THE HASHEMITE KINGDOM OF JORDAN

JORDAN'S THIRD NATIONAL COMMUNICATION ON CLIMATE CHANGE

SUBMITTED TO
The United Nations Framework Convention on Climate Change (UNFCCC)

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The views expressed in this publication are those of the author and do not necessarily represent those of the United Nations Development Programme (UNDP), the report is the work of an independent team of authors sponsored by UNDP.

TABLE OF CONTENTS

FOREWORD

It is a very suitable timing to launch Jordan's Third National Communication report on Climate Change which will be submitted to the UNFCCC and then to the international community of Climate Change stakeholders. As the UNFCCC negotiations are approaching the crunch time of developing an ambitious, fair and effective new climate agreement Jordan is committed to being an active player in the international climate efforts based on the principles of the UNFCCC.

The following pages will provide all interested parties and institutions with a long term, scientifically sound description of the projected impacts of Climate Change on Jordan, as well as a comprehensive mitigation assessment and a detailed inventory of GHG emissions. As documented using modern downscaling projection models Jordan will be highly vulnerable to climate change impacts, especially the projected decrease in precipitation and increase in temperature and dry spells. This is of extreme concern for a country that is now considered the 2nd poorest in availability of water resources in the world, and is facing a huge challenge of accommodating the massive influx of refugees from troubled neighboring countries putting higher pressure on scarce natural resources. The report contains comprehensive vulnerability assessments for major developmental sectors in Jordan and identifies cost effective opportunities for mitigation and adaptations that Jordan will pursue with support of the international community.

The process of developing the TNC report was as important as the final report itself. It involved all national stakeholders and experts in a two year effort supported by GEF and UNDP and using the best available guidelines. The TNC was produced through the use of national expertise, with international support in the area of climate projection downscaling. The capacity building components of the TNC have helped to increase national capacity to produce national reports in a sustainable manner and with the best scientific quality. The knowledge created and generated within the TNC process will drive further research and enhance the information base for all stakeholders for years to come.

Jordan is undergoing a rapid and effective process of enhancing its institutional and policy relevant framework for addressing climate change challenges. After becoming the first country in the Middle East to develop a national climate change policy in 2013 Jordan has created a special directorate for Climate Change at the Ministry of Environment to act as a coordinating platform for all climate change activities in the country. By having a representative national committee on Climate Change since many years, Jordan is now well positioned to act positively and effectively to contribute to global effort in climate protection.

I would like to extend my appreciation to all the national experts who have participated in producing this report through relentless efforts and positive passionate attitudes. This effort was highly supported by both GEF and UNDP and enhances the strategic partnership between the Ministry of Environment and GEF-UNDP in the implementation of global environmental conventions.

Jordan is hereby providing its climate change identity card to the international community and is committed to active participation in a comprehensive and fair global effort to address the challenge of climate change in parallel with the challenges of sustainable development and human well-being.

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Minister of Environment

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The process of preparing the Third National Communication (TNC) report included the participation of tens of national institutions and hundreds of experts, professionals, researchers, activists and other members of the Climate Change community in Jordan. Without the positive and influential involvement of such stakeholders the TNC process would have not been successful.

Special thanks have to be spared for the efficient oversight and coordination process managed by the Ministry of Environment and UNDP Jordan. The project has benefited hugely from the strategic involvement of HE Eng Ahmad Al Qatarneh, Secretary General of the Ministry of Environment and Mrs Zena Ali-Ahamd UNDP Country Director who have collaborated in paving the road for the project implementation with great care and positive attitude. Technical and management support was provided to the project team with relentless engagement and support by Ministry of Environment Climate Change Director Indira Al Dhahabi and UNDP Environment and Climate Change team Mohammad Al Atoom and Rana Saleh.

Data availability and sources of information were the key factor behind the project and in this context special gratitude is offered to the Ministry of Water and Irrigation and the Jordan Meteorology Department for providing the project with comprehensive historical data of climate indices. Special thanks are also extended to the members of the National Committee for Climate Change which has provided the project with all needed information and documents. The positive and cooperative feedback from national institutions involved in the project as sources of GHG emission data is highly appreciated.

The project has benefited from the highly skilled technical support provided by the national consultant organizations working in the Mitigation and Adaptation sectors, in particular the Royal Scientific Society and the IUCN Regional office for West Asia. The UNDP GEF Global National Communications Support Programme (NCSP) has been instrumental in ensuring the quality of the TNC document and the process that led to its development.

Special appreciation is extended to all institutions and individuals who have participated in the various TNC meetings, workshops, focus groups and other exchanges that led to the development of the report.

Project Management Unit

LIST OF ABBREVIATIONS

ARI	Acute Respiratory Infections
BURs	Biennial Update Reports
CCIVA	Climate Change Impacts, Vulnerability & Adaptation
CORDEX	Coordinated Regional Climate Downscaling Experiment
CRiSTAL	Community Based Risk Screening Tool for Adaptation and Livelihood
DALY	Disability-Adjusted Life Year
DNA	Designated National Authority
DOS	Department of Statistics
ENPEP	Energy and Power Evaluation program
ESGF	Earth System Grid Federation
FAO	Food and Agriculture Organization
GAM	Greater Amman Municipality
GCM/RCM	Global Circulation Model/Regional Circulation Model
GHG	Greenhouse Gases
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
JCI	Jordan Chamber of Industry
JMD	Jordanian Meteorology Department
JREEEF	Jordan Renewable Energy and Energy Efficiency Fund
JV	Jordan Valley
LEDS	Low Emission Development Strategy
LNG	Liquefied Natural Gas
LULUCF	Land Use, Land Use Change and Forestry
MEMR	Ministry of Energy and Mineral Resources
MRV	Monitoring, Reporting and Verification
MoEnv	Ministry of Environment
NAAP	National Adaptation Action Plan
NAMAs	Nationally Appropriate Mitigation Actions
NCCC	National Committee on Climate Change
NEEAP	National Energy Efficiency Action Plan
NMVOC	Non-methane volatile organic compounds
NPP	Net Primary Productivity
RCP	Representative Concentration Pathway
RSCN	Royal Society for the Conservation of Nature
RSS	Royal Scientific Society
RWH	Rain Water Harvesting
PA	Protected Area
PMR	Partnership for Market Readiness
SCA	Special Conservation Area
SNC	Second National Communication
TNA	Training Needs Assessment
TNC	Third National Communication
WAJ	Water Authority of Jordan
UNFCCC	United Nations Framework Convention on Climate Change

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

1. National Circumstances

Located at the heart of the Middle East Jordan is a middle income county shaped by its Geography, history, Geopolitics and scarcity in natural resources. Jordan is located about 80 km to the East of the Mediterranean Sea with a predominantly Mediterranean climate; hot and dry summers and wet and cool winters. Jordan is also characterized by a unique topographic nature, where the western part represents the world lowest valley that lies north–south between two mountain ranges.

The demographic characteristics of the Jordanian population show that the Jordanian development process faces a challenge in providing basic needs in such a developing country. One of the main demographic determinants is migration. Migration movements from, to and through Jordan have continually played a key role in shaping its demographic situation as well as the economic and political structure. In both 1948 and 1967 Jordan received a great influx of Palestinian refugees from the wars with Israel that resulted in the creation of Israel in historic Palestine. In 1991 and 2003 Jordan received about a million refugees from Kuwait and Iraq during the two Gulf wars while in 2011-2014 it was the turn of Syrian refugees escaping turmoil in their homeland. In March 2014 The National Resilience Plan (NRP) was drafted by the Government of Jordan, in cooperation with UNCT, other donors and NGOs and seeks to address the accumulating fiscal burden as a result of the Syrian crisis on the Kingdom. This plan includes a request to extend $4.295 billion to Jordan to support the implementation of priority projects in the education, health, energy, municipalities, water, housing and security sectors.

Jordan has three distinct ecological systems: (i) Jordan Valley which forms a narrow strip located below the mean sea level, and has warm winters and hot summers with irrigation mainly practiced in this area; (ii) the western highlands where rainfall is relatively high and climate is typical of Mediterranean areas; and (iii) the arid and semiarid inland to the east (estimated to cover over 80% of the total area), known as the "Badia", where the annual rainfall is below 50 mm. Badia is an Arabic word describing the open rangeland where Bedouins (nomads) live and practice seasonal grazing and browsing. According to the IUCN Red List of 2006, Jordan has 47 globally threatened species. Of the 83 mammals species existing in Jordan, 12 are considered globally threatened. As for birds, there are 15 globally threatened species in Jordan. Around 2,500 species of vascular plants have been recorded, belonging to 152 families, representing about 1% of the total flora of the world.

Despite the relatively small size as a body of water, the Gulf of Aqaba, the only coastal zone in Jordan is host to an extraordinarily diverse marine system. The calm and clear waters provide a suitable environment for the growth of corals, and favorable salinity levels provide a suitable environment for countless varieties of marine-life forms.

Jordan is among the poorest countries in the world on on the basis of per capita water availability, with only 147 cubic meters per person per year in 2010. Renewable water resources are less than 130 cubic meters per person per year. Current total uses exceed the renewable supply. The difference (the water used that is not renewable) comes from nonrenewable and fossil groundwater extraction and the reuse of reclaimed water. If supply remains constant, per capita domestic consumption is projected to fall to 90 cubic meters per person/year by 2025, putting Jordan in the category of having an absolute water shortage that could constrain economic growth and potentially endanger public health.

Several policies, strategies and plans have being developed by the government to enhance the development, management and use of water resources. Jordan's "Water for Life" strategy 2008–2022 highlights in its irrigation water chapter drought management and adaptation to climate change as future challenges to be addressed through proper policies and regulations.

The contribution of agriculture to GDP has declined in relative terms from 20% in 1974 to less than 2.9% in 2011 while its contribution in absolute terms has increased (e.g. from JD 57 million in 1974 to JD 598.3 million in 2011.

Generally, rainfall amounts and climatic conditions of the country do not support good rainfed agriculture, except for few areas in the northern and western highlands. The rainfed agricultural zone is lying in areas where rainfall exceeds 250 milimeters although significant production of cereals does occur in some areas where rainfall is between 200 and 250 millimeters.

The rapid growths in economic activities, population and successive influxes of refugees over the last decade have imposed additional demands on energy resources. Moreover, Jordan is a country with limited indigenous energy resources; leaving Jordan heavily depending on its imports of energy to meet growing demand, expected to double to a forecasted 15.08Mtoe (million tonnes of oil equivalent) by 2020 from 7.58 Mtoe in 2007.

The prices of energy imports have increased with high risk in constant supplies, this situation spurred governmental action to improve energy efficiency and provide additional energy resources. Jordan imports 96 % of its oil and gas, accounting for almost 20% of the GDP which makes the country completely reliable on and vulnerable to the global energy market. The current energy strategy is to transform the energy mix from one heavily reliant on oil and natural gas to one more balanced with a higher proportion such as the of energy supplied by oil shale and renewable sources. The energy strategy seeks to increase reliance on local energy sources, from the current 4 % to 25 % by 2015, and up to 39 % by 2020. Placing more emphasis on the utilization of renewable energies will alleviate the dependency on the traditional energy sources, especially oil which is imported from neighboring countries. This will also be paralleled with the reduction of energy produced from oil from 58% currently to 40% in 2020.

2. National GHG Emissions Inventory

Jordan's anthropogenic (human-induced) emissions by sources, and removals by sinks, of all greenhouse gases (GHGs) not controlled by the Montreal Protocol have been estimated for the base year 2006 using the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories.

The GHG emissions and removals from the following sectors were estimated: energy, industrial processes, agriculture, land use, land-use change and forestry (LULUCF), waste and solvents.

The direct GHGs whose emissions have been estimated in this national inventory are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF6), Perfluorocarbons (PFCs), and Hydrofluorocarbons (HFCs).

Emissions of the following indirect GHGs have also been estimated and reported in this inventory: oxides of nitrogen (NO_x), carbon monoxide (CO), non-methane volatile organic compounds (NMVOC); and sulphur dioxide (SO_2).

Jordan's 2006 Greenhouse Gas Inventory by Sector and by Gas

In the year 2006, Jordan contributed about 28717gigagrams (Gg) or 28.72 million tonnes (Mt) of CO_2 equivalent (CO_2 eq.) of GHGs to the atmosphere. A sectoral breakdown of Jordan's total emissions of GHGs is as follows:

- Energy (20938Gg CO_2eq), 72.9%;
- Industrial processes (about 2550Gg CO_2 eq.), 8.9%;
- Agriculture (1318Gg CO^2 eq.), 4.6%;
- Waste (3045Gg CO_2 eq.), 10.6%, and
- LULUCF(866Gg CO_2 eq.), 3.0 %

In the energy sector, the contribution of the subsectors to national GHG inventory was:

- Energy industries 7916 Gg CO_2 eq (27.6%)
- Transport 4706 Gg CO_2 eq. (16.4%)
- Other sectors (Commercial, residential and agricultural) 2883 Gg CO_2 eq. (10%)
- Others 2715 Gg CO_2 eq. (9.5%)
- Manufacturing industries 2675 Gg CO_2 eq. (9.3%)

A breakdown of Jordan's total emissions on a GHG basis is as follows:

- Carbon dioxide (about 24003Gg CO_2), 83.58%;
- Methane about (3087Gg CO_2 eq.), 10.75%; and
- Nitrous oxide (about 1627Gg CO_2 eq.), 5.67%.

The Jordan's emissions of the fluorinated gases of sulphur hexafluoride, perfluorocarbons and hydrofluorocarbons were negligible in the year 2006

GHGs Inventory by sector

- **Energy Sector**

  The total emissions from the energy sector were 20938Gg CO_2 eq., i.e., 72.9% of the total GHG emission of Jordan in the year 2006.

  Carbon dioxide was the largest contributor (20896Gg) at a percentage of 99.8 % of the total energy sector emissions.

  On a per gas basis, the contribution of the energy sector in the year 2006 was 87.05% of the total CO_2

emissions of the country, 1.4 % of the CH_4 emissions, 47.8 % of the NMVOCs emissions and more than 99% of the total emissions of each of NO_x, CO and SO_2.

On a per sub-sector basis, the largest contributor to emissions in the energy sector is the energy industries subsector, which accounted for 37.9% of energy emissions, followed by the transport sector which contributed 22.5 % of the energy emissions.

- **Industrial Processes Sector**

In the year 2006, emissions from industrial processes sector category reached 2550Gg CO_2 eq at 8.9% of Jordan's total GHG emissions. The CO_2 emissions originated mainly from cement production (2041Gg CO_2 , 91% of the sector emissions). The industrial processes sector was the second largest source of NMVOC emissions and accounted for 62Gg at around 39.5% of Jordan's total NMVOC emissions in the year 2006.

In addition to CO_2 and NMVOC, this sector generated negligible emissions of NO_x, CO, SO_2 and HFCs.

- **Solvents and Other Products Use Sector**

In the year 2006, NMVOC emissions generated from the solvents and other products use sector were only 20Gg at around 12.7% of Jordan's total NMVOC emissions. The key sub sector source of NMVOC emissions in this sector was the application of oil and water based paints (14.05Gg). Other sources within the chemical products, manufacture and processing sub-sector were pharmaceuticals production, printing industry, glue use, edible oil extraction and paint production.

- **Agriculture Sector**

The GHG emissions of the agriculture activities accounted for 4.6 % (1318Gg CO_2 eq.) of Jordan's total GHG emissions in the year 2006. These emissions were composed of methane and nitrous oxide. Emissions of indirect GHGs of CO and NO_x were negligible. The emissions were from the following sub sectors

  - Methane (CH_4) emission from enteric fermentation and manure management 0.02 Giga grams
  - Nitrous oxide N_2O from Agriculture Soil = 4.21 Gg (80 % of total N_2O emissions)

- **Land Use, Land Use Change and Forestry Sector (LULUCF)**

The land-use change and forestry sector was a net source of CO_2. The emissions were estimated to be 866Gg of CO_2 for the year 2006.

- **Waste Sector**

In the year 2006, GHG emissions from the waste sector totaled 3045Gg CO_2 eq. at 10.6% of Jordan's total GHG emissions. Most of the emissions originated from disposal of domestic solid waste which accounted for 98.6 % (3003Gg CO_2 eq) of the total waste emissions, while wastewater handling accounted for 1.4 % (42Gg CO_2 eq) of the total waste emissions.

3. Greenhouse Gas Mitigation Analysis

The GHG Mitigation Analysis aims at identifying and assessing potential economic, social and policy measures and human interventions that can be implemented in Jordan to reduce anthropogenic emissions of greenhouse gases (GHGs) in different sectors at the national level to limit the magnitude and/or rate of long-term induced global warming.

Potential mitigation measures were analyzed and assessed for the different sectors for the period (2007-2040). For this purpose, two types of scenarios were constructed: a) baseline scenarios and b) mitigation scenarios.

a) The baseline scenario reflects a future in which there are no additional policies or programs designed to encourage or require actions that reduce GHG emissions or enhance carbon sinks. Defining a reasonable baseline scenario is considered a critical element in the abatement assessment since the benefits and incremental costs of mitigation options are directly linked to the sound definition of the baseline scenario. The baseline scenario was constructed based on the trends, plans and policies prevailing in the Jordanian context at the time of preparing this report (2014). The development of this scenario required a projection of the current levels generated to future levels of each type each activity for the time period 2007-2040. This projection drew on assumptions made about population growth, GDP and other macro variables, which were obtained from official institutions.

b) The mitigation scenario was structured according to a set of criteria reflecting country-specific conditions such as potential for large impact on greenhouse gases reduction, direct and indirect economic impacts, consistency with national development goals, potential effectiveness of implementation policies, sustainability of an option, data availability for evaluation and other sector-specific criteria.

Baseline Scenarios for Energy Sector:

The baseline scenario for the energy sector is based on the following main assumptions:

a) The Jordan Petroleum Refinery will continue its operations with the same capacity of production of 14 thousand tons per day, or about 100 thousand barrels to meet 60% of the need of the domestic market for oil products

b) Continue to meet Jordan's need for crude oil by importing 90% of the need of crude oil

c) Construction of a pipeline to export Iraqi crude oil across the Jordanian territory to the terminal in Aqaba with a capacity of 1 million barrels/day

d) Sustain the liberalization of prices of petroleum products by pricing them according to international prices, on a monthly basis

e) Construction of storage units with a capacity to store 100 thousand tons of crude oil in Aqaba

f) Complete construction of a project aimed at importing liquefied natural gas (LNG) through the port of Aqaba

g) Continue to produce 20 million cubic feet of natural gas from Risha gas field, located in East Jordan, at a constant rate until the year 2040

h) Construction by an Estonian company of a power plant (to be in operation in 2018) that uses direct oil shale burning and with a capacity of 450 MW

I) The maximum expected capacity of absorbed energy by the electric grid until 2020 from renewable energy projects will be 1500 MW. It is planned to start the implementation of a project in 2017 to be ready in 2020 to increase the capacity of the national electric grid

Baseline Scenario for Waste Sector:

- In line with Jordan's water strategy all wastewater needs to be treated and used as a replacement of fresh water and utilized by the agricultural sector.
- Current wastewater treatment plants need to be regularly upgraded to account for the population increase and thus to the increase in water consumption. However, extension will be mainly at plants serving urban areas.
- Current water consumption and generated wastewater per capita is assumed to be fixed.
- Biogas utilization from sludge digestion is mainly practiced at Samra WWTP and will continue to be so.
- Most of the sludge produced from other treatment plants will be dried out and disposed at landfill sites.

Baseline Scenario for Agriculture and LULUCF Sector

- Field crops production: Increase productivity per unit area, by promoting water-harvesting techniques that will allow cropping areas to expand and maintain productivity with predicted decreases in rainfall.
- Animal production: Promote high productive animal species under increase in prices of fodder, and other production inputs.
- Fodder production: Reclamation of rangelands and control of overgrazing in rangelands, introduce species with high productivity under drought conditions and promote wastewater reuse in fodder production.
- Forestry conservation: Maintain the forests under predicated continuity of drought cycles, urban and rural expansion, expected fire occurrences and trees cutting for fuel.

Baseline assumption for Industrial processes:

- Support the adoption of Best Available Technology (BAT) and Best Environmental Practices (BEP) in the industrial processes.
- Update regulations to encourage industrial investment.
- Support and encourage cooperation between the private and public sectors.
- Establish a national strategy to improve the exportation of local products to the international market.
- Improve the financial support mechanisms to encourage industrial investments

GHG Emission in baseline scenario:

Jordan's anthropogenic emissions by sources, and removals by sinks, of all GHGs in 2006, were estimated to be 28,717 Gg of CO_2eq, these emissions are expected to grow according to the baseline scenario to 38,151 Gg, 51028 Gg and 61,565 Gg of CO_2 eq in the years 2020, 2030 and 2040 respectively.

The role of the energy sector and subsectors as the leading emitter of GHGs is expected to increase in the future from 72.9 percent of total emissions in the year 2006 to 83 percent in the year 2040. Therefore, it is important to focus the mitigation efforts on this sector. With regards to energy subsectors, electricity generation and transport are the leading emitters and their share from energy sector total emissions falls between 39-43 percent, followed by a share of around 7 percent for the residential subsectors and 6 percent for the industrial subsector. The commercial, agriculture and refinery processes and transportation of fuel are marginal contributors to the total emissions from energy sector.

The waste sector contribution is expected to increase to 5300 Gg CO_2 eq with decrease of its share to 9% of the total GHG emissions in 2040. As WAJ converted Samra WWTP as well as other WWTPs to Aerobic mode, the emissions of methane were considered to be negligible.

The industrial sector is the third contributor to GHG emissions in Jordan according to the 2006 GHG Inventory. The sector contributed to 8.9% of the total emissions and its share it is expected to decrease to 6% in 2040 with total emissions of 3,480 Gg CO_2 eq

The agriculture GHG emissions contribution is 4.6% of the total GHG emissions in Jordan according to the 2006 GHG Inventory, and as expected the agriculture share to the total emissions is modest. The considered assumptions to build the scenario were in general consistent with the national population growth and GDP as there are no major changes expected within the sector.

The LULUCF is supposed to be a sink for GHGs, but it has contributed 3 % to the total GHG emissions according to the 2006 GHG Inventory as a result of having only a small forest area, less than 1 percent of the country's total area. It is assumed in the baseline projections that these emissions will be reduced with the increasing concern of forests protection and higher law enforcement at national level.

Mitigation Scenario:

A total of 43 GHG mitigation projects were proposed in the following areas:

- Primary energy,
- Renewable energy,
- Energy efficiency,
- Transport,
- Industrial processes,
- Waste, and
- Agriculture.

The cost, benefits and CO_2 emission reduction were analyzed for each proposed mitigation project. Net present value method was used in the financial calculations, by converting all of the future revenues and costs over the period of the project based on today's cost. The same approach was utilized when calculating CO_2 emission reductions over the lifetime of the proposed projects. A discount rate of 8 % was used in all calculations. The discounted unit cost of reduced emissions is the quotient of the discounted net cash flow to the discounted emission reductions.

If the analyzed mitigation projects are executed, they will lead to annual reductions of 3538. Gg in the year 2020; and are expected to increase to 5176 Gg in the year 2040, which represents around 9% of baseline emissions. Based on the unit abatement cost and abatement marginal cost curve, the most feasible options seem to be linked with the energy projects in general. Energy efficiency and renewable energy projects with unit cost range from -13 to -274 JD/t CO_2.

4. Vulnerability Assessment and Adaptation Measures

Climate Projections and Scenarios:

Based on long historical data obtained from Jordan Metrology Department (JMD), climatic variables are changing significantly at both national and station level, indicating that climate change is becoming more apparent. Both the Mann-Kendall rank trend test and linear regression trends indicate that the annual precipitation tends to decrease significantly with time at a rate of 1.2mm per year. Simultaneously, the mean, maximum and minimum air temperature tends to increase significantly by 0.02, 0.01, and 0.03 °C/year, respectively. On the other hand, the relative humidity tends to increase significantly by an average of 0.08%/year, while class A-pan evaporation seems to have non-realistic estimations of decreasing significantly by 0.088mm/year. The number of days of dust storm tends to decrease significantly by 0.09 days/year and 0.06 days/year for visibility less than 1km and 5km. In addition, the historic data tested in both annual and monthly basis indicated that precipitation reduction is highly significant during the whole rainy season except for January. Similarly during the dry seasons of June, July and August, the precipitation has tended to increase over time, although this increase is considered negligible in its quantity as indicated by the magnitude of the slope. Interpolated spatial maps shows the locations of these changes to be more apparent at both northern and southern parts.

Dynamic downscaling for this study was achieved using Africa CORDEX domain, in which 43 grid points with 50 km resolution were crossed throughout the country. Nine different GCM coupled with two RCMs for two RCPs (4.5 and 8.5) were used to assess future projections as compared to reference historic data (1980-2010). Three time horizons were selected; 2020-2050, 2040-2070, and 2070-2100. Climatic indices were extracted, processed, and debiased using delta and quantile-quantile scientific techniques. The selected climatic variables represent precipitation, mean temperature, maximum temperature, minimum temperature, wind speed and direction, relative humidity, class A evaporation, drought indices at 3 and 6 months basis, number of consecutive dry days, number of heavy rainfall days, and snow depth. The suggested reference model that was close to the median from all 9 models was "SMHI – NCC-NorESM-LR" a combination between Norwegian Earth System Model as global climate model, and Swedish SMHI regional climate model. This model was further used to further to interpolate the climatic indices at 1km resolution using combined statistical projections at the stations level (Delta method) and geostatistical interpolation using digital elevation model (DEM).

Based on the definitions of exposure consisting of likelihood, geographic magnitude, and confidence, the IPCC definitions were used. The qualitative measures (e.g. rare, unlikely, possible, likely, and extremely likely were based on the probability of occurrence per year, while the confidence scale was based on the processing of a multi-model ensemble (i.e. Very high, high, medium, low and very low confidence).

The projections' results totally agree with previous work of Second National Communication (SNC) to UNFCCC and are consistent with IPCC-AR5. For the year 2085, the two RCPs ***extremely likely*** predicted rise in mean temperature for all of the country, up +2.1°C [+1.7 to +3.1°C] for RCP 4.5, and +4°C [3.8- 5.1°C] for RCP 8. The increase was predicted to be homogeneous for the RCP 4.5, and stronger for the Eastern and the Southern regions for RCP 8.5. Future dynamic projections predict ***extremely likely*** warmer summer compared to other seasons.

Compared to the SNC that used CMIP3 results, multi-ensemble projections of CMIP5 results coupled with regional climate models in CORDEX give a more consistent trend to a ***likely*** drier climate. In 2070-2100, the cumulated precipitation could ***likely*** decrease by 15% [-6% to -25%] in RCP 4.5, by – 21% [-9% to -35%] in RCP 8.5. The decrease would be more marked in the western part of the country. It is more ***likely*** to have drier autumn and winter as compared to spring, with a median value of precipitation decrease reaching -35% in autumn in 2070-2100.

Also, the dynamic projections predict more ***extremely likely*** heat waves where the analysis of summer temperature, monthly values and the inter-annual variability reveal that some thresholds could be exceeded especially for a summer month where the average of maximum temperature for the whole country could exceed 42-44°C.

Drought events were ***likely*** predicted as indicated by the two indices of consecutive dry days and SPI. The maximum number of consecutive dry days would ***likely*** increase in the reference model of more than 30 days for the 2070-2100 period. The SPI indicates more frequent droughts with 3 to 4 years lag. In contrast to drought, annual values still show possible heavy rainy years at the end of the century. More intense droughts would be (partly) compensated by rainy years, in a context of a general decrease of precipitation. Potential evaporation would also ***likely*** increase. However, the occurrence of snow would be ***unlikely*** to decrease. Finally, the future projections ***unlikely*** predict no trend for winds, where maximum wind speed does not evolve significantly.

Climate exposure, risks, sensitivity, impacts and adaptive capacity:

The study applied a robust methodological framework that relies on two main pillars:

1. A qualitative and quantitative climate change impact and vulnerability assessment (CCIVA)
2. Identification and prioritization of adaptation for all the prioritized regions and sectors.

The study strongly benefited from the most recent developments in climate modeling research achieved by the ''Coordinated Regional Climate Downscaling Experiment'' (CORDEX) global program. The forecasts were developed for nine GCM-RCM model couples and the two IPCC's Representative Concentration Pathways (RCPs) 4.5 and 8.5. This allowed the generation of multi-model ensembles of projections and thus, helped to analyze the uncertainty originating from the different GCMs/RCMs through comparison of different models outcomes for the selected climate variables. At the study area, exposure of each selected hazard was assessed against three main determinants: i) likelihood of occurrence of the hazard (gradual change or extreme event), ii) geographical magnitude (from limited to widespread) and iii) confidence (of the projection results being correct).

Water Resources:

Based on the Climate trends analysis using CORDEX and RCP 4.5 and 8.5 the main climate hazards that the water sector faces in Jordan are temperature increases, precipitation decreases, increased incidents of drought and increased evaporation. Climate sensitivity indicators in water sector were determined as reduced groundwater recharge, groundwater quality deterioration, stream flow reduction and increased water demand. Assessment of sensitivity showed that the average sensitivity level is 3.71 (out of 5) and can be classified as high. That indicates how the system can be adversely impacted by the investigated climate change hazards.

Adaptation strategies and measures suggested for the water sector are:

- Rainwater harvesting
- Wastewater treatment
- Desalination
- Increasing Efficiency of irrigation technologies
- Grey water Reuse
- Public awareness

Agriculture Sector:

Poor in rural areas in Jordan are expected to face the most severe consequences of climate change through disruption of livelihood options that depend on natural resource management. The expected impacts of climate change, particularly reduced agricultural productivity and water availability threatens livelihoods and keeps vulnerable people insecure. Poor families and households are the most vulnerable group to the impacts of climate change and deserve the priority the in design of appropriate adaptive measures.

The major climate exposure risks associated with agriculture in Jordan were identified as: 1) Temperature increase, 2) Rainfall decrease 3) Droughts and 4) Shift in rainy season. The major sectors of high climate sensitivities were 1) cropping systems, 2) livestock production and 3) livelihood and food security.

The key adaptation measure to climate change is setting and implementing a sustainable agriculture policy. Adaptation measures vary horizontally according to the agricultural subsectors and their vulnerability to climate change. These measures vary vertically according to the different actors involved in the development and implementation of this policy.

The Adaptation strategies to a changing climate include:

- Agronomic and crop strategies that are intended to offset either partially or completely the loss of productivity caused by climate change through the application of defense tools with different temporal scales, e.g. short term adjustments and long term

adaptations, and spatial scales, e.g. farm, regional or national level adaptation; and
- Socio-economic strategies intended to meet the agricultural costs of climate change.

Generally, the most important adaptation measures in Agriculture are: modification of cropping pattern, modification of crop calendar including planting and harvesting dates, implementation of supplemental irrigation and water harvesting techniques, improve water use efficiency, use of different crops varieties and modification of policies and implementation of action plans.

Most of the interventions to upgrade rainfed agriculture can be cost-effective in farming systems, especially where irrigated agriculture is not feasible. For example, supplemental irrigation (the watering of rainfed crops with small amounts when rainfall fails to provide sufficient moisture) has proven to be a drought-proof strategy in most areas.

Increase of water available for supplementary irrigation can be achieved through on-farm rainwater harvesting and management system, i.e. small farm ponds for micro-irrigation using drip or sprinkler irrigation systems. Larger rainwater storage structures can also be constructed to provide supplementary irrigation water to a number of small farms or fields by using the micro-dams.

Conservation agriculture, on the other hand is very efficient, leading to increased crop yield. In this adaptation measure, several techniques are used to enhance soil water storage. Water conservation is usually enhanced through mulching and crop residue retention through zero or minimum tillage, stubble mulch tillage, strip tillage and crop rotation. Conservation agriculture, however, requires extension programs such as training and provision of equipment.

Biodiversity and Ecosystems:

The expected impacts from climate change on ecosystems in Jordan according to climate exposure and sensitivity of ecosystems in Jordan are droughts, forest dieback, community composition change, expansion of drier biomes into marginal lands, habitat degradation and species loss.

The highest exposure to Climate Change impacts is expected to be in the Eastern and Southern areas in Jordan and in the mountainous areas in the North, according to exposure and vulnerability analysis carried by the TNC. The highest sensitivity based on vegetation type is expected to be in the northern highlands and across the Middle areas in Jordan especially the Jordan Valley.

For water vegetation the TNC impact analysis study expects Reduced growth and reduced growth range due to lower soil moisture. For evergreen Oak forests and Pine forests it is expected to have lower regeneration rate, change in community composition and shrinkage in geographic range. For Mediterranean non-forest vegetation it is expected to have reduced growth in lower elevations and shift toward higher elevation with time.

Highest adaptive capacity was noticed to be in desert vegetation, tropical vegetation and to lower extent in marginal vegetation types such as steppe vegetation.

Overall it was noticed that the highest vulnerable ecosystems are forests (especially in the north) and fresh water ecosystems (especially in Jordan rift valley), that highlights the priority to perform adaptation interventions within these two ecosystems.

Adaptation measures and programs that can be adopted in Jordan include:

1. Restoration of degraded forests and encouraging the establishment of community forests to control soil erosion.
2. National wide, using diverse conservation governance forms including Protected Areas (PAs), Hima and Special Conservation Areas (SCAs) that empowers local communities to conserve their Natural resources and improves their livelihoods
3. Protecting and enhancing ecosystem services in conservation areas; Improve the access to ecosystem services and improve the quality of such services empowers local communities and increases the resistance/resilience of local communities to climate change impacts.
4. Preserving water quality and flows in water catchment areas using buffer zones surrounding PAs and SCAs.
5. Restoration and protection of rangelands to reduce the vulnerability of livestock to drought.
6. Adopt water management procedures providing alternative water sources for fauna and avifauna such as retention dams.

According to the prioritization done by the TNC it was found that enhancing ecosystem services provided by conservation areas and empowering local communities is the most important adaptation measure in Jordan followed by diversification of conservation methodologies and governance systems

Coastal Areas:

Impacts on coastal areas in Aqaba from Climate Change are expected to occure through 1) sea level rise, 2) extreme rainfall events or droughts in upstream terrestrial areas which are connected to run off and flooding, 3) sea surface temperature and 4) CO_2 concentrations.

Although changes in global mean sea-level could reflect changes in sea-level at the Gulf of Aqaba, the relationship between global mean sea level rise and local sea level rise will depend on a combination of factors, including changes in ocean circulation (which can alter sea-levels at local and regional scales), variations in oceanic levels due to thermal expansion and relative sea-level change associated with land movements. All this requires extensive in-depth research which is currently lacking at the national level.

The northern parts of Aqaba are the most vulnerable regions for flashflood hazards since they are located downstream from areas of major wadis. In addition, they contain most of the town residential expansion areas. Despite the establishments of flood diversion channels at the northern parts of the Gulf of Aqaba, floods are still a threat, if rainfall events exceed the thresholds. Based on the provision of regional climate projections using CORDEX, and for RCP 4.5 that predicts decreases of rainfall by 2050 reaching less than 50% of current rainfall in the North of Aqaba. Until 2100, the decrease of rainfall extends to the whole country, except the northeastern part. In addition, for the RCP 8.5, the precipitation decreases everywhere by 2050 except in two small areas in the mountains and in the rift and the northern parts of Aqaba that are the most affected regions.

An increase in mean sea surface temperature will cause changes as sea temperature and CO_2 concentration favor algal blooms in combination with increased nutrient run-off, which could lead to critical changes in ecosystems and species diversity. In addition, increases in temperature may intensify conditions of poor water oxygenation (lower solubility of O_2) and may promote the spread of diseases. However, rates of future warming in the Red Sea and Gulf of Aqaba are currently uncertain.

The most likely event at the Gulf of Aqaba is sea level rise, and the extreme rainfall or drought events from the upstream areas especially after analyzing the modeling data provided for precipitation rate. Based on the short coastline of the Gulf of Aqaba, the hazard impacts will have a widespread geographical magnitude. However, there is a low confidence in the results due to the current lack of a model, in Jordan, that accurately models the possible impact of climate change on sea level.

Ecosystem services are very fragile and have low adaptive capacity due to the limited coastal areas at the Gulf of Aqaba with about 27 kilometers and relatively short batches of major ecosystems. In addition, a moderate adaptive capacity is observed for both the economic and social capabilities and infrastructures at Aqaba.

The vulnerability assessment showed clearly that the geographically restricted coastline of the Gulf of Aqaba is vulnerable to climate change impact. The high vulnerability was noticed for main exposure determinants which are: sea level rise, increase of sea surface temperature and CO_2 concentrations. This is true as the Gulf of Aqaba contains sensitive ecosystems and habitats, which are very vulnerable to any changes in sea composition. Despite that modeling showed that precipitation is anticipated to be very low at the upstream areas of Aqaba, but still moderate vulnerability results was obtained due to the high adaptive capacity expected.

Urban Sector:

At the kingdom level, the overall exposure in RCP 4.5 is low and moderate in RCP 8.5, although the exposure is low, the events concentrate in certain geographic areas and thus the kingdom exposure is not the best representation for specific urban areas as Amman and Salt. The main factor, which reduced the exposure score, is the confidence of occurrence due to the large geographic coverage which is not uniform in exposure. For the purpose of better representation of climate change impact on communities, the exposure has been assessed for the pilot area specifically and for the Kingdom to cover the adjacent urban centers; Amman and Salt.

Adaptation measures suggested for the urban sector in the TNC include:

a) Introduce climate responsive building techniques and elements to reduce the effect of heat and reduce demand on energy for cooling.

b) Promote the use of energy saving devices, and raise awareness on the long-term benefits of energy efficiency and saving devices.

c) Amendments to sector policies and regulations, such as building codes, to reflect climate change risks and direct people towards insulating buildings to reduce energy demand

d) Construct proper storm water network to discharge storm water from built environment

e) Zoning and development changes to reflect increased vulnerability of specific locations and/or resources

Health Sector:

One of the most important effects of climate change in Jordan is shortage of water. One of the adaptation measures to cope with water shortage includes reuse of grey or treated wastewater in irrigation of trees or vegetables; this could increase the opportunity for transmission risk of several pathogens through crop contamination with pathogens that could cause outbreaks like Typhoid fever or Hepatitis A if the water is not well treated.

In addition, rising temperature due to climate change will increase microorganisms growth; leading to increases in water and food-borne diseases, in contrast flooding which is a result of extreme rainfall through concentrating the annual rainfall in a small interval lead to disruption of water purification and contamination with sewage disposal systems, leading to increase the probability of epidemics due to vector borne "VBDs," water and food-borne diseases.

Climate change may also influence on the seasonal pattern for respiratory diseases, cardiovascular diseases and mortality. The most visible effect of climate change on respiratory diseases is on chronic respiratory diseases including bronchial asthma and chronic obstructive pulmonary diseases "COPD"; acute infectious respiratory diseases seems that are not going to be directly affected.

In general the main climate change exposure issues for the health sector in Jordan are drought, dust or sand storms, decreasing precipitation, rising temperatures, Flooding due to extreme rainfall and shifting in the rainy season.

The sensitivity of health sector in Jordan is directly or indirectly affected by climate change. The influence scale ranged from insignificant (malnutrition) to catastrophic emerging epidemics (hemorrhagic fevers). Young children and elderly are the most sensitive group mainly to foodborne and waterborne diseases where the admission rate will be increased followed by respiratory diseases where the admission rate and mortality rate will be increased.

Main adaptation measures suggested in the TNC include:

- Establishment early warning system
- Adopt healthy buildings, through formulation building guidelines which include instructions for advanced sanitary installation that separate grey water from black water.
- Sustaining and improving sanitary conditions

Socio-economic Analysis:

The TNC has developed a socioeconomic analysis to determine expected impacts of Climate Change on local communities and their adaptive capacities by employing socioeconomic and adaptation analysis tools on the pilot area composed of four villages in the Amman- Zarqa Basin.

The study used the income assessment as a main critical indicator to the sensitivity of local community to the climate change. The importance of these indicators are linked to the impacts of climate change on the yield agricultural productivity at the study site especially that 54.47% of the community income based on agriculture which was considered the most sensitive sector to climate change.

Main results of the analysis include the following:

- Communities with less agricultural experiences such as Subeihi and Bayoudah will suffer severe effects due to climate change and it is expected that they will lose 10% or 20% of their income due to the decrease of their crop yields' productivity.
- It is well noticed that farmers above 60 years are less affected than others by external factors. This explains the importance of local knowledge and experience in agricultural practices.
- Seehan community will suffer an insignificant impact as the community scored the highest level in agricultural experiences.
- Because of diversification of their income sources,

Seehan will not suffer major impacts on their livelihoods.

- Al-Irmemeen was an exception among the other communities where younger farmers (between 20-40 years) have reported higher income level from agriculture compared with older age groups. The reason behind this is that the dominant production system is irrigated agriculture and farmers used modern technology and protected agriculture.

Further measures are required to explore the linkages between socio-economic studies and climate change impacts to enhance the adaptive capacity in communities Such measures include:

- Increase women's skill-development and capacity building opportunities through training in community and political participation skills and link them to general literacy and education initiatives
- Take measures to increase the labor productivity of rural women through improved access to training, extension services and technology.
- National governments must prioritize inclusive economic growth that, rather than excluding the rural poor, improves their well-being and reduces rural poverty.
- Mainstream the role of media in climate change and support NGOs and community based organizations (CBOs) are well placed to spearhead awareness raising efforts in different community segments, and in their climate change media-targeting activities.
- A pilot study on vulnerability to food security due to climate change using a multilevel approach, including an analytical and relatively comprehensive chain of logical events regarding the impacts of climate change for farm households is needed.

5. Means of Implementation

This chapter aims to provide a description of the current and proposed enabling environment for the implementation of the TNC and other national activities related to UNFCCC framework and climate change in general, as well as how Jordan is integrating climate change and national communications findings in sustainable development programmes.

Gaps and Constraints in National Communications:

Technical Gaps and constraints in the preparion of GHG inventory, mitigation assessment and vulnerability and adaptation assessments were identified. Practical response measures were suggested to close the gaps in the process of preparation of National Communications and future development of Biennial Updates Reports (BURs).

For GHG inventory the only way to address the gap in information management is by creating a sustainable system for the collection and processing of GHG inventory data on a sustainable level. This system should go beyond personal arrangements and relationships, to one that is grounded in statutory requirements, memoranda of understanding (MoU), institutional mandates and possible legal structures. Data quality and format for the new national system should be designed such that the GHG will be perceived more as a national activity with benefits for national development.

The GHG Mitigation analysis, suffers from influential gaps in data collection and processing. As such data gaps can be fixed and improved, other external factors provide negative impacts on the quality and reliance on long term planning. Influence of external factors such as energy supply and security, waste management policies, lack of a suitable infrastructure for public transport and reduced agricultural productivity which all contribute to increasing the levels of uncertainty in future planning.

The "complex" and "uncertain" landscape of mitigation actions and initiatives that are being developed and implemented within the UNFCCC. The various potentials and features of CDM, NAMAs, LEDs, PMRs, INDCs and other mitigation tools make it difficult for a holistic planning perspective in climate change mitigation. The TNC mitigation chapter should be used as a main reference for developing future mitigation project concepts under any of the initiatives mentioned above.

The availability and accessibility of meteorological data has improved during TNC project implementation. The TNC project has facilitated the development and adoption of an Understanding (MoU) between the National Meteorology Department (MD) and the Ministry of Environment. This MoU will regulate the flow of data from MD to the Ministry and other stakeholders and provides MD with the required capacity building programmes and activities that will enhance its ability to collect data by expanding the scope of indices and the distribution of stations.

During the TNC a paradigm shift was achieved from statistical downscaling through reliance on local data to dynamic downscaling based on the CORDEX system, GCM and relating the results to various RCPs. The expertise for achieving such an endeavor is still lacking in Jordan.

In August 2014 and based on recommendations of the National Climate Change Policy the Ministry of Environment has created it is first directorate for climate change. The directorate will act as the institutional hub for coordinating and developing all climate change activities in Jordan in relation to the UNFCCC and the global climate change governance system and initiatives. This step is a vital milestone in strengthening the institutional power and coordination mechanisms for Climate Change in Jordan and for enhancing the quality of future national communications and reporting requirements to the UNFCCC.

Public Education and Awareness (Article 6):

The TNC project has conducted the first public opinion survey to find out the state knowledge and perspectives on climate change, in Jordan and beyond, of five sectors of the general opinion. The aim of the survey is expanded to include a suggested communication plan based on the results of the survey.

- About 38% of the sample stated they have a "very good" knowledge of the climate change issue.
- Around 78% stated that there is a change in the climate during the past years
- Around 67% stated that they sensed a change in the climate and this change was negative and annoying to them.
- Around 73% stated that climate change was due to anthropogenic activities like industrial activities, energy sector and transportation.
- The sample's knowledge of some climate change terms as "Kyoto Protocol" was weak with a percentage of 41% stating they have no idea what this protocol is about.
- Around 60% stated that they believe that CO_2 concentrations in the atmosphere have hit the highest levels in the history of earth.
- Around 75% of the sample stated that the impacts of climate change at the national levels will be mainly manifested in the form of rise in temperature and 65% stated that climate change will negatively affect levels of precipitation

Based on the results of the Public Opinion Survey the TNC project has developed a national outreach plan that aims to respond to the requirements and guidelines in Article 6 of the UNFCCC and also aims to the improvement of national capacities and performance in public awareness on climate change issues.

