anjar-Chamsine (Liban). Ph.D. Thesis, University Montpellier II & University Saint Joseph, Beirut, Lebanon.
31. Evaluating the Vulnerability of Forest Sector in Syria to Climate Changes (2009). Meslmani Y. and Ali M. K.; General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. (INC-SY_V&A_Forest); March, 2009.
32. Evans J. (2008). Evans plot of the change in precipitation by amount (hue) and significance (sat). http://web.maths.unsw.edu.au/~jasone/eplots/pics/evans_4_1_lg.png.
33. FAO (1979). Irrigation and Drainage Paper No. 33. Food and Agriculture Organization of the United Nations. Rome, Italy.
34. FAO (2003). Water Resources, Development and Management Service. CLIMWAT: A climatic database for CROPWAT. FAO Land and Water Development Division. Food and Agriculture Organization of the United Nations. Rome, Italy.
35. FAO (2008). Crop prospects and food situations. Publ. No. 4, October 2008. Rome.
36. Ferragina, E. and D. Quagliarotti (2008). Climatic change in the Mediterranean basin: territorial impact and search for a common strategy. New Midit. N. 4. FAO. Rome.
37. First national communication on climate change for republic of Turkey (2007).
38. GEF Country Portfolio Evaluation: Syria (1994–2008), Global Environmental Facility (GEF), Evaluation Office, Report No. 52, Washington, November 2009.
39. General Greenhouse Gas (GHG) Emissions Inventory in Syria (2009). Meslmani Y. and Khorfan S.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_GHG_General Inventory); July 2009.
40. General Vulnerability Assessment and Adaptation Measures to Climate Change in Syria (2009). Meslmani Y. and Abido M. S.; General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. (INC-SY_V&A_General Assessment) March, 2009.
41. Greenhouse gas (GHG) Emissions Inventory of the Industrial sector in Syria (2009). Meslmani Y. and Housami N.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_GHG_ Industrial Inventory) July 2009.

42. Greenhouse gas (GHG) Emissions Inventory of the Energy Sector in Syria (2009). Meslmani Y. and Hainoun A.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_GHG_ Energy Inventory). July 2009.
43. Greenhouse gas (GHG) Emissions Inventory of the Waste Sector in Syria (2009). Meslmani Y. and Kabekli R.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_GHG_ Waste Inventory), Damascus, Syria. July 2009.
44. Greenhouse gas (GHG) Emissions Inventory of Agriculture, Land use, Land use Change and Forestry (ALULUCF) in Syria (2009). Meslmani Y. and Jabour E.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_GHG_ALULUCF Inventory); July 2009.
45. General Assessments of Greenhouse gas emission Mitigation opportunities in Syria (2010). Meslmani Y. and Kordab M.; Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP), Damascus, Syria. (INC-SY_Mitigation_General Assessments). February 2010.
46. Global Water Partnership (2007). Policy Brief on Intelligent Water Strategies for Adapting to Climate Change.
47. General Organization for Remote Sensing, GORS 2006. Damascus, Syria.
48. Hainoun A, Seif-Eldin M. K., Almoustafa S. (2005). Analysis of the Syrian Long-Term Energy and Electricity Demand Projection Using End-Use Methodology, Energy Policy.
49. Hainoun A., Seif-Eldin M. K., Almoustafa S. (2009). Formulating an Optimal Long-term Energy Supply Strategy for Syria using MESSAGE Approach, Energy Policy.
50. Hainoun A., Seif-Eldin M. K., Alkhatib A., Almoustafa S. (2004). Analysis of Energy and Electricity Demand Projection and Identifying the Optimal Expansion Strategy of Electric Generation System in Syria (Covering the period 1999-2030), AECS-NE/FRSR 316.
51. Hanssen-Bauer I., and Forland E. J. (1994). Homogenizing long Norwegian precipitation series. J. Climate, 7, 1001–1013.
52. Hilbig Alexandra, Solar Thermal Application in Egypt, Jordan, Lebanon, Palestinian Territories & Syria (2009): Technical Aspects, Framework Conditions and Private Sector Needs, Cairo 23rd – 25th March, 2009.