This plan sets out four outreach objectives that should be achieved within two years, they are, namely:

1. Strengthening the capacity of the Ministry of Environment and its national partners in developing and conducting Climate Change outreach programmes.

2. Promote effective knowledge and awareness of the causes and effects of climate change at the levels of individuals and community and support open access to relevant information.

3. Advocate for the main stakeholders to mobilize and establish partnerships aimed to address the current and projected impacts of climate change in their programmes.

4. Support the mainstreaming of climate change education, awareness and capacity building in all relevant developmental sectors.

Technology Needs Assessment:

Within the TNC process Jordan has developed a Technology Needs Assessment (TNA) study specific for mitigation. The TNA has been undertaken to introduce technologies that could improve Jordan's developmental and environmental integrity. The main objective is to identify and assess environmentally sound technologies that have synergies between reducing the impact of climate change and the rate of GHG emissions and Jordan's national development objectives.

According to the results that main mitigation technology options for the energy sector are solar energy, wind energy and biogas to generate electricity. Major mitigation technology options for the transports sectors are Bus Rapid Transit (BRT), hybrid vehicles, Light Rail System and replacement of old cars with modern ones exempted from customs.

Roadmap for implementation:

The TNC has developed a suggested roadmap for Climate Action in Jordan for the implementation of TNC and other Climate initiatives. The proposed suggestions are presented in the following Table.

Item	Actions
1. Technical gaps in National Communications 1.1 GHG Inventory	1.1.1 Create a single entity at the newly-established Climate Change directorate in the Ministry of Environment to act as a hub to collect, process and report GHG inventory and exploring the possibility of creating a National GHG Inventory System 1.1.2 Conduct an intensive training programme on the development of a GHG inventory system, including detailed use of IPCC guidelines 1.1.3 Develop a legal structure that "adheres" activity data producers to submit information to the MoEnv 1.1.4 Prepare Jordan's First Biennial Update Report (FBUR) 1.1.5 Explore the potential to develop national emission factors for major GHG sources like energy, waste and industrial processes based on available capacities
1.2 Mitigation Assessment	1.2.1 Expand the expertise base and the knowledge capacity for conducting mitigation analysis through an extensive training programme on LEAP and other tools.
1.3 Vulnerability & Adaptation	1.3.1 Enhance the capacity of the Meteorology Department in expanding the scope of climate indices recorded and the distribution of monitoring stations and improvement of equipment performance 1.3.2 Improve the use of existing meteorological data through the production of maps, datasets and comparative tables that process raw data into policy-oriented knowledge products. 1.3.3 Expland the base of national experts trained in conducting climate projections and scenarios using dynamic downscaling and improving access to global climate data and use of various models 1.3.4 Undertake and integrated analysis of the country's vulnerability to climate change including local vulnerability maps, taking into account the direct, indirect and cumulative effects
2. Institutional Setup	2.1 Strengthen the capacity of the newly established Climate Change unit at MoEnv through proper organizational management, enhancing human resources and developing roles and mandate 2.2 Expand and enhance the role and mandate of the national climate change committee.
3. Policy Mainstreaming	3.1 Develop a coordinated policy approach for mitigation that integrates CDM, NAMA, PMR, MRV, LEDS and INDCs 3.2 Activate the national policy of climate change through stakeholders' coordination and mainstreaming of CC concepts in sectoral policies. 3.3 Develop a National Climate Change Adaptation Action Plan (NAAP)
4. Public Awareness	4.1 Implement the TNC learning and outreach plan
5. Education and Capacity Building	5.1 Integrate climate change concepts in national curricula 5.2- Develop informal education programmes/plans in climate change issues 5.3- Conduct a national needs assessment exercise for capacity building and responding to resulting priorities
6. Knowledge Management	6.1 Develop a clearing house of GHG inventory, mitigation, vulnerability and adaptation data
7. Scientific research and innovation	7.1 Increase support for scientific research in climate change issues 7.2 Enhance the role of researchers and scientists in the climate change policy making process
8. Financial resources	8.1 Map of all available financial resources in climate change and exploring opportunities for resource mobilization 8.2 Integrate climate change issues in bilateral and multilateral international cooperation programmes in Jordan 8.3 Channel available domestic financial resources into areas of direct connection with climate change
9. Technology Transfer	9.1 Map all available opportunities for technology transfer in climate related issues 9.2 Conduct a national needs assessment exercise for adaptation technologies required

NATIONAL CIRCUMSTANCES 1

1.1 GOVERNANCE STRUCTURE

Located at the heart of the Middle East Jordan is a middle income county shaped by its Geography, history, Geopolitics and scarcity in natural resources. Jordan is a constitutional monarchy based on the constitution enacted on January 8, 1952. His Majesty King Abdullah II is the Head of State. Executive authority is vested in the King and through the Prime Minister and the Council of Ministries, or Cabinet. The Cabinet is accountable to a two-house parliament. The Upper House (the Senate), is appointed by the King, while the deputies of the Lower House (the Parliament) are elected by popular vote.

Jordan is divided into twelve Governorates, each headed by a Governor and subdivided into administrative regions. The Governors are considered extensions of the central government, and are supervised by the Ministry of Interior Affairs. Governors enjoy wide administrative authority, and in specific cases they exercise the powers of ministers.

The second level within a Governorate is the Municipal Council, which is elected by local residents for a four-year term. Starting in July 1995, nationwide municipal council elections were held on the same day, with a number of women winning seats for the first time. The Government appoints the mayor and half of the council, of the Greater Amman Municipality, and the other half is elected directly by voters in the capital.

The governance system in Jordan links multiple-governmental organizations in developing and implementing environmental policies. The leading body is the Ministry for Environment (MoEnv), which was established in 2003. The Ministry's mission is to maintain and improve the quality of Jordan's environment, conserve natural resources and contribute to sustainable development through effective policies, legislation, strategies, monitoring and by mainstreaming environmental policies into all national development plans.

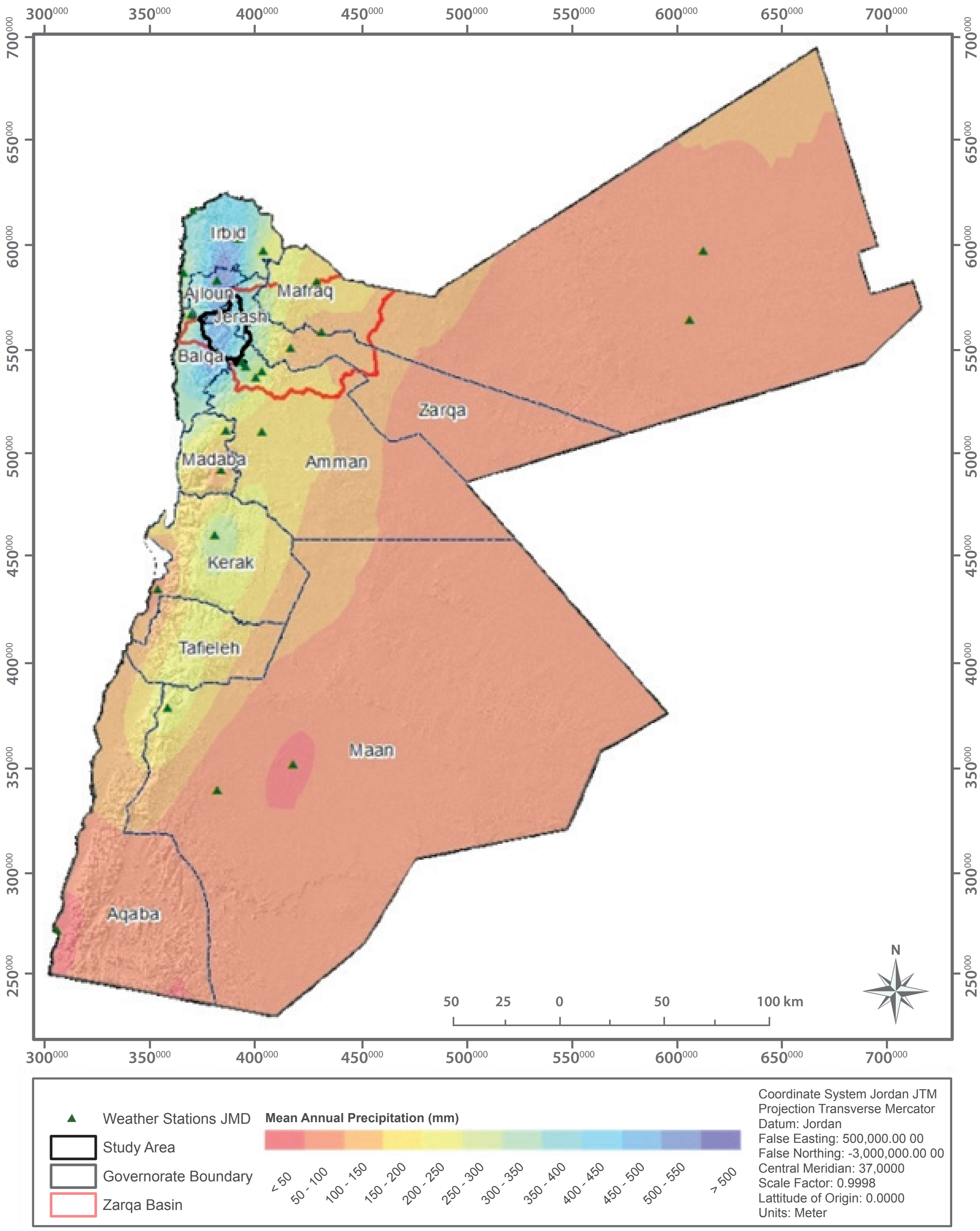
1.2 GEOGRAPHY AND CLIMATE

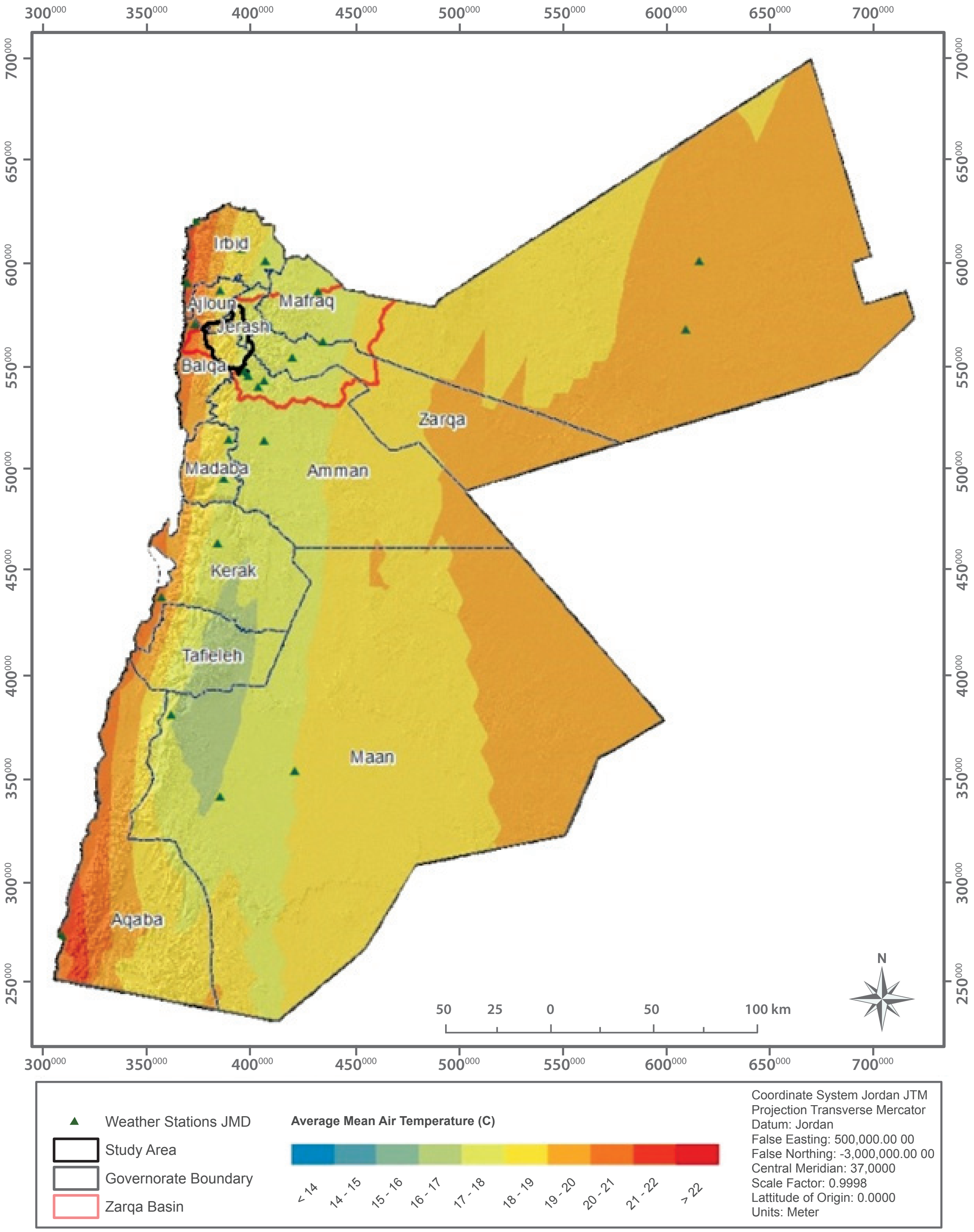
Jordan is located about 80 km to the East of the Mediterranean Sea with a predominantly Mediterranean climate; hot and dry summers and wet and cool winters. Jordan is also characterized by a unique topographic nature, where the western part represents the world lowest valley that lies north–south between two mountain ranges with a length of about 400 km and a width that varies from 10 km in the North to 30 km in the South and elevation between 170 – 400 meters below Mean Sea Level (MSL). The Jordan River passes through this valley from north to south down to the Dead Sea. Just to the East of the Jordan Valley the north-south mountain range reaches about 1,150 meters above MSL in the northern parts and about 1,500 meters above MSL, in the southern parts of the kingdom. To the east of this mountain range a semi desert plateau extends to cover approximately 80% of the total area of the country.

According to the geographic and topographic characteristics, Jordan is divided into three main climatic regions (FAO, 2012); the Ghor region (lowlands), Highlands, Badia and Desert region

- The Ghor (Lowlands) is part of the Great Rift Valley with a length of about 400 kilometers extending from north to south. The Ghor consists of three parts; the Jordan River, the Dead Sea (The lowest elevation on earth) and Wadi Araba. The elevation of the Ghor ranges from 197 meters below MSL, in the north to more than 400 meters below MSL. at the Dead Sea. The width of the Ghor is approximately 15 kilometers in the north expanding gradually to about 30 kilometers in the south. The area of the Ghor east of River Jordan and Dead Sea is about 3,000 square kilometers.
- The Highlands and Marginal Steeps Region that extends north-south to the east of the Ghor. The Mountainous Region extends from the Yarmouk River in the north to Ras El-Naqab in the south; the mountain ranges are dissected at several locations by valleys such as Zerqa River, Wadi Mujib and Wadi El-Hasa. The elevation of the peaks of these mountains varies from 1,150m above MSL in the north (Ras Muneef) to about 1,365m above MSL in the south (Al–Shoubak), some peaks exceeds 1,500 meters above MSL (El-Qurain). The total

Figure 1.1: The spatial distribution maps of mean annual precipitation, average mean temperature, average maximum temperature, average minimum temperature, mean annual evaporation and average relative humidity across the country





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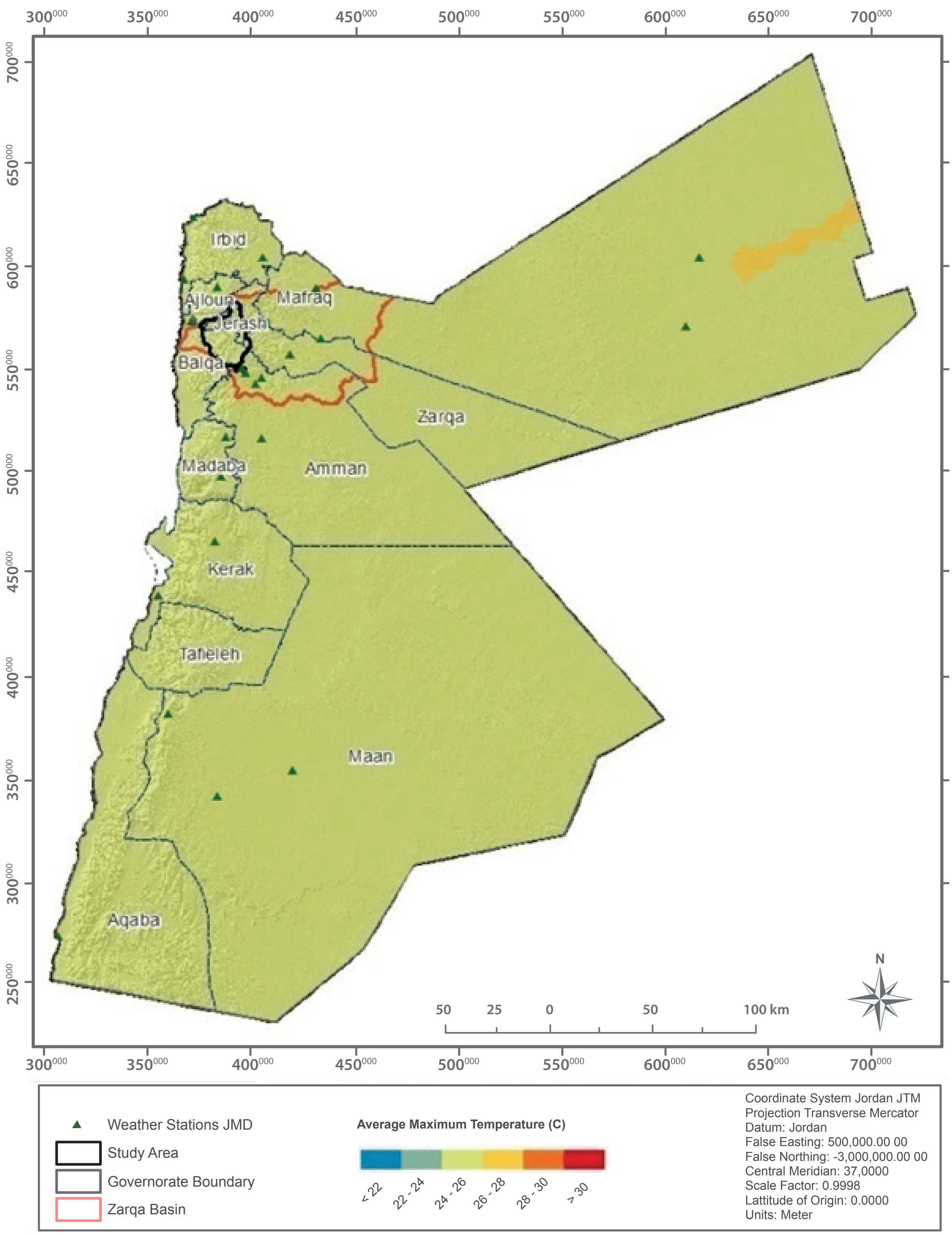
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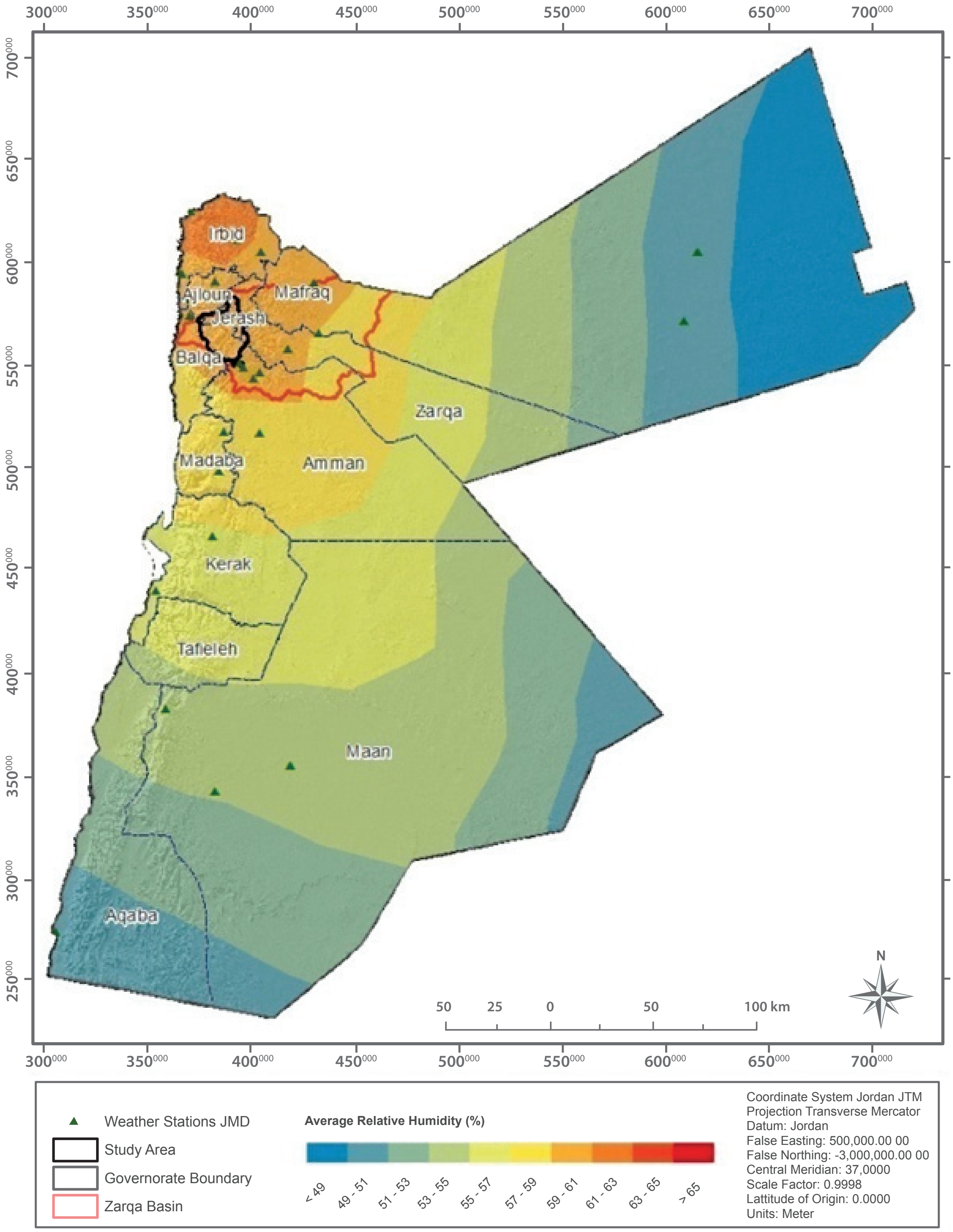

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Study Area
Governorate Boundary
Zarqa Basin
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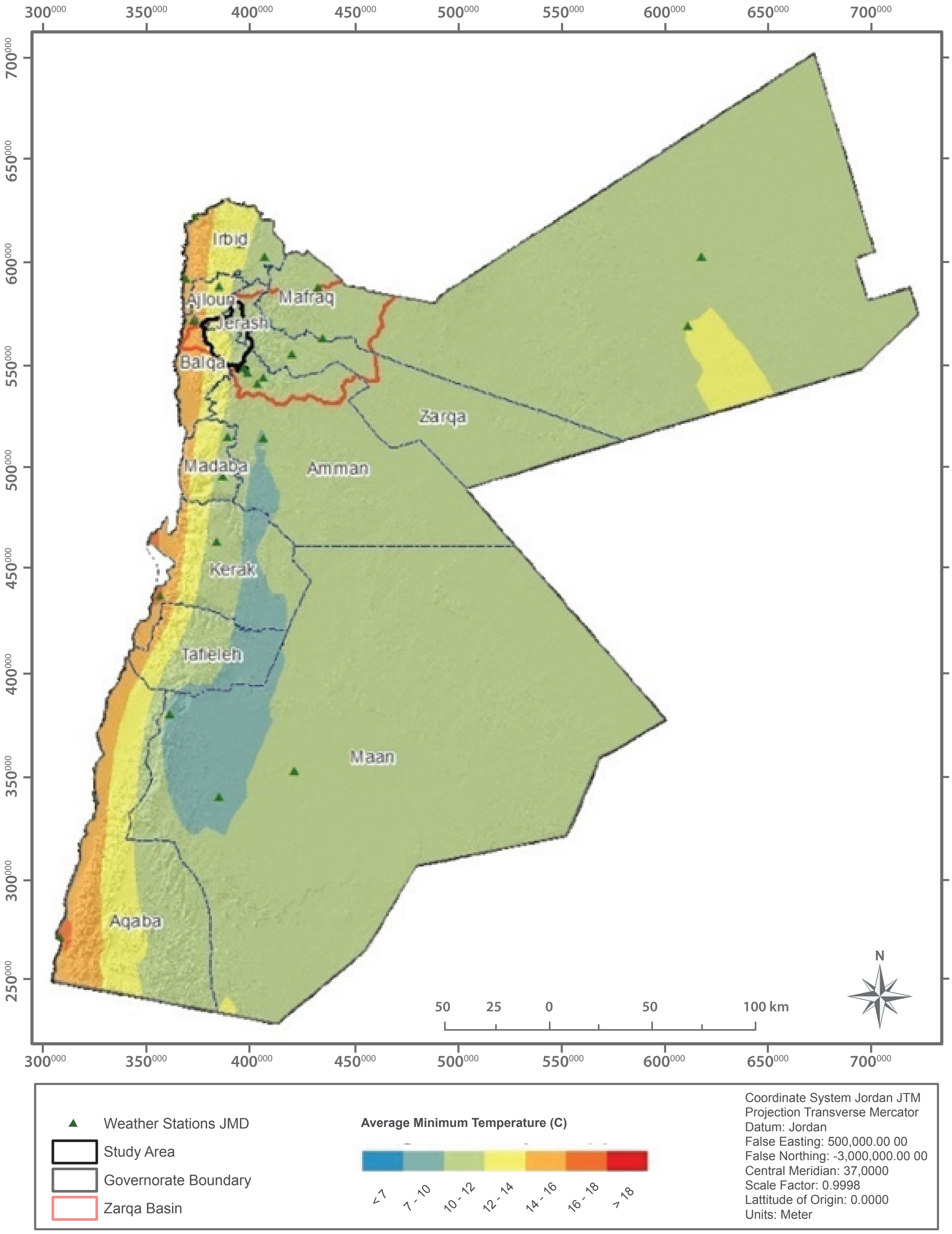
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Average Minimum Temperature (C)
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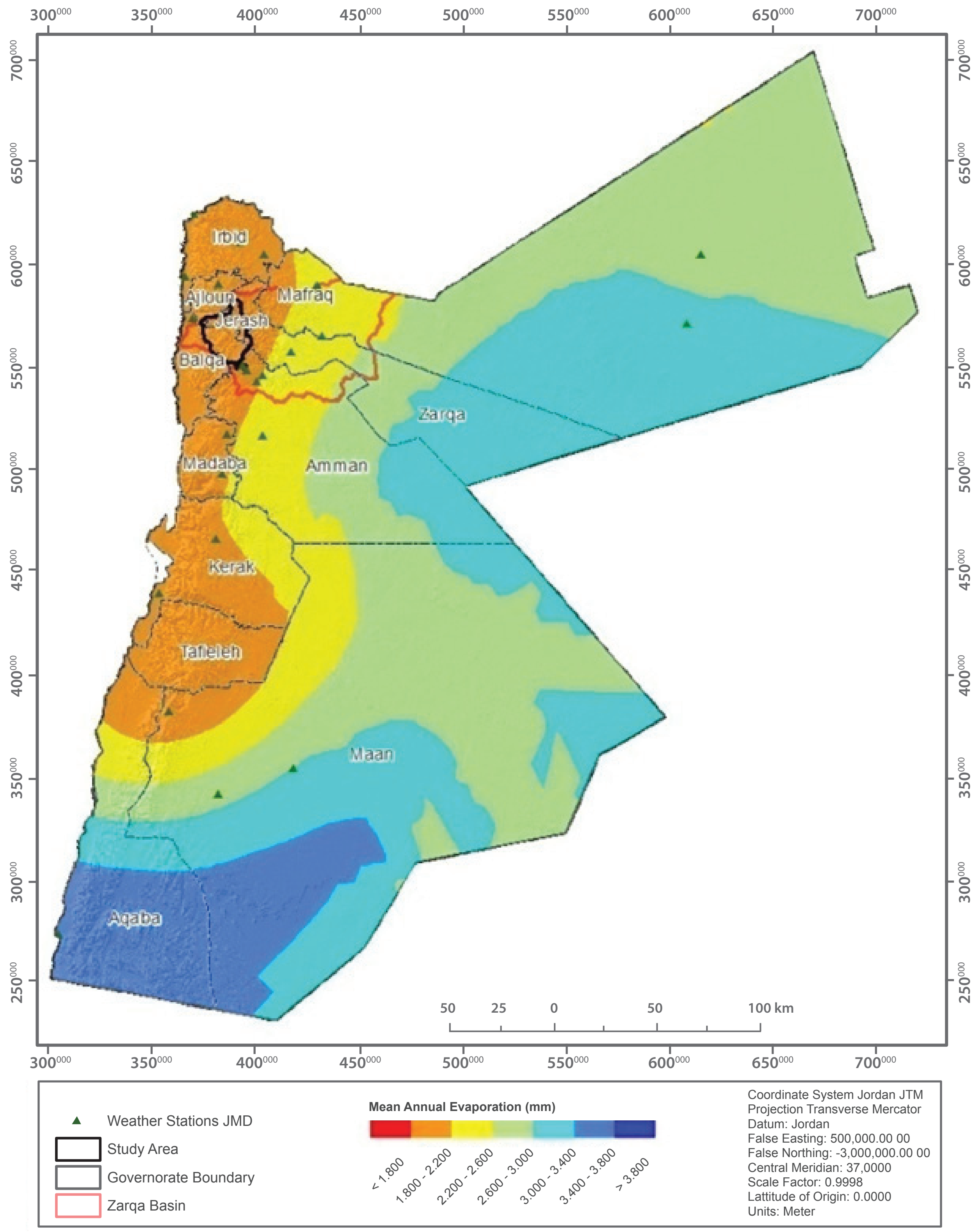
16 - 18
> 18
Coordinate System Jordan JTM
Projection Transverse Mercator
Datum: Jordan
False Easting: 500,000.00 00
False Northing: -3,000,000.00 00
Central Meridian: 37,0000
Scale Factor: 0.9998
Lattitude of Origin: 0.0000
Units: Meter


Irbid
Ajloun
Jerash
Mafraq
Balqa
Zarqa
Madaba
Amman
Kerak
Tafeleh
Maan
Aqaba
50 25 0 50 100 km
Weather Stations JMD
Study Area
Governorate Boundary
Zarqa Basin
Mean Annual Evaporation (mm)
< 1.800
1.800 - 2.200
2.200 - 2.600
2.600 - 3.000
3.000 - 3.400
3.400 - 3.800
> 3.800
Coordinate System Jordan JTM
Projection Transverse Mercator
Datum: Jordan
False Easting: 500,000.00 00
False Northing: -3,000,000.00 00
Central Meridian: 37,0000
Scale Factor: 0.9998
Lattitude of Origin: 0.0000
Units: Meter

area of the mountains regions is about 7,900 square kilometers. The Marginal Steeps Region stretches from north to the southeast of the Mountainous Region, from the Syrian borders in the north to Ras Al-Naqab in the south. It has an area of 9,000 square kilometers that represents the best potential rangeland of Jordan.

- The Badia and Desert Region extending north-south from the foot of the Highlands eastward. The total area of the Badia and the Desert is about 70,000 square kilometers, with an elevation of about 600-750 above MSL., the annual rainfall of the Badia ranges from 50 to 100 millimeters. The south–east of the region is a true desert with an annual rainfall of less than 35 millimeters; the total area of the Jordanian Desert is around 30,000 square kilometers.

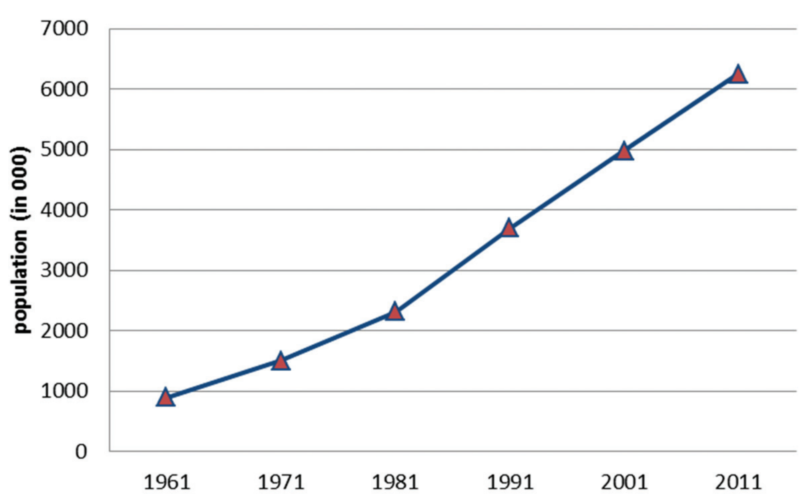
According to historic Jordanian Meteorology Department (JMD) data, the major part of the country (90%) is arid to semi-arid, characterized by a very low annual precipitation, averaging less than 220 millimeters. The rainy season extends from around October to May of the next year. About 80% of the seasonal rainfall occurs through the months of December to March, reaching a maximum average during the month of January. The annual total precipitation vary sharply from one climatic region to another, from a minimum of 28 millimeters at the southern Badia region to a maximum of 570 millimeters at the upper northern highlands region of Ras Muneef. Along the Ghor region, the highest point located in the the north were the annual precipitation it may reach 280 millimeters at Deir-Alla and decreases towards the south to 71 millimeters at Ghor Safi.

On the other hand, the average temperature across the country varies between 13 ° C in the southern Badia region to 28 ° C at Aqaba, with a mean of 18.6 ° C all over the country. The variability in mean air temperature is attributed to the existed variability in minimum temperature that varies from 5.6 ° C in the eastern region to 19.8 ° C in the western region, while the maximum temperature is almost distributed uniformly, across the country, with an average of 25.3 ° C varying from 18.7 to 31.3 ° C . On the other hand, the country seems to have an oriented spatial distribution of both evaporation and relative humidity. The annual evaporation averages 2,502 millimeters and varies from 1,460 millimeters in the northern highlands of Ras Muneef to 3,886 millimeters at the eastern region especially at Aqaba (Similarly, the relative humidity ranges from about 57% to 76.2% in the northern highlands of Ras Muneef to 48.8% in the northern Badia region and 47.6% in Aqaba.

1.3 DEMOGRAPHIC PROFILE

The demographic characteristics of the Jordanian population show that the Jordanian development process faces a challenge in providing basic needs in such a developing country (Figure 1.2). The current population profile shows that Jordan has a total population of approximately 6.388 million. Life expectancy at birth has increased from 63.8 years in 1961 to 72.9 years (DOS, 2012), and the population growth rate decreased to 2.2 % (DOS, 2010).

Figure 1.2: Population in Jordan for the period of 1961-2011 (Dos 2012)



One of the main demographic determinants is migration. Migration movements from, to and through Jordan have continually played a key role in shaping its demographic situation as well as the economic and political structure. In both 1948 and 1967 Jordan received a great influx of Palestinian refugees from the wars with Israel that resulted in the creation of Israel in historic Palestine. In 1991 and 2003 Jordan received about a million refugees from Kuwait and Iraq during the two Gulf wars while in 2011-2014 it was the turn of Syrian refugees escaping turmoil in their homeland.

Furthermore, being at the crossroads of two major areas of instability and prolonged conflicts, Jordan has become the destination for several waves of forced migrants from Palestine, the majority of whom were granted Jordanian citizenship – but also from Syria, Lebanon and Iraq. Since 2011, and up to February 2014 Jordan has hosted over 620,000 refugees from Syria (UNHCR,2014), with approximately three-quarters living in urban areas across the country and one-quarter living in refugee camps in the northern region. The waves of refugee influxes are still on going as the conflict has no foreseeable solution.

The internal migration in Jordan had a significant impact on the population distribution between rural and urban areas. In 2012, the urban population reached 82.59% of the total population (DOS, 2012). The urban population is mainly concentrated in three major cities: Amman, Zarqa and Irbid. Moreover, internal migration and refugees influxes imposed additional pressure on the infrastructure and basic services and the demand on food.

The Jordanian population pyramid (structure) reflects the youthfulness of the population, around 12.75% of the population is under 4 years of age, and almost 24.57% is under 14 years of age, 3.23% of the population is over 65 years old. 60% of the population is between 15-64 years, representing the dominant group. This last age group represents the demographic opportunity, which provides insights about political and social stability, as well as economic development as this group is the one entering the workforce and contributing to economic growth.

1.4 REGIONAL POLITICAL CONTEXT

In terms of political context, Jordan is located in a turbulent region. Recently and since early 2011, Jordan has been significantly affected by the domestic events related to the "Arab Spring" and ongoing regional unrest, specifically in the neighboring countries: Egypt and Syria. This situation was further stressed with the consequences of the global financial crises. The regional political conditions impacted the Jordanian economy through two channels: (1) the drop in gas supply from Egypt which led to a surge in Jordan's current fiscal deficits due to the need to purchase fuel oil from the international market, and (2) the Syrian conflict which led to a large influx of refugees further straining Jordan's difficult fiscal position and scarce natural resources.

Since early 2011, Egypt faces unsettled political situation and thus the political situation is unstable. As a result, the Natural Gas supplying line in Sinai has been exposed to several bombing incidents, therefore the gas supply from Egypt had been reduced to 16% of the contractual terms in 2012. This has forced Jordan to replace gas imports from Egypt with more expensive fuels for electricity generation which has put a drag on growth and has resulted in a marked deterioration in the balance of payments and fiscal position in 2012. The International Monetary Fund (IMF) approved urgent aid in 2012 (about US$ 2 billion). In the year 2012, the overall fiscal deficit increased by 8.5% of GDP (WB, 2013).

Moreover, the Syrian- crisis has worsened the difficult fiscal position. While the trade balance was affected as exports had stalled due to the disruption of trade routes, due to the conflicts in Syria and Iraq. The imports have increased as energy and food imports rushed at least 50% (Oxford Business Group, 2013). Food imports have increased by 20% as a result of the influx of Syrian refugees in Jordan. The kingdom imported 87% of its food requirements in 2012 (Oxford Business Group, 2013) which makes it highly vulnerable to shocks in global food prices As the food prices increased by 5% (Oxford Business Group, 2013), Inflation accelerated towards 7.25% in 2012.

The government has spent an estimated $53 million on medical care for refugees between January and April, with only $5 million provided in direct support by UN agencies during this period. In order to cope with this situation, the government has needed to increase its total annual health expenditure by $135 million in 2013 to provide the same level of care to the new refugees projected to arrive by the end of the year. It is estimated that an additional $180 million will be needed to expand and upgrade ten existing facilities in the northern governorates to cope with the massive demands on the health care system there (Oxford Economic Group, 2013). Measures such as: rising public sector wages and the elimination of petroleum product price subsidies helped in reducing the acute macroeconomic pressures.

In March 2014 The National Resilience Plan (NRP) was drafted by the Government of Jordan, in cooperation with UNCT, other donors and NGOs and seeks to address the accumulating fiscal burden as a result of the Syrian crisis on the Kingdom. This plan includes a request to extend $4.295 billion to Jordan to support the implementation of priority projects in the education, health, energy, municipalities, water, housing and security sectors.

1.5 SOCIAL CONDITIONS

One of the most important factors shaping the household's social conditions are the household expenditures and income. In Jordan the average annual household income was about JD 8,842 in 2010, (12,488 USD) which represent a 10.5% increase from income measured in 2008 (JD 7911). Furthermore, household expenditure on food items increased by 3% and non-food items by 9.6% measured according to prices of year 2010 (DOS, 2012). Gender plays a significant role in determining the level of household expenditure and income. Being a female household head means less income (by JD 1,992) and thus less expenditure by JD 1,677. This situation is referred to as the gender gap (the differences between male and female in all social and economic aspects) (DOS, 2010). Unemployment, underemployment, differences in wages and occupational segregation are the four main factors in the economy that impact women's level of labor.

According to the DOS (2012) the percentage age of poor population has increased from 13.3% in 2008 to around 14.4% in 2010, which reflects the economic and social context for Jordan (Table 1.1). Even though governmental wages and subsidies increased. Food and oil prices have increased dramatically in 2010, as a result more households were classified to be poor for the first time. Nevertheless, Gini coefficient of income disparity had decreased in 2010 to be 0.376 which express the success of the economic reform in raising the equity of income distribution among the population. Amman hosts the largest density of poor population in Jordan (30.6%), even though the southern governorate (Ma'an) hosts the poorest population (26.6% of the population are poor).

Table 1.1: Poverty indicators in Jordan, variation between 2008-2010

Indictors	2008	2010
Poor population %	13.3	14.4
Absolute poverty line (JD/ person / year)	680	814
Abject poverty line (Food poverty line)[1] (JD /person / year)	292	336
Average household expenditure (JD / year)	8617	9240
Average household income (JD/ year)	7911	8842
Gini's coefficient[2]	0.393	0.376

Source: DOS, Household Expenditure & Income Survey, 2012

Education is a top priority in Jordan, as the country has limited natural resources, Human capital is the source by which the government can achieve economic viability in the future.

Males and females attend basic education at an equal rate (37%). Parity exists for upper secondary and higher education. Women's enrollment at higher levels of education considerably increases, as females tend to receive better scores on the secondary-level exam and young males leave the system to enter the labor market. The formal education sector provides a number of non-formal education programs through the MoE, private actors and NGOs, including both literacy programs and vocational programs.

1. Abject poverty line (food poverty line) : which is the expenditures or income level at which a person's typical food energy intake is just sufficient to meet a predetermined food energy requirement.
2. Gini's coefficient: represent the inequality in income distribution among the population. As the value approach zero, it represents perfect equality, and a value of one represents perfect inequality.

1.6 ECONOMIC STRUCTURE AND ACTIVITIES

Jordan is a small lower-middle income country with scarce natural resources (in particular water), and a small industrial base within the service sector (this sector contributes around 70% of GDP) dominates the economy. The per capita GDP of Jordan at current prices was JD 3438.6 in 2012 (4855 USD) (Table 1.2). The government identified poverty and unemployment as two of the most important challenges they face.

Jordan's economy is supported by foreign loans, international aid, and remittances from expatriate workers.

Table 1.2: Indicators of National Accounts, 2009-2012

Indictors	2009	2010	2011	2012
Gross Domestic Product at Current Prices (million JD)	16,912.2	18,762.0	20,476.6	21,965.5
Gross Domestic Product at Constant Prices million JD) (1994=100)	9,759.9	9,985.5	10,243.8	10,515.3
GDP Growth Rate At Current Prices (%)	5.5	2.3	2.6	2.7
GDP Per Capita (JD)	2,828.1	3,069.2	3,276.8	3,438.6

Source: National accounts, DOS 2012

Jordan has been affected by adverse regional and global developments such as; the political situations in some neighboring Arab countries; the continuing global financial and economic crises as well as the rise in commodity prices in the international markets. The national accounts statistics published by the Department of Statistics (DOS) showed that the real growth rate stood at 2.7% in 2012, and 2.6 % in 2011 compared with 2.3 % in 2010. There was a minor improvement in the growth in 2012 compared with the average growth rate over the period (2000-2008) which recorded 6.6% per year (CBJ, 2012). The mild improvement in the growth rate was driven by the recovery in the commodity-producing sectors, particularly in manufacturing industries.

Jordan's economically active population is extremly low (only around 35% of those of working age are employed. The economically inactive are overwhelmingly females (68%,) who are most likely to be less educated (54%). Among the economically active, males are entering the labor market at normal rates but exiting early (17%). On the other hand females are not entering the labor market at sufficient rates and those who do, are leaving the labor force too quickly (21%). There are differential hiring patterns between the public and private sectors: 45% of public sector employees are female, but only 13% of private sector employees are female.

According to the Employment and Unemployment Surveys, the overall unemployment rate has hovered in the range of 12-14% throughout the last decade. The unemployment rate increased to 12.9% in 2011, from 12.5% in 2010. This increase reflects the (deceleration) decrease? in domestic demand for Jordanian workers. Considering the gender aspect, the male unemployment rate was 10.4% compared with 19.9% for the unemployment female rate in 2012. The proportion of unemployed persons for more than one year was about 38.2%, out of which 48.8% are between ages of 15-24. (DOS, 2013).

The public debt reached 64.6% of the GDP in the first quarter of 2012 (MoF, 2012). The actual debt increased to stand JD 14,352 million in 2012, compared to JD 13,401.71 million in 2011.

The budget performance showed slight improvements in revenues in 2011 to stand at JD 751.1 million. This increase was an outcome of the rise in foreign grants (increased by 202%). On the side of expenditures, there was a 19.2% of increase in public expenditure, in 2011 totaling JD 6,801.8 million. This hike was driven by the expansion in current and capital expenditures at 21.0 % and 10.1%, respectively, compared with the 2010 (CBJ, 2012).

1.7 HEALTH

Jordan's current population and health profiles are a result of both the demographic and epidemiological transitions that characterize most middle-income countries. Drastic declines in death rates and continued high birth rates along with the shifting composition of illness away from infectious diseases to non-communicable diseases shape Jordan's population and epidemiological circumstances (WHO, 2011).

Table 1.3: List of basic Health indicators for Jordan

Indictors	2011	2012
Crude Birth rate (per 1000 .pop.)	28.9	28.1
Total Fertility Rate	3.8	3.5
Life Expectancy At Birth (Yrs) Male	71.6	71.6
Life Expectancy At Birth (Yrs)Female	74.4	74.4
Crude Death rate (per 1000 .pop.)	7.0	7.0
Infant Mortality Rate per 1000 .live births)	17	17.0

Source: Ministry of Health, demographic health indicators 2012.
DOS, Jordan Population and Family Health Survey, 2012.

Even with the high rate of Infant and child mortality as indicated by Organization for Economic Cooperation and Development (OECD) standards, these indicators are generally satisfactory compared other countries at similar levels of income and other countries in the region. Table 1.3 demonstrates the basic health indicators for Jordan, these impressive indicators are, as explained below, due in large measure for better-off education level and improvements in the nutritional status of the population.

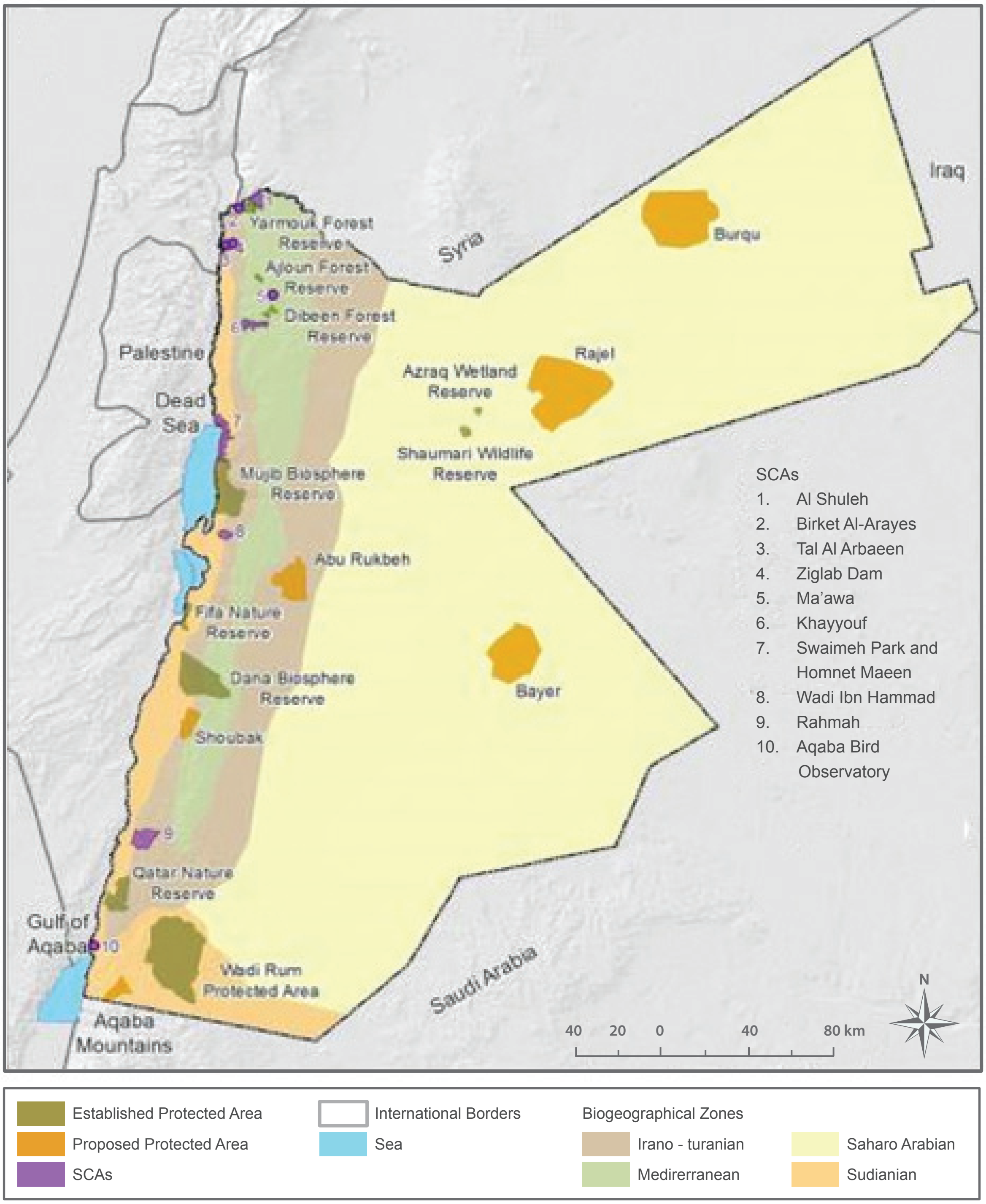
In 2012, the total public expenditure on health services accounted for about 6.3% of the GDP, Jordan's total expenditure on health is among the highest in the region. Health expenditure per capita was JD 278. Each of the health care subsectors has its own financing and delivery system that reflects directly on the delivery services among these sectors.

1.8 ECOSYSTEMS AND BIODIVERSITY

Jordan has three distinct ecological systems: (i) Jordan Valley which forms a narrow strip located below the mean sea level, and has warm winters and hot summers with irrigation mainly practiced in this area; (ii) the western highlands where rainfall is relatively high and climate is typical of Mediterranean areas; and (iii) the arid and semiarid inland to the east (estimated to cover over 80% of the total area), known as the "Badia", where the annual rainfall is below mm. Badia is an Arabic word describing the open rangeland where Bedouins (nomads) live and practice seasonal grazing and browsing.

According to the IUCN Red List of 2006, Jordan has 47 globally threatened species. Of the 83 mammals species existing in Jordan, 12 are considered globally threatened. As for birds, there are 15 globally threatened species in Jordan. Around 2,500 species of vascular plants have been recorded, belonging to 152 families, representing about 1% of the total flora of the world. One hundred species are endemic, forming about 2.5% of the total flora of Jordan, which is considered high in world standards. Many species are considered rare or threatened, but the status of many plants remains unknown, especially the ones considered globally threatened. Of the total plant species recorded 349 recorded are considered to be rare, 76 threatened species; in addition 18 species are included in the IUCN lists. 83 species of mammals have been recorded in Jordan (Amr, 2000), belonging to 7 orders and 26 families. Around 425 bird species are recorded in Jordan belonging to 58 families (Andrews, 2000), of which more than 300 are migrant, 95 are resident with definite breeding records, 111 are winter visitors, 202 are passage migrants, 81 are vagrants, and 63 are different summer visitors. Jordan's location by the Great Rift Valley makes the country one of the most important flyways for migratory birds. Millions of birds cross the area yearly, some of which are globally threatened, such as the Corncrake (*Crex crex*).

Figure 1.3: Protected Areas and Special Conservation Areas overlaid with Biogeographical zones of Jordan



Source: RSCN

1.9 COASTAL ZONES

The Gulf of Aqaba is considered the only maritime region in Jordan and is located at the most south western parts of the Hashemite Kingdome of Jordan (North latitude 29° 30' ; East longitude 35° 00') in the vicinity of Aqaba. It is the northward arm of the Red Sea and situated within the Syrian-African Rift Valley. The Gulf of Aqaba is separated from the Red Sea by the edges of the Strait of Tiran, which is a narrow opening about 250-300m deep. The coastline of the Gulf of Aqaba extends for 27 kilometers along a narrow and very deep arm of the Red Sea with an average width of 20 kilometers and reaches a maximum of 26 kilometers. The average depth is about 800 meters, with depths exceeding 1,850 meters in its deepest areas.

Despite the relatively small size as a body of water, the Gulf of Aqaba is host to an extraordinarily diverse marine system. The calm and clear waters provide a suitable environment for the growth of corals, and favorable salinity levels provide a suitable environment for countless varieties of marine-life forms. More than 50% of the Gulf's shoreline is covered by an ancient coral reef where more than 151 scleractinian (stony-reef-building coral species) and 120 species of soft coral were recorded; some of them, such as the red and black corals, are globally endangered. In addition, the Jordanian coastline is distinguished by extensive fringing reefs, which are considered one of the most dynamic and diverse of all natural ecosystems.

The Gulf of Aqaba has certain differences in its physical and chemical characteristics, which make the northern end different from the southern and even the eastern side from its western side. These differences are caused mainly by several factors such as tides, currents, temperature, salinity and transparency leading to changes in coral reef communities. In general, the water temperature in the Gulf of Aqaba is higher in the northern section than in the southern part, where the lowest temperature occurs in early March with 20 C° and the highest in August and September with a temperature of 26 C°.

Coastal areas in the Gulf of Aqaba are under high pressure inflicted by urban and industrial pollution as well as tourism. More than 40% of the Jordanian coastline has been changed from a pristine natural environment to heavily used ports and industrial areas during the last 25 years. Negative human impact on the natural environment and the coral reefs at the Gulf of Aqaba is caused by:

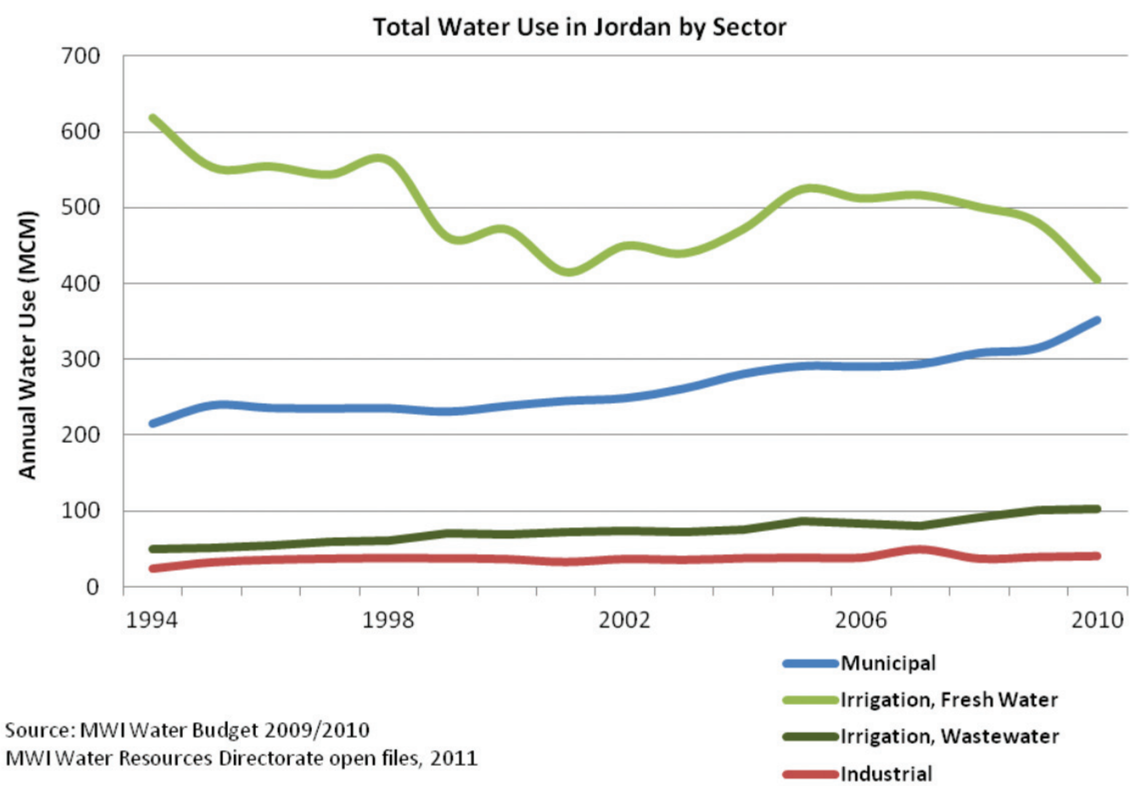
1. The development of a shipping, industry and urban centers along the coast,
2. absence of effective management planning and implementation in the Aqaba marine reserve,
3. Lack of public awareness and support for the preservation and protection of the marine system,
4. Insufficient baseline information available in relation to marine biodiversity,
5. Increasing tourism load without sustainable management,
6. Improper diving attitudes like stepping on coral and feeding fish,
7. Water contamination and pollution caused by oil spills,
8. Destruction of coral reefs and shallow water habitat for investments priorities, by-catch of non targeted or protected species,
9. Use of illegal fishing gear and fishing out of season, and
10. Introduction of alien species.

1.10 WATER RESOURCES

Jordan is among the poorest countries in the world on on the basis of per capita water availability, with only 147 cubic meters per person per year in 2010. Renewable water resources are less than 130 cubic meters per person per year. Current total uses exceed the renewable supply. The difference (the water used that is not renewable) comes from nonrenewable and fossil groundwater extraction and the reuse of reclaimed water. If supply remains constant, per capita domestic consumption is projected to fall to 90 cubic meters per person/year by 2025, putting Jordan in the category of having an absolute water shortage that could constrain economic growth and potentially endanger public health.

Due to the ongoing Syrian situation, the number of Syrian refugees in Jordan is expected to triple to 1.2 million by the end of the year (2014) according to UN officials. This magnifies the stress applied on the water and sanitation services and infrastructure.

Figure 1.4: Water Use by Sector since 1994



Source: USAID Review of Water Policies in Jordan, 2012

Municipal water use is met primarily using groundwater sources. Per capita municipal consumption has impressively remained at a fairly constant level since 1994 despite the 48% population growth (1.97 million). In most urban sites, water is supplied on an intermittent, rationed basis that requires household storage in cisterns and/or roof tanks.

Industrial water use in 2010 was 40 MCM (million cubic meters). The sectors with the highest consumption are: the fertilizer industries, potash, phosphate, oil refineries, thermal power plants, cement factories and other light and medium industries.

Irrigation water is heavily subsidized, with very low tariffs for surface water deliveries to the Jordan Valley, and also very low tariffs and small restrictions on over-abstraction of groundwater in the Highlands. This over-abstraction in the Highlands is anticipated to be unsustainable and would terminate at different rates in the 11 over-exploited groundwater basins as the supply is exhausted, saline water is - found, or pumping costs exceed financially supportable levels on private farms. Nevertheless, as tariffs increase, shifting to higher value crops and more efficient production technologies, and administrative closures will be needed to reduce over-abstraction of groundwater and shift its allocation towards domestic and industrial use.

Over the past two decades Jordan's Government supported by donors has made substantial efforts to convince agricultural producers to use treated wastewater as an additional resource, by ensuring that treatment levels comply with agricultural re-use standards, and convince consumers of the safety of food produced from reclaimed water blended with freshwater. The use of treated wastewater in the Northern and Middle Jordan Valley has increased from about 40% in 2000 to about 56% in 2010. By 2015. Treated wastewater is expected to increase by an additional 76 MCM/year, bringing the total wastewater available for reuse to about 180 MCM/year, most of which would be used to irrigate fruits and vegetables, other food crops, and tree crops, with a small allocation to support forage and fodder production for livestock.

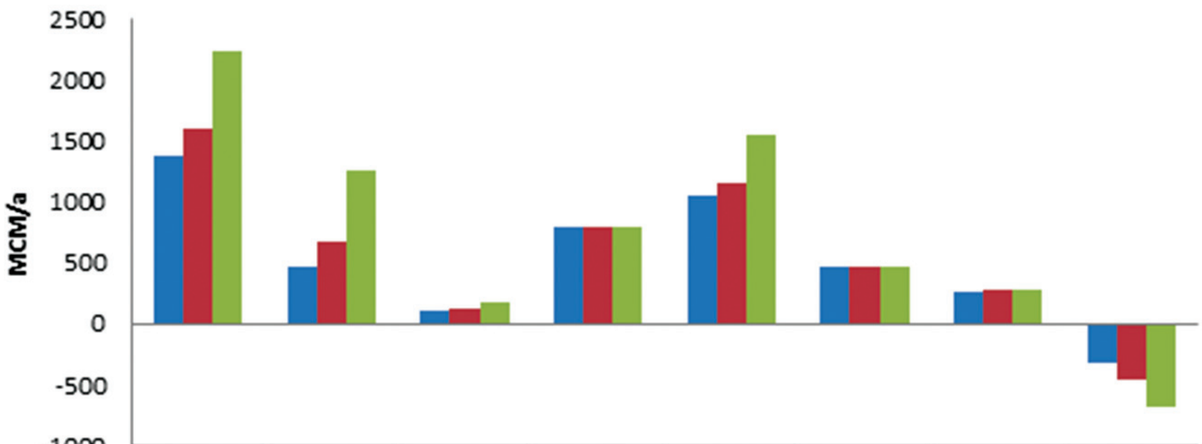
The reuse of wastewater is now regulated by several sets of standards: including one governing the discharge of toxic materials to sewers and others that established standards for reuse of wastewater and the processing and use of sludge. Challenges facing the expansion of the re-use of reclaimed wastewater from industries include the location of these industries relative to wastewater treatment facilities, the quality of treated wastewater relative to industry standards, the cost of refining the treatment levels to higher standards, and the cost of building new conveyances from central wastewater treatment facilities to industrial sites.

Huge investments from public and private sectors in the supply side of water have been witnessed in the past decades. This has been manifested in the development of public desalination facilities for municipal use and micro and small private desalination facilities for drinking water and agricultural use; the extraction of fossil freshwater from the aquifer shared with Saudi Arabia; the exploration of very deep (1,000–2,000 meters) sources of brackish water for eventual desalination; and the study of options for Red Sea-Dead Sea conveyance to reduce the decline of the Dead Sea level and provide desalinated seawater for municipal and industrial use. The cost of new urban bulk water supply to Amman is expected to exceed US$1.35 per cubic meter as in the case of the Disi-Amman Water Conveyance Project.

The increasing cost of water supply is adding to the large burden of the fiscal budget in terms of new capital expenditure and subsidy needs. The gap between current tariff levels and full cost recovery is too big to be bridged by tariff increase alone. Full cost recovery is too expensive for the majority of water users, especially for the low-income residents. Thus, prospects of reducing water subsidies are very likely.

Water deficits will continue to grow and the gap between demand and supply will lead to an increase in bulk water supply costs for priority domestic use from average current levels of 0.JD 35/cubic meters to JD 0.95-1.10/cubic meters or more.

Figure 1.5: Water Demand, Supply and Deficit in Jordan



	Total water demand	Domestic	Industrial	Irrigation	Total water supply	Surface water	Ground water	Water deficit total
2010	1383	477	110	796	1054	470	271	-329
2020	1602	670	130	802	1152	470	277	-451
2040	2236	1263	170	803	1549	470	277	-687

Source: MWI 2014

Several policies, strategies and plans have being developed by the government to enhance the development, management and use of water resources. Jordan's "Water for Life" strategy 2008–2022 highlights only in its irrigation water chapter drought management and adaptation to climate change as future challenges to be addressed through proper policies and regulations. Despite being clear on the water sector vision and adopting an Integrated Water Resources Management approach, the strategy lacks provisions to address climate change issues and its magnified impact coupled with water scarcity.

One of the major solutions for the water scarcity problem is the Disi Water Conveyance Project, a water supply project that is designed to pump 100,000,000 cubic metres of water per year from the Disi aquifer, which lies beneath the desert in southern Jordan and northwestern Saudi Arabia. This project aims to provide Amman and the middle regions with new freshwater resources. The project was inaugurated in 2013 aiming to pump 120,000 cubic metres of water daily to fill a growing gap between supply and demand.

After stumbling for years due to its complex nature and huge funding requirements. The MWI announced that Jordan is moving ahead with the first phase of the Jordanian version of the Red Sea–Dead Sea Project. The plan is to draw water from the Gulf of Aqaba at the northern tip of the Red Sea and transfer it north to the Araba Valley where a desalination plant will be built. Another pipeline will extend from the plant to the Dead Sea.

The new project is estimated to cost some $980 million, adding the government plans to secure some $400 million in grants. It will also provide hundreds of jobs.

1.11 AGRICULTURE

The Jordanian agricultural sector is established along three major climatic regions: the lowlands (Jordan Valley) that thinly stretches from the northwest to the southwest, the highlands and Marginal steppe where most of the rain-fed farming is practiced, and Badia (or desert) mostly livestock systems and some cultivation in watershed and from deep bore irrigation.

Agriculture (animal and crop farming) is mostly influenced by water availability and the ability to adopt advanced water harvesting and to use technologies and interventions to mitigate the impact of the climate change.

The contribution of agriculture to GDP has declined in relative terms from 20% in 1974 to less than 2.9% in 2011 while its contribution in absolute terms has increased (e.g. from JD 57 million in 1974 to JD 598.3 million in 2011 as shown in Table 1.4 (source: MoA and Central Bank of Jordan periodic reports).

The importance of the agricultural sector stems from the fact that it is not only the major source of food items especially dairy products, fruits and vegetables, but also one of the sources of hard currencies originated from exports. About 25% of the total poor in Jordan live in the rural areas depending mostly on agriculture (livestock keepers, smallholder farm households and landless former agriculturalists), and in spite of poor motivation of the rural youth, agriculture is an important employer of the rural communities.

Table 1.4: Contribution of Agriculture to GDP (1954-2011)

YEAR	1954	1964	1974	1984	1994	2010	2011
Contribution in actual terms (million JD)	15	32	57	98	193	560	598.3
Contribution in relative terms (%)	40	30	20	6	4.5	2.9	2.9
Total national GDP (million JD)	15	200	281	1,764	4,300	18,762	20,476

According to 2012 statistics, 2% of employed Jordanians work in the agriculture, forestry and fishing jobs. The sector generated 17% of total national exports (equivalent to JD 795 million) in 2011 of which the contribution of vegetables and fruits has amounted to JD 385 million; vegetables JD3 13 million; and fruits JD 67.9 million. Agriculture is not a sector that stands alone, it has its own forward and backward linkages, and requires the proper enabling environment to flourish. Supportive infrastructure and services such as schools, health, rural roads and rural development activities must be made available in order to motivate the farming communities to adopt profitable and sustainable agricultural practices. Youth – unlike parents – are not attracted to work in the agriculture sector compared to other sectors, likely due to limited financial benefits.

Generally, rainfall amounts and climatic conditions of the country do not support good rainfed agriculture, except for few areas in the northern and western highlands. The rainfed agricultural zone is lying in areas where rainfall exceeds 250 milimeters although significant production of cereals does occur in some areas where rainfall is between 200 and 250 millimeters. There are three main sub-divisions within the rainfed sector, namely fruit trees, field crops and to less extent the vegetables. Fruit tree crops dominate the hilly and steep sloping lands of the western part of the highland plateau (e.g. western parts of both Yarmouk and Zarqa basins). Slopes are generally too steep for cereal and other annual crop production even with soil conservation measures. However, wheat is grown on inappropriately steep slopes in some places. The main threat to rainfed cultivation in Jordan is urban expansion and land fragmentation, in addition to the frequent droughts.

Irrigated agriculture is taking place in the Jordan Valley and the highlands. The main source for irrigation in highlands is the ground water. In northern Jordan Valley (JV), the area under cultivation is served by surface water supplies transported via the King Abdullah Canal (KAC) from Yarmouk River while the irrigation water to the middle and southern parts of Jordan Valley are mainly served by water coming from KTD on Zarqa River after mixing with that coming from KAC.

The total area under irrigation in Jordan Valley and the southern Ghors is estimated to be about 33,000hectares. The major crops are vegetables and trees including citrus and bananas. Important irrigated agriculture is also taking place on the basalt plateau soils of northern Jordan, in Mafraq governorate. In these areas, the utilization of groundwater resources was expanded rapidly into the steppe zone, often for the production of fruit crops. The agricultural area in Jordan varies from one year to another depending on the rainfall amounts and available water resources.

In view of the increasingly competitive demand for water magnified by the impact of the impeding climate change, there is a pressing need to develop and adopt innovative approaches and technologies that would address such challenges. Some of the approaches include the maximization of water use efficiency; crop diversification and cultivation of high value crops that fetch competitive local and international markets while replacing crops that use proportionately higher amounts of water; development of food and feed crop varieties that are tolerant and adaptive to climate change; and enhancement of the integration and complementarity between crop and livestock production systems.

In the Poverty Reduction Strategy 2013 – 2020, Jordan emphasizes the strong linkage between agriculture, rural development and environment. The key policy and technical issues related to the design of the pro-poor agriculture, environment and rural development component of this strategy include creating productive employment and income generation opportunities for the rural poor, especially small holders who need support in farming their land by microfinance and extension services, development of agro-processing value chain that will create new jobs and increase local food production for consumption by rural residents and for food supplies to Jordan's urban population and for its tourism industry (Ref: PRS, 2013).

1.12 LAND-USE

The vast majority of land surface of Jordan is government owned, and is of limited use by the majority of the population. An average of 259,400 hectares was cultivated in 2010, of which 102,000 hectares were irrigated). The population density is very low (7.2 inhabitants per square kilometre) of the total land mass. However, the population density per arable land is among the highest in the world (about 26,000 persons per square kilometre of cultivable land).

With the increased urbanization and cities expansion, Jordan has realized the importance of land-use and urban planning. The Ministry of Municipal Affairs prepared a 2006–2012 comprehensive plan designating the land use throughout the Kingdom. This Master Plan is distinctive in that it is a directive map illustrating the natural, geographic and demographic characteristics, including the sustainability of natural resources. In a way that fulfils the government's development and economic plans. While the first phase of the project focused on the preparation of a general master development plan for land use in Jordan, it identified appropriate land that is outside the municipal organisation for any use (agricultural, industrial and residential).

The second phase of the project, 2008-2012, involved the preparation of detailed master development plans for the governorates' centres, specifically the areas that fall within the organisational boundaries of the various municipalities. It is projected that these plans should be extended to include all 93 municipalities in the Kingdom by the year 2012 (excluding the Greater Amman Municipality, the Aqaba Special Economic Zone Authority, and later other special economic zones Authorities).

Land use in Jordan is a complex pattern and mixture of rural and urban activities that reflect both climatic and socioeconomic characteristics. Most studies and figures show that agricultural areas form a small portion of the country. According to the Department of Statistics (2003), 93% of the country is dominated by non-cultivated areas, classified as rangeland. Cultivated areas form 2.7% of the total area of Jordan. These figures proportion a broad categorization of land use in Jordan. However, for climate change studies more detailed information and maps are needed.

The map of land use/cover (Figure 1.6) includes five main categories of land use/cover (following CORINE classification system) that included 14 classes.

Analysis of land use/cover map showed that agricultural areas cover 5% of the country's total land. Figures of land use showed that 93% of the area is not cultivated, due to limitations of climate, water availability, soil suitability and surface cover of stones. Intersecting land use/cover and agro-climatological maps show that 90% of rainfed agriculture is taking place in the northern and southern highlands. Irrigation is taking place in JV, highlands and desert areas. Although the eastern and western arid lands and deserts are used as open rangelands, however irrigation is practiced in these hot areas.

The preparation of master development plans for certain areas of competitive advantage, such as Azraq, Jabal Ajloun, the Jordan Valley and Ruweished, have also been completed.

1.13 ENERGY PROFILE

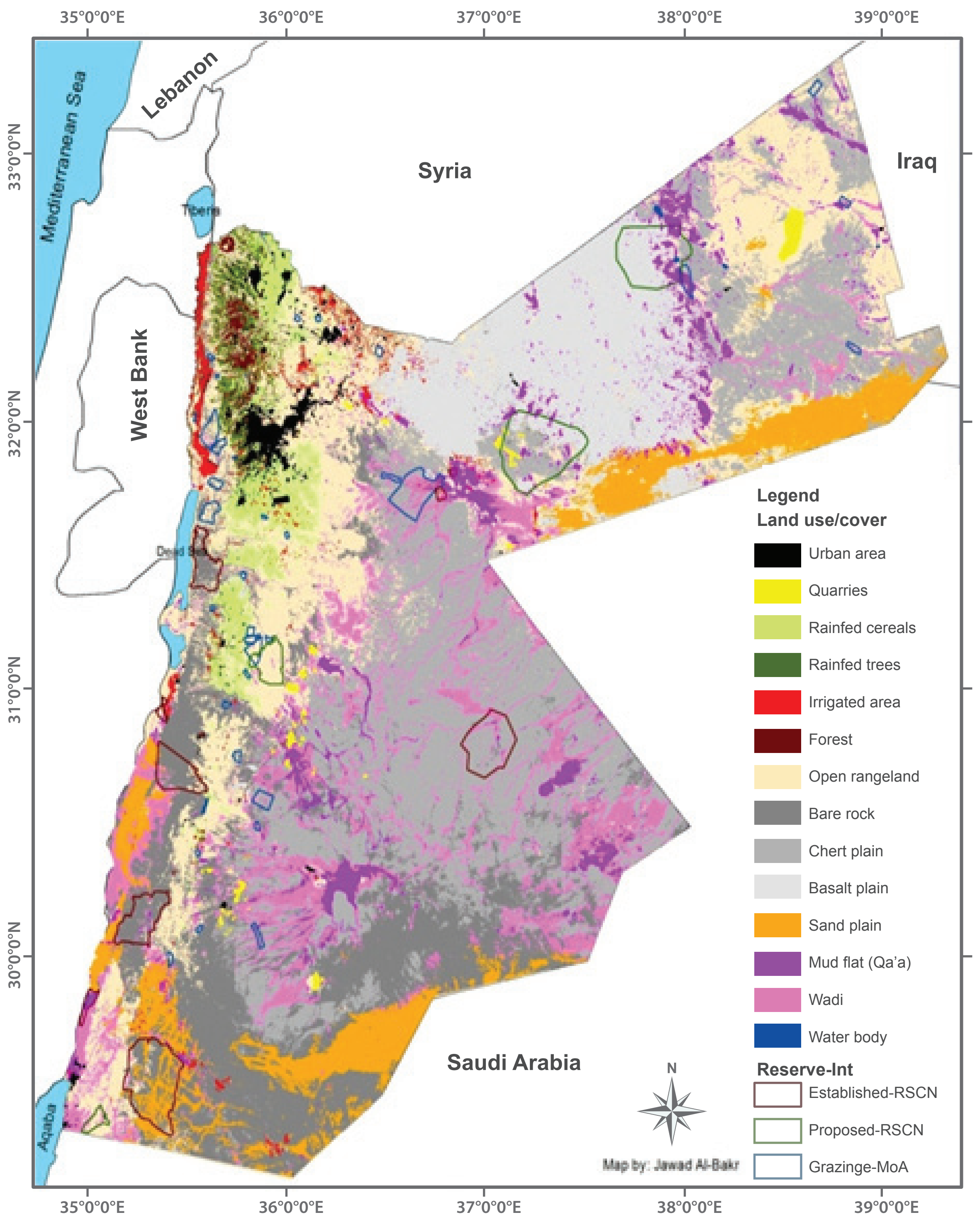
The rapid growths in economic activities, population and successive influxes of refugees over the last decade have imposed additional demands on energy resources. Moreover, Jordan is a country with limited indigenous energy resources; leaving Jordan heavily depending on its imports of energy to meet growing demand, expected to double to a forecasted 15.08Mtoe (million tonnes of oil equivalent) by 2020 from 7.58 Mtoe in 2007 (MEMR, 2012).

The prices of energy imports have increased with high risk in constant supplies, this situation spurred governmental action to improve energy efficiency and provide additional energy resources. Jordan imports 96 % of its oil and gas, accounting for almost 20% of the GDP which makes the country completely reliable on and vulnerable to the global energy market. The current energy strategy is to transform the energy mix from one heavily reliant on oil and natural gas to one more balanced with a higher proportion such as the of energy supplied by oil shale and renewable sources.

The estimated investment needed in the renewable energy sector by 2020 is approximately 2.1 billion USD and around 152 million USD in energy conservation. The national strategy estimates jobs created by only installing, maintaining and running renewable energy facilities to be around 3,000 by 2020. Education, vocational training and innovation support need to be streamlined in order to prepare the needed manpower for the penetrating clusters. A special center of excellence for vocational training in the energy sector has been on the government's plans for a while.

The Ministry of Energy and Mineral Resources (MEMR) defined three main routes through which renewable energy production will proceed in Jordan: a tendering process, direct proposals, distributed generation and net metering.

Figure 1.6: Map of existing land use/cover of Jordan. (Al-Bakri et al., 2010)



The government has decided to negotiate prices with the shortlisted bidders on phase one under the direct proposals process since prices defined earlier were lower than current estimated cost of fossil fuel power generation.

Table 1.5: Reference Prices of renewable energy sources under Article 6 of the Renewable Energy & Energy Efficiency Law

$ per KWh	Fils per KWh	Technology Type
0.12	85	Wind
0.19	135	CSP
0.17	120	Solar PV
0.13	90	Biomass
0.08	60	Biogas

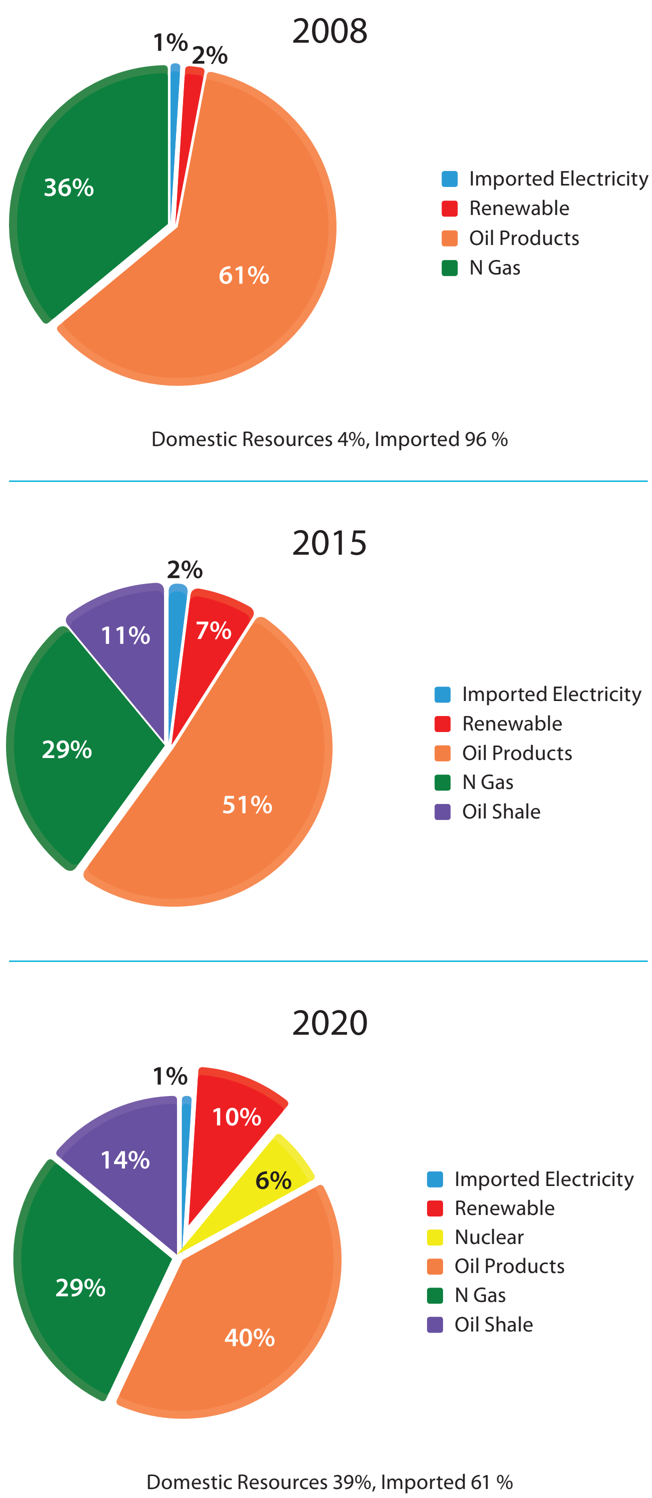
Source: Study of Mechanisms to Incentivize the financial sector to scale up financing of green investment in Jordan, 2013, Adam Smith International and VividEocnomics.

In 2011, the overall demand for primary energy was about 7,457 thousand TOE, thereby posting an increasing demand rate of 1.4% compared to the 2010's demand. The total demand for final energy which is the energy available to consumers was nearly 4,888 thousand TOE with an increasing rate of 0.3% compared to the 2010 demand levels. On the other hand, the amount of demand for oil products was 3,593 thousand TOE (MEMR, 2012).

Even though Jordan has limited local energy resources, in particular resources of crude oil and gas, the current energy mix is heavily weighted in favor of these resources that constituted 93.9% of the total energy mix in 2011. Between 2011-2013 several explosions of Egyptian pipeline occurred. This pipeline supply Jordan with a substantial amount of natural gas, these incidents brought about a significant drop in imported gas from 2,152.3 bcm in 2010 to about 872.7bcm in 2011.

Natural gas is utilized in generating 80% of electricity in Jordan, such a huge drop in natural gas supply had to be replaced by crude oil, and this replacement drove up the weighting of oil in the energy mix to 82.2% in 2011 from 64.9% in 2010 and thus increased the cost of electricity generation. Through a national energy strategy, the government adopted an ambitious program to increase new and renewable energy share to the energy mix to reach 7% by 2015 and 10% by 2020 (MERM, 2012).

Figure 1.7: The energy mix in Jordan 2008-2020



The energy strategy seeks to increase reliance on local energy sources, from the current 4 % to 25 % by 2015, and up to 39 % by 2020. Placing more emphasis on the utilization of renewable energies will alleviate the dependency on the traditional energy sources, especially oil which is imported from neighboring countries. This will also be paralleled with the reduction of energy produced from oil from 58% currently to 40% in 2020 (figure 1.7)

Still Jordan has a great potential in alternative energy resources (i.e. oil shale, solar energy, wind energy and nuclear energy), and the energy strategy is looking for re-weighing these alternative resources in the Jordanian energy mix.

Jordan is one of the five richest countries in terms of oil shale reserves, with over 40 billion tons spread under around 60% of the country's surface. In spite of this rich energy resource, there is a remarkable environmental and monetary cost for its exploitation. Due to fluctuations in natural gas supplies from Egypt, exploring oil shale is economically recognized as feasible with the current high crude oil prices. The commercial production of electricity using oil shale is expected to be a reality by 2016. Renewable energy already contributes by 2% in the existing energy mix; additional plans have been designed to invest in renewable energy projects to raise the contribution to 10% of the energy mix by 2020.

Jordan has significant wind energy resources that could be potentially exploited for power generation. The country's Wind Atlas indicates that some areas in the northern and western regions have wind speeds that exceed 7 meters/second (M/S). Two wind pilot projects exist in the country with a capacity of 1.5 MW. They have been running since early 1990. Moreover, Jordan is recognized to have a very high potential to generate energy using solar energy, which is evident from the annual daily average solar irradiance on a horizontal surface that ranges between 5-7 Kilowatts/hr (kWh) /m^2; one of the highest figures in the world. There are PV (photo voltaic power) stations in rural areas with a total capacity of 1,000 kW providing electricity for lighting, water pumping and other social services.

Biogas produced from municipal waste represents another viable resource for electricity generation in Jordan. A 1 MW pilot demonstration project using municipal solid waste (MSW) through landfill and biogas technology systems was constructed and commissioned in 2001. The project was expanded in 2008 to about 4 MW. Jordan plans to introduce about 40-50 MW waste energy power projects by 2020.

Hydropower resources are very limited in Jordan. The country's only hydropower plant is the King Talal Dam with 7 MW installed power capacity which generates 25 GWh of electricity annually. Hydropower turbines with total rated capacity of 6 MW were also installed at Aqaba Power Station using the available head of returning cooling sea water. Various studies show an additional hydro resource potential of 400-800 MW could be exploited from the 400-meter elevation difference between Red and Dead Seas through the proposed Red-Dead Sea Canal project.

Due to population growth and the political context in the Middle East, there was a dramatic increase in the consumption of oil products. This is due to the significant rise in the consumption of fuel oil used in electricity generation as the supply of natural gas declined. The volume of consumption in oil products reached about 6,076 thousand tons in 2011 while the volume of consumption in 2010 reached about 4,907 thousand tons.

There has been an increase in the demand for electricity in 2011 by all sectors due to the high temperatures in summer, and thus the expansion in using the air conditioning units. The industrial sector registered the highest growth rate to be 6.8%, then the domestic sector 4.2% and pumping water 3.8%, and as a result of this growing demand, electricity imported through the interconnection network with Egypt and Syria has increased to reach 1738 GWh with a registered growth rate reaches to 159% from 2010 (MEMR, 2012).

In the government's executive program (2011–2013), a number of policies were identified in the energy sector: restructuring of the oil sector; expanding the natural gas, oil shale and renewable energy; regulating the electricity sector; supporting the nuclear program and increasing investment in the mineral sector.

In addition to the dedicated energy pillar, encouraging private sector partnerships in implementing major energy projects is also something the government is aggressively pursuing. Special attention is paid in the government plan to saving energy in government buildings and in the water sector. On the training and employment side, the executive program includes a project on establishing a vocational center on energy efficiency.

A major step towards achieving the renewable energy and energy efficiency targets in Jordan was the issuance of the Renewable Energy and Energy Efficiency Law No (13) of

(2012). The law provides the legal framework for renewable energy production and energy conservation incentives. The law also establishes Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) under the umbrella of the Ministry of Energy and Mineral Resources. The Ministry of Energy and Mineral Resources (MEMR) issued several bylaws to complete the regulatory framework including those needed to attract investments in renewable energy projects and is still working on a number of others.

Starting with the issuance of the above mentioned law and the associated bylaws and resolutions to regulate the renewable energy and energy efficiency sectors; Jordan's energy sector is an appealing opportunity and would require several phases of organization and learning until it gives back to the economy and community. There is a lot to be done to complete the legislative and regulatory framework, providing needed infrastructure and grid upgrades and activating the JREEEF.

Recently the first batch of agreements was signed between the government and renewable energy developers. This was a major achievement and started the first solar and wind power generation projects, enabled by the recently issued comprehensive legislative and regulatory framework for renewable energy. Furthermore, the MEMR issued the second call for submission of expression of interest under direct proposal submission process for the second phase of the RE projects. This year, the Government has also issued the call for submission of expression of interests in the waste to energy (WTE) investment opportunities.

On the oil shale side, Jordan has just concluded an agreement with Chinese firms to invest up to $2.5 Billion in oil shale-fired power plant.

Such investments are expected to contribute to the energy security goals, create green jobs for Jordanians, alleviate the burden on the government budget, and position Jordan on the clean energy map. As promising as this is, Jordan needs to proactively pursue the other elements of the value chain, namely; education, innovation and technology, training and entrepreneurship.

Jordan and Iraq are keen to invite companies to bid for the oil pipeline worth $18 billion to export crude oil from Basra to Aqaba. The double pipeline will supply the Kingdom with crude oil and natural gas and is expected to be operational by the end of 2017. The 1,680 kilometer long, double pipeline will pump one million barrels of oil per day from Basra to Aqaba Port and around 258 million cubic feet of gas. About 150,000 barrels of oil will meet Jordan's daily needs, while the rest will be exported through Aqaba.

The energy sector regulatory framework in Jordan focuses on improving management of energy resources for sustainable economic growth by:

- Creating an enabling environment (regulatory, institutional),
- Building national capacity especially within the energy players to design and implement clean energy projects, and
- Raising awareness and reaching out to sectors and target groups regarding opportunities in the sector.

The NEEAP (National Energy Efficiency Action Plan endorsed in 2013) which sets a national energy efficiency target of 20% by 2020 proposes concrete measures in a number of key sectors to guide Jordan towards achieving this target. These tackle both, the demand side (e.g. energy labels, lighting, reduction of energy consumption of public buildings by 10%, buildings code, development of minimum standards/specifications for appliances) as well as the supply side (e.g. solar water heaters, PV, capacity building in wind energy and concentrating solar power, solar energy code). The NEEAP furthermore outlines several horizontal and cross-sectoral measures (tax exemptions for energy efficient and renewable energy equipment, development of energy service companies, green lending program, university curricula). It is furthermore envisaged to conduct a survey on energy consumption in the residential sector and thus improve the knowledge base for policy design.

Bylaw No (73) on Regulating Procedures and Means of Conserving Energy and Improving Its Efficiency passed in 2012; regulates the energy efficiency and conservation sector and obliges large energy consumers to prepare and implement energy conservation plans. The bylaw requires buildings of specific area size to install Solar Water Heaters. The main challenge would remain in the enforcement of such bylaw that requires a cross-agency cooperation to cover various industries/sectors and codes.