53. Ibrahim A. (2003). National Diagnostic Analysis (NDA) of Syria, technical report UNEP/MEDU.
54. IEA statistics, www.iea.org.
55. Inception Report of Syria's Initial National Communication (2007). Meslmani Y.; General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP); Damascus, Syria. (INC-SY_ Inception Report); December 2007.
56. INC-SY (2009). Position of the Syrian Arab Republic on Climate Change Negotiations. The 15th COP to the UNFCCC and the 5th Meeting of the Parties to the Koyoto Protocol. Copenhagen, December 2009. Ministry of State for Environment Affairs (MSEA) 2009.
57. Impacts of Climate Change on water sector and adaptation in the MENA region and Syria (2008). Meslmani Y. and Hoff H.; Modernization Programme for the Syrian Water Sector and German Development Cooperation - GTZ, Damascus, Syria. June 2008. (Arabic report).
58. IPCC Guidelines for National Greenhouse Gas Inventories (2006). Vol. 1-5, NGGIP, IGES, Japan. (http://www.ipcc-nggip.iges. or.jp).
59. IPCC (2007-a). IPCC Guidelines for National Greenhouse Gas Inventories IPCC Report 2007. The Fourth Assessment Report (AR4).
60. IPCC (2007-b). Climate Change and Water. IPCC Technical Paper VI. Intergovernmental Panel on Climate Change.
61. IUCN 2008. The IUCN Relist of Threatened Species “2008”. http://www.iucnredlist.org/documents/2008RL_stats_table_6a_v1223294385.pdf.
62. Friedrich T. and Kienzle J. (2008). Direct Drilling; an Agro-Environmental Approach to Prevent Land Degradation and Sustain Production.
63. Jarrud M. and Topfer K. (2004). 16th years of scientific assessment in support of the climate change. IPCC, Dec., (2004).
64. Kayal M. (2007). Horizon of water resources management in Syria up 2027.
65. Kolars J. (1991). The Future of the Euphrates River. World Bank: Washington, DC.
66. Koyoto Protocol (2005). United Nations Framework Convention on Climate Change (UFCCC). Informal 83 UN, 2005. www.unfccc.int.
67. Kunstmann H., Suppan P., Heckl A. and Rimmer A. (2007). Joint high resolution climate-hydrology simulations for the Upper Jordan River catchment. Abstract IAHS-Conference 2007 in Perugia, Italy.

68. Manual for the United Nations Framework Convention on Climate Change (UFCCC) non-Annex I. GHG Inventory Software, Version1.3.2.
69. Manual for the UNFCCC non-Annex I, GHG Inventory Software, Version 1.3.2.
70. Maya R. (2003). "Les Politiques en Urbanisme et en Aménagement face aux défis du développement durable. Essai méthodologique d'analyse et d'évaluation de la mise en œuvre des pratiques", Université Paris XII, Institut d'Urbanisme de Paris (IUP). Centre de Recherche sur l'Espace, les Transports, l'Environnement et les Institutions Locales (C.R.E.T.E.I.L), Paris, 2003, p. 480.
71. Maya R. (2008). "The importance of regional planning in the processes of development and modernization in Syria: the challenges and the scopes of priority for working". Journal of Strategic studies, Center for Strategic Studies and Research, Damascus University, Spring 2008, 33p.
72. Meslmani Y. and Al-Oudat M. (2001). Noise Pollution in Aleppo City. 11th European-Arabian Conference for the Environment 24 – 26 April 2001, Rostock-Germany.
73. Meslmani Yousef (2002). View of Air pollution problem in Damascus. European-Arabian Conference for the Environment, 10 – 14 October 2002, Rostock, Germany.
74. Meslmani Yousef (2004-a). Proposal of Air Quality Program for Damascus City (2004). International Conference on Atmospheric Pollution, Dubai International Convention Center, 21 –24 February 2004. Dubai – UAE.
75. Meslmani Yousef (2004-b). Some Trends Related to Air Production in Damascus. Management of Environmental Quality: an International Journal, Vol. 15 No. 4, 2004.
76. Meslmani Y. and Al-Oudat M. (2004-c). Noise pollution in the old city of Damascus. The 44th Annual Sciences Week Conference on Environmental and Sustainabel Development, Homs University Campus, 22 – 25 November 2004. Homs – Syria.
77. Meslmani Y. and Al-Oudat M. (2004-d). Dust full study in the surrounding area of a cement factory and determination of the major elements of the dust fall using Neutron Activation Analysis, NAA. Seventh Arab Conference on the peaceful uses of Atomic Energy, 4 – 8 December 2004. Sanaa– Yemen.
78. Meslmani Y., Al-Aoudat M., Al-kharfan K. (2005). The effects of cement dust on olive trees in the area surrounding Tartous cement factory. 3rd International Symposium on Air Quality. Management at Urban, Regional and Global Scales, 26 – 30 September 2005, Istanbul– Turkey.
79. Meslmani Yousef (2006). Review of Air Quality in Syria: 1999-2006. Environmental Protection Division, Atomic Energy Commission of Syria. AECS-PR/Rss 697; September, 2006.
80. Meslmani Y., Al-Oudat M., Al Kharfan K., Al Shamali K. (2006).Effect of using unleaded gasoline on lead concentration in air, soil and plants in Damascus-Syria. Eighth Arab Conference on the peaceful uses of Atomic Energy. 3 – 7 December 2006, Amman-Jordan.
81. Meslmani Y., Al-Oudat M., Al Kharfan K., Al Shamali K. (2007). Influence of Cement Dust Emission on Olive trees around Tartous cement factory in Syria: A case study for the eastern Mediterranean region. 14th International Symposium on Environmental Pollution and its Impact on Life in the Mediterranean Region with focus on Environment and Health. October 10-14, 2007; Seville - Spain.
82. Meslmani Yousef, An Junlin, Wang Yuesi and Hu Fei (2007). The relationship between the vertical distribution of the Boundary Layer Ozone and preexisting NOx concentrations. 12th International Conference of the Pacific Basin Consortium for Environment & Health Sciences. 26th -29th October 2007; Peking University, Beijing - China.
83. Meslmani Y. and Eido M. (2008). Climate Changes and-the Mediterranean Environmental and Societal Iimpacts. (INC-SY_V&A_Climate-Changes-and-the-Mediterranean-Ar); June 2008. United Nation Development Programme (UNDP) / GCEA. (Arabic report).
84. Meslmani Y. and Hoff H. (2008). Impacts of Climate Change on water sector and adaptation in the MENA region and Syria. Modernization Programme for the Syrian Water Sector and German Development Cooperation - GTZ, Damascus, Syria. June 2008. (Arabic report).
85. Meslmani Yousef (2008-a). Feature of the National Climate Change Adaptation Strategy in Syria. Workshop held by the Arab Center for the Studies of Arid zones and Dray Lands (ACSAD) and the Deutsche Gesellschaft für Technische Zusamenarbeit Gmbh (gtz); 22nd January 2008. Omayyad Hotel, Damascus – Syria.
86. Meslmani Yousef (2008-b). Enabling activities for preparation of Syria's initial national communication. Second Technical workshop on Programs Containing Measures to facilitate Adaptation to Climate Change, Related to the Project Activity. Sheraton –Damascus, 11 November 2008.
87. Meslmani Yousef (2008-c). Possible Land Resources Stresses to climate change in Syria. Regional experts Meeting on Climate Change & land Degradation in the MENA Region, Arab Center for the Studies of Arid zones and Dray Lands (ACSAD) in collaboration with Deutsche Gesellschaft für Technische Zusamenarbeit Gmbh (gtz); Duma, 3-4 December 2008.

88. Meslmani Yousef (2008-d). The role of public campaign awareness environmental issues to fighting Climate Change. Workshop on Communicating Climate Change; supported by Syria's information ministry and Danish Institute in Damascus, December 15-21st, 2008, Damascus, Syria.
89. Meslmani Yousef (2009-a). Proposal for National adaptation action plan of climate change in Syria. Climate change and security workshop, supported by International Institute for Sustainable Development (IISD) and Danish Institute in Damascus, January 22, 2009, Damascus, Syria.
90. Meslmani Yousef (2009-b). Vulnerability assessment and possible Adaptation measures on some vital sectors and ecosystem in Syria. Third international Engineering Convention in Islamic World. 11-13 May 2009. Damascus, Syria.