Bylaw No (10) for Exempting Renewable Energy and Energy Conservation Systems and Equipments (2013) exempts 'green energy' goods and services from sales tax and custom duties. It also establishes a committee that studies requests for exemptions and provides recommendations to the Minister of Energy who has the final decision. It is a case-by-case response and many businessmen and investors are calling for a more streamlined and transparent process.

1.14 TRANSPORT

Jordan plays an important role in serving as a transit country within the Middle East Region. It contributes to enhancing the regional economic development and cooperation through the facilitation of movement of passengers and goods through its borders.

Jordan's transportation sector is dominated by road transportation since there are no rail networks and marine transportation is negligible due to the geographical location of the country.

Jordan has a well-developed road-network, with over 28,781 kilometers of highways and 4,221 kilometers of secondary roads (JIB). Moreover, it has land borders with Israel, Syria, West Bank, Iraq and Saudi Arabia. According to the Jordan's Third Competiveness Report, Amman as a capital city has one of the lowest public transportation mode share ratios in the world, at 11.1%. This is in sharp contrast to some of Jordan's more rural areas such as Ma'an and Karak, where the public transportation mode share is around 90%.

Transport contributes to about 39% of overall energy use (passenger cars accounting for around 57% of this) and to a large share of air emissions (estimated by World Bank's Country Environmental Assessment at 80% for NOx; 20% for SO_x, and 40% for TSP). The Transportation Regulatory Commission is regulating this sector by defining the routes and issuing permissions and controlling the whole sector operations. In addition, the internal transportation (inside cities) especially small cars (service and taxis) have their own regulations and are mostly controlled by Municipalities.

When it comes to emissions, Jordanian quality standards for fuel and exhaust emissions do exist but with limited monitoring and enforcement.

The Transport Strategy is being prepared; one of the sectorial objectives is focused on the reduction of environmental impacts from the transport sector. However, this has not developed into any projects in the implementation plan.

Recent Cabinet of Ministers resolution to stop imports of cars older than five years of age is helping to get rid of old vehicles, which in turn has a positive impact on the environment. In addition, Jordanians who wish to exchange their old car with a new hybrid one (less than 2,500 cc) will benefit from customs exemptions (will only pay 12.5%). However, overall policy related to hybrid cars is still unclear. The government's attempts to set up public transportation systems would significantly reduce adverse environmental impacts.

The land transport sector suffers from a number of weaknesses. Key weaknesses include an aging trucking fleet, absence of rail freight network, high cost of inland trucking, undeveloped multi-modal transport and low densities of highway networks. On the rail side, key weaknesses include: high cost of investments in rail projects (about BJD 4) and somewhat low initial rail demand.

Royal Jordanian Airlines has its own comprehensive programs for minimizing its impact on the environment which are widely recognized as being among the most responsible and progressive in the industry. As part of its policy, emission reduction is a key pillar.

Aviation is different from other energy-using activities. Currently it accounts for about 2% of the global CO_2 emission from the emission produced by aircrafts due to fuel consumption, but it is rising fast. Aviation emissions of CO_2 have the same effect on climate as terrestrial emissions, from power stations, industry or transport sources.

Ground support equipment in total is usually the second largest contributor to local air pollution at an airport. It includes emissions from the non moving aircraft (e.g. Auxiliary Power Units, APU), all Ground Support Equipment (including GPU) for handling aircraft, and all vehicles circulating on airside premises.

1.15 WASTE

Jordan per capita daily waste generation is 0.9 kilograms, of which about 55%-70% of waste is organic. Waste collection rates are estimated at 90% in urban areas and 75% in rural areas. About 50% of waste is disposed of in 16 open dump sites without lining, leachate and biogas connections. The exceptions are Russeifah and El Ghabawi, in Greater Amman which account for 50% of total waste. Voluntary burning of waste or aerobic decomposition (self ignition) in open dumps are common ways of waste disposal. The most significant health impacts and risks are associated with the open dumps around the large cities of Amman, Zarqa, Irbid, Madaba, Tafila, Ramtha, Middle Shuma and Aqaba. Scavengers are permitted to sort waste and take away recyclable materials.

According to Sweep Net 2011 Jordan Country Report, all municipalities are operating without full cost recovery. In Amman the cost recovery reached 63% in 2009, while other municipalities are operating with less than 50% cost recovery. The difference is usually subsidized from municipal budget.

Despite being highlighted in the national agenda (2005), the role of the private sector in the Solid Waste Managment (SWM) in Jordan is still limited. Except for some pilot projects, Aqaba is the only city with private sector involvement in the collection and transport of solid waste. This suggests that there is a need to develop plans to create incentives for private sector to take role in SWM.

Greater Amman Municipality (GAM) is putting forward efforts to engage the private sector in SWM. In an effort to enhance the efficiency of the solid waste collection and transfer, GAM considered the construction of two new transfer stations in the northwest and southwest areas of Amman. These two facilities are aimed at increasing the proportion of municipal solid waste (MSW) transported through transfer stations thereby reducing the cost of collection and transfer of MSW in Amman. The project was part of the project funded by the World Bank. However, due to the public opposition, GAM decided to cancel the project and divert the allocated finance to other solid waste management component.

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GREENHOUSE GAS INVENTORY 2

2.1 INTRODUCTION AND METHODOLOGY

This chapter presents the anthropogenic (human-induced) emissions by sources, and removals by sinks, of all greenhouse gases (GHGs) not controlled by the Montreal Protocol for Jordan in the year 2006.

As per Article 4, Paragraph 1, Article 12, Paragraph 1 of the United Nations Framework Convention on Climate Change (UNFCCC), each party is required to report to the Conference of Parties (COP) information on its emissions by sources and removals by sinks of all Greenhouse Gas Emissions (GHGs) not controlled by the Montreal Protocol.

Jordan ratified the convention in 1993. As a non-Annex I country, the inventory information provided by Jordan is according to the guidelines for Parties not included in Annex I as required by decision 17/CP.8, the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1997) has been used. In addition, and as encouraged by decision 17/CP.8, the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Inventory (IPCC 2000), and the IPCC Good Practice Guidance on Land Use, Land Use Change and Forestry (IPCC 2003) have been also used specially in the uncertainty estimation. The UNFCCC software for Non-Annex I countries has been used for the preparation of this inventory.

Sectoral (bottom-up) approach has been used to estimate the GHG emissions and removals from the following sectors:

- Energy;
- Industrial processes;
- Agriculture;
- Land use, land-use change and forestry (LULUCF);
- Waste; and
- Solvents.

Furthermore, GHG emissions from bunker fuels have also been estimated and reported as a memo item (these emissions are not included in the national total).

In addition to the sectoral approach, the reference approach has also been used for the estimation of CO_2 emissions from the overall fuel consumption figures for the time frame between 2000- 2010.

The direct GHGs whose emissions have been estimated in this national inventory are:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Sulphur hexafluoride (SF6);
- Perfluorocarbons (PFCs); and
- Hydrofluorocarbons (HFCs).

Emissions of the following indirect GHGs have also been estimated and reported in this inventory:

- Oxides of nitrogen (NO_x);
- Carbon monoxide (CO);
- Non-methane volatile organic compounds (NMVOC); and
- Sulphur dioxide (SO_2).

However, as the indirect GHGs have not been allocated global warming potential, they are not included within Jordan's aggregate emissions.

The GHG inventory has been compiled by a team of twelve local experts from different relevant ministries and institutions who worked on a part-time basis. The engagement of those stakeholders has benefited dissemination and validation of the project's results in addition to facilitation of data and information collection.

Primary activity data for the various sectors covered in the inventory have been collected from the annual reports, surveys, studies and brochures of the concerned ministries (Ministry of Environment, Ministry of Energy and Mineral Resources, Ministry of Agriculture, etc) and public and private institutions (Department of Statistics, Amman Chamber of Industry, Greater Amman Municipality, Jordan Petroleum Refinery, Civil Aviation Authority, National Energy Research Centre, etc).

The collected information of the industrial sector has been complemented by a field survey of selected Jordanian industries. Wherever possible, activity data have been verified by multiple sources including government documents, publications by industrial chambers, and technical reports from research institutions, publications of international institutions and United Nations organizations, and data collected directly from the industry.

In the current inventory tier one method has been used except for the estimation of emissions from domestic and international aviation where tier two methods was used based on the number of landing and take-off (LTOs), types of aircrafts and total fuel consumption and for the Agriculture sector tier two was used for the first time.

For the energy sector available emission factors were used when applicable.

2.2 JORDAN'S 2006 GREENHOUSE GAS INVENTORY

In the year 2006, Jordan contributed about 28,717 gigagrams (Gg) or 28.72 million tonn (Mt) of CO_2 equivalent (CO_2 eq.) of GHGs to the atmosphere. Table (2.1)) summarizes Jordan's direct and indirect GHGs emissions with proper notations as required by decision 17/CP.8.

A sectoral breakdown of GHGs total emissions are as follows:

- Energy (20,938Gg CO_2 eq): 72.9%;
- Industrial processes (25,50Gg CO_2 eq.): 8.9%;
- Agriculture (1,318Gg CO_2 eq.): 4.6%;
- Waste (3,045Gg CO_2 eq.): 10.6%; and
- LULUCF (866Gg CO_2 eq.), 3.0 %

Table 2.1: Sectoral breakdown of Total GHG emissions in 2006

Sector	Emissions Gg In CO_2 Equiv.	Percentage
Energy	20,938	72.9%;
Industrial processes	2,550	8.9%;
Agriculture	1,318	4.6%;
Waste	3,045	10.6%
LULUCF	866	3.0 %

Detailed Emissions sources are documented in table 2.2

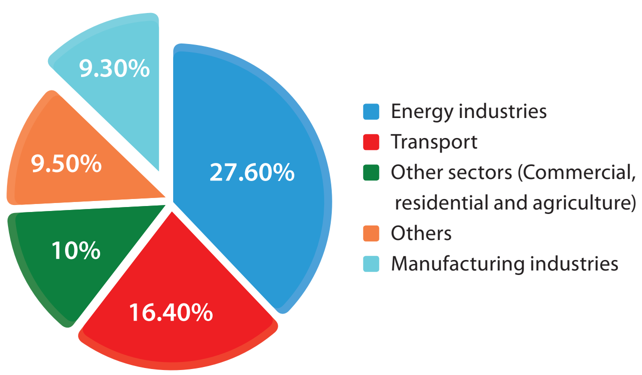
In the energy sector, the contribution of the subsectors to national GHG inventory is shown in table 2.3 and Figure 2.1.

Table 2.2: Breakdown of GHG emissions from various energy sebsectors

Sub-sector	Emissions	Percentage
Energy industries	7,916 Gg CO_2 eq	27.6%
Transport	4,706 Gg CO_2 eq	16.4%
Other sectors (Commercial, residential and agricultural)	2,883 Gg CO_2 eq.	10%
Manufacturing industries	2,675 Gg CO_2 eq	9.3%
Others	2,715 Gg CO_2 eq	9.5%

Figure 2.1: Breakdown of GHG emissions from various energy sebsectors

Energy Sectors contribution to GHG Emissions
(In percentage)



A breakdown of Jordan's total emissions on a GHG basis is as follows:

- Carbon dioxide (about 24,003Gg CO_2), 83.58%;
- Methane about (3,087 Gg CO_2 eq.), 10.75 %; and
- Nitrous oxide (about 1,627Gg CO_2 eq.), 5.67 %.

Table 2.3: Jordan's GHG Emissions Summary (by sector and by gas) for 2006

National greenhouse gas inventory of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol and greenhouse gas precursors

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
Total national emissions and removals	**24,003**	**0**	**147**	**5**	**117**	**290**	**157**	**139**
1. Energy	**20,896**	**0**	**2**	**0**	**116**	**288**	**75**	**137**
A. Fuel combustion (sectoral approach)	20,896		2	0	116	288	69	134
1. Energy Industries	7,916		0	0	21	2	1	70
2. Manufacturing industries and construction	2,675		0	0	7	0	0	11
3. Transport	4,706		1	0	53	246	60	18
4. Other sectors	2,883		0	0	4	1	0	23
5. Other (please specify)	2,715		0	0	30	38	8	12
B. Fugitive emissions from fuels	0		0		0	0	6	3
1. Solid fuels			0		0	0	0	0
2. Oil and natural gas			0		0	0	6	3
2. Industrial processes	**2,241**	**0**	**0**	**1**	**1**	**0**	**62**	**2**
A. Mineral products	2,241				0	0	54	1
B. Chemical industry	0		0	1	1	0	0	0
C. Metal production	0		0	0	0	0	0	0
D. Other production	0		0	0	0	0	8	0
E. Production of halocarbons and sulphur hexafluoride								
F. Consumption of halocarbons and sulphur hexafluoride								
G. Other (please specify)	0		0	0	0	0	0	0
3. Solvent and other product use	**0**			**0**			**20**	
4. Agriculture			**0**	**4**	**0**	**2**	**0**	**0**
A. Enteric fermentation			0					
B. Manure management			0	0			0	
C. Rice cultivation			0				0	
D. Agricultural soils				4			0	
E. Prescribed burning of savannahs			0	0	0	0	0	
F. Field burning of agricultural residues			0	0	0	2	0	
G. Other (please specify)			0	0	0	0	0	

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
5. Land-use change and forestry[1]	**866.37**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
A. Changes in forest and other woody biomass stocks	0	-415						
B. Forest and grassland conversion	0	0	0	0	0	0		
C. Abandonment of managed lands		0						
D. CO_2 emissions and removals from soil	1283.33	0						
E. Other (please specify)	0	0	0	0	0	0		
6. Waste			**145**	**0**	**0**	**0**	**0**	**0**
A. Solid waste disposal on land			143		0		0	
B. Waste-water handling			2	0	0	0	0	
C. Waste incineration					0	0	0	0
D. Other (please specify)			0	0	0	0	0	0
7. Other (please specify)	**0**	0	0	0	0	0	0	0

Memo items								
International bunkers	**909**		**0**	**0**	**7**	**4**	**1**	**1**
- Aviation	748		0	0	4	2	1	1
-Marine	161		0	0	3	2	0	0
CO_2 emissions from biomass	**0**							

2.3 GREENHOUSE GAS EMISSIONS BY SECTOR

2.3.1 Energy Sector

Energy-related activities have the dominant share of GHG emissions in Jordan. Emissions from this sector are classified into two main categories:

- Emissions from fuel combustion, and
- Non-combustion (fugitive) emissions.

The total emissions from the energy sector were 20938Gg CO_2 eq., i.e., 72.9% of the total GHG emission of Jordan for the year 2006. Carbon dioxide was the largest contributor (20,896Gg) representing 99.8% of the total energy sector emissions.

On a per gas basis, the energy sector contributed in the year 2006 with 87.05% of the total CO_2 emissions of the country, 1.4% of the CH_4 emissions, and 47.7 % of the NMVOCs emissions and more than 99 % of the total emissions of each of NO_x, CO and SO_2.
On a per sub-sector basis, the largest contributor to emissions in the energy sector is the energy industries sub-sector, which accounted for 37.9% of energy emissions, followed by the transport sector which contributed to 22.5% of the energy emissions.

2.3.2 Emissions from Fuel Combustion

a- Energy Industries

According to the 1996 Revised IPCC Guidelines, the subsectors of energy industries are:

- Public electricity and heat production;
- Petroleum refining; and
- Manufacturing of solid fuels and other energy industries.

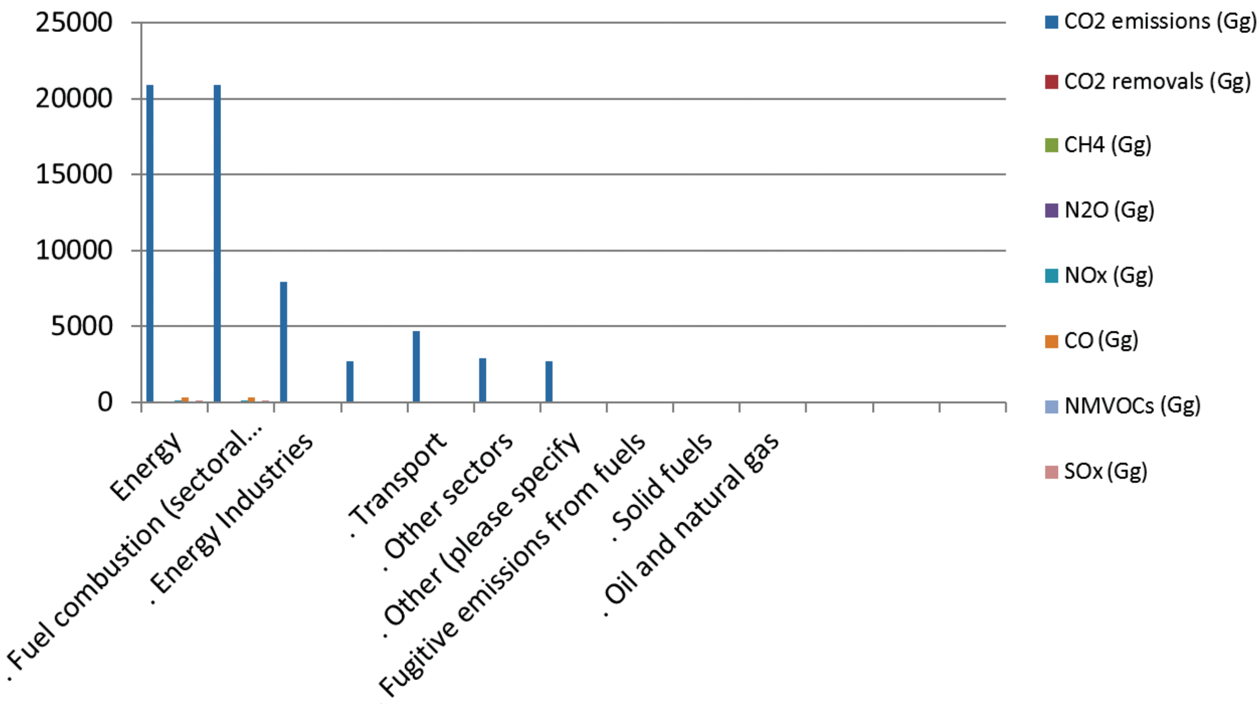
During this inventory, fuel combustion emissions from public electricity generation and petroleum refining activities were the only ones included as there was no manufacturing of solid fuels in Jordan during the 2006 year.

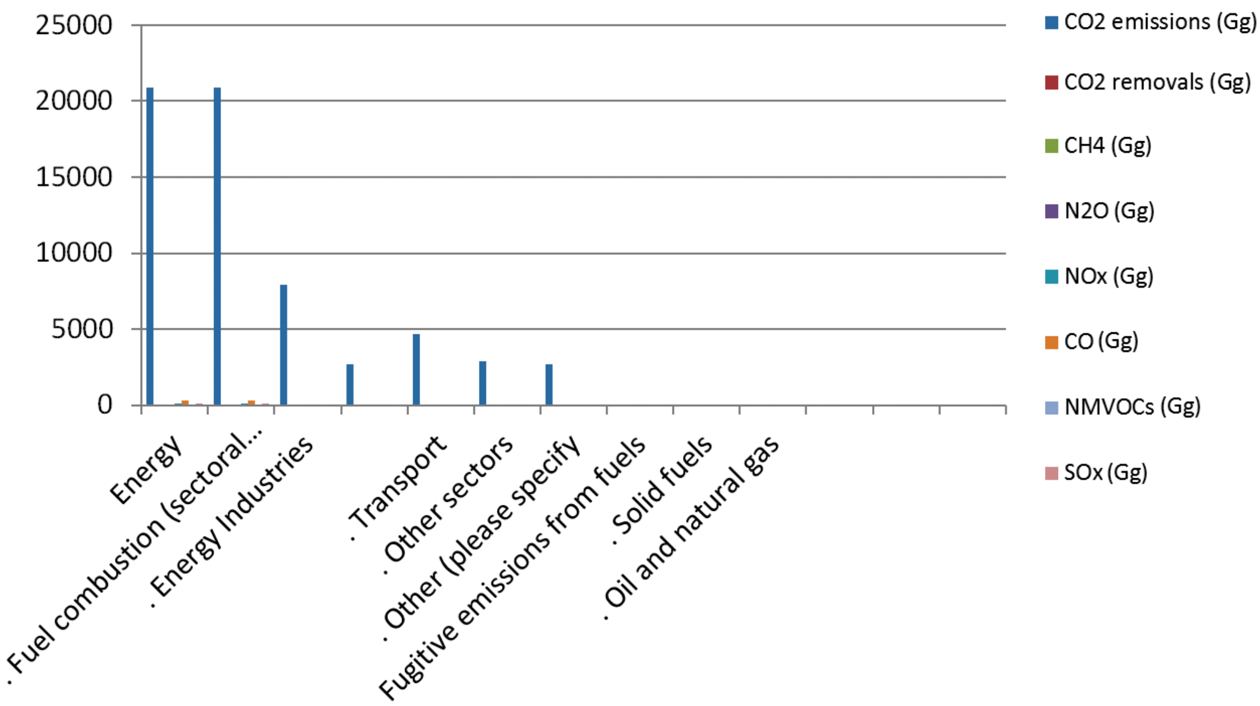
The energy industries are the largest source of emissions and accounted for (7,916Gg CO_2eq.) at 27.57 % of Jordan's GHG emissions during the year 2006.

Table 2.4: Detailed breakdown of sources of GHG emissions from energy sector

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
Energy	20,896	0	2	0	116	288	75	137
Fuel combustion (sectoral approach)	20,896		2	0	116	288	69	134
Energy Industries	7,916		0	0	21	2	1	70
Manufacturing industries and construction	2,675		0	0	7	0	0	11
Transport	4,706		1	0	4	1	0	23
Other sectors	2,883		0	0	30		8	12
Other (please specify)	2,715							3
Fugitive emissions from fuels							6	3
Solid fuels							0	0
Oil and natural gas							6	3

Figure 2.2: Detailed breakdown of sources of GHG emissions from energy sector





As there is no nuclear power or hydropower in Jordan, fossil fuel is used for power generation. Heavy fuel oil with high sulphur content of about 3-4% by weight was the main fuel used for public electricity generation in the year 2006. Thus the energy industries sub-sector contributed 70Gg SO_2 out of the total 139 Gg SO_2 national emissions in the year 2006, representing more than 50% of the emissions for this gas. This amount was less than what was calculated in the SNC due to the use of natural gas for electricity generation.

b- Manufacturing Industries and Construction

Emissions from the manufacturing industries and construction sub-sector include the combustion of fossil fuels for generation of electricity (autogeneration) and for heat production. Industrial categories that should be included in this sub-sector according to the 1996 Revised IPCC Guidelines are:

- Iron and steel;
- Non-ferrous metals;
- Chemicals;
- Pulp, paper and print;
- Food processing, beverage and tobacco; and
- Other: emissions from fuel combustion of the remaining industries including emissions from construction.

The main industrial companies that were considered in this sub-sector included a Potash Company, Phosphate Mines Company, Cement companies and many other companies. Emissions from fuel combustion in non-ferrous metals industries and in coke ovens (within the iron and steel industry) were not considered as there were no such industries in Jordan in the year 2006.

The manufacturing industries and construction sub-sector occupies the fourth place in GHG emissions among all sub-sectors. In the year 2006, GHG emissions from this sub-sector totaled 2,675Gg CO_2 eq. at 12.8% and 9.3% of the energy sector emissions and the total national GHG emissions respectively.

c- Transport

The transport sub sector was the second largest source of emissions; it accounted for (4706Gg CO_2 eq.) at 22.5 % and 16.4 % of the energy sector emissions and the total national GHG emissions in the year 2006; respectively.

Transport is a major sub-sector contributing to GHG emissions from fuel combustion for the passenger and freight. The following subcategories were included:

- Domestic aviation;
- Road transport;
- Rail transport;
- National Navigation; and
- Pipeline transport.

Among all energy sub-sectors, transport was the largest contributor to the emissions of N_2O, NO_x, CO and NMOVCs.

Domestic aviation is limited to relatively small number of trips between Amman and Aqaba cities. Only around 1 % of jet fuel was used for domestic aviation in Jordan in the year 2006. Rail transport is also limited to one train transporting phosphate from Al Shadiya mine to the Jordanian port of Aqaba.

d- International Bunkers

International bunkers include aviation and navigation. However, emissions from marine were not estimated due to lack of data. Emissions of CO_2 from international aviation accounted for 748Gg, while emissions of other gases were insignificant. These emissions are not counted in national totals.

e- Other sectors

The other sectors category comprises fuel combustion emissions from the following subcategories:

- Commercial/institutional;
- Residential; and
- Agriculture/forestry/fishing.

In the year 2006, emissions from other sectors category were 2,883Gg CO_2eq. at 13.8% and 10% of the energy GHG emissions and of Jordan's total GHG emissions; respectively.

However, the emissions of the non CO_2 emissions were insignificant. The fuels consumed by this category are LPG (for cooking), Kerosene (mainly for space heating and cooking) and diesel (mainly for space heating). The residential activities accounted for 71.1% (2049Gg) of the total CO_2 emission of this other sectors category (2883Gg), followed by the commercial/institutional activities which accounted for 24.2% and finally agriculture fuel combustion activities which accounted for 4.7%.

f- Other (not elsewhere specified)

This category covers all sectors that are not included elsewhere in estimating GHG emissions from fuel combustion. The total emissions of this category were estimated to be 2,715Gg CO_2eq. at 13% and 9.5% of the energy GHG emissions and of Jordan's total GHG emissions respectively.

g- Fugitive Emissions from Fuels

According to the Revised 1996 IPCC Guidelines, the following sub-sectors should be considered:

- Methane emissions from coal mining and handing;
- Methane emissions from oil and natural gas activities;
- Ozone precursors and SO_2 from oil refining including;
- Ozone precursor and SO_2 from catalytic cracking;
- SO_2 from sulphur recovery plants;
- NMVOC emission from storage and handling.

The methane emissions from coal mining and handling, ozone precursors, and SO_2 from sulphur recovery plants were excluded as there were no such sub-sectors in Jordan during the year 2006.

2.3.3 Industrial Processes Sector

This sector comprises emissions from industrial processes where GHGs are by-products of these processes. Thus, this sector accounts for emissions generated from no energy related activities as all energy activities in the industries are covered in the previous section under energy sector.

Industrial processes GHG sources in industrial processes sector according to the revised 1996 IPCC Guidelines above with their status in Jordan in the year 2006. The inventory results show that only two sub-sectors were sources of GHG's in the industrial processes sector in Jordan during the year 2006.

According to the Revised 1996 IPCC Guidelines, Greenhouse Gas Emissions (GHGs) were calculated for the industrial process for the following key sources shown in Table 2.5.

Mineral production mainly includes cement, lime, limestone, dolomite production and ash production, and use of asphalt for roofing and paving.

In the year 2006, emissions from industrial processes sector category were 2,550Gg CO_2 representing 7.8 % of Jordan's total GHG emissions. These CO_2 emissions came mainly from: cement production (2241Gg CO_2). The industrial processes sector was responsible for a large NMVOC emissions and accounted for 62 Gg equal to 40.5% of Jordan's total NMVOC emissions for the year 2006. (Table 2.6)

2.3.4 Solvents and Other Products Use Sector

This category covers mainly NMVOC emissions resulting from the use of solvents and other products containing volatile compounds. According to the 1996 Revised IPCC Guidelines, this sector includes the following subsectors:

- Paint application;
- Degreasing and dry cleaning;
- Chemical products, manufacture and processing; and
- Other: includes use of N_2O as a carrier gas, anaesthetic, and propellant in aerosol products.

There are no methodology and emission factors in the 1996 Revised IPCC Guidelines to estimate GHG emissions from solvents and other products use sector. The estimations for this sector are based on other countries experiences and emission factors, namely; Bulgaria (CORINAIR), Czech Republic (local studies) and Poland (research in Polish industries). Three sub-sectors were covered in this inventory: the paint application, and chemical products and manufacture/ processing.

In the year 2006, NMVOC emissions generated from the solvents and other products use sector were only 20 Gg around 13.1 % of Jordan's total NMVOC emissions. The key source of NMVOC emissions in this sector was the application of oil and water based paints (14.05Gg), other sources within the chemical products, manufacture and processing sub-sector were pharmaceuticals production, printing industry, glue use, edible oil extraction and paint production.

2.3.5 Agriculture Sector

Emissions from all anthropogenic activities within the agriculture sector, excluding fuel combustion and sewage, are covered in this sector. According to the 1996 Revised IPCC Guidelines, the following sub-sectors should be included in this sector:

- Enteric fermentation;
- Manure management;

Table 2.5: Status of existence for main GHG sources and sinks in industrial processes in 2006:

Greenhouse Gas Source And Sink Categories in the Industrial Sector	Status in Jordan in 2006
A. Mineral Products	
1. Cement Production	Present
2. Lime Production	Present
3. Limestone and Dolomite Use	Present
4. Soda Ash Production and Use	Present
5. Asphalt Roofing	Present
6. Road Paving with Asphalt	Present
7. Other	
- Glass Production	Not Present
- Concrete Pumice Stone	Not Present
B. Chemical Industry	
1. Ammonia Production	Not Present
2. Nitric Acid Production	Present
3. Adipic Acid Production	Not Present
4. Carbide Production	Not Present
C. Metal Production	
1. Iron and Steel Production	Not Present
2. Ferroalloys Production	Not Present
3. Aluminum Production	Not Present
4. SF6 Used in Aluminum and Magnesium Foundries	Not Present
D. Other Production	
1. Pulp and Paper	Present
2. Food and Drink	
- Production of Beer, Wine, Spirits	Present
- Production of Meat, Poultry	Present
- Production of Bread and Biscuits & Cakes	Present
- Production of Animal Feed	Not Present
- Production of Margarine & Solid Fats	Present
- Coffee Roasting Process	Present
E. Production of Halocarbons and Sulphur	
1. By-product Emissions	Not Present
2. Fugitive Emissions	Not Present
F. Consumption of Halocarbons and Sulphur	
1. Refrigeration and Air Conditioning Equipment	Present
2. Foam Blowing	Not Present
3. Fire Extinguishers	Not Present
4. Aerosols	Not Present
5. Solvents	Not Present

Table 2.6: The Industrial processes sub sector emissions

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
Total emissions from Industrial processes	2,241	0	0	1	1	0	62	2
A. Mineral products	2,241				0	0	54	1
B. Chemical industry	0		0	1	1	0	0	0
C. Metal production	0		0	0	0	0	0	0
D. Other production	0		0	0	0	0	8	0
E. Production of halocarbons and sulphur hexafluoride								
F. Consumption of halocarbons and sulphur hexafluoride								
G. Other (please specify)	0		0	0	0	0	0	0

- Rice cultivation;
- Agricultural soils;
- Prescribed burning of savannas;
- Field burning of agricultural residues; and
- Other.

As there is no rice cultivation or savanna in Jordan, these sub-sectors were excluded.

The GHG emissions of the agriculture activities were very small and accounted only for 4.6% (1318Gg CO_2 eq.) of Jordan's total GHG emissions in the year 2006. These emissions are composed of methane and nitrous oxide. Emissions of indirect GHGs of CO and NO_x were negligible. Emissions of methane from agriculture sector were insignificant, and were estimated at 0.13Gg.

Almost all nitrous oxide emissions in agriculture sector were emitted from agricultural soils (4.21Gg), while the contributions of manure management and field burning of agricultural residues were negligible. Table (2.7) represents the sources of N_2O in agricultural soils.

The total direct N_2O from cultivation equals 1.83 Gg, total direct N_2O from Animals equals 1.47 Gg and the total indirect N_2O from volatilization and leaching equals 0.91 Gg.

2.3.6 Land Use Change and Forestry Sector

The GHG emission/removals for the year 2006 were calculated for the Land Use Change and Forestry sector (LULUCF). According to the Revised 1996 IPCC Guidelines, the following key sources should be covered:

- Changes in forest and other woody biomass stock;
- Forest and grassland conversion;
- Abandonment of managed lands;
- Carbon dioxide emissions and removals from soil; and
- Other.

The CO_2 emissions in this national inventory were calculated for the following relevant and applicable sub-sectors:

- Changes in forest and other woody biomass stock
- CO_2 emissions or uptake by soil from Land-Use Change and Management
- Change in soil carbon for mineral soils
- Agriculturally impacted lands
- Agriculturally impacted soils

The land-use change and forestry sector was a net source of CO_2; contrary to what is expected. The emissions were estimated to be 866.4Gg of CO_2.

Table 2.7: Estimated sources of N_2O in agricultural soils

Practices	N_2O Emissions (Gg)	Comment
Usage of Synthetic Fertilizer (Urea)	0.267	Imported Urea minus export
Animal Waste applied for plant cultivation	0.723	It is assumed as a usage of animal waste in agriculture practices
Nitrogen fixing crop residues	0.393	Calculated mainly from production of nitrogen fixing crops (field crops)
Non-Nitrogen fixing crops	0.456	Calculated from the production of the remaining field crops which is not fixing nitrogen ex. wheat
Animal waste in pasture and ranges (grazing, sheep and goats)	1.47	All sheep and goats considered grazing
Leaching and volatilization of Ammonia from cultivated soil	0.9	
Total	**4.21**	

Negative impacts due to decrease in SOC of the Rangelands, which cover more than 80% of the total area of the exceeded positive impacts from the forests and non-forest trees as a source of CO_2 removal.

The table 2.8 below summarizes the results for the sinks and sources of CO_2 in the LULUCF sector.

Table 2.8: Estimated sinks and sources of CO_2 in the LULUCF sector

GREENHOUSE GAS SOURCE AND SINK CATEGORIES (Gg)	CO_2 Emissions	CO_2 Removals
Total Land-Use Change and Forestry	1283.33	0
Changes in Forest and Other Woody Biomass Stocks	0	-416.96
CO_2 Emissions and Removals from Soils	866.37	0

Total CO_2emissions form soils is 1283.33 and Changes in Forest and other woody biomass stocks has a CO_2emission of -416.96 resulting of a net emission of 866.37 for the LULUCF sector.

2.3.7 Waste Sector

According to the 1996 Revised IPCC Guidelines, this sector includes the following sub sectors:

- Solid waste disposal on land;
- Managed waste disposal on land;
- Unmanaged waste disposal on land;
- Wastewater handling;
- Industrial wastewater;
- Domestic and commercial wastewater;
- Waste incineration; and
- Other.

As there was no waste incineration in Jordan in year 2006, the related section is not included in this report. Methane is produced from anaerobic decomposition of the organic matter in solid waste and wastewater while N_2O is released from human sewage.

In the year 2006, GHG emissions from the waste sector totaled 3,045Gg CO_2eq. at 10.6% of Jordan's total GHG emissions. Most of the emissions were from disposal of domestic solid waste, which accounted for 98.6% (3,003Gg CO_2eq) of the total GHG emissions, while wastewater handling accounted for 1.4% (42Gg CO_2eq) of the total GHG emissions.

In the current national inventory, the key source of methane was from the managed domestic solid landfill sites at around 98.6% (around 143Gg CH_4) of the total methane emissions in this sector. Whereas the contribution of the domestic and commercial wastewater was estimated to be around 1.4% of the total (around 2Gg CH_4) generated methane.

The inventory of methane emissions from solid waste disposal sites of year 2006 showed an increase of about 15% compared to the SNC of 2000 which correlates with a similar rate of population increase. The waste disposal practice in Jordan has improved the amount of methane recovered from Ruseifeh landfill.

As for the industrial wastewater plants, Methane emissions from these plants were negligible as their operation mode is activated sludge. Nitrous oxide emissions were estimated within the domestic wastewater sub-sector at 0.42 Gg.

2.4 GAS BY GAS EMISSION INVENTORY

This section presents a brief description of emissions by greenhouse gas type of Jordan's inventory in the year 2000. Greenhouse gases included are CO_2, CH_4, N_2O, NO_x, CO and NMVOC.

Carbon Dioxide

Net CO_2 emissions were estimated to be 24,003 Gg at 83.6 % of Jordan's total greenhouse emissions in the year 2006. These emissions arise from energy sector at 87.1 % of the total CO_2 emissions; respectively. Thus, the main source of CO_2 is combustion of fossil fuels.

Methane

Methane has the second largest share of Jordan's greenhouse gas emissions. CH_4 emissions were estimated to be 147Gg at 10.8 % of Jordan's total greenhouse emissions in the year 2006.

Nitrous Oxide

Emissions of nitrous oxide were small and estimated to be 5.248 Gg or around 5.5% of Jordan's total greenhouse emissions in the year 2006. Nitrous oxide emissions were generated mainly from agriculture, which were accountable for 80% of the total N_2O emissions.

2.5 CARBON DIOXIDE EMISSIONS FROM THE ENERGY SECTOR USING THE REFERENCE APPROACH

Reference approach was used to estimate the CO_2 emissions of the energy sector based on the Revised 1996 IPCC Guidelines for the years 2000- 2010.

Table 2.9: Estimations of CO_2 emissions of the energy sector for the years 2000- 2010

Year	1000 Gg CO_2
2001	15.03
2002	15.755
2003	16.671
2004	18.6
2005	20.293
2006	20.26
2007	20.691
2008	19.83
2009	20.806
2010	20.381

The reference approach calculation for the year 2006 in comparison to the sectoral approach shows that there is a deference of 3.4%, which is acceptable.

2.6 COMPARISON BETWEEN THE SECOND AND THIRD NATIONAL COMMUNICATION

GHG emissions show an expected increase between the SNC (base year 2000) and the TNC (base year 2006) due to the increase in economic and developmental activities as well as the forced migration of hundreds of thousands of people from Iraq to Jordan in the aftermath of the Iraq war in 2003 and their settlement in the country and integration in the socioeconomic dynamics.

Table 2.10: Comparison between SNC (2000) and TNC (2006) results

Inventory	Second	Third
Base Year	2000	2006
Total GHGs	20140	28717
Energy sector %age	74.0%	72.9%
Industrial processes	7.9%	8.9%
Agriculture	0.9%	4.6%
LULUCF	3.7%	3.0%
Waste	13.5%	10.6%
Local emission Factor use	In Waste	In Waste and Energy sector
Use of Tire 2	No	Yes in Aviation and Agriculture

2.7 UNCERTAINTY ANALYSIS

For the emission data of 2006 excluding LULUCF, an uncertainty analysis on Tier 1 level was carried out resulting in a level uncertainty of 2.42%. The analysis was also carried out including the LULUCF sector resulting in an increase of the uncertainty level to 8.42% . The level of uncertainty associated with total CO_2 (excluding LULUCF), CH_4 and N_2O emissions are 2.86, 42.55, and 50.92 per cent, respectively. The level of uncertainty associated with total CO_2 (including LULUCF) is 9.88%. The uncertainty estimate for this inventory is lower now than the previous ones.

This is partly due to a considerable work made to improve the calculation methodology, and it is also partly due to the fact that the uncertainty estimates themselves have been improved. Energy sector's overall uncertainty estimate is relatively low at 3.19 per cent. CO_2emissions from energy industries was the largest contributor to the GHG emissions from the energy sector and their combined uncertainty it is estimated to be 5.8 per cent. CO_2 from the transport sector, the next largest contributor, has an uncertainty of 5.1 per cent.

The overall uncertainty level for the industrial processes is 27.4 per cent. For both the agricultural and waste sectors, uncertainty estimates based on source category analysis are 44.4 and 41.9 per cent respectively. LULUCF sector's uncertainty is estimated the largest at 253%. Emission's factor uncertainty was estimated from the available ranges of emission factors and default uncertainty estimate in the IPCC 1996, 2000 and 2006 guidelines as appropriate, while the activity data uncertainty was determined by expert judgment.

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41. إدارة الغابات في الأردن ، د. لاسلو بانتسل ، ترجمة وتنقيح المهندس الزراعي عبد المعطي، ١٩٩٣
42. التقرير السنوي / مديرية الحراج – وزارة الزراعة ، ٢٠٠٦
43. الموقع الرسمي لدائرة الإحصاءات العامة.

GHG MITIGATION ASSESSMENT 3

3.1 INTRODUCTION AND METHODOLOGY

This chapter aims at identifying and assessing potential economic, social and policy measures and human interventions that can be implemented in Jordan to reduce anthropogenic emissions of greenhouse gases (GHGs) in different sectors at the national level to limit the magnitude and/or rate of long-term induced global warming. The abatements analyses are tackled in a sector-specific manner and were based on the GHG inventory of the base year 2006, undertaken during the implementation of the Third National Communication. The following sectors were considered: Energy (Primary Energy, Renewable Energy, Energy Efficiency and Transport), Waste, Industrial Processes, Land Use, Land Use Change and Forestry (LULUCF) and Agriculture.

Potential mitigation measures were analyzed and assessed for the different sectors for the period (2007-2040). For this purpose, two types of scenarios were constructed: a) baseline scenarios and b) mitigation scenarios.

- The baseline scenario reflects a future in which there are no additional policies or programs designed to encourage or require actions that reduce GHG emissions or enhance carbon sinks. Defining a reasonable baseline scenario is considered a critical element in the abatement assessment since the benefits and incremental costs of mitigation options are directly linked to the sound definition of the baseline scenario. The baseline scenario was constructed based on the trends, plans and policies prevailing in the Jordanian context at the time of preparing this report (2014). The development of this scenario required a projection of the current levels generated by to future levels of each type each activity for the time period 2007-2040. This projection drew on assumptions made about population growth, GDP and other macro variables, which were obtained from official institutions.

- The mitigation scenario was structured according to a set of criteria reflecting country-specific conditions such as potential for large impact on greenhouse gases reduction, direct and indirect economic impacts, consistency with national development goals, potential effectiveness of implementation policies, sustainability of an option, data availability for evaluation and other sector-specific criteria.

The analytical methodology used for energy sector is based on the Energy and Power Evaluation program (ENPEP), which is an integrated energy modeling system. The ENPEP was used to construct the baseline scenario and to assess different mitigation options in the energy sector. For other sectors, the selected options were assessed using appropriate financial and economic tools, i.e. the cost-benefit analysis of emission reduction of the options.

3.2 BASELINE SCENARIOS FOR THE DIFFERENT SECTORS

3.2.1 Baseline Scenario for Energy Sector

Jordan has limited energy resources and the country depends heavily on imported crude oil for its energy use. The national energy sector's main concern is the provision of adequate energy for economic development with the least possible cost and best quality. The sector suffers from the extreme fluctuations of oil prices and also by the lack of ability to secure a constant and sustainable energy supply for the country.

The policy of the Government of Jordan (GoJ) in the field of energy was shaped by the adoption of the Updated Master Strategy of Energy Sector in Jordan for the period of 2007-2020. The main goals of the Energy Strategy are to secure reliable energy supply through increasing the share of local energy resources, expanding the development of renewable energy projects, promoting energy conservation and awareness and generating electricity from nuclear energy.

The most probable baseline scenario in the energy sector was constructed based on the current situation of the energy sector at national level., the government's efforts to achieve security of energy supply in all its forms, the national goals, policies, and laws in the sector, and the committed activities and projects.

The following are the set of assumptions that were considered in energy sector and its subsectors and used in the baseline scenario construction:

a) **Oil sector**

- The Jordan Petroleum Refinery will continue its operations with the same capacity of production of 14 thousand tons per day, or about 100 thousand barrels to meet 60%of the need of the domestic market for oil products according to statistics in 2013. The remaining domestic demand will be met through imports. This arrangement is assumed to continue until the year 2040.
- Implement the expansion of the Jordan Petroleum Refinery (to be completed in 2021) in order to start converting petroleum derivatives into light derivatives and improve the specifications of the petroleum products.
- Continue to meet Jordan's need for crude oil by importing
- 90% of the need of crude oil, equivalent to 25 million barrels per year from Saudi Arabia by sea, and by trucks to the oil refinery in the center of the kingdom. The remaining 10% of the crude oil need will be imported from Iraq, which is equivalent to 3.6 million barrels annually trucked by road to the refinery. This arrangement will continue until 2022.
- Construction of a pipeline to export Iraqi crude oil across the Jordanian territory to the terminal in Aqaba with a capacity of 1 million barrels/day. The pipeline will have a branch to supply the Jordan Petroleum Refinery with 150 thousand barrels/day of crude oil. The pipeline is expected to be completed by the year 2022.
- Sustain the liberalization of prices of petroleum products by pricing them according to international prices, on a monthly basis. The pricing policy is considered to be one of the most efficient mechanisms aimed at improving consumption efficiency.
- Complete the implementation of the program restructuring the oil sector and the establishment and operation of logistics companies.
- Work on the implementation of a policy that will provide strategic stocks of petroleum products sufficient for 60 days. This policy will be implemented through the following measures: (1) Construction of storage units with a capacity to store 100 thousand tons of crude oil in Aqaba on Engineering, Procurement and Construction (EPC) basis, (2) Construction of strategic storage capacities for light oil products with a capacity of 250-300 thousand tons, and 8 thousand tons for Liquefied Petroleum Gas (LPG) in the middle of Jordan. The project will be built on EPC basis, and will be in operation by 2017.

b) **Natural Gas**

- Continue to import amounts of natural gas from Egypt via the Arab Gas Pipeline, until it reaches 100 million cubic feet per day and at a steady rate until the year 2033; the end date for the Jordanian-Egyptian agreement.
- Complete construction of a project aimed at importing liquefied natural gas (LNG) through the port of Aqaba. This project could be operational by the beginning of 2015, the project includes:
    - Construction of LNG jetty at Aqaba port that is connected with Arab Gas Pipeline.
    - Leasing a floating storage and re-gasification unit with a capacity of 160 thousand cubic meters of liquefied gas, which can provide up to 715 million cubic meters/day.
- Continue to produce 20 million cubic feet of natural gas from Risha gas field, located in East Jordan, at a constant rate until the year 2040.
- Utilize all natural gas produced and imported from all domestic sources for electricity generation.
- The share of natural gas in the total energy mix will decrease as a result of the increased reliance on local sources for electricity generation, including renewable energy sources, oil shale and nuclear energy.

c) **Oil Shale**

The oil shale will not contribute to the total energy mix in 2015, as planned by the comprehensive national strategy for the energy sector (2007-2020). The main reason for the delay is the inability of the companies contracted to obtain adequate financing in light of the global economic crisis that affected the financial markets. The direct burning technology is a mature technology to generate electricity from oil shale and thus will be used. The oil shale will start to contribute to the generation of electricity starting in 2018, if the following projects are to be completed:

- Construction by an Estonian company of a power

plant (to be in operation in 2018) that uses direct oil shale burning and with a capacity of 450 MW.
- Construction of a power plant that uses direct oil shale burning by an Emirati and Chinese consortium, with a capacity of 600 MW. The first unit will start operation in 2018 and the second unit will start operation in 2020 with a capacity of 300 MW of each unit.

d) Renewable Energy

The following are the main renewable energy assumptions that are considered within the baseline scenario:

- Wind and solar energy projects that are committed to be constructed and completed by the year 2015 and thus were considered as part of the baseline scenario:
  - Wind power project in the Tafila area with a capacity of 117 MW.
  - Wind power project in the Fujeij area with a capacity of 90MW.
  - Wind power project in Maan area with a capacity of 70 MW.
  - Photo Voltaic (PV) solar project in Quweirah area with a capacity of 70 MW.
  - Photo Voltaic (PV) solar project in the area of Mafraq in the area of Mafraq with a capacity of 10 MW.
  - Direct proposal solar projects with a capacity of 200 MW.
  - Photo Voltaic (PV) solar project with a capacity of 5 MW.
  - Wind energy projects from direct proposals with a capacity of 100 MW.
- The maximum expected capacity of absorbed energy by the electric grid until 2020 from renewable energy projects will be 1500 MW. It is planned to start the implementation of a project in 2017 to be ready in 2020 to increase the capacity of the national electric grid.
- PV solar self-generation projects of electric power in homes and government institutions, banks, hotels, hospitals, the capacity is considered to be 35 MW until 2015 and 125 MW in the year 2020.
- In light of the mechanisms to deal with projects to generate electricity from domestic waste by the private sector, which was approved in April 2013, and has received 36 requests for expression of interest by the companies to invest in this area, it has been assumed that:
  - A power plant will be built for direct burning of solid waste with a capacity of 50 MW in the middle of the Kingdom.
  - Bio–gas power plant will be built in Ghabawi landfill site with a capacity of 25 MW in 2020.
- The above mentioned renewable energy projects were considered within the baseline scenario and were identified according to:
  - Finalizing a national legal framework, legislative and regulatory, and issuance of a renewable energy and energy conservation law No. 13 in the year 2012.
  - The completion of all instructions governing the investment process, including the preparation of a list of indicative prices for electric power from renewable energy projects (Law No. 13 for 2012).
  - Allowing homes and small businesses to install renewable energy systems and to sell their electricity surplus electricity to distribution companies (net metering).

e) Raise the efficiency of energy consumption

In light of the issuance of the Bylaw No. 73 for the year 2012 on regulating procedures and means of Conserving energy and improving the efficiency:

- The assumption that the percentage of homes that will install solar water heaters will be 18%, 20 %, 22 %, and 24 % in the years 2018, 2020, 2025 and 2030 respectively.
- The installation of up to 3 million energy-saving bulbs in homes and government buildings.

f) Nuclear Energy: Based on the government program announced in connection with the introduction of nuclear energy as one of the sources of generating electricity to meet the peak load, it is assumed that a nuclear power plant to generate electricity will be constructed with a capacity of1000 MW to be operational by 2023.

TRANSPORT SECTOR:

The transport sector plays a major role in Jordan’s economy, accounting for about 12% of GDP, and employs about 10%

of the workforce. The main mode for passenger and freight transport is the land transport sector (roads). The main transport infrastructures existing in Jordan are: One sea port at Aqaba city, two railways systems, road networks totaling approximately 7200 km and three international airports.

The road network in Jordan is well developed; there are 4,600 km of primary paved roads (main and side paved roads) and 2,607 km of rural roads (MOT Annual report 2012). The network provides connections to all governorates, communities, and neighboring countries. In terms of rail, the Jordanian government prepared a Railway Master Plan to build an entirely new standard gauge railway network. The existing railway network in Jordan consists of 620 km of narrow-gauge tracks, operated by the Jordan Hejaz Railway (217 km of operational lines, and 111 km of abandoned lines).

According to Jordan's Third Competiveness Report, Amman as a capital city has one of the lowest public transportation mode share ratios in the world, at 11.1%. Likewise land transport sector suffers from a number of weaknesses such as:

- an aging trucking fleet,
- absence of rail freight network,
- high cost of inland trucking,
- undeveloped multi-modal transport and
- low density of highway networks.

It is assumed that not many changes will occur within the transport sector in Jordan; the road transport will continue to be the main transport mode, public transportation will continue to be low with the absence of railway transport and inefficient traffic management. Thus the development of transport baseline scenario was based on the current levels and projections of future growth of population, and GDP rates, that were obtained from official reports.

The following two projects were assumed to be part of the Baseline Scenario:

- Implementation of Amman Bus Rapid Transit in year 2016.
- Introducing more hybrid cars into the local market. This is part of a government decision that took place in July 2013 aimed at reducing the special tax from 55% to 25% on imported Hybrid cars with an engine capacity of less than 2500 cc; and from 55% to 12.5% in case of phasing out cars that are older than ten years old.

Primary and Final Energy Demand

The energy baseline scenario was constructed based on the information and assumptions mentioned above. Table A.1 in Appendix A; summarizes the actual primary and final energy demand including electricity by sector and by fuel type for the period 2006-2040. Table A.2 in Appendix A, shows the actual and forecasted electricity demand for the period 2006-2040. The MACRO-E model of ENPEP was used to analyze the feedbacks between the energy sector and the economy as a whole. The DEMAND model was used for calculating the growth rate of oil product's demand by any form of energy.

The model was based on several macroeconomic variables; such as: GDP in constant prices, added value for economic sectors separately, and population growth rate. A summary of the population and GDP growth used in energy and electricity demand projections is shown in table A.3 in Appendix A. The MAED module of ENPEP was used for projection of the electricity demand. The WASP module was used to determine an electric system expansion plan that meets the growing demand for electricity at minimum cost while respecting user-specific constraints, and desired system reliability.

As shown in table A.1, the primary energy demand is expected to increase from 8.5 Million ton of oil equivalent (Mtoe) in 2013 to 11.2, 16.2, 19.9 Mtoe in the years 2020, 2030 and 2040 respectively, with an annual average growth rate of 3.6% during the period 2013-2020 and 3.1% during the period 2020-2040. As a result of this analysis the per capita energy consumption was calculated to be at 1285 kgoe in 2013 and is expected to be 1410 kgoe by 2020 and 1960 kgoe by 2040.

The electricity demand grew by 7.4% in the period 2006-2013, and is expected to grow by 7.1% up to the year 2020 and 4% on the long run up to the year 2040. The electricity demand which was 18400 GWh in 2013 is expected to be 30060 GWh in 2020 and 64075 GWh in 2040, growing by 3.5 times compared to that of the year 2013.

3.2.2 Baseline Scenario for Waste Sector

The waste sector in Jordan deals with waste generated from three main sources: municipal solid waste, domestic wastewater and industrial wastewater.

Domestic solid waste

Solid waste collection and disposal is the responsibility of local municipalities in accordance with municipal law No.13/ 2011 as specified in article 40. Final disposal sites are managed by common services councils, except for Gabawi landfill, which is operated by Greater Amman Municipality (GAM). Gabawi landfill serves the municipalities of Zarqa and Russifa in addition to GAM, it receives about half of the solid waste generated in Jordan. According to Sweep-net report, 2010 solid waste is generated at a rate of 0.9 kg/ capita/day, however, slight variation is seen between urban and rural areas. Waste collection coverage ranges between 90% for urban areas and 70% for rural areas (SWEEP Net, 2014). Ninety percent of the waste collected is dumped into landfills where only 10% is recycled. Waste generation is increasing at a rate of 3.3% per year. Accordingly, waste quantities generated increased from 1.5 million ton per year in 2000 to about 2 million tons per year in 2012. Organic matter represents the major constituent of solid waste with average percentage of 55-70% by weight.

There are 21 landfill sites operating in Jordan with seven closed sites, it is assumed that the current landfills will continue to be utilized until 2040 (Table A.4 in Appendix A). About 50% of the waste is dumped in sanitary landfills (Gabawi), 35% is disposed under controlled dump conditions and only 5% of the waste is openly dumped. The vision of Ministry of Environment (MoEnv) is to have three central landfills at north, south and central region of Jordan, an option which will facilitate the control and management of waste disposal in Jordan.

Ministry of Environment has prepared the general framework of a law for waste management (not yet active). The law aims at reducing waste generation, encourage waste reuse, and waste recycling in addition to ensuring a safe disposal of the waste. The law covers all types of waste except radioactive waste, gaseous emissions and wastewater.

The law stated that the MoEnv must prepare a five-year national waste management plan. Accordingly each municipality must prepare its own waste management plan that complies with the national plan prepared by the MoEnv, in coordination with all relevant stakeholders. Also, according to the draft law, any entity producing more than 1,000 tons of domestic waste and/or 10 ton of hazardous waste must develop its own waste management plan.

Table A.5 in Appendix A shows the actual and projected amounts of generated domestic solid waste for the period of 2007 to 2040. Calculations were based on a waste generation rate of 0.9 kg/ capita/day.

Domestic and industrial wastewater

According to Jordan's water strategy (2008-2022), wastewater is considered as a source of water in the national water budget. In 2007 treated domestic wastewater represented 10.3% of the water budget with 87 million cubic meter (MCM) while industrial treated wastewater represented 1.3 % with 4MCM. In 2022, treated domestic wastewaters will represent 13.3% of the water budget with 220 MCM and industrial treated wastewater will represent 2.3% with 27 MCM.

Water Authority of Jordan (WAJ) is the responsible entity for domestic wastewater management. Currently, there are 27 working wastewater treatment plants (WWTP) in Jordan. Table A.6 in Appendix A, shows quantities of wastewater discharged to working WWTPs (2006-2012) while Table A.7 in Appendix A shows the influent organic load to working WWTP in 2012. Samra WWTP receives more than 70% of wastewater diverted to WWTPs while Mansourah WWTP for septic tanks receives only around 0.005% of the total wastewater discharged in 2012. The greenhouse gas emitted from wastewater treatment depends on the used treatment technology. Considerable amounts of GHG emissions are generated from anaerobic wastewater treatment usually from natural treatment ponds such as in the old Samara WWTP. However, it is planned that all future needed WWTPs will be mainly mechanical, using activated sludge treatment methods and consequently GHG emissions will decreased significantly.

Most of the industries in Jordan are small and medium enterprises (SMEs). They are located within Industrial Estates, Qualified Industrial Zones or located separately. Amman-Zarqa region is the largest urban center in Jordan and where the largest industrial congregation, where the majority of the Jordanian industry is located.

The ratio of water used in the industrial sector in relation to the total use is very small, around 5%. In industrial states industries usually have WWTPs or pretreatment units that are used before discharging their wastewater to the central WWTPs or to other locations to be used for tree irrigation or to nearby Wadis. Also, many industries (food processing, yoghurt, etc) are connected to the sewage network as their wastewater complies with connection requirements. It is assumed that aerobic treatments method are used in the industrial estate wastewater treatment plants, as a result the GHG emission is considered negligible.

The following is a summary of the main assumptions related to wastewater:

- In line with Jordan's water strategy all wastewater needs to be treated and used as a replacement of fresh water and utilized by the agricultural sector.
- Current wastewater treatment plants need to be regularly upgraded to account for the population increase and thus to the increase in water consumption. However, extension will be mainly at plants serving urban areas.
- Current water consumption and generated wastewater per capita is assumed to be fixed.
- Biogas utilization from sludge digestion is mainly practiced at Samra WWTP and will continue to be so.
- Most of the sludge produced from other treatment plants will be dried out and disposed at landfill sites.
- For the calculation of Nitrous Oxides from human waste protein consumption per capita is estimated at 29.6 kg/capita/year.

3.2.3 Baseline Scenario for Industrial Sector

Industry in Jordan is divided into two main types; manufacturing sector (includes the production of cement, lime, fertilizers and chemicals) and "mining and quarrying" sector (including limestone quarrying). The manufacturing sector contributed 20.2% to Jordan's GDP at constant basic prices in 2012. The "mining and quarrying" sector contributed 1.7% to Jordan's GDP in 2012.

The total number of industrial firms reached 16,033, employing 169,749 workers (Main Industrial Indicators 2013, Jordan Chamber of Industry (JCI)), 2,172 industrial companies were registered in 2012 (Annual report 2012, CBJ).

The governmental policies, strategies and plans for the industrial sector namely; the ministerial statement (governmental working plan 2013 – 2016) and the national industrial policy (industrial support program 2010 – 2014), aim at improving the industrial performance (production and expansion).

The following are the main government plans/activities aimed at enhancing the industrial performance in Jordan:

- Improve the investment environment to attract the foreign investments.
- Improve the infrastructure service to meet the need of industrial activities.
- Improve the education and vocational training to satisfy the need for qualified laborers.
- Enhance the communication between the technical research and development and industries to improve their knowledge and use of new techniques/ technologies.
- Support the adoption of Best Available Technology (BAT) and Best Environmental Practices (BEP) in the industrial processes.
- Update regulations to encourage industrial investment.
- Support and encourage cooperation between the private and public sectors.
- Establish a national strategy to improve the exportation of local products to the international market.
- Improve the financial support mechanisms to encourage industrial investments.
- Provide technical support to industries in order to comply with national-international technical and environmental standards and support their participations in defining new standards and decision making.

The industrial processes that generate GHGs in Jordan are mainly Cement production, Lime production, Nitric Acid production, use of Limestone and Soda Ash.
The average annual population growth and GDP at a constant rate is used to predict the baseline scenario for the period (2014 – 2040). For the Soda Ash a huge jump in the imported quantities was noticed in 2013 and for lime a huge drop in produced quantities was noticed in 2013, therefore; the growth for future years is based on the average values of the period (2006-2013) for these two products.

Table A.8 in Appendix A shows the annual productions/ extraction/import of lime, limestone, soda ash and nitric acid and specific national indicators (2006–2013). And table A.9 describes the annual growth of these products (2007–2013). Table A.10 shows the projected productions/ extraction/import of lime, limestone, soda ash and nitric acid for the period (2014 – 2040).

3.2.4 Baseline Scenario for Agriculture and LULUCF Sector

The baseline scenario for this sector was constructed based on available governmental plans, programs, policies and strategies announced and published by the Ministry of Agriculture, the Directorate of Forests and other relevant institutions. Although the contribution of agriculture sector to GDP is only 3%, it has an extremely important role in social and environmental aspects. The macroeconomic and demographic variables considered for the scenario are similar to those of the other sectors. The National Agricultural Strategy, the Agriculture Charter & Policies, the annual reports and the National Executive Program for Agriculture (2013-2016) were all reviewed and given due attention.

The following were common objectives among all documents mentioned above:

- Promotion of sustainable and long-term use of resources and conservation of biodiversity used in the agricultural production.
- Combat desertification and strengthen technical capacities of the people working in the agricultural sector to cope with predicted climate and environmental changes.
- Control urban expansion on agricultural and forest lands.
- Restore degraded ecosystem of rangelands and forests through community based rangeland rehabilitation.

Based on the above objectives, the following assumptions were used to project the mitigation activities in the agricultural sector between the years (2013-2040):

- Field crops production: Increase productivity per unit area, by promoting water-harvesting techniques that will allow cropping areas to expand and maintain productivity with predicted decreases in rainfall.
- Animal production: Promote high productive animal species under increase in prices of fodder, and other production inputs.
- Fodder production: Reclamation of rangelands and control of overgrazing in rangelands, introduce species with high productivity under drought conditions and promote wastewater reuse in fodder production.
- Forestry conservation: Maintain the forests under predicated continuity of drought cycles, urban and rural expansion, expected fire occurrences and trees cutting for fuel.

Tables A11 to A18 in Appendix 1 summarizes the actual and projected numbers of livestock between 2006-2040, the actual and projected plant production (Gg) for various crops between 2006-2040, the actual and projected quantities of nitrogen applied in agriculture production process from various sources for the period between 2006-2040 and the actual and projected areas of forest plantations and number of non-forest trees in Jordan between 2006-2040.

3.3 GHG EMISSIONS IN BASELINE SCENARIO

3.3.1 Emissions from energy related activities

For the energy sector and its subsectors, the GHG emissions of the baseline scenario were calculated for the period 2006-2040 using BALANCE and IMPACTS modules of the ENPEP modeling software where actual and projected primary and final energy demand produced earlier were used as inputs to these modules.

Table A.19 in Appendix A shows the GHG emissions for the baseline of the energy sector and its subsectors while table 3.1 and figure 3.1 below show the emissions for selected years. It is clear that the energy sector is the main source of GHG emissions in Jordan according to the 2006 GHG Inventory. According to ENPEP the role of the energy sector and subsectors as the leading emitter of GHGs is expected to increase in the future from 72.9 percent of total emissions in the year 2006 to 83 percent in the year 2040. Therefore, it is important to focus the mitigation efforts on this sector.

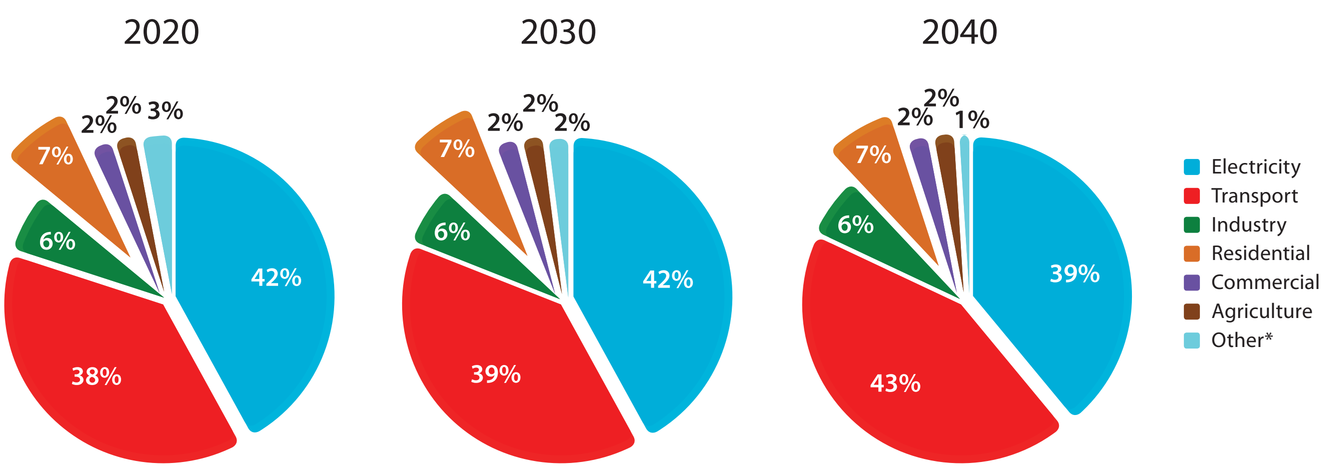
With regards to energy subsectors, electricity generation and transport are the leading emitters and their share from energy sector total emissions falls between 39-43 percent, followed by a share of around 7 percent for the residential subsectors and 6 percent for the industrial subsector. The commercial, agriculture and refinery processes and transportation of fuel are marginal contributors to the total emissions from energy sector.

Table 3.1: GHG emissions, baseline scenario for the energy subsectors for selected years (Gg CO_2 eq.)

Emission Sources	2010	2015	2020	2025	2030	2035	2040
Electricity	7477	9140	12562	10114	17517	19019	19264
Transport	7573	9052	11145	13584	16221	18934	21550
Industry	1843	1407	1664	1947	2261	2605	2984
Residential	1471	1737	2030	2344	2684	3049	3332
Commercial	439	407	486	574	670	764	853
Agriculture	395	526	649	766	902	1046	1181
Others*	792	973	870	591	668	555	447
Total energy	**19990**	**23242**	**29406**	**29920**	**40923**	**45972**	**49611**

*:Emissions from refinery processes and fuel transportation

Figure 3.1: Share of the energy subsectors in the GHG emissions of the baseline scenario for selected years



EMISSIONS OF THE ENERGY BASELINE SCENARIO BY GAS

Carbon Dioxide Emissions (CO_2)

Total CO_2 emissions by sector under the baseline scenario are shown in Table 19 Appendix A for the period 2006-2040. Emissions will increase at an average rate of 2.7% annually between 2006-2040 and will reach a total of 48.6 M tons in 2040, compared to 18.6 M tons and 26 M tons in 2006 and 2013 respectively. CO_2 emissions from various sectors are as follows:

- Electricity generation: The most significant change in sectoral contribution is in the electricity generation where emissions will grow at an average rate of only 1.5% due to the introduction of non-fossil and renewable energy to generate the electricity despite the increase of the use of oil shale.
- Transport sector: CO_2 emissions will grow at an average rate of 3% during the period 2006-2040. And will reach 20.7 M tons in 2040 compared to 8 M tons and 10.7 M tons in 2013 and 2020 prospectively. This is mostly due to the expected increase in the transportation service fleet.
- Industrial sector: CO_2 emissions will grow at a below-average rate of 0.5% annually between 2006-2020 with the sector contribution declining from 12.8% in 2006 to 6% (2.9 M tons) in 2040.
- The residential sector: CO_2 emissions will increase slightly from 10.2% (1.88 M tons) in 2006 to 10.7% (2.0 M tons) in 2020 and to 6.8% (3.27 M tons) in 2040.

CO_2 emissions from electricity, transport and from the overall energy sectors are illustrated in figures A.1, A.2 and A.3 in Appendix A.

Methane (CH_4) Emissions

CH_4 emissions will increase at an average rate of 3.3% annually between 2006-2040 and reach a total of 16,558 tons in the year 2020 and 3,1520 tons in the year 2040.

Nitrous Oxide (N_2O) Emissions

Total N_2O emissions will increase from 578 tons in 2006 to 866 tons and 1,166 tons in 2020 and 2040 respectively

3.3.2 Emissions from waste sector activities

The waste sector is the second contributor of GHG emissions in Jordan according to the 2006 GHG Inventory. It contributed to 10.6 % of the total emissions with a share of 1.5% from wastewater and 98.5% from solid waste. The waste sector contribution is expected to increase to 5300 Gg CO_2 eq with decrease of its share to 9% of the total GHG emissions in 2040. As WAJ converted Samra WWTP as well as other WWTPs to Aerobic mode, the emissions of methane were considered to be negligible. Nitrous oxide emissions from human sewage was calculated based on the population growth in Jordan and based on the protein consumption factor of 29.6 kg per capita per year published by the Department of Statistics. Recovery of methane from landfills is considered under the mitigation scenario except for Russiefa landfill where methane is being recovered and used to generate electricity.

Baseline emissions for the waste sector for the years (2006-2040) are listed in Table A.20 of Appendix A while table 3.2 below provides a summary for selected years.

Table 3.2: GHG emissions of the baseline scenario for the waste sector for selected years (Gg CO_2 eq.)

Years	CH_4 emissions from domestic Landfills	CH_4 emissions from domestic Wastewater	N_2O From human waste	Total emissions (Gg CO_2 eq.)
2010	2876	0	141	3017
2015	3140	0	161	3301
2020	3524	0	179	3703
2025	3831	0	195	4026
2030	4154	0	211	4364
2035	4638	0	225	4863
2040	5059	0	239	5299

3.3.3 Emissions from industrial activities

The industrial sector is the third contributor to GHG emissions in Jordan according to the 2006 GHG Inventory. The sector contributed to 8.9% of the total emissions and its share it is expected to decrease to 6% in 2040 with total emissions of 3,480 Gg CO_2 eq. The main contributor to the industrial process emissions is the cement industry. Other contributors are the production and use of lime, limestone, soda ash and nitric acid. Baseline emissions for the industrial processes for the years (2006-2040) are listed in Table A.21 of Appendix A, while table 3.3 below provides a summary for selected years.

Table 3.3: GHG emissions of the baseline scenario for the industrial processes for selected years (Gg CO_2 eq.)

Years	N_2O	CO_2	CO_2eq (Gg)
2010	0.49	1214	1365
2015	0.59	1816	1998
2020	0.67	2094	2303
2025	0.71	2376	2598
2030	0.76	2665	2900
2035	0.76	2961	3195
2040	0.77	3242	3481

3.3.4 Emissions from agriculture activities

The agriculture GHG emissions contribution is 4.6% of the total GHG emissions in Jordan according to the 2006 GHG Inventory, and as expected the agriculture share to the total emissions is modest. Baseline emissions for the agriculture activities for the years (2007-2040) were mainly CH_4 and N_2O resulting from enteric fermentation and manure as listed in Table A.22 of Appendix A, while table 3.4 below provides a summary for these selected years. The considered assumptions to build the scenario were in general consistent with the national population growth and GDP as there are no major changes expected within the sector.

Table 3.4: GHG emissions of the baseline scenario for agriculture sector for selected years (Gg)

Annual Emissions Agriculture	CH_4 Livestock (Fermentation +Manure)	CH_4 Agricultural residues	Total CH_4	N_2O-Indirect Soil emissions	N_2O-Direct Soil emissions	N_2O-Agricultural residues	Total N_2O	Total CO_2eq (Gg) for Agriculture
2010	0.0182	0.0825	0.1006	3.30	1.06	0.0007	4.35	1351.75
2015	0.0197	0.0878	0.1075	3.48	1.13	0.0008	4.67	1449.04
2020	0.0212	0.0945	0.1158	3.59	1.22	0.0009	5.03	1561.02
2025	0.0229	0.1018	0.1247	3.75	1.31	0.0009	5.42	1681.67
2030	0.0247	0.1097	0.1344	3.86	1.42	0.001	5.83	1811.63
2035	0.0266	0.1182	0.1448	4.04	1.52	0.0011	6.29	1951.64
2040	0.0286	0.1273	0.1559	4.16	1.64	0.0012	6.77	2102.47

3.3.5 Emissions from land use, land use change and forestry activities

The LULUCF is supposed to be a sink for GHGs, but it has contributed 3 % to the total GHG emissions according to the 2006 GHG Inventory as a result of having only a small forest area, less than 1 percent of the country's total area. It is assumed in the baseline projections that these emissions will be reduced with the increasing concern of forests protection and higher law enforcement at national level. Table A.22 of Appendix A illustrates the baseline scenario for the agricultural activities and the LULUCF for 2007-2040 while table 3.5 below provides a summary for selected years.

Table 3.5: GHG emissions of the baseline scenario for LULUCF sector for selected years (Gg CO_2 eq.)

Year	CO_2 Emissions from Changes in forest and other woody biomass stock	CO_2 Emissions by Soil from Land-Use Change and Management	Total CO_2 (Gg) for LULUCF
2010	430.53	1283.33	852.80
2015	449.97	1650.00	1200.03
2020	472.93	1650.00	1177.07
2025	497.05	1650.00	1152.95
2030	522.41	1650.00	1127.59
2035	549.05	1650.00	1100.95
2040	577.06	1650.00	1072.94

3.3.6 Total GHG emissions of the baseline scenario

Jordan's anthropogenic emissions by sources, and removals by sinks, of all GHGs in 2006, were estimated to be 28,717 Gg of CO_2eq, these emissions are expected to grow according to the baseline scenario to 38,151 Gg, 51028 Gg and 61,565 Gg of CO_2 eq in the years 2020, 2030 and 2040 respectively. Figure 2 below and Table A.23 of Appendix A illustrates the overall GHG emissions of the baseline scenario and those of the emitting sectors of primary energy (PE), industrial processes (IP), waste, agriculture and LULUCF while Figure 3.2 and table 3.6 below provide a summary for selected years.

Figure 3.2: Jordan's Baseline Scenario for (2007-2040)

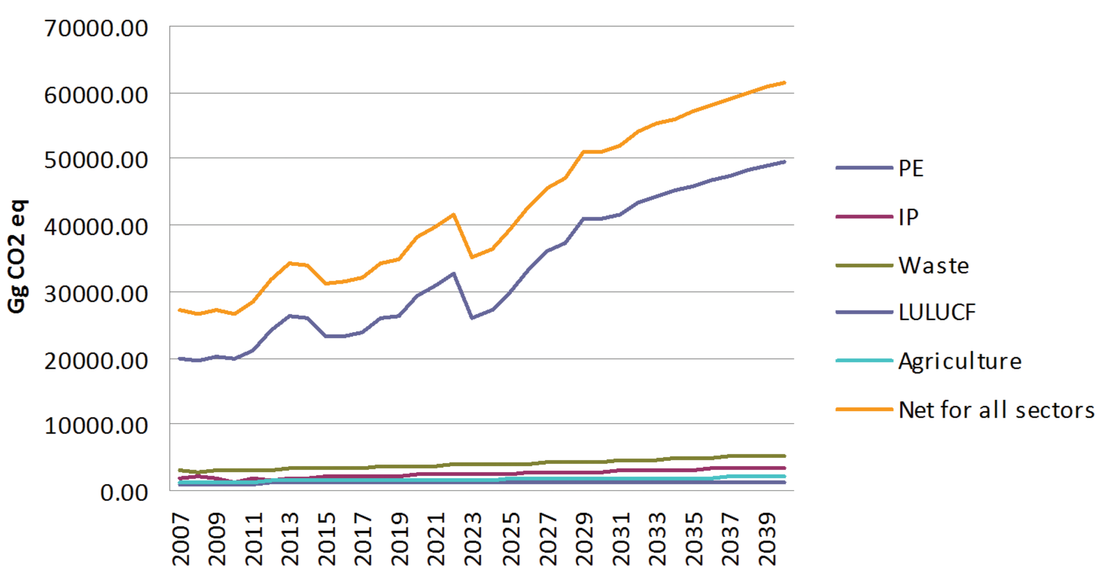


Figure 3.3: Share of various sectors in the total GHG emissions for selected years in the baseline scenario

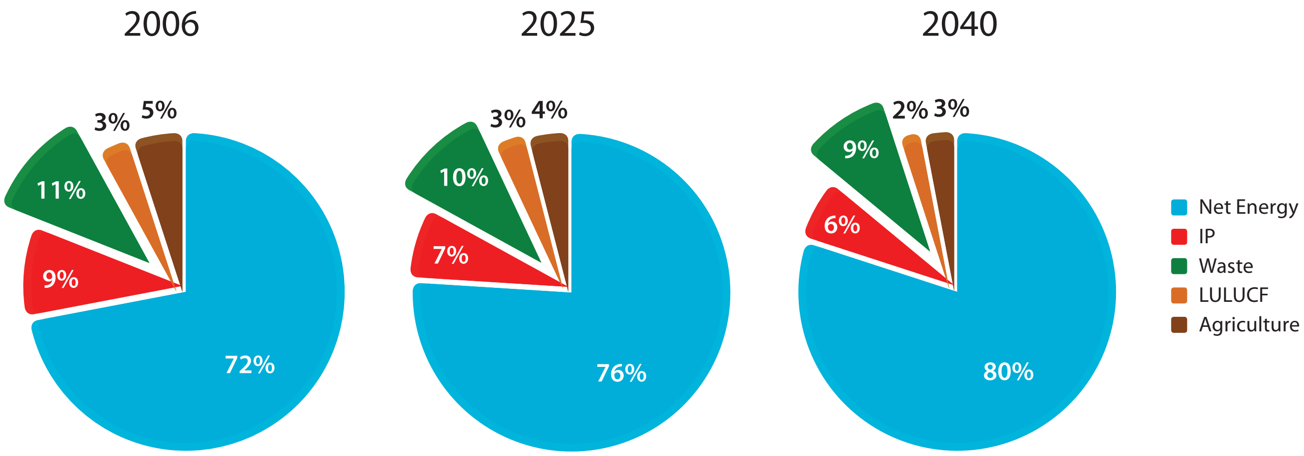


Table 3.6: Jordan's GHG emissions of the overall baseline scenario for selected years

Year	Primary Energy	Industrial processes	Waste	LULUCF	Agriculture	Net for all sectors CO_2eq (Gg)
2010	19990.16	1365.00	3017.00	852.80	1351.75	26576.71
2015	23242.98	1998.00	3301.00	1200.03	1449.04	31191.05
2020	29406.49	2303.00	3703.00	1177.07	1561.02	38150.58
2025	29884.65	2598.00	4026.00	1152.95	1681.67	39343.27
2030	40824.52	2900.00	4364.00	1127.59	1811.63	51027.74
2035	45972.27	3195.00	4863.00	1100.95	1951.64	57082.86
2040	49610.01	3481.00	5299.00	1072.94	2102.47	61565.42

3.4 MITIGATION SCENARIO

A mitigation scenario reflects a future in which explicit policies and measures are adopted to reduce the sources (or enhance the sinks) of GHGs.

In this section, the impact of specific emission reduction actions/options was assessed against the baseline scenario. Relative costs and benefits of mitigation actions were also assessed.

A total of 43 GHG mitigation projects were proposed in the following areas:

- Primary energy,
- Renewable energy,
- Energy efficiency,
- Transport,
- Industrial processes,
- Waste, and
- Agriculture.

The cost, benefits and CO_2 emission reduction were analyzed for each proposed mitigation project. Net present value method was used in the financial calculations, by converting all of the future revenues and costs over the period of the project based on today's cost. The same approach was utilized when calculating CO_2 emission reductions over the lifetime of the proposed projects. A discount rate of 8 % was used in all calculations. The discounted unit cost of reduced emissions is the quotient of the discounted net cash flow to the discounted emission reductions. The results of the analysis are presented in the following sub-sections.

3.4.1 Proposed Mitigation Projects in Primary Energy

A wide range of GHG mitigation options in the primary energy supply and demand were reviewed and investigated to identify the most applicable options to the existing infrastructure and options to be considered for future system expansion. Five mitigation projects were proposed which could lead to noticeable and cost-effective emission reductions. The proposed projects are:

- **Project No. (1) : Loss Reduction in Electricity Transmission and Distribution (T&D)**

  This project is aiming to reduce the T&D losses to drop to 12% in 2020 compared to 17.5% in 2013. The duration of the project will be 6 years starting 2016 and will be executed gradually. The main components of the project will be optimizing the utilization of the distribution generation, improving the system power factor, upgrade or replacing existing conductor and insulators with lower-resistance equipment. The cost is estimated to be 275 $/Kw. This project can lead to a significant reduction in fuel consumption and CO_2 emissions of 8453 thousand tons CO_2 through the next 25 years. At an incremental cost of -57.54 US$ per ton CO_2.

- **Project No. (2): Improving Combustion Efficiency in Rehab Power Plant**

  Rehab is one of the main power plants in the electricity generation system with a capacity of 480 MW. The average heat rate for the plant in 2012 was 8675 KJ/Kwh. This GHG mitigation project is aims to reduce the unit heat rate, i.e, the amount of fuel needed to generate one Kwh and decreasing the on-site power consumption to make more electricity available to the grid. This will be achieved through improving boiler tuning as part of a regular scheduled plant maintenance programs and upgrading and replacing plant maintenance program and upgrading and replacing plant equipment, such as turbine blades, controls, and values and also by treating the fuel to remove impurities to improve combustion characteristics. Implementing the above options will improve plant performance and decrease the unit heat rate by 5%. Or in terms of efficiency, a gain of 2.4%. Rehab is a base load unit with a capacity factor of 1.0, it is assumed that efficiency improvement will be finished in one year, that is 2017, and the natural gas will be used in Rehab power plant during the period 2015-2040. This project can also lead to noticeable reduction in fuel consumption as well as CO_2 emissions reduction which account to 300 thousand tons through the next 24 years. At an incremental cost of -39.47 US$ per ton CO_2.

- **Project No. (3): Combined Cycle Gas turbine in Risha Plant**

  The Risha power plant consists of (5X30) MW gas turbine with total capacity of 150 MW. Currently, two units are in operation due to shortage of natural gas production in Risha field. It is suggested to convert the two gas turbines into combined cycle power plant by adding 50 MW steam turbine, in this configuration, a natural gas is burned to operate the two gas turbine to generate electricity. The hot turbine exhaust gasses are passed through a steam boiler to produce steam for a steam turbine. The steam turbine utilizes waste heat from the turbine that, in a simple cycle would have been rejected to the atmosphere. This project will add 50 MW to the plant capacity without any extra cost for additional fuel. The additional electricity increases the overall system efficiency. It is suggest that the project to be implemented in 2017, 2018. With a total cost of 55 million US$.

This project will be very efficient. This technology will add (50) MW to Risha plant without any extra cost and this could lead to significant reduction in natural gas consumption and CO_2 emissions reduction which account to 1601 thousand tons through 22 years from 2019-2040. At an incremental cost of -27.52 US$ per ton CO_2.

- **Project No. (4): Distribution Network of Natural Gas in Aqaba**

To diversify the natural gas resources, the decision was taken to construct LNG Jetty at Aqaba port and connect with main Arab Gas Pipeline and leasing Floating Storage and Regasification Unit (FSRU). It is expected to start importing LNG by the first quarter of 2015. The capacity of the (FSRU) will be (160) thousand cubic meters of liquefied gas and can provide up to (715) million cubic feet/day with more than the needs of the electricity generation system during the period (2015-2040). Therefore, the ability to exploit the excess of the (FSRU) and to diversify the energy source and to reduce the environmental impact of oil products, Jordan must enhance the usage of Natural Gas in all sectors such as the Residential, Commercial and transportation: the use of natural gas instead of liquefied petroleum gas for cooking, diesel in central heating and water heating, gasoline for cars. To deliver gas to smaller customers, it will be necessary to construct new low-pressure gas distribution networks and connect customers to the new infrastructure. Investments required in this industry are large.

In light of the forgoing, a new low-pressure gas network in Aqaba has been proposed to deliver gas to small customers. The duration of this project will be 5 years, starting in 2017 and will be executed gradually with a capital cost of 45 million US$.

Natural gas combustion emits 1.2 times less CO_2 that that of oil, which indicates that using natural gas in industries as an alternative for diesel and fuel oil will mitigate a significant quantity of CO_2 emissions. Using the natural gas in distributing network in Aqaba will mitigate about 1135 thousand tons of CO_2 emissions in the next 24 years. At an incremental cost of -7.71 US$ per ton CO_2.

- **Project No. (5): Demand Side Management (DSM)**

DSM includes any actions implemented to reduce the contribution to system peak load or reduce overall energy consumption. The basic objective of DSM is to reduce costs (operating and capital costs) through improving efficiency of end uses of electricity or modifying their electricity consumption pattern. This DSM project is designed for what so called Variable Speed Drive Program which consists of optimizing motors used for different types of equipment including pumps, ventilators, conveyors, industrial equipment etc. The optimization is to take place by introducing speed controls for the electrical motors. This is done by varying the frequency, voltage and amperage supplied to the motor. The study showed that the variable speed drive program can reduce the peak load demand by app. 100 MW at evening peak and an energy saving of app. 660 GWh. The total investment in the variable speed drive program is 65 Million US$.

The variable speed drive program is rather complex to implement due to the involvement of many actors in the market. This program will be applied over a period of five years. Of course, the owners of the motors need an initiative for investing in the controllers. The energy saving is a strong argument for the owners to introduce this control, but indirectly an energy saving will influence many actors in the market including the generation, transmission and distribution companies. This project will be very efficient and can lead to significant reduction in CO_2 emissions which account to 2488 thousand tons through the next 24 years. At an incremental cost of -30.1 US$ per ton CO_2.

The cost and the CO_2 emission reductions were analyzed for the five proposed projects. A summary of the results is shown in following table 3.7.

Table 3.7: Emission reduction and emission reduction unit cost for the primary energy mitigation projects

Project Name	Total discounted cost (M JD)	Total Discounted Emission Reductions (KTons CO_2eq)*	Reduction Unit Cost (JD/Ton CO_2eq) **
Reduction of Loss in Electricity Transmission and Distribution (T&D)	-343.4	8435	-40.7
Improving Combustion Efficiency in Rehab Power Plant	-8.5	300	-27.9
Combined Cycle Gas Turbine in Risha Plant	-31.2	1601	-19.5
Distribution Network of Natural Gas in Aqaba	-6.4	1135	-5.5
Demand Side Management: introducing activities to reduce overall energy consumption	-61.6	2488	-21.3
Total reductions for the sector		13959	

*: KTons= Gg
**: Figures are rounded

3.4.2 Proposed Mitigation Projects in Renewable Energy

The following foreseen projects were investigated in the area of renewable energy. These projects include five projects to generate electricity from wind energy, solar (photo voltaic and concentrated solar power) and biogas for domestic solid waste. Three projects were proposed to install solar water heaters in houses.

Table 3.8: Description of proposed renewable energy projects in mitigation scenario

Project No.	Project Name	Description
1	150 MW Wind Farm	This project is included in planned renewable energy projects to be implemented until 2020 within the second round of the Direct proposals. The project capacity will be 150 MW and the estimated electricity production from the project will be around 341640000 KWh annually with a total estimated cost of around MJD 195. It is expected that this project will be in operation by 2018 and will reduce GHG by 198 Kt annually with an estimated mitigation cost of (-45.7) JD/ton.
2	100 MW Concentrated Solar Power (CSP)	This project has been selected based on the current development of Concentrated Solar Power in the world and it is expected that the concentrated technology will play a major role in producing electricity with a great possibility of using thermal storage to utilize excess heat during night time to insure the continuity of power production. The proposed capacity of this project will be 100 MW as a first large scale project of its kind with an estimated annual electricity production of around 236520000 KWh and a total cost of around MJD 350. It is expected that this project will be in operation by 2019 and will reduce GHG by 137 Kt annually with an estimated mitigation cost of (6.24) JD/ton.

Project No.	Project Name	Description
3	PV 1-200 MW	Photovoltaic systems are widely used in the world and it is a well-known technology by the public in Jordan. This 200 MW PV project will be installed in the northern part of Jordan, according to the planned projects by MEMR until 2020. The proposed capacity of this project will be 200 MW with an estimated annual electricity production of around 304000000 KWh and a total cost of around MJD 300. It is expected that this project will be in operation by 2016 and will reduce GHG by 176 Kt annually with an estimated mitigation cost of (-13.01) JD/ton.
4	PV 2- 200 MW	This proposed project will also be implemented according to the direct proposals by MEMR until 2020. The capacity of this project will be 200 MW with an estimated annual electricity production of around 304 GWh and a total cost of around MJD 200 (it is expected that the unit cost JD/KW will be declining by time). It is expected that this project will be in operation by 2018 and will reduce GHG by 176 Kt annually with an estimated mitigation cost of (-66.09) JD/ton.
5	300 MW CSP	It is expected that the cost of CSP technology will decline by time and might reach 2500 JD/KW. The proposed capacity of this project will be 300 MW with an estimated annual electricity production of around 709.56 GWh and a total cost of around MJD 750. It is expected that this project will be in operation by 2023 and will reduce GHG by 412 Kt annually with an estimated mitigation cost of (-61.98) JD/ton.
6	Biogas power plant-15 MW AL-EKADER WASTE DUMPING SITE	This project is included in MEMR plan to be implemented by private sector in the northern part of Jordan at Al-Ekader waste dumping site. The proposed capacity of this project will be 15 MW with an estimated annual electricity production of around 30 GWh and a total cost of around MJD 30. It is expected that this project will be in operation by 2018 and will reduce GHG by 17 Kt annually with an estimated mitigation cost of (58.01) JD/ton..
7	Solar Water Heaters1-30000 houses	Solar water heaters are widely used in Jordan many years ago. It can save a lot of energy which is used to heat water for domestic use. A plan of installing solar water heater for household sector is proposed in three stages during 2016-2020. It is assumed that solar water heaters will replace electric heaters and every house requires a solar water heater of 4.6 m^2 and every m^2 can produce around 740 KWh/year (applies for all proposed projects on solar water heaters in this document). This proposed project includes the installation of 30000 solar water heaters. The installed capacity of this project will be 54 MW with an estimated annual electricity reduction of around 102 GWh and a total cost of around MJD 15. It is expected that this project will be in operation by 2016 and will reduce GHG by 81 Kt annually with an estimated mitigation cost of (-104.83) JD/ton.
8	Solar Water Heaters2-30000 houses	This proposed project includes the installation of 30000 solar water heaters. The installed capacity of this project will be 54 MW with an estimated annual electricity reduction of around 102 GWh and a total cost of around MJD 13.5 (the cost is expected to decline by time). It is expected that this project will be in operation by 2018 and will reduce GHG by 81 Kt annually with an estimated mitigation cost of (-107.01) JD/ton.
9	Solar Water Heaters3-30000 houses	This proposed project includes the installation of 30000 solar water heaters. The installed capacity of this project will be 54 MW with an estimated annual electricity reduction of around 102 GWh and a total cost of around MJD 12 (the cost is expected to decline by time). It is expected that this project will be in operation by 2020 and will reduce GHG by 81 Kt annually with an estimated mitigation cost of (-109.18) JD/ton.