91. Meslmani Yousef (2009-c). National Greenhouse Gases (GHG) Inventory from the Waste Sector in Syria. The 49th Science Week, Conference on Management of Solid and Liquid Wastes in Syria, Status and Prospects for Development; 09 – 11 November 2009. Al-Baath University, Homs, Syria.
92. Meslmani Yousef (2010). Assessing the impacts of climate change and the water sector in Syria. Presented at the Climate Change and Water in the Middle East- course at the Finnish Institute in Damascus; 16-18 May 2010. Damascus, Syria.
93. Ministry of Local Administration and Environment, MOLA (2007). Reports, Damascus- Syria.
94. Ministry of Electricity (2005). Final Energy Balance for the year 2005, Damascus, Syria.
95. Ministry of Electricity (2006). Annual Electricity Report (AER), Damascus, Syria.
96. Ministry of Oil and Mineral Wealth (2005-2009). Gas Movement in Syria.
97. Ministry of Electricity. Damascus (2006). Technical Statistical Report.
98. Ministry of Agriculture and Agrarian Reform, MAAR (2007). Agricultural Statistical Abstracts, Dept Statistics; Damascus, Syria.
99. Ministry of Agriculture and Agrarian Reform, MAAR (2005). A memorandum for shifting to modern irrigation for 2004. The National Project for Transfer to Modern Irrigation. March 2005; Damascus, Syria.
100. Mourad K. (2006). Situation of IWRM in Syria, Malta, (Informal data, power point presentation).
101. National Agricultural Policy center, NAPC (2002). Syrian Agricultural Trade. Ministry of Agriculture and Agrarian Reform. Damascus, Syria.
102. National Circumstances of Syria's Initial National Communication (2008). Meslmani Y., Maya R., Eido M., Khalil I., Mawed K., Saker A. and Alwanous N., (INC-SY_ National Circumstances); General Commission of Environmental Affairs (GCEA)/United Nation Development Programme (UNDP). Damascus, Syria. June 2008.
103. North Eastern Region Rural Development Project (2007). Design Document-Appraisal report. Working Paper 3: Irrigation and Water Management. Appendix 1: data on Water resources and Irrigation in Syria.
104. Lehner B.; Henrichs T.; Döll P.; Alcamo J. (2001). EuroWasser — Model-based assessment of European water resources and hydrology in the face of global change. World Water Series 5, Center for Environmental Systems Research, University of Kassel.
105. Onol B. and Semazzi F. (2006). Regional impacts on climate change on water resources over Eastern Mediterranean: Euphrates -Tigris basin. 18th conference on climate variability and change, 86th AMS meeting. USA.
106. Position of the Syrian Arab Republic on Climate Change Negotiations; COP-15 to the UNFCCC and the 5th Meeting of the Parties to the Koyoto Protocol in Copenhagen. Meslmani, Y., and Abido, M. S., (INC-SY_V&A_ Syrian Position on COP-15 Negotiations) Ministry of State for Environment Affairs (MSEA) / United Nation Development Programme (UNDP). Damascus, Syria. December 2009.
107. Request for Qualification (RFQ) for Developers/Sponsors of a 50-100 MW Wind Park Independent Power Producer (IPP) Project through International Competitive Bidding (ICB), Ministry of Electricity, Public Establishment of Electricity, for Generation & Transmission (PEEGT), November 2009.
108. Revised IPCC Guidelines for National Greenhouse Inventories (1996). Vol. 1-5. NGGIP, IGES, Japan. (http://www.ipcc-nggip.iges. or.jp).
109. Review of Air Quality in Syria: 1999-2006; (2006). Meslmani Yousef; Environmental Protection Division, Atomic Energy Commission of Syria. AECS-PR/Rss 697; September, 2006.
110. Amous S. and Abdel-Aziz A. O. (2009). Preliminary Inventory of Potential CDM Opportunities in the MENA region. Middle Eastern and North African Carbon Forum, Cairo, 6-7 May 2009.
111. Smith M. (1992). CROPWAT, a computer program for irrigation planning and management. Author, Smith M. Irrigation and Drainage Paper 46, FAO, Rome, Italy.