The following table (3.9) summarizes the emission reductions and emission reduction unit cost for each proposed project in the sector.

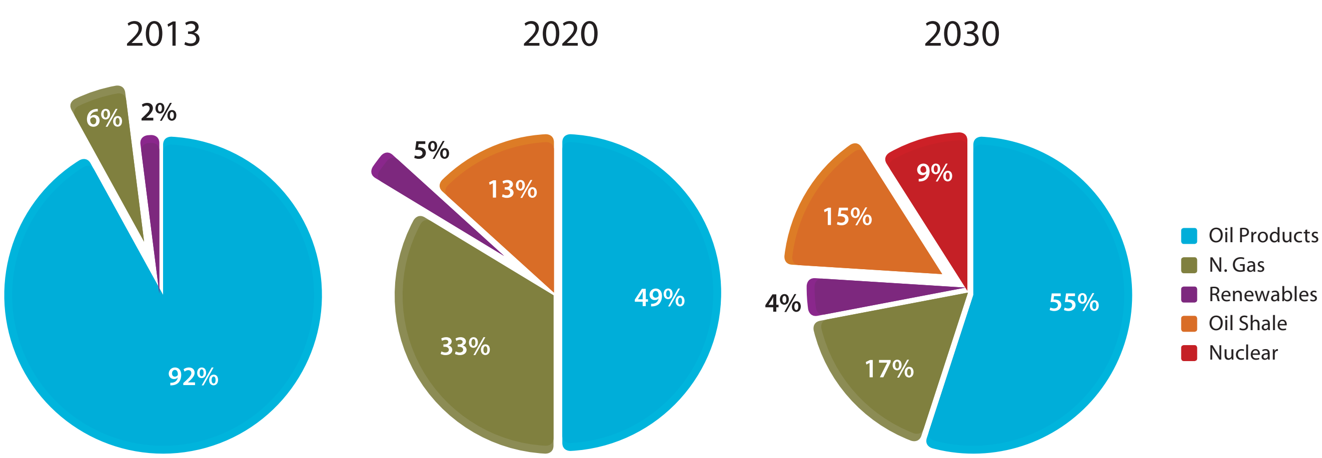
Impact of implementation of renewable energy projects on the overall energy mix

The energy mix before and after taking into consideration the proposed renewable energy mitigation projects were assessed to evaluate the impact of these mitigation projects. Based on the baseline analysis, the energy mix in 2013 consists of oil products at 92%, natural gas at 6% and renewable energy at 2%. While in 2020 it is expected to be 49% oil products, 33% natural gas, 13% oil shale, and 5% renewable energy. And for the year 2030 the contribution of all types of energy in the energy mix will be oil products 55%, 17% natural gas, 15% oil shale, 4% renewable and 9% nuclear energy. Figure 3.4 illustrates the primary energy mix for the years 2013, 2020 and 2030.

Table 3.9: Emission reduction and emission reduction unit cost for the renewable energy mitigation projects

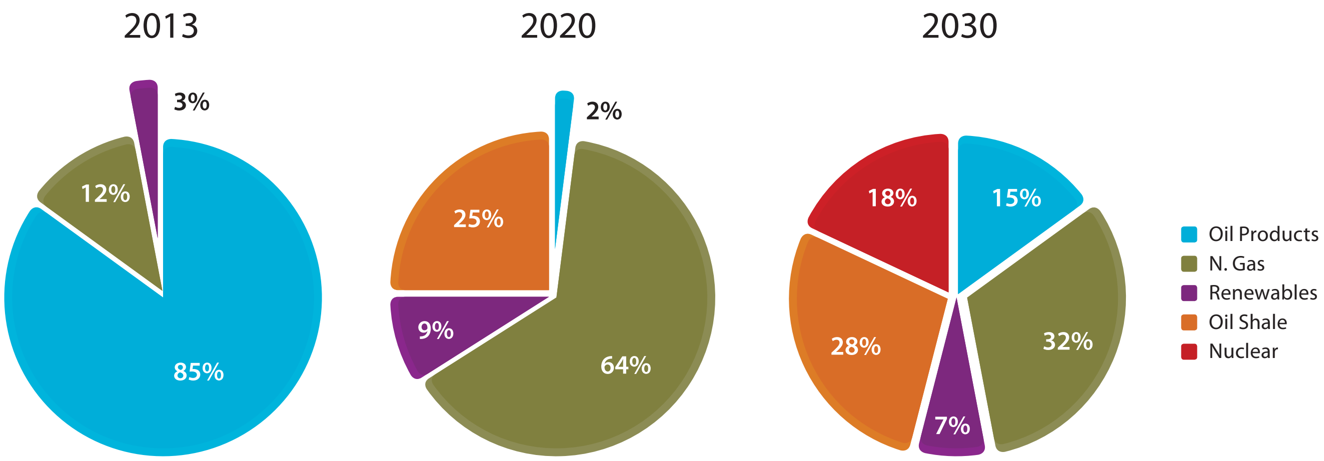
Project Name	Total discounted cost (M JD)	Total Discounted Emission Reductions (KTons CO_2eq)	Reduction Unit Cost (JD/Ton CO_2eq)
150 MW Wind Farm	96.8	2117.2	-45.7
100 MW Concentrated Solar Power (CSP)	9.2	1465.8	6.2
Photo Voltaic (PV) 1-200 MW	24.5	1884.0	-13.0
Photo Voltaic (PV) 2- 200 MW	124.5	1884.0	-66.1
300 MW Concentrated Solar Power (CSP)	272.5	4397.3	-62.0
Biogas Power Plant- 15 MW	10.8	186.0	58.0
Solar Water Heaters 1-30000 Houses	72.3	690.0	-104.8
Solar Water Heaters 2-30000 Houses	73.8	690.0	-107.0
Solar Water Heaters 3-30000 Houses	75.3	690.0	-109.2
Total reductions for the sector		**14003.3**	

Figure 3.4: Primary energy mix for the years 2013, 2020, 2030



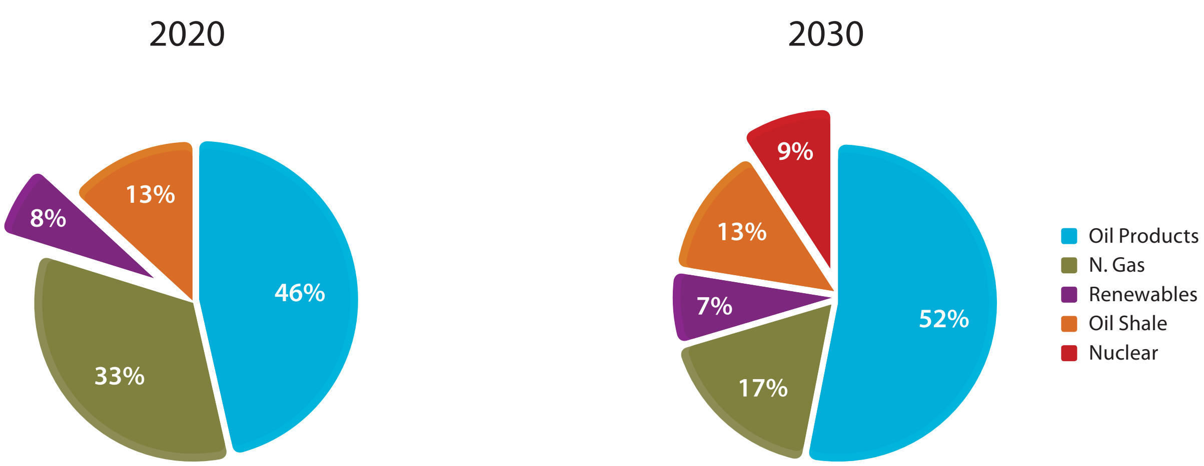
The contribution of all types of energy in electricity generation in 2013 consists of oil products at 85%, natural gas at 12% and renewable energy at 3%. While in 2020 it is expected to be 2% oil products, 64% natural gas, 25% oil shale, and 9% renewable energy. And for the year 2030 the contribution of all types of energy in the energy mix will be oil products 15%, 32% natural gas, 28% oil shale, 7% renewable and 18% nuclear energy. Figure 3.5 illustrates the primary energy mix for the years 2013, 2020 and 2030.

Figure 3.5: The contribution of all types of energy in electricity generation



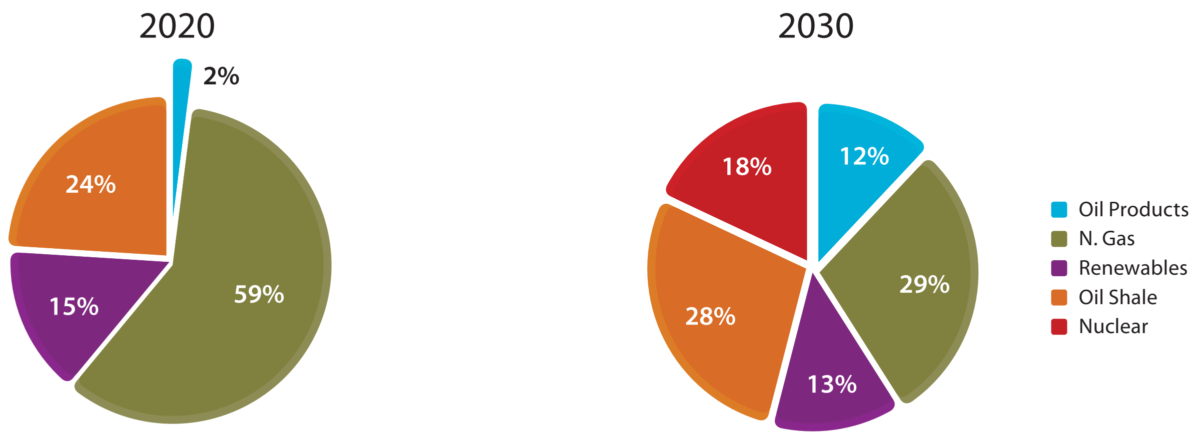
With the implementation of the suggested renewable energy mitigation projects the energy mix in 2020 is expected to consist of 46% of oil products , natural gas at 33% and renewable energy at 8%. While in 2030 it is expected to be 52% oil products, 17% Natural gas, 15% oil shale, and 7% renewable energy and 9% from nuclear energy (Figure 3.6).

Figure 3.6: Primary energy mix for the years 2020 & 2030 with mitigation options



With the implementation of the suggested renewable energy mitigation projects the contribution of all types of energy in electricity generation in 2020 consists of oil products at 2%, natural gas at 59% and renewable energy at 15%. While in 2030 it is expected to be 12% oil products, 29% Natural gas, 28% oil shale, 13% renewable energy and 18% from nuclear energy (Fig 3.7).

Figure 3.7: The contribution of all types of energy in electricity generation for the years 2020 & 2030 with mitigation options



In summary, according to the baseline scenario the renewable energy share in the energy mix is 2%, 5% and 4% in 2013, 2020 and 2030 respectively and its share in electricity generation is 3%, 9% and 7% in 2013, 2020 and 2030, respectively. With the proposed renewable energy mitigation measures, the renewable energy share in the energy mix is 8% and 7% in 2020 and 2030, respectively and its share in electricity generation is 15% and 13% in 2020 and 2030, respectively. From this analysis it can be concluded that with the implementation of the proposed renewable energy mitigation measures the country will be approaching the ambitious target of 10% share of the renewable energy in the energy mix in 2020 as set by Jordan energy strategy. However, more efforts have to be done at all levels to raise the share of renewable energy in the future.

3.4.3 Proposed Mitigation Projects in Energy Efficiency

Seven proposed projects were investigated in the area of energy efficiency with four projects in the industrial sector, one in the commercial sector, one in the residential sector and one in street lighting. Table 3.9 summarizes the emission reductions and emission reduction unit cost for each proposed energy efficiency project.

(1) Project name: Replacing High Thermal Mass with Low Thermal Mass (LTM) in Ceramic factories

Sanitary ware industry uses the open flame tunnel kiln to fire the products. The open flame tunnel kiln is a continuous type kiln, wherein the raw product is fed at one side and on the other side the finished product is taken out. The raw product undergoes firing and cooling cycles, as it moves from the front end to the back end of the kiln. The material movement through the tunnel kiln is by kiln cars, run on rails. The kiln cars are like train bogies designed to hold the products. Diesel is used as a fuel in tunnel kiln. The kiln cars are constructed with refractory and insulating bricks. Due to high thermal mass, kiln cars consume considerable amount of heat energy supplied to the kiln.

The weight reduction of the kiln cars gives the significant amount of energy savings in tunnel kiln. Low thermal mass materials (LTM) are now being used for kiln car construction, which reduces the weight of the kiln car considerably. In local Ceramic Factories, kilns are used to produce sanitary wares. Some parts of the kiln cars are made of materials with high thermal mass. Consequently, a huge amount of energy is spent in heating these masses. Therefore, reducing the thermal mass of these parts will result in a saving in energy needed to heat these masses. It is recommended replacing some parts in the present kiln cars with Low Thermal Mass (LTM) materials; this will result in 7.5 % saving in energy. The approximate present fuel consumption in these factories is about 2000,000 liters of diesel annually.

(2) Project Name: Returning Un-returned condensate to the feed water tanks in Food Industry:

In food factories, condensate resulting from the condensation of steam in some production processes is drained without the use of its heat. The value of this valuable condensate is represented by the water treatment cost, heating cost using a Heavy oil-operated steam boiler and the cost of the water itself. Therefore, returning this condensate to the boiler feed water tank will save energy. A condensate collection station can be used for this purpose from which the condensate is pumped to the feed water tank. A condensate pump is required for this purpose; Energy saved as a result of this measure is 9500000 MJ. Fuel used in the steam boilers is Heavy Fuel Oil.

For a single plant, total initial investment needed for this purpose is: Tank +Insulated piping +Pump = 7000 JD, the annual running cost of the system is represented by the pumps only. The running cost is 2500 JD annually.

(3) Project Name: Insulating the Un-insulated pipes, fittings and tanks in food industries;

In some food factories, the steam and condensate lines, steam and condensate valves and feed water tank are un-insulated which Insulating them will save energy. Total Energy Saved is 10590000 MJ; Total investment needed is 85000 JD.

(4) Project Name: Replacing the Fluorescent lamps fixtures with LED lamps fixtures in commercial buildings:

In commercial office buildings, there are 100000 fluorescent tubes units (18 watt).All these fluorescent tubes have conventional ballasts. Replacing these units with (18X4) LED fixtures will result in 60 Watts saving in each fixture. Operational hours = 1400 hours. Initial investment (cost of LED fixture) = (12.8 JD/lamp) X (4 lamps /fixture) X100000 fixture= 5120000 JOD.

(5) Project Name: Insulating walls and roofs in 35000 new houses.

A survey showed that 80 % of the new residential buildings are not insulated. It is there for suggested to insulate walls and roofs in these houses. Saving resulting from this measure is about 50% of the annual heating and cooling bills in theses dwellings. The heating and cooling demands are assumed to be satisfied by a heat pump. The annual energy consumption in a single dwelling is 10500 kWh, for a 150 m2 dwelling. The total energy consumption is 29.40 Million kWh or 29400 MWh. The saving resulting from using insulation will therefore be 14700 MWh. The estimated cost for roof and wall insulation is about 950JD. Arab center energy cost is 0.115JD/kWh.

(6) Project Name: Street Lighting: Replacing 125 W Mercury lamps with 70 W high Pressure Sodium lamps.

In steel lighting, it is suggested to replace 200,000 lamps that are now of Mercury type with 200,000 lamps of High Pressure Sodium lamps .Each 125 W Mercury lamp is 137 W (including ballast), and each 70 W HPS lamp is 84 W (including ballast). The resulting saving is (137 W - 84 W) = 53 W Operational Hours for every street light is 12 hours/day= 4380 h/year. For the 200000 lights, the operational hours will be 876000000 hours. The energy saved= 876000000X53 W= 46428000000 Wh= 46428 Mwh the cost of each Luminaries including installation is about 50 JD, the total cost of the new luminaries is 10 Million JD. Life cycle of HPS lamp = 24000 hours Street Lighting electric Tariff= 0.106 JD/kWh.

(7) Project Name: Using Regenerative burners instead of conventional burners in Steel Reheating Industry.

In steel factories, the reheating furnace use heavy fuel oil to reheat the billets. High speed pressure jet burners are used for this purpose Regenerative burners can be used efficiently for this purpose. A potential energy saving of 10 % can be achieved by using this technology. The annual Heavy Fuel Oil consumption is 24000 tons with the cost of 11448000 JD. The 10 % saving in energy for 5 factories, it will be 1144800 JD. Total initial investment needed for this purpose is 800 000 JD for all burners in the furnace including labor coat. Also the annual additional periodic maintenance cost will be about 500 JD.

(8) Project Name: Using Variable Speed Drives in the pumps

For eight paper factories, the flow of a certain set of pumps varies according to the production process. This suggests using Variable Speed Drives (VSD) for these pumps. About 360 kW of electrical power can be saved by using this approach. An annual energy saving of 1800MWh can be achieved. This translates to 112000 JD can be saved annually. Initial investment needed to implement this measure is about 200,000 JD.

3.4.4 Proposed Mitigation Projects in Transport

1. THE BUS RAPID TRANSIT - AMMAN AND AL-ZARQA.

The project cost is around 68 million JD, and the project is expected to be financed as a grant from the Kuwaiti Fund for Arab Economic Development.

Assumptions

- Annual increase of reduction of fuel consumption and CO_2 emission after using BRT project equal to annual population growth which was 2% for the year (2008-2012).
- The project will start working in 2016.
- Basis of calculations:
  - Conversion factor for Diesel = NHV diesel/ NHV crude oil= 42.396/42.082 =1.007473
  - Diesel density =0.84 kg/m^3
  - Diesel price = 0.67 JD

2. REPLACING CONVENTIONAL SMALL PASSENGER PUBLIC CARS WITH HYBRID CARS.

Assumptions

- Replacing conventional small passenger public cars with Hybrid cars within 10 years staring from 2015.
- Fuel saving 38%, (Prioritizing Climate Change Mitigation Alternatives: Comparing Transportation Technologies to Options in Other Sectors June 2008, Nicholas Lutsey).
- Average annual growth for small passenger public cars is 1%.
- Cost of hybrid car is higher than conventional car about 4000 JD.
- Life time for hybrid public passenger car is (10) years.

3.4.5 Proposed Mitigation Projects in Waste Sector

Ten mitigation projects in the waste sector were assessed, five of them deal with biogas collection from landfill sites and their utilization in electricity generation and the other five projects deal with biogas generation from the sludge generated from domestic WWTP and utilization in electricity generation.

Five projects were proposed for the most important domestic solid waste landfills in Jordan where these projects aimed at collecting the generated biogas from the landfills, treating the collected biogas from impurities and generating the electricity using biogas generator then connecting the generated electricity to the national electricity grid. For domestic wastewater treatment plants, Even though the ministry of water and irrigation had shown no desire in investigating in digesters, five projects were proposed. These projects aimed at utilizing the generated sludge from the domestic wastewater treatment plants to generate biogas and connecting the generated electricity to the national electricity grid. All of the proposed projects will contribute in reducing the amount of fuel used for generating the electricity.

One project is proposed to reduce quantities of waste transferred to landfill form small marginal communities in Ajlun governorate. The main saving of such project is attributed to reduction in transportation trips to landfill by municipality trucks.

For the proposed projects and for the purpose of financial calculations (feasibility study), net present value was used where all costs, revenues and CO_2 emission reductions over the lifetime of the proposed project were converted to a base of today cost. For all proposed projects, 8% discount rate was used and the discount unit cost was calculated as the ratio between the discounted net cash flow and the discounted emission reductions. All calculations were based on some assumptions that were mentioned in the report.

Table 3.10: Emission reduction and emission reduction unit cost for energy efficiency mitigation projects

Project Name	Total discounted cost (M JD)	Total Discounted Emission Reductions (KTons CO_2eq)	Mitigation cost (JD/ton)
Replacing high thermal mass with low thermal mass in ceramic factories	968,140	4,214	-229.73
Returning un-returned condensate to the feed water tanks in Food Industry	941,178.25	7,546.32	-124.7
Insulating the un-insulated pipes, fittings and tanks in food industries	2,046,252.61	8,053.3	-254.09
Replacing the Fluorescent lamps fixtures with LED lamps fixtures in commercial buildings	9,738,183.69	51,348.75	-189.65
Insulating walls and roofs in 35000 new houses.	24,688,867.17	89,852.42	-274.77
Street Lighting: Replacing 125 W Mercury lamps with 70 W high Pressure Sodium lamps.		37,023,238	279,541.52
Using Regenerative burners instead of conventional burners in Steel Reheating Industry.	7,320,932.99	76,611	-95.56
Total reductions for the sector		**517,167**	

Table 3.11: Reduction of CO_2 by Introducing Amman – Zarqa BRT Project

	Emissions CO_2 (g)/ passenger /km (*)	Distance (km)	No of Passengers	CO_2 Emissions 000 ton / day	CO_2(000) ton /300 day
Amman – Zarqa BRT	80				
Conventional bus	190				
Reduction form Amman- Zarqa BRT	110	26	100,000	0.286	85.8

Table 3.12: Reduction Cost of CO_2 for Public Passenger Cars

Saving (*)	no of public passenger cars in year 2012 (**)	no. of hybrid cars replaced by conventional passengers cars yearly (10%)	gasoline consumption by public cars 2012 TOE (***)	average yearly gasoline consumption by each conventional public passenger car year 2012 TOE	Reduction of gasoline consumption for each car by using hybrid public passenger car TOE	Reduction of gasoline consumption by replacing 10% yearly of conventional passengers cars by hybrid cars (000) TOE	Reduction of CO_2 emissions (000 ton) by using hybrid cars for public passenger cars
38%	23817	2381.7	180000	7.56	2.872 #	6.84	19.75

(*)Prioritizing Climate Change Mitigation Alternatives: Comparing Transportation Technologies to Options in Other Sectors June 2008, Nicholas Lutsey.
(**) MOT Annual Report 2012.
(***) MEMR Transport Sector Survey year 2012.
: Reduction of gasoline consumption for each car by using hybrid public passenger car TOE=no. of cars *7.56*38%

Projects proposed for landfills shows positive values for discounted unit cost figures while those proposed for wastewater treatment plants shows negative discounted unit value. Despite the fact that all the proposed projects were already proposed within the Second National Communication report, reconsidering them again with new assumptions in calculation has resulted in different unit cost.

All electricity produced is assumed to be sold to the national grid at a cost of 60 fils per kwh which is the maximum cost proposed by the government and seems to be very ambitious.

Proposed projects for domestic solid waste landfills

The following tables show the summary results for the most important domestic solid waste landfills in Jordan. The following assumptions were used during the calculation:

- The staring year for implementing the proposed projects is 2015.
- The construction activities, commissioning and test run will take 1 year (the actual running for the proposed projects will be in year 2016).
- Total amount of solid waste generated and received for each landfill is calculated as the amount of solid waste generated in the base year (2006) multiplied by the average growth rate of the population.
- Density of methane = 0.717 kg/m^3.
- The captured methane for all landfills is calculated according to PRIF study (Environment and use of methane from municipal waste), Amman, 1993 where the average value is used (35% capture rate).
- The calculations of CO_2 saved from electricity generation are according to the factor of 0.580548 published in Jordan NAMA report.
- The calculation of total MW is based on that the working hours per year are 8000 hours.
- The generated electricity will be sold at fixed price of 0.06 JD/kWh according to reference of electricity prices from renewable sources issued based on clause 2 of renewable energy and energy efficiency law (13/2012) as published in national gazette
- The cost of 1 MW biogas electricity generation system (generator, wells, piping etc) is 1.5 MJD (from IRENA).
- The operation and maintenance cost was taken as 10% form capital cost for landfills.

The following table (3.14) summarizes the emission reductions and emission reduction unit cost for each proposed project in the waste sector.

3.4.6 Proposed Mitigation Projects in Industrial Sector

As the cement process is the leading contributor to CO_2 emissions in Jordan, three mitigation projects were analyzed to reduce emissions of cement industry. Also one project is related to the use of biomass as an alternative fuel and the other one proposed to reduce N_2O emissions in the fertilizer industry.

Project No. 1: Use of steel slag and/or fly ash to substitute the raw materials needed to produce clinker

Certain steel slag and fly ash materials (decarbonated kiln feedstocks) could be added to the raw material feed to reduce the amount of raw material needed to produce a given amount of clinker (EPA, 2010).

Jordan has more than 5 steel melting and galvanizing factories, therefore; there is available stock of steel slag and fly ash to be used in cement industry. However; the implementation of such option needs an experimental investigation of the impact of using the steel slag and/ or fly ash on the properties of produced cement as well as the maximum percentage of raw materials that could be replaced by such additives. To have a reasonable option; a substitution could be estimated to produce new type of cement CEM V (Composite Cement) at one of the cement industries; mainly the one that has a neighbor steel manufacturing Company and can try the production of such project with minor additional costs in comparison to other existing companies. The percentages of blast-furnace slag and natural pozzolana ranges between 31-49% per each to produce CEM V/B as per the following table 7, accordingly; a 40% substitution of steel slag/fly ash and a 10% production of new CEM V/B will be assumed at this company.

Since the cost of energy and raw materials reach 61% of total cost (Blominvest Bank, 2010) as mentioned above, this option will reduce the cost by **29.9 JD/ton cement**. No annual increase in the production costs will be assumed for the period (2015 – 2040). Investment cost to grind

Table 3.13: Emission reduction and emission reduction unit cost for transport mitigation projects

Project Name	Total discounted cost (M JD)	Total Discounted Emission Reductions (KTons CO_2eq)	Mitigation Cost (JD/ton)
Reduction by using hybrid cars for public passengers	316.2	1575.0	200.8
Reduction by Amman – Zarqa Bus Rapid Transit (BRT)	302.5	1087.0	215.7
Total emission reductions for the sector		2662.0	

Table 3.14: Emission reduction and emission reduction unit cost for municipal solid waste and WWTP mitigation projects

Project Name	Total discounted cost (M JD)	Total Discounted Emission Reductions (KTons CO_2eq)	Reduction Unit Cost (JD/Ton CO_2eq)
Biogas collection and utilization from Al-Dhulil domestic solid waste landfill	11.6	3168.4	-3.7
Biogas collection and utilization from Al-Ekader domestic solid waste landfill	0.1	657.0	-0.2
Biogas collection and utilization from Al-Salt (Hamra) domestic solid waste landfill	5.2	1313.4	-4.0
Biogas collection and utilization from Al-Karak domestic solid waste landfill	5.2	1313.4	-4.0
Biogas collection and utilization from Maddaba domestic solid waste landfill	0.1	657.0	-0.2
Biogas generation by utilizing the sludge generated from Baqa'a tertiary domestic wastewater treatment plant	-2.5	304.4	8.2
Biogas generation by utilizing the sludge generated from Madaba domestic wastewater treatment plant	-2.3	312.6	7.3
Biogas generation by utilizing the sludge generated from Ramtha domestic wastewater treatment plant	-2.6	169.9	15.5
Biogas generation by utilizing the sludge generated from Salt domestic wastewater treatment plant	-1.9	224.2	8.5
Biogas generation by utilizing the sludge generated from Wadi Arab domestic wastewater treatment plant	-2.5	180.2	13.8
Total emission reductions for the sector		**8300.7**	

the steel slag will be estimated as **758,330 JD** (based on the maximum produced tons of CEM II in 2040) based on the estimated cost of 0.75 $/ton cement. (EPA, 2010) Accordingly, table 8 shows the annual cost, saving and net cash flow in JD as a result of implementing this option.

The total discounted cash flow (Discount Rate= 8 %) in 2014 equals 1,892,040 JD and the total discounted CO_2 reduction at the same discount rate of 8 % equals 152.1 Gg CO_2, which means that total discounted cash flow per CO_2 reduction equals **12,440 JD/Gg CO_2** (12.4 JD/ton CO_2).

Project No. 2: Increase the percentage of Pozzolana in CEM II

More than 90% of cement produced at the local cement companies is CEM II (Portland–Pozzolana Cement) with a percentage of Pozzolana ranges between 21-32%. Therefore; there is an area to increase the percentage of Pozzolana in CEM II by improving the reactivity of the produced clinker and the raw mix to produce CEM II/B-P to achieve the required strength of 42.5N that cause the use of Pozzolana of less than 32% (the 3% is substituted by gypsum). Based on the provided data from one of the Cement Companies (Annex 2), the average percentage of Pozzolana in CEM II is around 32% (65% clinker as per the following information and calculations and 3% Gypsum), so this option is not required to be implemented for this company.

Total cement produced (CEM I and CEM II) in 2012 and 2013 = 1298398 ton

Total clinker produced in 2012 and 2013 = 877283 ton

The Company produced 10% of CEM I (95% of clinker) and 90% of CEM II, so the average percentage of clinker in CEM II = ((877283 / 1298398) - (0.1*95)) / 0.9 = 65%

A reasonable 2% more substitution could be assumed on average and so a reduction of CO_2 emissions by 2% could be assumed as well.

The price of pozzolana is estimated to be 20 JD/ton. And as mentioned above, this option will reduce the cost by 29.9 JD/ton cement to save both energy and raw materials and no extra investment cost is needed. Accordingly, table 9 shows the annual cost, saving and net cash flow in JD as a result of implementing this option.

The total discounted cash flow (Discount Rate= 8 %) in 2014 equals 5,860,130 JD and the total discounted CO_2 reduction at the same discount rate of 8 % equals 245.4 Gg CO_2, which means that total discounted cash flow per CO_2 reduction equals 23,880 JD/Gg CO_2 (23.9 JD/ton CO_2).

Project No. 3: Produce new cement product CEM IV with 45% of Pozzolana

It is estimated that 10% of currently produced CEM II/B-P will be changed to CEM IV, strength 22.5X in which the Pozzolana substitution will reach 45% (more by at least 13% (=45-32). CO_2 reduction will be calculated by multiplying the annual CO_2 emissions by the reduced percentage of 13% regarding that for our case this percentage will be also multiplied by the percentage of the products that will be converted from CEM II/B-P to CEM IV which is assumed to be 10% of CEM II/B-P. Therefore; annual CO_2 emissions from producing CEM II/B-P will be multiplied by 1.3% to calculate the CO_2 emissions reduction because of implementing this option.

the price of pozzolana is estimated to be **20 JD/ton** and also this option will reduce the cost by **29.9 JD/ton cement** to save both energy and raw materials and no extra investment cost is needed. Accordingly, table 10 shows the annual cost, saving and net cash flow in JD as a result of implementing this option.

The total discounted cash flow (Discount Rate= 8 %) in 2014 equals 4,109,880 JD and the total discounted CO_2 reduction at the same discount rate of 8 % equals 171.2 Gg CO_2, which means that total discounted cash flow per CO_2 reduction equals **24,000 JD/Gg CO_2** (24.0 JD/ton CO_2).

Project No. 4: Use of biomass (MSW or/and Sewage Sludge) as alternative fuels

A potential reduction of CO_2 emissions in cement industry could be achieved by switching from a traditional fossil fuel to a biomass fuel which is based on the specific emission factor for the fuel as related to its calorific value and carbon content.

Since most of local cement factories are licensed to burn coal, petcoke and alternative fuels such as waste tires, oil shale and used oil to replace the expensive heavy fuel oil, they are equipped with multi-purpose burners which reduce the investment costs for using biomass as alternative fuels. However, the required capital cost depends on the needed storage, segregation, handling, grinding and metering as well as environmental pollution control measures.

To have time for the experimental trials, studies of the maximum percentage of MSW and dried sewage sludge to be used, availability of stocks at market, testing the emissions, conduct EIA study and get the environmental clearance; it is expected to start the implementation of such project in 2016. The project lifetime will be as the lifetime of Cement Plants which expected to be more than 50 years.

Project No. 5: Catalytic Reduction of N_2O inside the Ammonia Burner of the Nitric Acid Plant

The project activity involves the installation of a new N_2O abatement technology that is not commonly used in nitric acid plants. The abatement technology is a pelleted catalyst that will be installed inside the ammonia burner just underneath the precious metal gauzes. This technology is capable to reduce approximately 75% to 80% of the N_2O formed at the precious metal gauzes inside the ammonia burner to atmospheric N2 and O2. (KEMAPCO, 2007)

The project lifetime of this project is estimated to be same as the lifetime of KEMAPCO plant which is estimated to be 25 years (till the year 2040). Table 13 shows the annual reduction of CO_2 and net cash flow from implementing option no. 5.

The total discounted cash flow (Discount Rate= 8 %) in 2014 equals -1,343,860 JD and the total discounted CO_2 reduction at the same discount rate of 8 % equals 1,454.0 Gg CO_2, which means that total discounted cash flow per CO_2 reduction equals **-924.5 JD/Gg CO_2** (-0.9 JD/ton CO_2).

The following table (3.15) summarizes the emission reductions and emission reduction unit cost for each proposed project in the sector.

Table 3.15: Emission reduction and emission reduction unit cost for the industrial processes mitigation projects

Project Name	Total discounted cost (M JD)	Total Discounted Emission Reductions (KTons CO_2eq)	Mitigation Cost (JD/ton)
Use of steel slag and/or fly ash to substitute the raw materials needed to produce clinker	-1.9	152.1	-12.4
Increase the percentage of Pozzolana in CEM II cement	-5.9	245.4	-23.9
Produce new cement product CEM IV with 45% of Pozzolana	-4.1	171.2	-24
Use of biomass (MSW or/and Sewage Sludge) as alternative fuels	-41.7	919.0	-63.1
Catalytic Reduction of N_2O inside the Ammonia Burner of the Nitric Acid Plant *	1.3	1454.0	0.9
Total emission reductions for the sector		**2941.7**	

3.4.7 Proposed Mitigation Projects in Agriculture and LULUCF

The agriculture sector in Jordan contributes a negligible amount of emissions to the overall emissions but nevertheless it can provide good opportunity in terms of decreasing emissions from agricultural activities and increasing the sink capacity by increasing biomass forest area. Five projects are presented in the following were considered by the mitigation team as the most promising.

1- Rangelands Project

Jordan natural rangelands play an important role in covering the livestock feed requirements. In spite of the damage, they sustained during the past five decades the livestock feed. They cover feed requirements for a period of 2- 3 months without complimentary feeding or 30% of food requirements. The productivity of rangelands is highly dependent on rainfall, topography and soil. Feed unit productivity of rangelands is estimated at 40 kilograms of dry feed matter per dunum in areas with 100-200 mm of annual rainfall; and 100 kilograms per dunum in the areas that receive more than 200 mm.

The Project suggest planting rangelands with perennial fodder shrubs in the Badia (Al Jafr and Al Husseinieh) sub-districts within the Maan Governorate; the used assumptions in calculations are:

- An area of 60000 du will be planted: 30000 du of Kochia Scoparia sp & 30000 du with indigenous plant type Atriplex halimus
- Annual rainfall within the targeted area is <100-150 mm
- 50 shrubs per du will give productivity of 50 kg/du as average.
- 50 shrub/du with soil organic carbon sequestration (SOC) rate of 2-4 g m^2/year
- Project lifetime: 15 productive years

It is estimated that productivity during the first and second years will be 10 and 30 kg DM/du, then productivity will increase to reach 50 kg dry matter/du.

Productivity is assumed to decrease gradually in the last three years 45, 35 and 10 Kg DM/du respectively.

2- Biodiversity Conservation Project

New Protected Rangeland Area As Natural Reserve

The total area of natural grazing land in the Desert (Badia) is approximately 70 million du which are concentrated in the area that receives less than 100 mm/year rainfall as short thundershowers and rainfall amounts decrease towards the east and the south till it reaches 50 mm/year or even less[3]. Of these 70 million du only 1 million du is considered as natural reserves. The project suggests to increase the protected area by another 100 000 du namely in the wide desert valleys south Badia. The project will harness direct benefit for protection of floral biodiversity through controlling the grazing of the indigenous Atriplex halimus shrubs.

Project Description and Calculations Assumptions:

- Much of this area is covered with chert and an underlying thin layer of fine textured soil.
- Artemisia herba- alba, Retama raetam, Achillea fragrantissima, Atriplex halimus and Poa bulbosa are common in the wadi beds.
- Despite its deterioration this region is known to be the main grazing land in Jordan.
- The project will achieve reductions through CO_2 emissions offset from natural soil carbon release caused by rangeland deterioration.
- The project will harness direct benefit for soil resources through rain harvest techniques as well as soil erosion control techniques (erosion is caused from flash floods flow).
- The average annual dry matter production is 4 kg/du in normal years and when protected can be increased to 15 kg/du in the range reserves.
- It is assumed to have an average of 35 average sized shrub/du and the sequestration rate is 4 g SOC/m^2/year.
- A lifetime of 15 years will be assumed for calculations purposes.

3- Adoption of climate-smart agriculture practices in the Jordan Valley area

Climate smart agriculture is not a new agricultural system, nor is it a set of practices. It is a new approach, a way to guide the needed changes of agricultural systems, given the necessity to jointly address food security and climate

3. FAO: http://www.fao.org/ag/AGP/AGPC/doc/counprof/Jordan/Jordan.htm#5. THE PASTURE RESOURCE

change. It contributes to the achievement of sustainable development goals and integrates the three dimensions of sustainable development (economic, social and environmental) by jointly addressing food security and climate challenges. It is composed of three main pillars: [4]

- sustainably increasing agricultural productivity and incomes;
- adapting and building resilience to climate change;
- reducing and/or removing greenhouse gases emissions, where possible.

Sustainable crop production, controlled grazing and maintained forest systems can sequester substantial and variable amounts of carbon from the atmosphere and store it in soils and vegetation. Carbon sequestration will not only stabilize climate but will also make agricultural increase the overall resilience of the agro-ecosystems. Widespread adoption of climate- smart practices has the potential to make major contributions to the achievement of national food security and development goals.

The project suggests two main practices to be promoted through the National Extension Department at NCARE, namely influencing farmers to:

1. Minimal mechanical soil disturbance (i.e. low tillage practices and direct seeding):
   Soil total carbon is 36 to 41% greater with no-tillage or low tillage treatments compared to deeper treatments.
2. Replacing 50 % of the Synthetic fertilizer by Compost (organic fertilizer) would decrease emissions by 0.26 ($MTCO_2E$/ton of compost) and will improve soil health in terms of structure, productivity and water holding.
   The project will work with farmers to:

   - Minimize the risk of loss of N fertilizer as N_2O and the risk of nitrate leaching and runoff through optimizing the timing of compost/fertilizer application where the timing is very important as nitrogen (N) is such a mobile nutrient, much of the N fertilizer may be lost (mostly through leaching and runoff) before the crop can make use of it, if it is not applied at the right time.
   - Optimization of amounts of compost/fertilizer application. Rate of application: taking into account the amount of N in the soil will enable the producer to apply only the amount of fertilizer required. Extra N does not translate into higher yields. A good part of it will be lost, thus, impacting the environment and increasing GHG emissions.

Incentive for farmers: practices will save money while maintaining yields will have a positive impact on soil health.

Project Capital Cost: 36 000 JD/ years.
A reduction of 625 tonnes will be accomplished annually.

Reforestation Projects

Reverse the storm Alexa- 2014 adverse effect on urban trees

- No formal estimations were published for the losses in urban trees, however some numbers estimations were published in the local newspapers. A review of those articles on average they were as follows:
  - Greater Amman municipality estimated a loss of 2100 pine and coniferous trees from public parks.
  - Jordan University estimated a loss of 1000 trees.
  - Royal Scientific society estimated a loss of 400 trees.
- Total number of trees suggested by the project= 3500 medium size coniferous trees
- A medium growth coniferous tree, planted in an urban setting and allowed to grow for 10 years, sequesters **0.039 ton CO_2 per planted tree.**
- No formal estimations were published for the losses in trees, but numbers in the local newspapers on average declared losses from Ajloun and Jerash were 26 000 trees.
- 26 000 trees will be planted over five years
  - 10 000 Jerash ➔2000 tree per year
  - 16 000 Ajloun ➔ 4000 first year and then 3000 trees per year
- Assumptions and Calculations:
  - A medium growth coniferous tree, planted in an urban setting and allowed to grow for 10 years, sequesters **0.039 ton CO_2 per planted tree.**
  - Cost per plant from Ministry of Agriculture nurseries= 10 JD/plant
  - Total Cost= 10*26000 ➔ 260 000 JD
  - Labor cost:
  - - One worker can plant up to 200 trees per month
  - - Cost of one month salary 200 JD (Working days per month 20 days)
    - Cost of planting =1JD/tree
- Capital cost over 5 years=286000

4. FAO - Hague Conference on Agriculture, Food Security and Climate Change in 2010

Table 3.16: Emission reduction and emission reduction unit cost for Agriculture and LULUCF mitigation projects

Project Name	Total discounted cost (M JD)	Total Discounted Emission Reductions (KTons CO_2eq) *	Reduction Unit Cost (JD/Ton CO_2eq) **
Forestry- Introduction of new plantations in Urban Areas	0.07	1.3	56.0
Forestry- Introduction of new plantations in Northern Area	0.48	8.3	58.0
Rangeland1- Restoration of Rangeland Areas	9.6	7.1	1356.0
Rangeland2- New Protected Rangeland Area As Natural Reserve	22.8	11.9	1922.0
Promoting for Climate-smart agricultural practices in the Jordan Valley	10.2	7.6	-1335.0
Total emission reductions for the sector		**36.2**	

3.5 EMISSIONS REDUCTION IN MITIGATION PROJECTS

Yearly emission reductions from all proposed mitigation projects over the period of 2016 to 2040 are illustrated in figure 3.8 and summarized in the following table 3.18.

If the analyzed mitigation projects are executed, they will lead to annual reductions of 3538. Gg in the year 2020; and are expected to increase to 5176 Gg in the year 2040, which represents around 9% of baseline emissions. Table 3.17 and Figure 3.9 provide a comparison between emissions of mitigation scenario in comparison to baseline scenario.

Figure 3.8: Yearly emissions reductions in Gg from all proposed mitigation projects over the period of 2015 to 2040

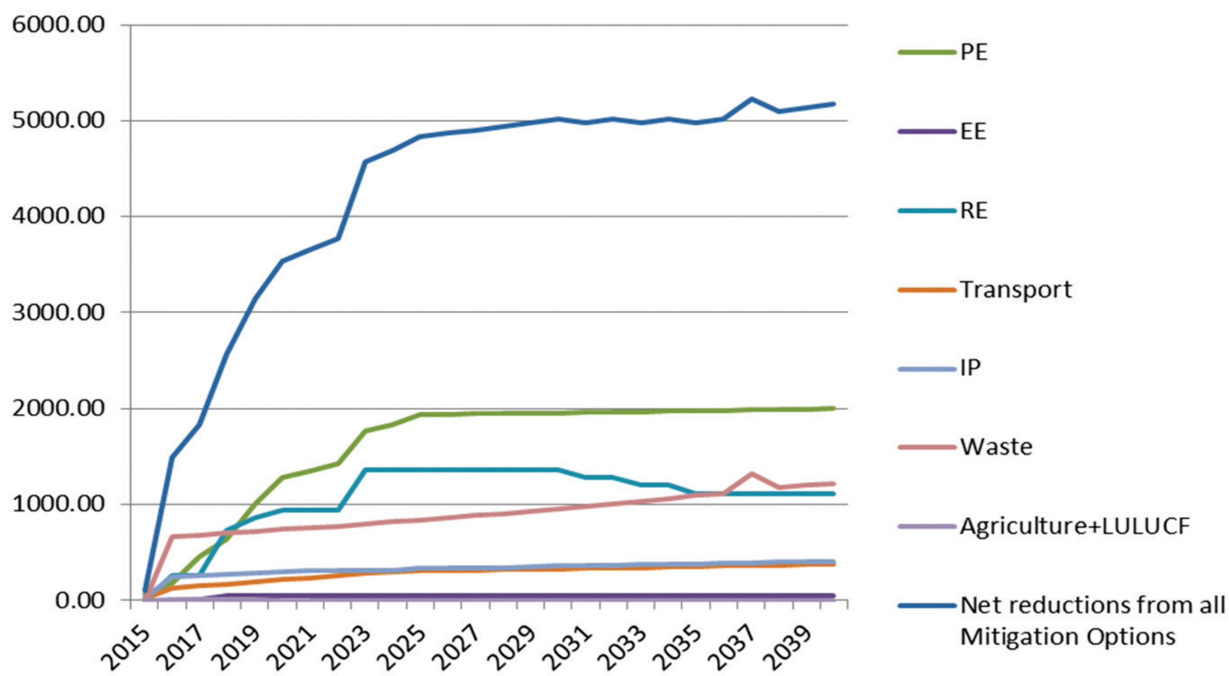
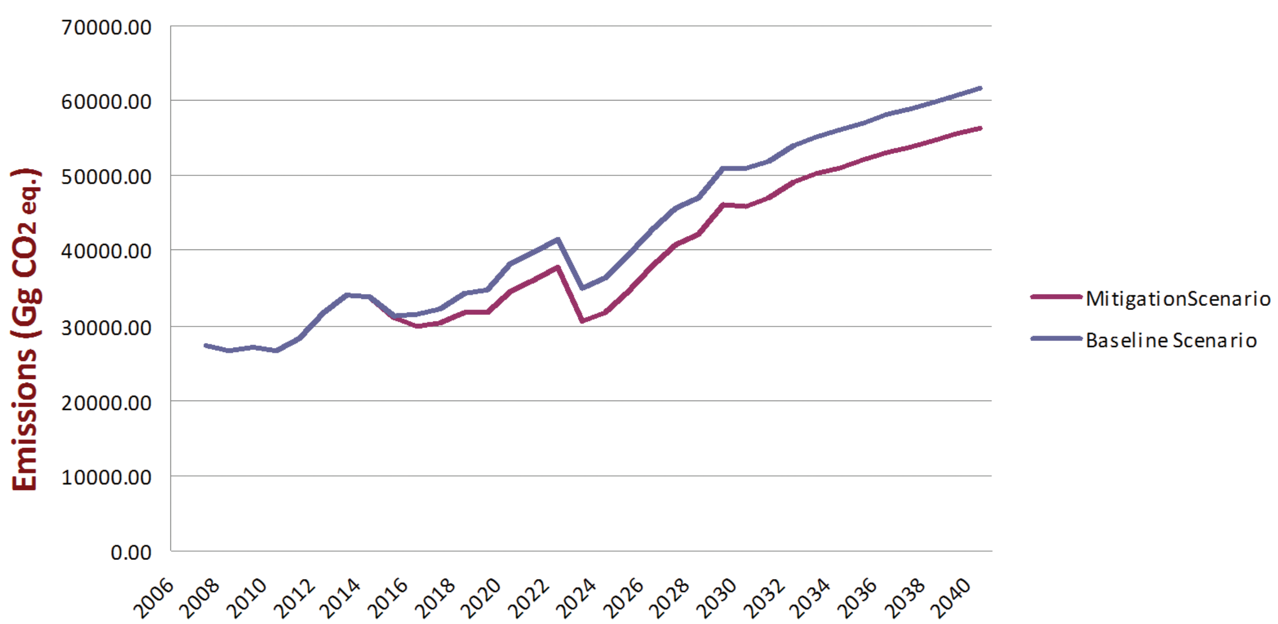


Table 3.17: GHG emissions for mitigation scenario, baseline scenario, net reduction of emissions from mitigation scenario and reduction percent

Year	Baseline scenario emissions for all sectors CO_2eq (Gg)	Mitigation scenario emissions for all sectors CO_2eq (Gg)	Net reductions from mitigation projects for all sectors CO_2eq (Gg)	Reduction %
2016	31456.13	29964.50	1491.63	4.7
2017	32241.27	30412.30	1828.98	5.7
2018	34365.76	31801.50	2564.26	7.5
2019	34824.14	31687.37	3136.77	9.0
2020	38150.58	34612.58	3538.00	9.3
2025	39343.27	34507.36	4835.91	12.3
2030	51027.74	46008.15	5019.59	9.8
2035	57082.86	52107.34	4975.52	8.7
2040	61565.42	56389.53	5175.89	8.4

Figure 3.9: Mitigation scenario in comparison to baseline scenario for (2006-2040)



3.6 MAIN RESULTS OF THE MITIGATION ANALYSIS

Main results for all sectors and abatement cost.

Based on the unit abatement cost and abatement marginal cost curve, the most feasible options seem to be linked with the energy projects in general. Energy efficiency and renewable energy projects with unit cost range from -13 to -274 JD/t CO_2. Figure 6 shows the abatement marginal cost for all mitigation measures ranked from the highest to the lowest while figure 7 grouped the projects according to their sectors.

In light of recent unprecedented increases in energy prices, this result is logical and currently supported at all levels. Financing of these projects in light of their feasibility could be obtained from private sector, grants, and national, regional and international green funds (such as renewable energy financing of Jordan's Central Bank and French Development Agency (AFD) green credit line).

Results of mitigation analysis show that the major areas that should receive the most attention are:

- Renewable energy projects
- Energy efficiency projects

The implementation of these mitigation options will enhance sustainable development through minimizing dependence on imported energy, maximizing security of supply through energy source diversification, minimizing energy cost to the economy, creating new employment opportunities and improving the local environment.

Climate change and development are interlinked. Climate change influences key natural and human living conditions, as well as social and economic development and, turning turn, society's priorities influence the GHG emissions. Climate change mitigation options offer an opportunity to revisit development strategies through a new perspective. The challenge is to ensure the balance between actions to address environmental problems, including climate change and national economic development. Some of the aspects that are critically important in this context are the use of natural resources, energy consumption, land use, technology choice, consumption patterns and lifestyles.

Figure 3.10: Abatement marginal cost for all mitigation measures ranked from the highest reduction cost to the lowest (for projects 1, 2 and 43 reduction costs are: 1922, 1356 and -1335 respectively)

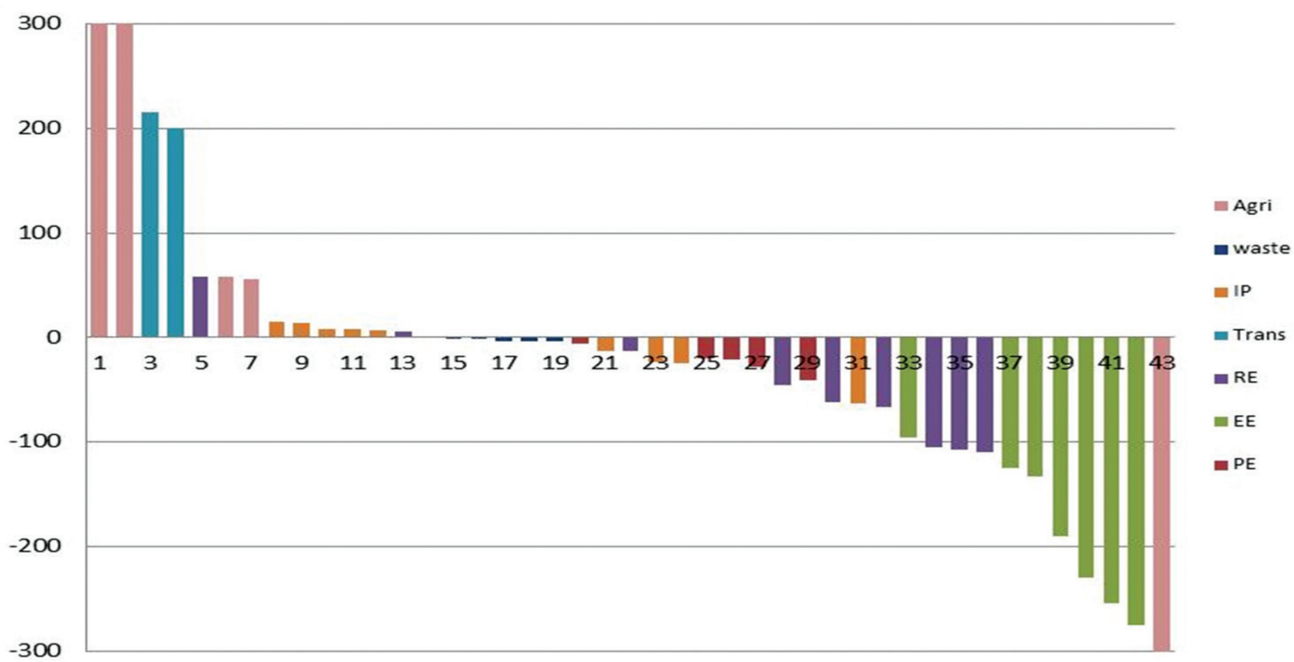
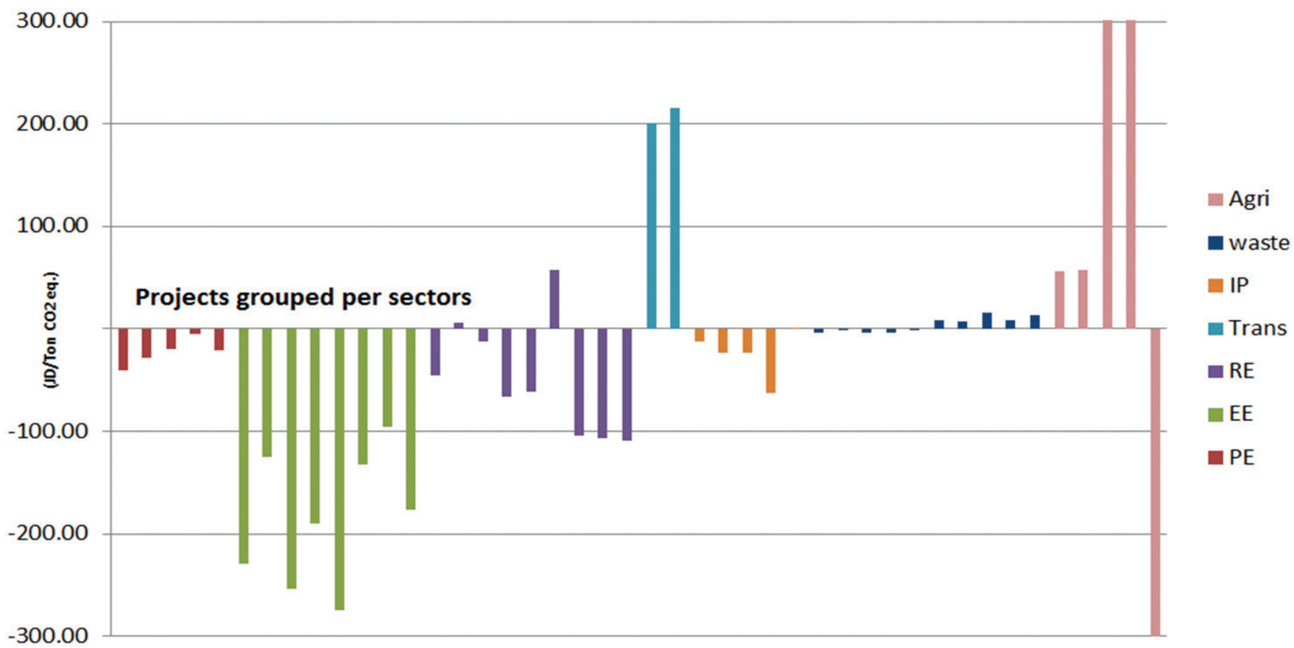


Table 3.18: All proposed Mitigation Projects ranked from the highest GHG reduction cost (JD/ton CO_2 eq) to the lowest cost

No.	Project Description	Cost of reduction (JD/ton CO_2 eq)
1	Rangeland 2- New Protected Rangeland Area As Natural Reserve	1922.0
2	Rangeland 1- restoration of Rangeland Areas	1356.0
3	Reduction by Amman – Zarqa Bus Rapid Transit (BRT)	215.7
4	Reduction by using hybrid cars for public passengers	200.8
5	RE: Biogas Power Plant- 15 MW	58.0
6	Forestry- Introduction of new plantations in Northern Area	58.0
7	Forestry- Introduction of new plantations in Urban Areas	56.0
8	Biogas generation by utilizing the sludge generated from Ramtha domestic wastewater treatment plant	15.5
9	Biogas generation by utilizing the sludge generated from Wadi Arab domestic wastewater treatment plant	13.8
10	Biogas generation by utilizing the sludge generated from Salt domestic wastewater treatment plant	8.5
11	Biogas generation by utilizing the sludge generated from Baqa'a tertiary domestic wastewater treatment plant	8.2
12	Biogas generation by utilizing the sludge generated from Madaba domestic wastewater treatment plant	7.3
13	RE: 100 MW Concentrated Solar Power (CSP)	6.2
14	IP: Catalytic Reduction of N_2O inside the Ammonia Burner of the Nitric Acid Plant	0.9
15	Waste: Biogas collection and utilization from Al-Ekader domestic solid waste landfill	-0.2
16	Biogas collection and utilization from Maddaba domestic solid waste landfill	-0.2
17	Waste: Biogas collection and utilization from Al-Dhulil domestic solid waste landfill	-3.7
18	Biogas collection and utilization from Al-Salt (Hamra) domestic solid waste landfill	-4.0
19	Biogas collection and utilization from Al-Karak domestic solid waste landfill	-4.0
20	PE: Distribution Network of Natural Gas in Aqaba	-5.5
21	IP: Use of steel slag and/or fly ash to substitute the raw materials needed to produce clinker	-12.4
22	RE: Photo Voltaic (PV) 1-200 MW	- 13.1
23	IP: Increase the percentage of Pozzolana in CEM II cement	-23.9
24	IP: Produce new cement product CEM IV with 45% of Pozzolana	-24.0
25	PE: Combined Cycle Gas Turbine in Risha Plant	-19.5
26	PE: Demand Side Management/ introduce actions to reduce overall energy consumption.	-21.3
27	PE: Improving Combustion Efficiency in Rehab Power Plant	-27.9
28	RE: 150 MW Wind Farm	- 45.7
29	PE: Loss Reduction in Electricity Transmission and Distribution (T&D)	-40.7
30	RE: 300 MW Concentrated Solar Power (CSP)	62.0-
31	IP: Use of biomass (MSW or/and Sewage Sludge) as alternative fuels	-63.1
32	RE: Photo Voltaic (PV) 2- 200 MW	- 66.9
33	EE: Using Regenerative burners instead of conventional burners in Steel Reheating Industry	-95.6
34	RE: Solar Water Heaters 1-30000 Houses	- 104.8
35	Solar Water Heaters2-30000 Houses	- 107.1
36	RE: Solar Water Heaters 3-30000 Houses	- 109.2
37	EE: Returning Un-returned condensate to the feed water tanks in Food Industry	-124.7
38	EE: Street Lighting: Replacing 125 W Mercury lamps with 70 W high Pressure Sodium lamps	-132.4
39	EE: Replacing Fluorescent lamps fixtures with LED lamps fixtures in commercial buildings	-189.7
40	EE: Replacing High Thermal Mass with Low Thermal Mass (LTM) in Ceramic factories	-229.7
41	EE: Insulating the Un-insulated pipes, fittings and tanks in food industries	-254.1
42	EE: Insulating walls and roofs in 35000 new houses.	-274.8
43	Promoting for Climate-smart agricultural practices in the Jordan Valley	-1335.0

Figure 3.11: Abatement marginal cost for all mitigation measures grouped according to sectors



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VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE 4

4.1 INTRODUCTION AND METHODOLOGY

The purpose of the "Vulnerability Assessment and Adaptation Measures" chapter is to contribute to developing and updating the national knowledge on climate conditions based on Jordan's past, present and future climate scenarios and their resulting impacts on key human and natural systems since the publication of the Second National Communication in 2009.

This analysis has focused on the sectors that were considered by previous studies (Jordan SNC, NEEDS, etc...) to be highly at risk from climate change: such as water resources, agriculture and health. For the first time in Jordan vulnerability and adaptation analysis were conducted for urban areas, biodiversity and coastal zones. The study also included a comprehensive analysis of the socio-economic and local impacts of climate change, and its gender implications in the targeted sensitive areas of Jordan.

However, there is a lack of understanding of the consequences of climate change at local level, as a consequence, decision makers are unable to link the regional and national conditions with global conditions, thus hampering their ability to take the most appropriate planning decisions in terms of vulnerability and adaptation.

For this reason the assessment of the priority sectors has focused on selected study sites located in the districts of Subahi, Seehan, and Bayoudah in Arda District and Al-Irmemeen in Zai District, in the lower Zarqa River Basin. These pilot study areas were selected based of consultation with the main government and national stakeholders. This chapter includes the basic results of the studies carried out at national level and also at targeted geographic regions of Jordan.

METHODOLOGICAL FRAMEWORK

The study applied a robust methodological framework that relies on two main pillars:

1. A qualitative and quantitative climate change impact and vulnerability assessment (CCIVA)

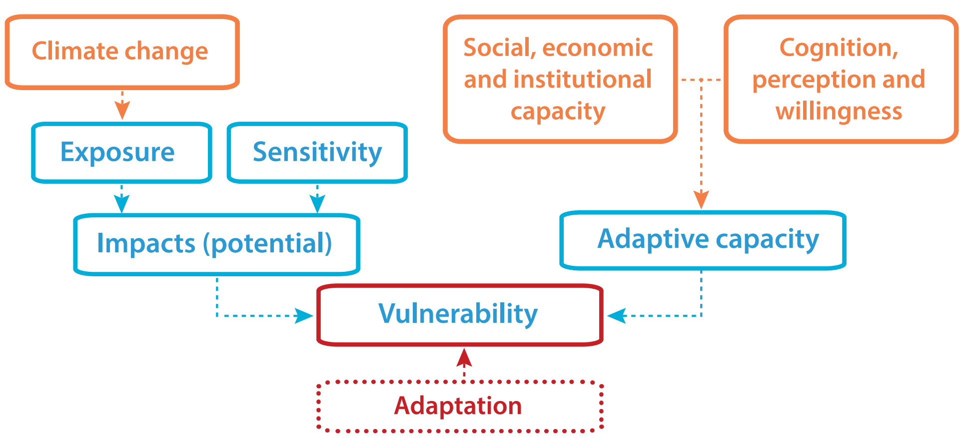
2. Identification and prioritization of adaptation for all the prioritized regions and sectors.

Climate change impact and vulnerability assessment

In line with the official IPCC's definition[5], the methodology has considered that the **vulnerability** of a particular system is highly contingent upon four main components: the magnitude of its **exposure** to climate change hazards, its degree of **sensitivity to the hazard**, the resulting amount of **impact** and its level of adaptive **capacity**. The relationship between these four dimensions, as depicted in Figure 4.1 below, is commonly expressed by the following conceptual formula:

Vulnerability = [Exposure to climate stimuli x Sensitivity = Impact] / Adaptive capacity

Figure 4.1: The Vulnerability Conceptual Framework (Schröter et all., 2004)



5. Vulnerability is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2007)

Basically, vulnerability can be viewed as the outcome of climate change potential impact minus its adaptive capacity.

The adverse effects of climate change, including climate variability and extremes depend, not only on this system's sensitivity but also on its adaptive capacity.

Exposure is the degree of climate stress upon a particular sector or system; it may be represented as either long-term change in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events (IPCC, 2007). **Sensitivity** is the degree to which a system will be affected by, or responsive to climate stimuli. Sensitivity is basically the biophysical effect of climate change; but sensitivity can be altered by socio-economic changes. For example, new crop varieties could be either more or less sensitive to climate change (IPCC, 2007). The potential **impact** is a function of the level of exposure to climate change hazards, and the sensitivity of the target assets or system to that exposure. **Adaptive capacity** is the potential or capability of a system to adjust to climate change, including climate variability and extremes, so as to moderate potential damages, to take advantage of opportunities, or to cope with consequences (IPCC, 2007).

Sensitivity: Is the degree to which a system, receptor or exposure unit would be affected, either adversely or beneficially, by a particular change in climate or climate-related variable. (E.g. changes in agricultural crop yield in response to a change in the mean, range or variability of temperature.) Different systems may differ in their sensitivity to climate change, resulting in different levels of impact.

Adaptive capacity: Is the ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, take advantage of opportunities, or cope with the consequences. Adaptive capacity can be an inherent property of the system, i.e. it can be a spontaneous or autonomous response. Alternatively, adaptive capacity may depend upon policy, planning and design decisions carried out in response to, or in anticipation of, changes in climatic conditions.

Accordingly, the main steps involved in the CCIVA process for each selected sector were the following (Figure 4.2):

Figure 4.2: Methodological approach used for the CCIVA in Jordan (authors)

Step 1: **Assessment of baseline conditions**	Qualify existing climatic and non-climatic conditions in the concerned sector/ area, including past experiences with extreme events, historical climate sensitivity, vulnerability thresholds, etc.
Step 2: **Assessment of exposure**	Assess frequency and magnitude of future climate change hazards using specific climatic indices
Step 3: **Assessment of sensitivity**	Assess the degree to which the the bio-physical and social components of the exposed sector/system may be affected by the climate change hazards
Step 4: **Impact ranking**	Evaluate the level of impact resulting from the combination of both exposure and sensitivity to climate change hazards
Step 5: **Assessment of Adaptive capacity**	Assess the ability of the system/community to withstand negative impacts and adjust to changing climatic conditions
Step 6: **Overal vulnerability rating**	Determine the level of climate change vulenrability as a function of both impact and adaptive capacity (Vulnerability ranking matrix)

The baseline assessment (Step 1) involved reviewing available scientific, socio-economic and development policies and publications, existing databases, consultation with local communities, to characterize the past and current situation in terms of climatic hazards and observed vulnerabilities of the selected sectors. It also involved collecting the experience and perception of recent changes in the selected local communities, and analyzing existing coping practices/ strategies and their effectiveness under historical climate.

The exposure assessment (Step 2) consisted of identifying the main climate change-related hazards (droughts, floods, heat wave, cold wave, increasing temperature, increasing aridity, etc.) through an analysis of past extreme events and trends and through climate modeling and downscaling of future climate and environmental conditions against various scenarios. The development of climate scenarios took a different approach from the one used by the Second National Communication. Climate hazards were approached using a set of climatic indices that were considered to be the most relevant to analyze the vulnerability of the selected sectors. For each index, forecasts were obtained for the years 2035, 2055 and 2075 by applying cutting-edge dynamic and statistical downscaling techniques for the very first time in Jordan.

The study strongly benefited from the most recent developments in climate modeling research achieved by the ''Coordinated Regional Climate Downscaling Experiment'' (CORDEX) global program. The forecasts were developed for nine GCM-RCM model couples and the two IPCC's Representative Concentration Pathways (RCPs) 4.5 and 8.5. This allowed the generation of multi-model ensembles of projections and thus, helped to analyze the uncertainty originating from the different GCMs/RCMs through comparison of different models outcomes for the selected climate variables. At the study area, exposure of each selected hazard was assessed against three main determinants: i) likelihood of occurrence of the hazard (gradual change or extreme event), ii) geographical magnitude (from limited to widespread) and iii) confidence (of the projection results being correct).

Sensitivity and adaptive assessments (Steps 3 and 5) were based on field research, household surveys as well as GIS and numerical modeling for areas such as biodiversity and water. Bio-physical as well as socio-economic determinants of sensitivity (e.g. proportion of rainfed areas, percent of population living in poverty, percept with access to safe water, etc.) were identified and analyzed based on actual data and expert judgments. Due to time constraints and limited data availability, it was not possible to develop future projections of sensitivity and adaptive capacity using, for example, socio-economic scenarios. To overcome this issue, it was decided to adopt the ''constant socio-economic baseline'' approach, whereby actual development conditions are supposed to remain constant over time. This approach is considered an acceptable one by the internal climate change community when there are certain barriers to the development of socio-economic scenarios.

Impact and overall vulnerability ranking (Steps 4 and 6) were conducted combining the results of the exposure, sensitivity and adaptive capacity and leading to a comparative score for vulnerability. Numerical scoring system and ranking tools (matrices) were developed using quantitative classes or qualitative terms from very low to very high. Each component of vulnerability was ranked through expert judgment using specific scoring scales.

Identification and Prioritization of Adaptation Measures

The second pillar of the methodology is linked with the selection and planning of adaptation measures that respond to the identified climate vulnerabilities and climate change impacts identified through application of the previous steps. The methodology first implied identification of options followed by detailed qualitative and quantitative assessment of these options.

This assessment involved the following steps:

1. Development of a long list of possible adaptation options/measures that respond to the identified hazards, vulnerabilities;
2. Through a screening process, identify a shortlist of preferred options that are environmentally, socially, technically, and legally feasible, by applying qualitative selection criteria;
3. Organize a national consultation workshop with selected stakeholders and technical experts in each sector to carry out and in depth analysis of the pros and cons of the identified adaptation options conduct a participatory process aimed at approving / prioritizing the adaptation options/measures;
4. Agree upon the adaptation measures/options to be prioritized.

Table 4.1: Scoring scales for exposure (likelihood, geographical magnitude and confidence)

Exposure factors	Score 1	Score 2	Score 3	Score 4	Score 5
Likelihood	Event is not expected to occur, but it is possible (there is less than five percent probability of occurrence per year <5%	Event or change is unlikely to occur, but not negligible (there is between 5-33% probability of occurrence per year)	Event or change less likely than not, but still possible (33-66% probability of occurrence per year)	Event or change likely to occur (66-95% probability of occurrence per year)	Event or change very likely to occur (>95% probability of occurrence per year)
Geographical magnitude	Less than 5% of the area is affected	5-33% of the area is affected	33-66% of the area is affected	66-95% of the area is affected	>95% Of the area is affected
Confidence of being correct	Very low: less than 10%	Low: 20% chance	Medium: about 50% chance	High confidence: 80% chance	Very high confidence: > more than 90% chance

Table 4.2: Vulnerability ranking scale

			Impact score				
		Score	**0,1-1**	**1,1 - 2**	**2,1 - 3**	**3,1 - 4**	**4,1 - 5**
Adaptive capacity	**Score**	Description	Very low	Low	Moderate	High	Very high
	0.1 – 1	Very low	Moderate	Moderate	Moderate	Very high	Very high
	1.1 – 2	Low	Low	Moderate	Moderate	High	Very high
	2.1 – 3	Moderate	Low	Moderate	Moderate	High	Very high
	3.1 – 4	High	Very low	Low	Moderate	Moderate	High
	4.1 - 5	Very high	Very low	Low	Low	Moderate	High

During this process, the TNC team strived to develop an optimum mix of adaptation actions including soft and hard measures.

The main criteria used for the appraisal and selection process are as follows:

- Social equity: does the measure benefit all groups, including women, youth, etc.?
- Financial (cost/benefit): is the measure cost-effective?
- Effectiveness: to what extent does the measure contribute to reducing the impact?
- Robustness to uncertainty: is the measure effective under different climate change scenarios?
- Synergies: does the measure have positive effects on other sectors?

DESCRIPTION OF THE STUDY AREA

The study area was selected because many studies including the SNC reveal that its exposure to climate change and impact of flow of Zarqa river , and the presence of surface water system, stream dependent agricultural, community which is health related problems prone, poor community and Special Conservation Area (SCA) namely Khyouf SCA that contain high biodiversity value in the area. In addition, it represents two types of water dependents use in agriculture, irrigation and rainfed systems, which are the most common agriculture systems in Jordan.

The study area is located in three governorates; Balsa, Jerash and Ajlun. It covers the lower parts of Zarqa River Basin and extends along the Zarqa River from Jerash-Amman High Way down to Jordan Valley. The approximate length and width of the study area is about 20 kilometers by 15 kilometers. It covers area on both Zarqa River sides including King Talal Dam and Tal Dahab Conversion Dam.

The study area shows diverse environmental conditions and land uses. They cover multiple and scattered communities and range from urban to rural conditions, high lands to below sea level, and from forest to agriculture to graze lands, and from rainfed to irrigated agriculture. The diversity of the study area in terms of biophysical and other characteristics qualifies it to adequately represent most populated areas in Jordan, especially those situated in high lands. The average annual rainfall over the study area ranges from slightly below 300 mm to over 400 mm, the soil type ranges from clay to sandy clay loam suitable terrains for rainfed agriculture. In addition to water resources availability, the diversity in topography, soil type, landscapes, and local experience all determined to have an important role in land use practices. However, the increased population and demand for infrastructure and services, has led to higher levels of urbanization that could result in severe urbanization at the expense of agricultural lands.

Four communities were selected within the study area to evaluate the climate change vulnerability of water, agriculture, urban, biodiversity and health sectors. These communities are Subahi, Seehan, Bayoudah form Arda District, and Al-Irmemeen from Zai District. All are located in Balqa Governorate. Climate change seems to have noticeable impacts on the study area in various forms and aspects. Water resources within the study area are facing serious challenges. For example, groundwater depletion and salinization are common problems and the disappearance of springs is noticeable. In addition to other factors, heat fluxes and water shortages have significantly degraded the agriculture sector and are causing severe changes in crop patterns and land use, leading to a partial failure in agriculture, in terms of revenue, and causing significant changes in ownership (land is being bought by investors), causing the owners tp emigrate to cities.

Biodiversity is also facing challenges. Desertification is progressing and the population of a considerable number of species of flora and fauna has decreased including some birds and Oak trees.

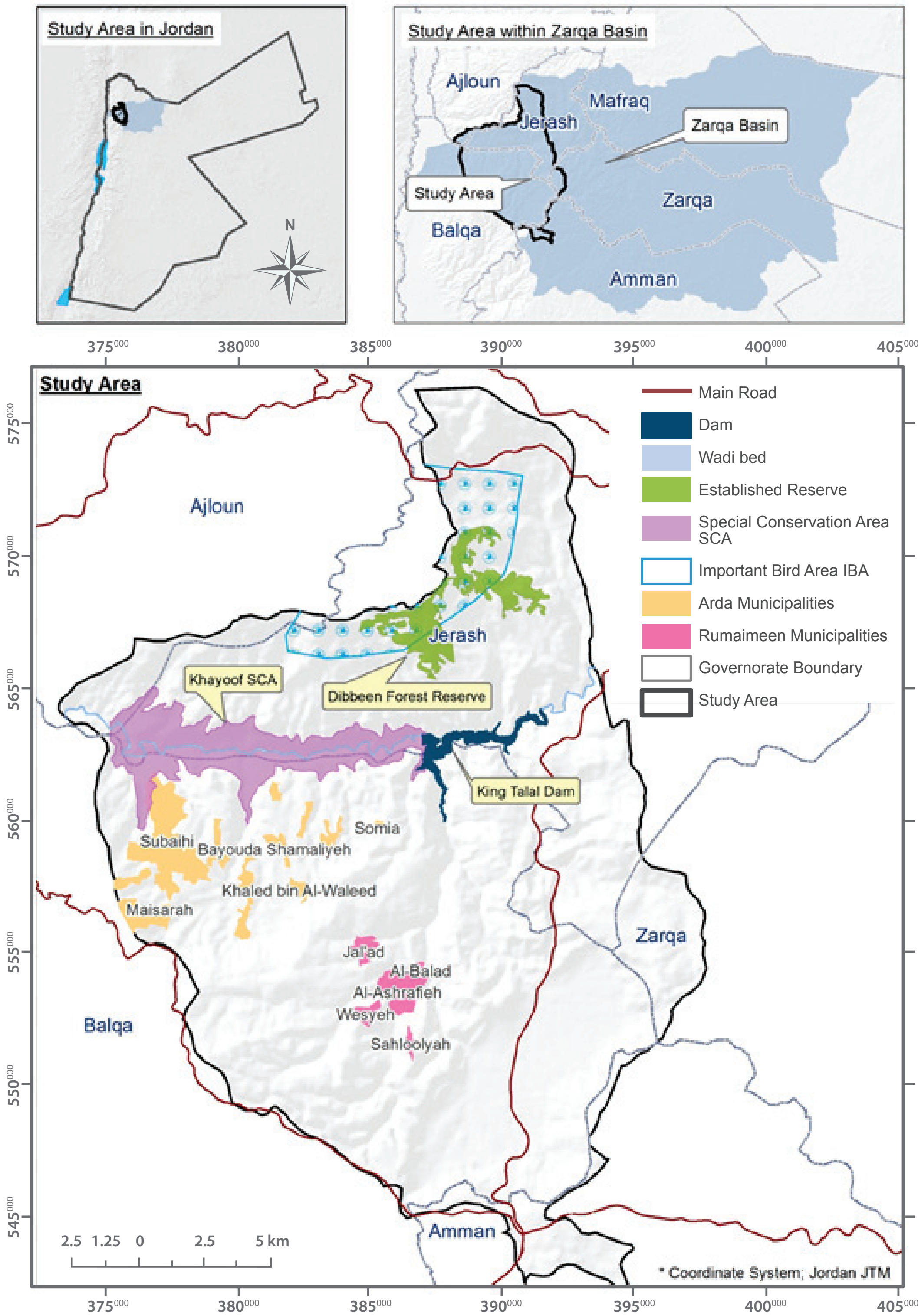
The oak trees in the study area were considered an essential component of the forest ecosystem in the area.

Climate change is limiting water resources, and supplementary irrigation is currently required. Houses are seeing the need to have cooling systems installed. Traditions and social aspects of the population are changing as a result of the new conditions. Communities are exposed to several stresses due to the new climate conditions and as a result their climate change vulnerability is increasing. It is reasonable to conclude that the community will face serious impacts, since their adaptive capacity is diminishing due mainly to economic constrains. However, a reasonable percentage of the communities of these four selected areas are adopting/implementing diverse adaptation strategies such as: rainwater harvesting, using drip irrigation techniques, rotating or changing crops and using treating waste water on their crops, etc.

Figure 4.3: Photos for oak trees near the Arqoub AlRashed area in Sbihi, tree on the left is damage due to the lack of water (Naser Almanaseer, May 15th 2014)

Figure 4.4: Photos for Tel Dahab conversion dam (left), Homrt Aldyghami near Tel Dahab conversion dam (left) and a rainfed olive farm that replaced annual crops near Zarqa River in Sbihi as an adaptation measure to climate change (Naser Almanaseer, May 15th 2014)

Figure 4.5: A map of the study area at three different scales.



4.2 CLIMATE TRENDS AND CLIMATE CHANGE PROJECTIONS

The Coordinated Regional Climate Downscaling Experiment (CORDEX) coordinated by the World Climate Research Program (WCRP) under the auspices of WMO-IPCC and UNFCCC was used for the multi-model ensembles dynamic downscaling analysis. Dynamic downscaling for this study was achieved using Africa CORDEX domain, in which 43 grid points with a resolution of 50 km were crossed throughout the country. Nine different GCM coupled with two RCMs for two RCPs (4.5 and 8.5) were used to assess future projections as compared to reference historic data (1980-2010). Three time horizons were selected; 2020-2050, 2040-2070 and 2070-2100.

4.2.1 Dynamic Downscaling and Climate Scenarios

The AFRICA CORDEX domain provided 8 GCMs and was coupled with the Swedish SMHI RCM and 1 GCM was coupled with Denmark DMI RCM at 0.44° resolution (50 km) at two RCPs (RCP 4.5 and RCP 8.5). The indices selection was based on consultations with experts in order to support the vulnerability assessment of their sector. These indices were used as descriptors or indicators of potential climate hazards or threats, and they were selected based on the sensitivity of the sectors to specific climate stimuli. Selected climate variables were extracted from Earth System Grid Federation (ESGF) nodes at a resolution of 50kmx 50km providing 43 grid points in the extent of the whole country (Figure 4.6). The extracted data were further processed for the ensemble projection and for the uncertainty analysis including both validation and debasing using local historic climatic variables obtained from local weather stations. Debiasing was achieved using (1) Delta method, and (2) "Quantile-Quantile" method (Meteo-France and at French INRA).

Four time horizons were selected for interpolating climate variables projections: (1) 1980-2010 was used as a reference period and was centered on the year 1995, (2) 2020-2050 was used for initial future projections and was centered on the year 2035, (3) 2040-2070 was used for middle future projections and was centered on the year 2055, and (4) 2070-2100 was used for far future projections and was centered on the year 2085.

Future projections were achieved using multi-model ensembles, to understand and tackle the associated uncertainty levels. However, a "reference model" was chosen as a reference for decision-making. The reference projection model was selected using a three-step procedure: (1) Computing delta-temperature / delta precipitation graphs, for 2 time horizons: 2050 and 2085 (i.e. 2035-2065, 2070-2100). The average changes in annual temperature and annual cumulated precipitation were compared with the local historic data, (2) choosing three models that across RCPs and time-horizons, were most frequently the closest to the median, and (3) evaluating the capacity of the three models to reproduce past climate (skill) conditions.

The most frequent and closest to the median models selected were SMHI – NCC-NorESM-LR, SMHI – ICHEC-EC-EARTH, SMHI – MIROC-MIROC5. According to the evaluation of these models regarding their capacity to model past climate, the combination between Norwegian Earth System Model as global climate model, and Swedish SMHI regional climate model "SMHI – NCC-NorESM-LR" projection emerged as the best reference projection.

Finally, geostatistical downscaling of the regional climatic data to 1 kilometer resolution was performed, using combined statistical projections at the stations level (Delta method) and geostatistical interpolation using digital elevation model (DEM) taking into account the altitude, orientation, slope, roughness, and encasement of the country (French National Centre for Scientific Research, CNRS).

Based on the definitions of exposure; a combination of likelihood of exposure, geographic magnitude and confidence. The IPCC definitions were used to assess the climate variables and indices in this section. The qualitative measures (e.g. rare, unlikely, possible, likely, and extremely likely were based on the probability of occurrence of the event per year, while the confidence scale was based on the processing of a multi-model ensemble (i.e. very high, high, medium, low and very low confidence).

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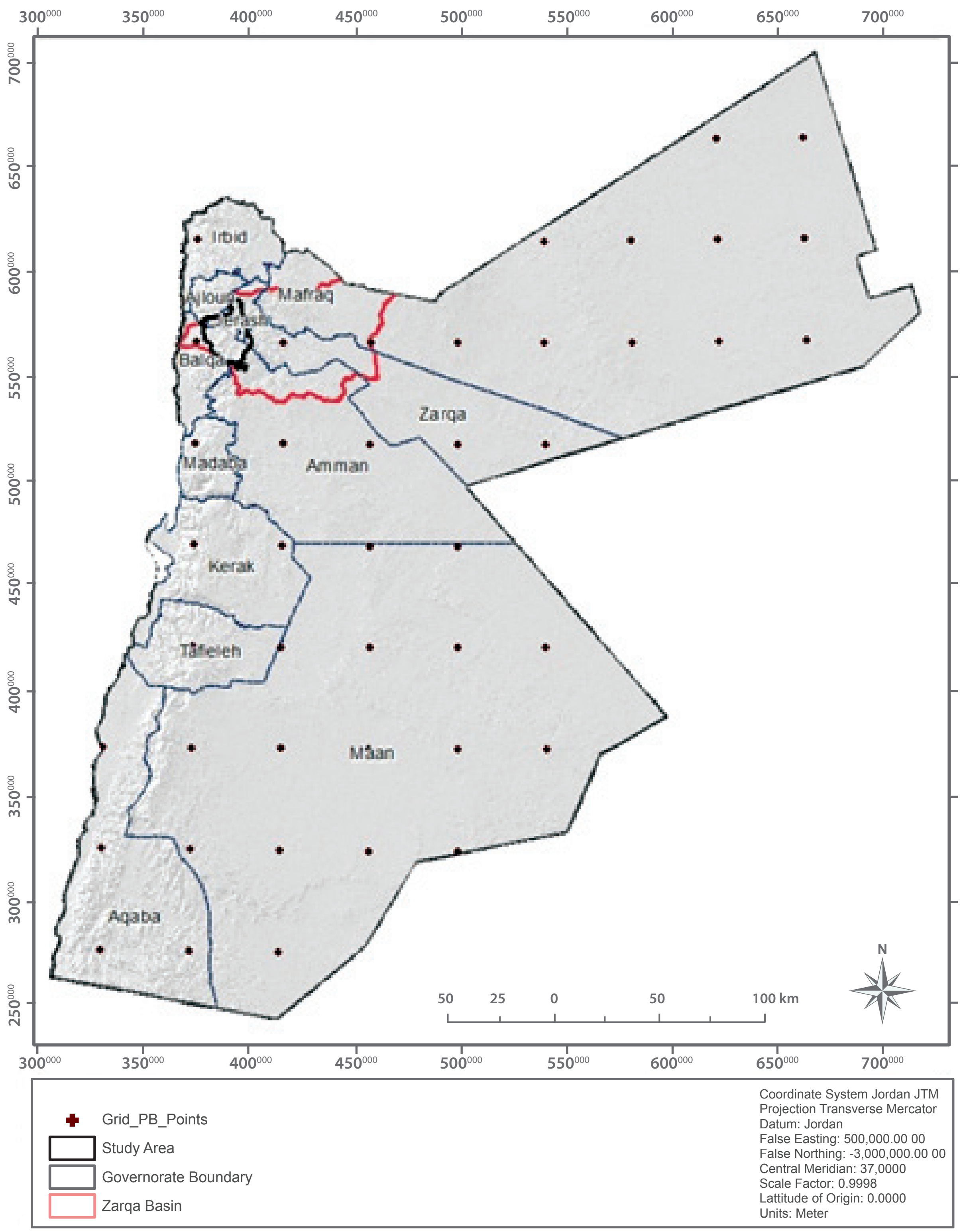
Table 4.5: Available nine GCM within the Africa CORDEX domain

RCM	Modeling Center	GCM	Institution	Combined Model Name
DMI	ECHEC-	EC-EARTH	EC-EARTH consortium	DMI_ECHEC-EC-EARTH
SMHI	CCCma	CanEMS2	Canadian Centre for Climate Modelling and Analysis	SMHI_CCCma-CanEMS2
	CNRM-CERFACS	CNRM-CM5	Centre National de Recherches Meteorologiques/ Centre Europeen de Recherche et Formation Avancees en Calcul Scientifique	SMHI_CNRM-CERFACS-CNRM-CM5
	ICHEC-EC-EARTH	EC-EARTH	EC-EARTH consortium	SMHI_ICHEC-EC-EARTH
	MIROC	MIROC5	Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology	SMHI_MIROC-MIROC5
	MOHC	HadGEM2-ES	Met Office Hadley Centre	SMHI_MOHC-HadGEM2-ES
	MPI-M	MPI-ESM-LR	Max Planck Institute for Meteorology (MPI-M)	SMHI_MPI-M-MPI-ESM-LR
	NCC	NorESM-LR	Norwegian Climate Centre	SMHI_NCC-NorESM-LR
	NOAA- GFDL	GFDL-ESM2	Geophysical Fluid Dynamics Laboratory	SMHI_NOAA-GFDL-GFDL-ESM2

Table 4.6: Description of selected indices retrieved from RCM archives

Climate index	Description
T2m mean	Mean temperature at 2m height
T2m min	Mean daily minimum temperature at 2 m height
T2m max	Mean daily maximum temperature at 2 m height
RR	Precipitation sum
R10 mm	Heavy precipitation days (> 10mm) daily/yearly/monthly?
CDD	Maximum no of consecutive dry days (RR<1mm) in a year/month/week?
SPI6	Six-month Standardized Precipitation Index; SPI is a probability index based on precipitation. It is designed to be a spatially invariant indicator of drought. SPI6 refers to precipitation in the previous 6-month period
SPI3	Three-month Standardized Precipitation Index; SPI is a probability index based on precipitation. It is designed to be a spatially invariant indicator of drought. SPI3 refers to precipitation in the previous 3-month period
PET	potential evapotranspiration as calculated by the Penman-Monteith parameterization
FXx	Maximum value of daily maximum wind gust (m/s).
(FXx)	Maximum value of daily maximum wind gust (m/s).
DD	Wind direction
RH	Mean of daily relative humidity
SD	Mean of daily snow depth (only for the pilot area)

Figure 4.6: The AFRICA CORDEX domain grid showing the points covering the country



(i.e. 2035-2065, 2070-2100). The average changes in annual temperature and annual cumulated precipitation were compared with the local historic data, (2) choosing three models that across RCPs and time-horizons, were most frequently the closest to the median, and (3) evaluating the capacity of the three models to reproduce past climate (skill) conditions.

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Based on the definitions of exposure; a combination of likelihood of exposure, geographic magnitude and confidence. The IPCC definitions were used to assess the climate variables and indices in this section. The qualitative measures (e.g. rare, unlikely, possible, likely, and extremely likely were based on the probability of occurrence of the event per year, while the confidence scale was based on the processing of a multi-model ensemble (i.e. very high, high, medium, low and very low confidence).

Table 4.7: Likelihood scale used to assess future climate projections

Qualitative measure	Rare	Unlikely	Possible	Likely	Extremely likely
Description	Event not expected to occur, but possible (<5% probability of occurrence per year in 2050s)	Event unlikely to occur, but not negligible (5-33% probability of occurrence per year in 2050s)	Event less likely than not, but still appreciable chance of occurring (33-66% probability of occurrence per year in 2050s)	Event more likely to occur than not (66-95% probability of occurrence per year in 2050s)	Event highly likely to occur (>95% probability of occurrence per year in 2050s)

Table 4.8: Geographical magnitude scale used to assess future climate projections

Qualitative measure	Negligible	Limited	Significant	Very significant	Widespread
Description	<5% of the area is concerned	5-33% of the area is concerned	33-66% of the area is concerned	66-95% of the area is concerned	>95% Of the area is concerned

Table 4.9: Confidence scale used to assess future climate projections

Qualitative measure	Description
Very high confidence	> 9 out of 10 chance
High confidence	8 out of 10 chance
Medium confidence	5 out of 10 chance
Low confidence	2 out of 10 chance
Very low confidence	< 1 out of 10 chance

4.2.2 Future Climate Projections

The following section summarizes the main results for each projected climatic index. Along all graphs, the minimum, maximum and median of climate change values are presented for moving averages over a 30-year period. The minimum term represents the minimum values of the 9 GCMxRCM ensembles of projections, while the maximum represents the maximum values of the 9 GCMxRCM ensembles of projections. Also, the median represents the median values of the 9 GCMxRCM ensembles of projections. On the other hand, the reference term represents the actual annual individual values of the selected reference model. The projected changes in the selected climate variables for the two RCPs at the whole country for all time horizons are presented in Table 4.10.