112. Smith R. B., Foster J., Kouchoukos N., Gluhosky P.A., Young R. and De Pauw E. (2000). Spatial analysis of climate, landscape, and hydrology in the Middle East: modeling and remote sensing. Center for Earth Observation Report No.2., Yale University, New haven, USA.
113. Socioeconomic Impacts of Climate Change in Syria (2009). Meslmani, Y., and Khazma, M., (INC-SY_V&A_Socioeconomic impacts); General Commission of Environmental Affairs (GCEA)/ United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
114. Solomon, S., D. et al. (2007). Climate Change: The Physical Science Basis (2007). Summary for Policymakers, Contribution of Working Group I to the Fourth Assessment Report of IPCC, Cambridge University Press, Cambridge, United Kingdom.
115. Spring flow Simulator Manual Vers. 1.0.2, (2007). ACSAD-BGR Technical Cooperation project-no. 2004, 2032.3, Management, Protection and Sustainable Use of Groundwater and Soil Resources.
116. State-and-Trends of the Environment: 1987–2007; Atmosphere. Lead authors: Mike Ashmore, Duncan Brack, Hans Eerens, Sara Feresu, Kejun Jiang, Héctor Jorquera, Sivan Kartha, Yousef Meslmani, Luisa T. Molina, Frank Murray, Linn Persson, Dieter Schwela, Hans Martin Seip, Ancha Srinivasan, and Bingyan Wang. Fourth Global Environment Outlook report (GEO-4). Division of Early Warning and Assessment (DEWA), United Nation of Environmental Programs (UNEP); P.O.Box: 30552, Nairobi-Kenya (can be downloaded on www.unep.org/geo/geo4/).
117. State Ministry for Environmental Affairs (2002). National Action Plan for Desertification Control in Syria. Damascus (Arabic).
118. State Ministry for Environmental Affairs (2002). National Biodiversity Strategy and Action Plan. Strategy and Action Plan Project, Syr/97/G31 UNDP/GEF.
119. State Ministry for Environmental Affairs (2001). National Environmental Action Plan for Syrian Arab Republic, UNDP and World Bank.
120. State Planning Commission "Analysis of the Macroeconomical Status Quo", 2003-2006.
121. State Planning Commission "Analysis of the Status Quo of the Tourism sector in Syria" and all numbers and percentages.
122. Statistical Agricultural Tables (2004, 2005, 2006). The annual agricultural statistical abstract. Ministry of Agriculture and Agrarian Reform, Syrian Arab republic.
123. Steinbrecht Dieter (2004). Waste to Energy -Workshop Faculty of Mechanical Engineering/University of Damascus/September 26th /27th , Damascus, Syria.
124. Stewart, et al. "Conservation Agriculture for Sustainable Land Management to Improve the Livelihood of People in Dry Areas". Proceedings of the international workshop. May, 9-10, Damascus-Syria.
125. Strategy and Action Plan for Adaptation to Climate Change in Syria (2010). Meslmani, Y., Wardeh M. F., (INC-SY_ Strategy & NAPA-En). Ministry of State for Environment Affairs (MSEA) / United Nations Development Programme (UNDP); Damascus, Syria. January 2010.
126. Studies on water-soluble salts in PM10 during the heavy pollution process in Beijing (2006). ZHANG Kai, WANG Yue-si, WEN Tian-xue, HU Bo, LIU Guang-ren and MESLMANI Yousef. CHINA ENVIRONMENTAL SCIENCE. 2006 Vol. 26 No.4, pp.385-389.
127. Syrian Sea Level Rise Vulnerability Assessment 2000-2100 (GIS), (2009). Meslmani, Y., and Faour, G., (INC-SY_V&A_Syrian Sea Level Rise); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
128. Syrian Supply Side Efficiency & Energy Conservation and Planning. Project Code: SYR/96/G31, UNDP/GEF.
129. The Global Environmental Fund (2007). Self-Assessment of National Capacity Building Needs in Syria to Manage Global Environmental Issues (NCSA); October 2007. Damascus, Syria.
130. United Nations Framework Convention on Climate Change, UNFCCC (1992).
131. United Nations Convention on Combating Desertification, UNCCD (2002). 5th Meeting of F.P. Asian Countries. 8-12 June. Damascus, Syria.
132. United Nations Convention for Combating Desertification, UNCCD (2002-2007). Meetings of the committee for the review of the implementation of the (CRIC1-CRIC3).
133. Von Hippel David F. (2004). Demand-Side Management (DSM) International Consultancy: DSM Assessment Project, November 2003 to December 2004 Project Code: SYR/96/G31, as Part of the GEF/UNDP, Supply Side Efficiency and Energy Conservation and Planning (SSEECP) Project.
134. Vulnerability Assessment and Possible Adaptation Measures of Water Policy (2009). Meslmani Y., and Droubi A., (INC-SY_V&A_Water-Policy); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
135. Vulnerability Assessment and Adaptation of Climate Sector in Syria (2009). Meslmani Y., Mawed K., Khaleel I. and Eido M.; (INC-SY_V&A_ Climate); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.

136. Vulnerability Assessment and Possible Adaptation Measures of Energy Sectors in Syria (2009). Meslmani Y. and Hainoun A.; (INC-SY_V&A_Energy); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
137. Vulnerability Assessment and Possible Adaptation Measures of Health Sector (2009). Meslmani Y., Murtada S., Jafari R. and Al Tawil A.; (INC-SY_V&A_Health); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
138. Vulnerability Assessment of Range Sector in Syria due to Drought and Climate Change (2009). Meslmani Y., Masri A. and Mawlawi B.; (INC-SY_V&A_Rangeland); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
139. Vulnerability Assessment and Adaptation Measures of Agricultural Sector (Modeling), (2009). Meslmani Y. and Jnad I.; (INC-SY_V&A_Agriculture Model); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
140. Vulnerability Assessment and Adaptation Measures of Water Resources: Modeling; (2009). Meslmani Y. and Al-Sibai M.; (INC-SY_V&A_Water Model); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
141. Vulnerability Assessment and possible Adaptation Policies on Agricultural Sector in Syria (2009). Meslmani Y. and Wardeh M. F.; (INC-SY_V&A_Agriculture-Policy); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
142. Vulnerability Assessment and Possible Adaptation Measures for Syria's Coastal areas (2009). Meslmani Y. and Ibrahim A.; (INC-SY_V&A_Socioeconomic impacts); General Commission of Environmental Affairs (GCEA) / United Nation Development Programme (UNDP). Damascus, Syria. March, 2009.
143. Wardeh M.F. (2005). Analysis of the National Action Plan for Combating Desertification in Syria. Ministry of Local Administration and the UNCCD. Damascus (Arabic/English).
144. Wardeh M. F. (2007). NCSA Strategy and Action Plan for Capacity, Damascus, Syria.
145. Wardeh M. F. (2007). NCSA Strategy and Action Plan for Capacity, Damascus, Syria.
146. World Bank (2007). Making the most of scarcity, Accounting for better water management in Middle East and North Africa. MENA development report on water.
147. ZHANG Kai, WANG Yue-si, WEN Tian-xue, HU Bo, LIU Guang-ren and MESLMANI Yousef (2006). Studies on water-soluble salts in PM10 during the heavy pollution process in Beijing CHINA; ENVIRONMENTAL SCIENCE. 2006 Vol. 26 No.4, pp.385-389.
148. Zhang Kai, Wang Yuesi, Wen Tianxue, Meslmani Yousef and Murray Frank (2007). Properties of nitrate, sulfate and ammonium in typical polluted atmospheric aerosols (PM10) in Beijing. Atmospheric Research, March 2007. Volume 84, Issue 1, pp. 67-77.
149. Zein A. (2008-a). Pre-feasibility Study for Wind Farm Development in Syria. Study funded by Al-Rajhi Company in Saudi-Arabia, 2008.
150. Zein A. (2008-b). Energy Audit Reports at 2 apartments, 2 restaurants and 2 hotels. Studies funded by Syrian-German Technical Cooperation GTZ. Program for Sustainable Urban Development , November 2008.

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Syrian's Initial National Communication to the United Nations Framework Convention on Climate Change (UNFCCC).

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