Table 4.10: Projected changes in selected climate variables generated by the two used RCPs at country level

	RCP 4.5					RCP 8.5				
	Year	Minimum	Medium	Maximum	Reference	Year	Minimum	Medium	Maximum	Reference
Precipitation (mm)	2035	-15.9	-8.2	9.2	-3.0	2035	-20.4	-12.9	-0.5	-12.9
	2055	-24.2	-15.4	0.7	-15.4	2055	-26.5	-15.0	-7.0	-12.9
	2085	-22.5	-13.6	-5.7	-12.0	2085	-38.0	-21.9	-10.9	-14.8
Mean Temperature	2035	0.9	1.2	1.8	1.2	2035	1.3	1.6	2.2	1.6
	2055	1.6	1.7	2.5	1.8	2055	2.1	2.6	3.4	2.6
	2085	1.8	2.1	2.8	2.5	2085	3.8	4.0	5.1	4.0
Maximum Temperature	2035	1.0	1.1	1.8	1.1	2035	1.3	1.5	2.3	1.5
	2055	1.6	1.7	2.5	1.7	2055	2.2	2.6	3.5	2.5
	2085	1.7	2.1	2.8	2.5	2085	3.8	4.1	5.0	3.9
Minimum Temperature	2035	0.9	1.1	1.7	1.3	2035	1.2	1.6	2.1	1.7
	2055	1.5	1.7	2.4	1.8	2055	2.0	2.5	3.3	2.7
	2085	1.7	2.0	2.8	2.5	2085	3.7	4.0	5.1	4.0

MEAN TEMPERATURE

The two RCPs predict that a rise in mean temperature throughout the country is **extremely likely**. 4.5 RCP predicts a rise up to 3.1°C and 8.5 RCP predicts a rise up to 5.1°C.

Regarding the mean temperature, RCP 4.5 projects show that it is **extremely likely** a homogeneous increase of temperature all over the country, while for RCP 8.5 the increase it is stronger for the eastern and southern regions. For the RCP 4.5, the mean temperature (Figures 4.7-4.8) could rise up to +3.1°C (maximum value of the 30 years moving average) and up to 2.1°C for the median. After 2060, a minimum increase in mean temperature is expected and will remain unchanged until 2085 when an increase of +1.70°C is expected. The median values are closer to the minimum and deviate from the maximum across time. Generally, the reference model shows an inter-annual variability (the difference between two consecutive years) of around 1°C, and up to nearly 2°C, sometimes exceeding the maximum of the model ensemble by more than 0.5°C indicating inter-annual changes that is always positive after 2000.

For 2085 the RCP 8.5 show that a high rise in temperature, up to +5.1°C in the max temperature and up to +4°C for the median and up to 3.8 °C for the minimum is **extremely likely**. The median is closer to the minimum average and deviates from maximum one too. The inter-annual variability is under 2°C, sometimes above the extreme averages and it is purely positive after 2000.

Figure 4.7: Projected average mean temperature (°C) over Jordan using the reference model, for 2035, 2055 and 2085 times-horizons and for RCP 4.5 and 8.5

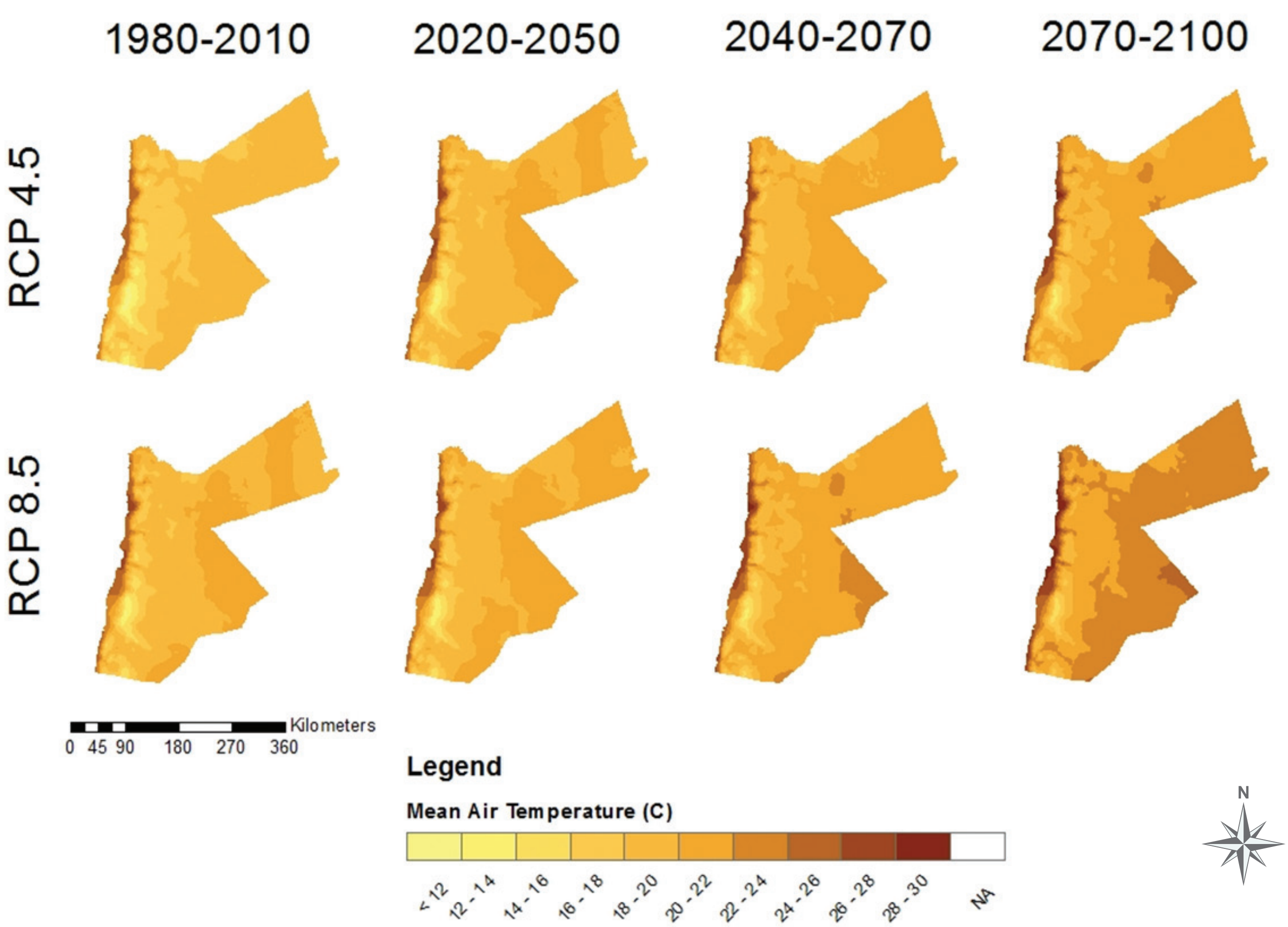
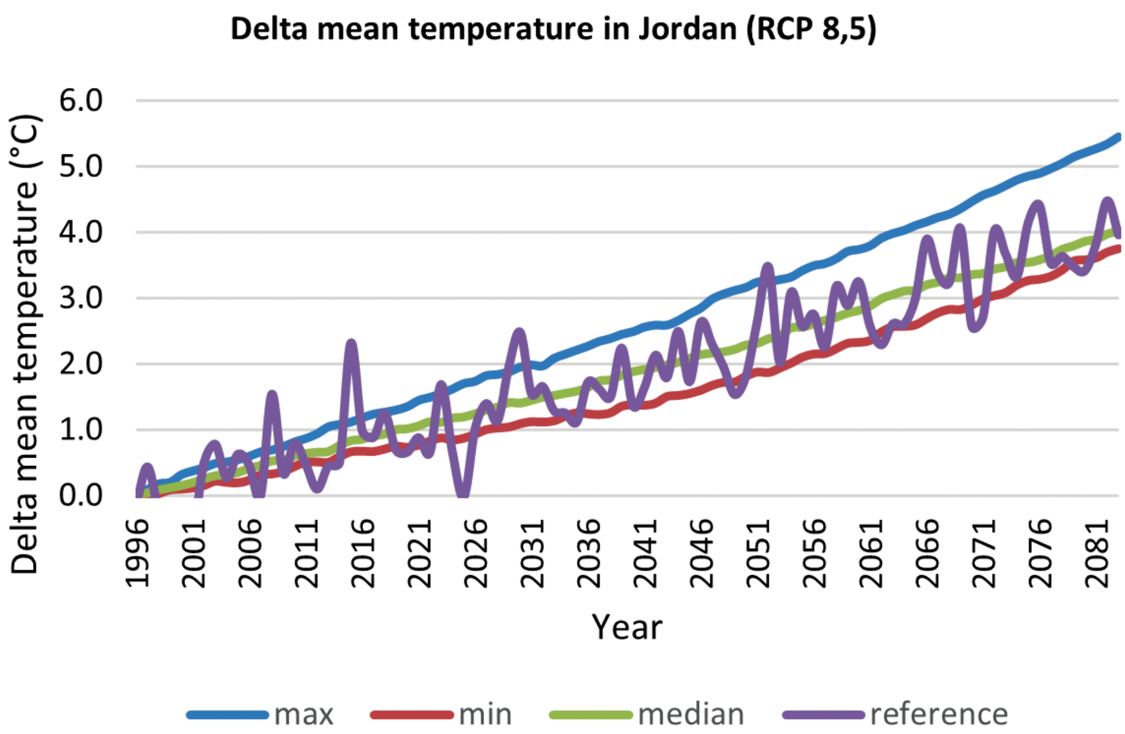
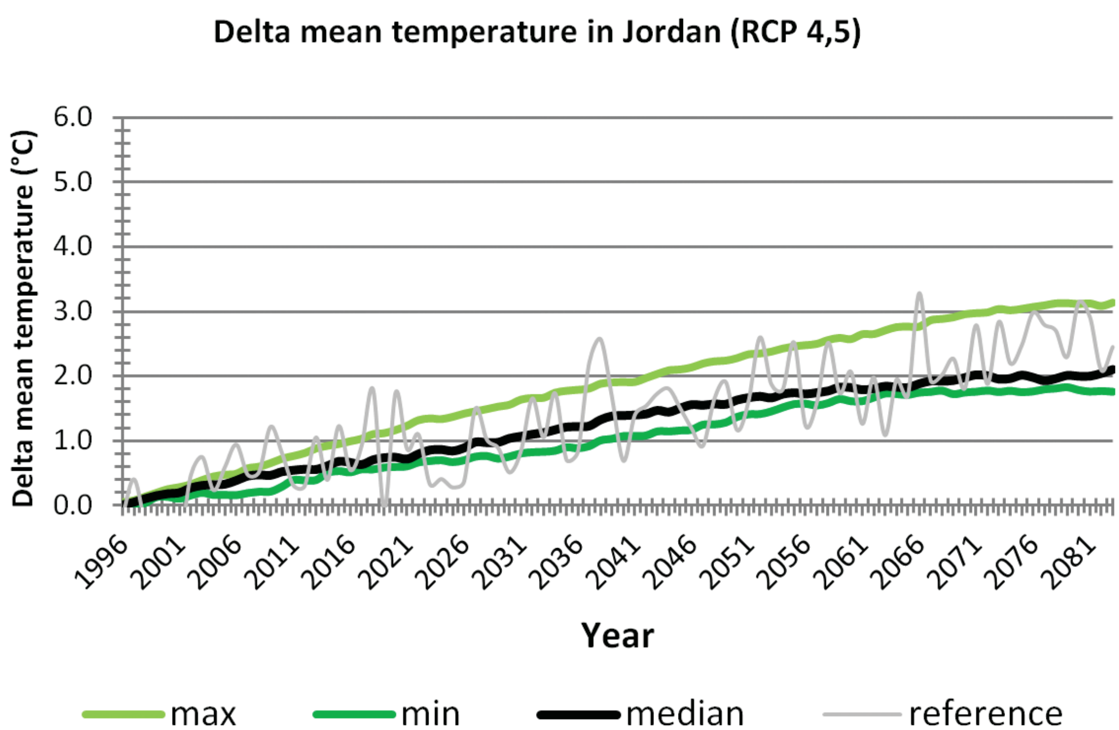


Figure 4.8: Projected changes in mean temperature (°C) over Jordan for RCP 4.5 and 8.5





MINIMUM TEMPERATURE

Minimum temperature projections for the RCP 4.5 predict that it is **extremely likely** that minimum temperatures will have a homogeneous rise up to 2050 (Figures 4.9-4.10). After, a global rise of up to +3°C is predicted, with local variations in the western regions. The stronger increase, will occur in the northwestern part of the Balqa region where an increase of up to +5°C is predicted. The RCP 8.5 shows a stronger rise, on the rift and mountain region, but this rise is not homogeneous. It is predicted that some localized decreases in temperature will occur up to 2050 in the highlands. In 2100 the rise reaches up to +5°C on the eastern region and it is predicted to be between +1°C and +9°C in the western region.

Changes in delta minimum temperature for the two RCPs predict that an increase in minimum temperature and an increase in the inter-annual variability (i.e. variations in individual annual predictions) is **extremely likely**. For the RCP 4.5, the temperature rises up to +2°C by 2085 (ranging from +1.7°C and +3°C). The inter-annual variability given by the reference model may reach more than 1.5°C, where it stays positive after 2000 and it exceeds maximum averages in some years. For RCP 8.5, the median temperature could rise up to +4°C by 2085, (ranging from +5.3°C to +3.7°C). The inter-annual variability remains positive after 2000 and it can reach up to 1.5°C and can exceed extreme averages.

Figure 4.9: Projected average minimum temperature (°C) over Jordan using the reference model, for 2035, 2055 and 2085 times-horizons and for RCP 4.5 and 8.5

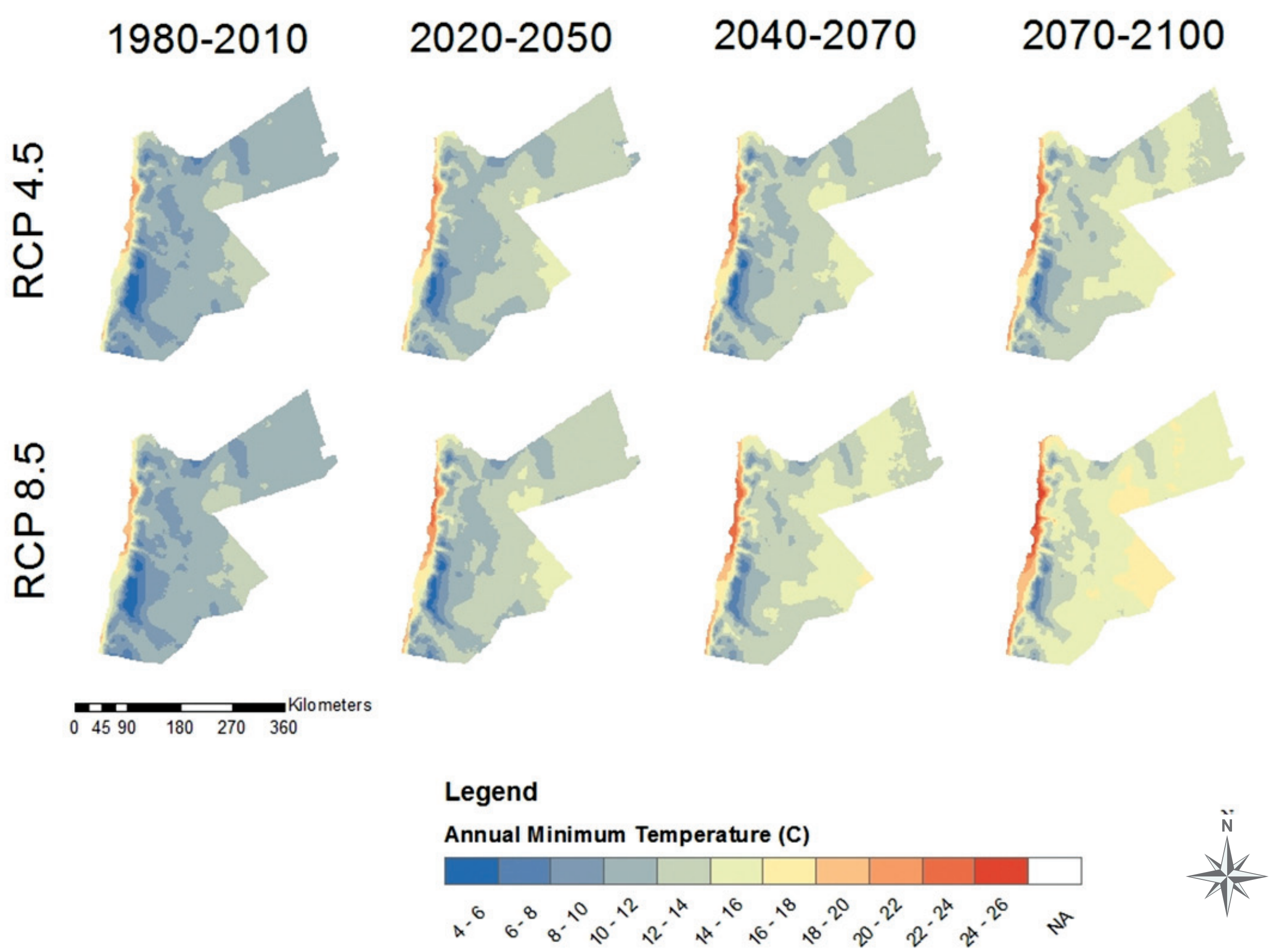
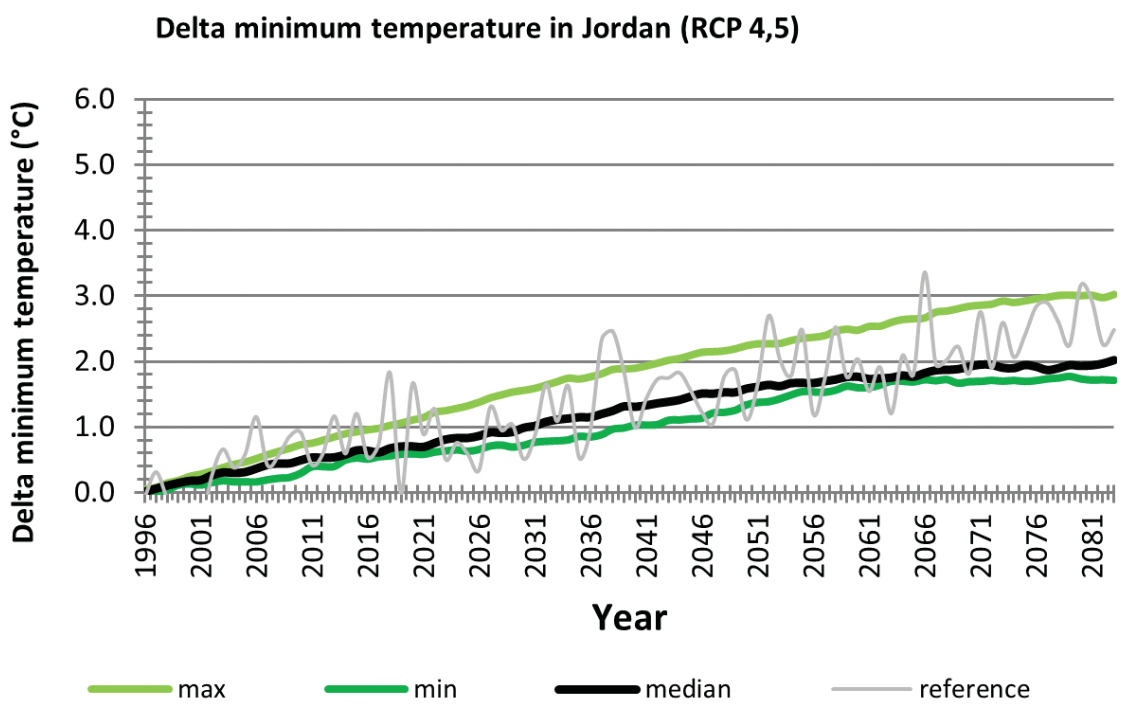
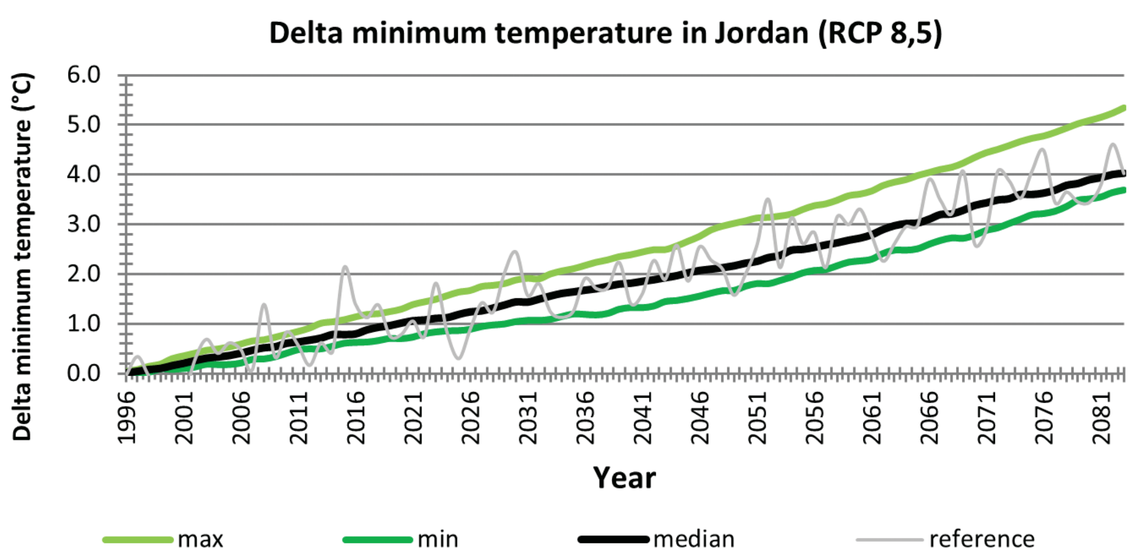


Figure 4.10: Projected changes in delta minimum temperature (°C) over Jordan for RCP 4.5 and 8.5





MAXIMUM TEMPERATURE

The RCP 4.5 predicts that the occurrence of a homogeneous and gradual rise in maximum temperature that could reach up to +3°C in 2100 (Figures 4.11-4.12) is **extremely likely.** The RCP 8.5 predicts that a stronger increase in max temperatures, but with sparsely spatial distribution is **extremely likely.** The strip along the southwest frontier could be less impacted up to 2070. However, in 2100, all the country will be subjected to a temperature increase between +3 and +5°C.

RCP 4.5, predicts that a rise in the projected maximum temperature up to 2.1°C in 2085 (ranging from +1.7 to +3.2°C) is **extremely likely**. The inter-annual variability is predicted to be globally positive except some years before 2025, and can exceed the extreme average by 0.5°C. For the RCP 8.5, the median of the projected maximum temperature is predicted to increase up to +4.1°C by 2085 (ranging between +3.7° and +5.5°C). The inter-annual variability figure indicates a continuous positive increase after 2000, where the temperature increase could reach 2° over the maximum average.

Figure 4.11: Projected average maximum temperature (°C) over Jordan using the reference model, for 2035, 2055 and 2085 times-horizons and for RCP 4.5 and 8.5

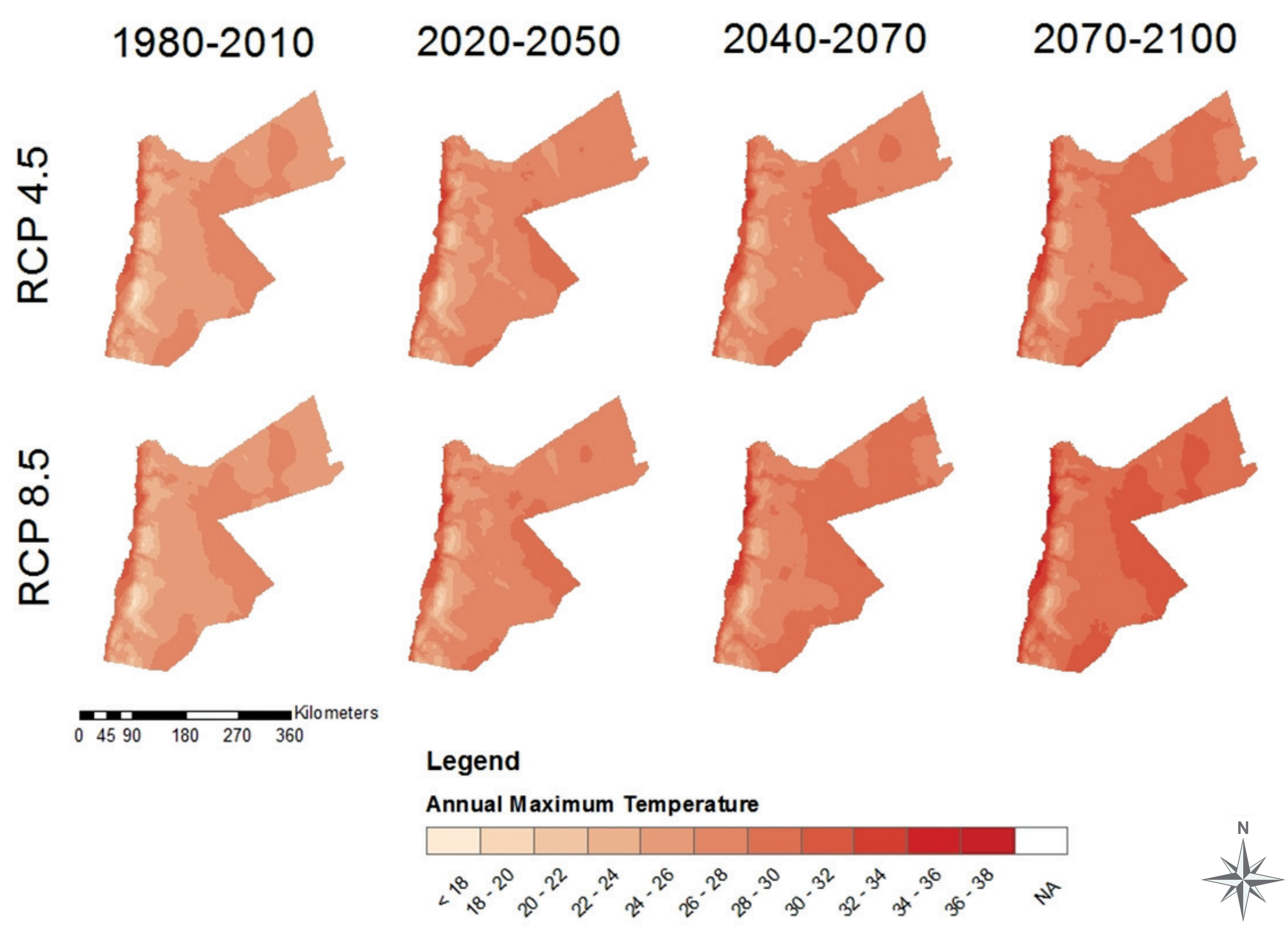
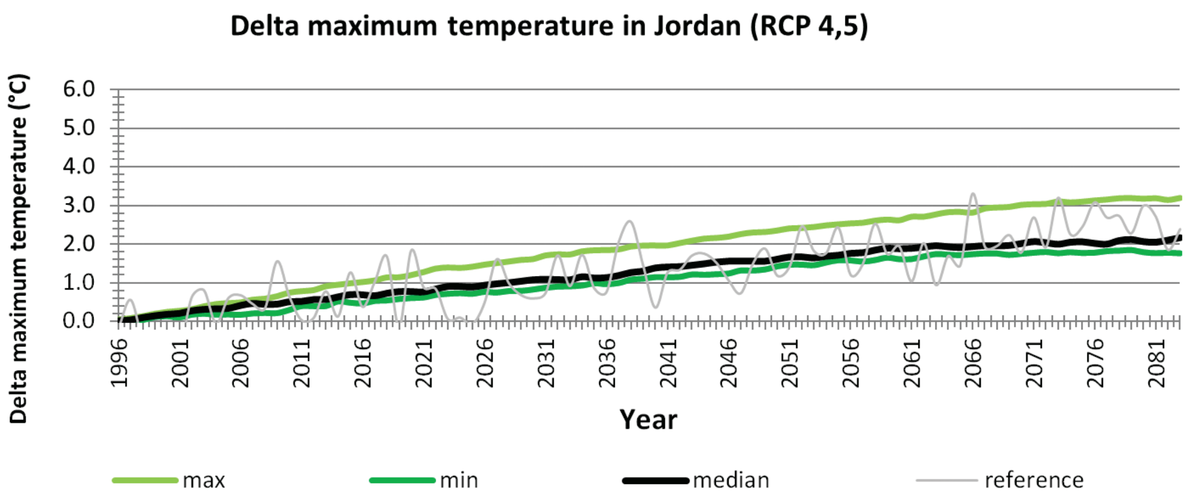
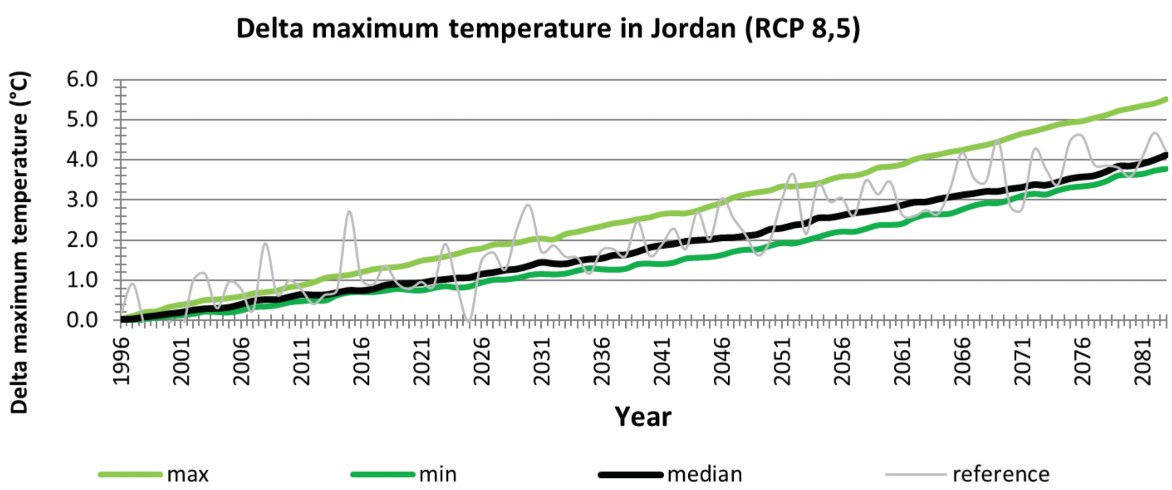


Figure 4.12: Projected changes in maximum temperature (°C) over Jordan for RCP 4.5 and 8.5





PRECIPITATION

The projected precipitation using two RCPs predicts that Jordan will **likely** suffer from a significant variability in the next 30-years moving average annual precipitation and the individual annual prediction over time. The RCP 4.5 predicts that there is **likely** to be an increase in precipitation up to the year 2050 on the Eastern and Southern Badia regions and at the Northern and Southern Highlands, while it predicts a decrease for the rest of the country and it could reach up to 50% in the North of Aqaba (Figure 4.13). Until 2100, the projected decrease in precipitation will cover the whole country, except the northeastern part. The RCP 8.5 predicts that the precipitation is **likely** to decrease all over the country by 2050, except in for the northern highlands of Irbid and highlands of Tafeeleh and Karak where there is expected to be an even higher increase. After 2050, the precipitation is expected to shift towards the southern Badia where a positive anomaly extends along the southeast frontier up to 2100.

The RCP 4.5 predicts that the median precipitation values all over the country will decrease by 20% by 2055. After 2055, the decrease in precipitation becomes quite constant and reaches values of –16% by 2085 (Figure 4.14). The maximum values show that more precipitation will occur until 2040, then the values becomes similar to the reference period. The minimum values decrease steadily until 2040 and then more irregularly reaching values of –24% by 2085. The reference model shows a large inter-annual variability between –60 and +85%, indicating variability between wet and dry years. Very wet years would still be likely possible at the end of the century, however the overall trend is still clearly towards a decrease in precipitation.

For the RCP 8.5 the median projected precipitation values decrease up to 21%. The minimum values could be reduced by up to 38%. The maximum values show a rise up +11% by 2025 then a decrease up to 9% by 2085. The reference model shows great variability between –60 and +75%, with an extreme year reaching up to +112%. Again, wet years are still **likely** possible at the end of the century, but also very dry ones.

Figure 4.13: Projected annual precipitation (mm) over Jordan using the reference model, for 2050, 2070 and 2100 times-horizons and for RCP 4.5 and 8.5

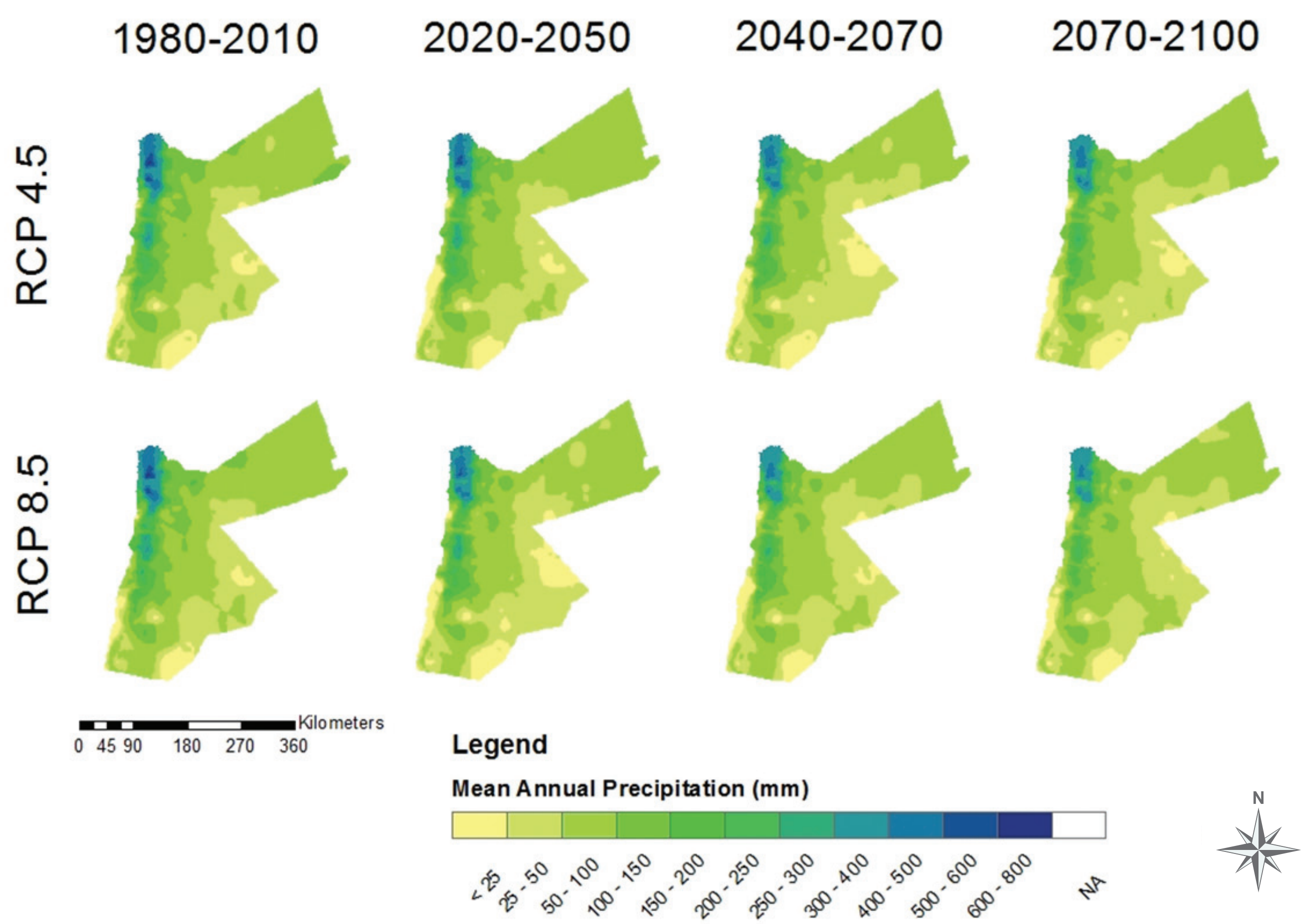
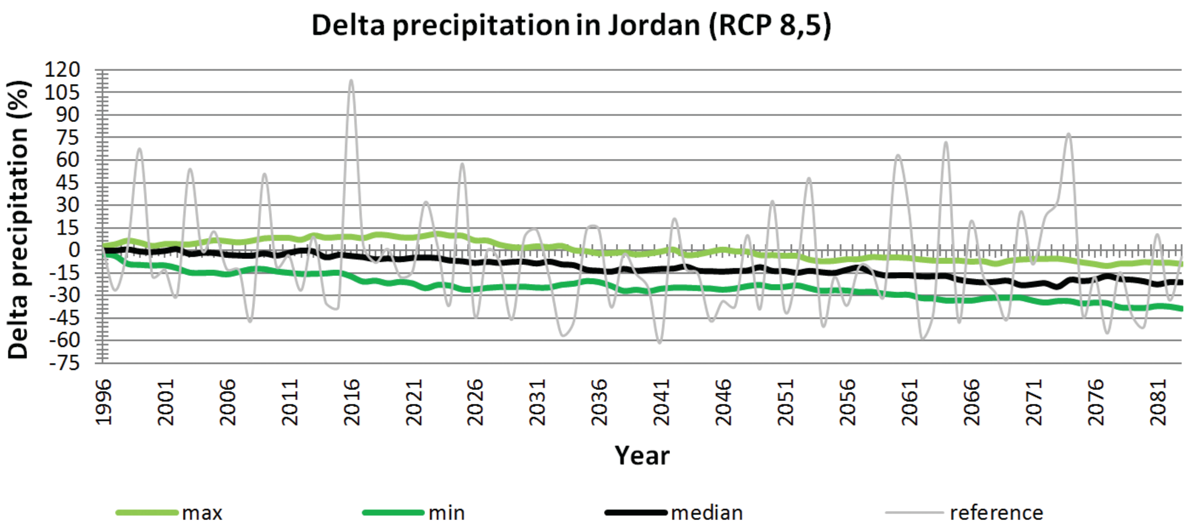
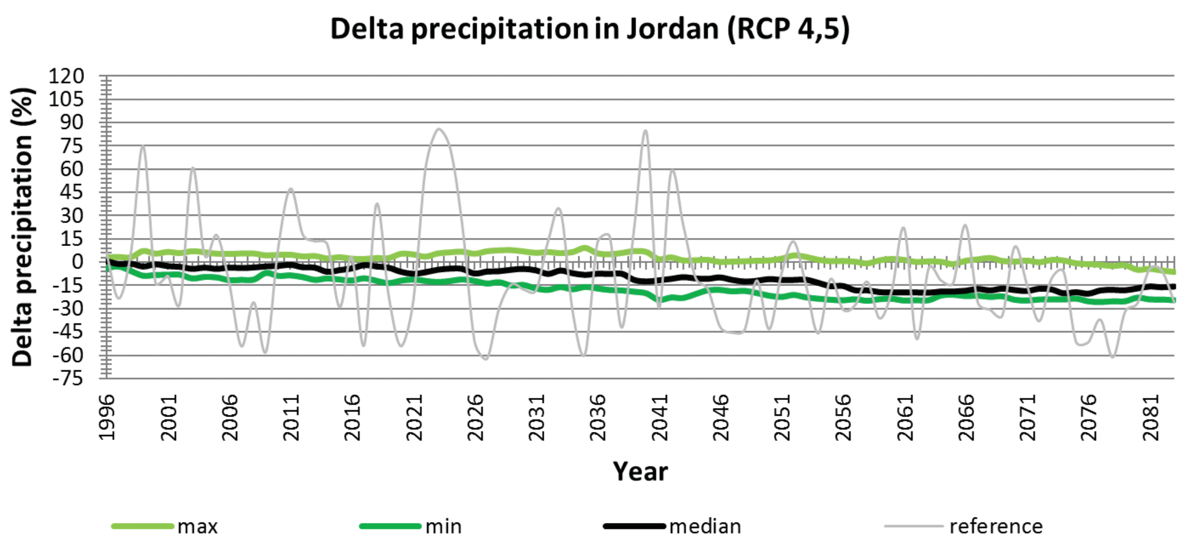


Figure 4.14: Projected changes in annual precipitation (%) over Jordan for RCP 4.5 and 8.5





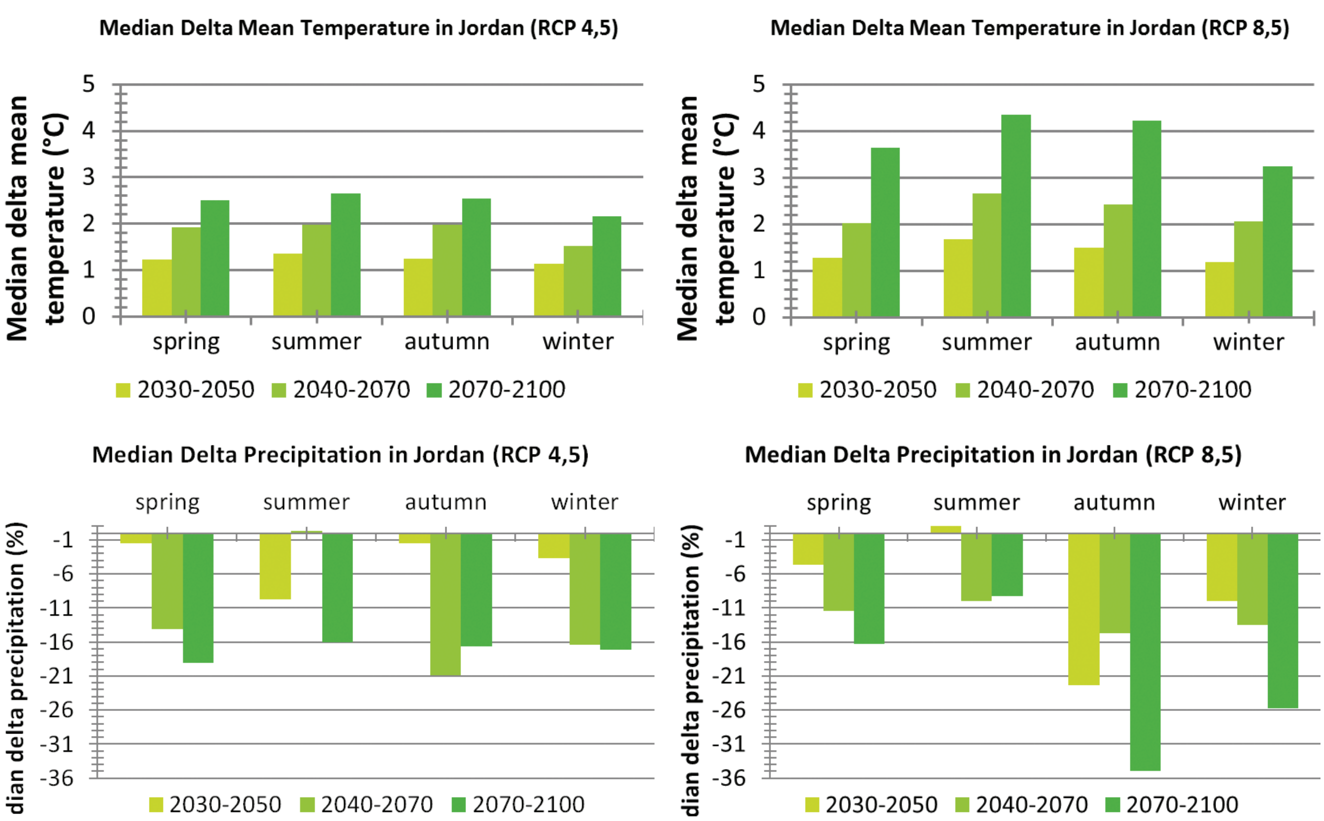
SEASONAL PERSPECTIVE

The two RCPs predict a gradual rise in seasonal mean temperatures (Figure 4.15). The rise is **extremely likely** to be higher in summer, and less in winter, which could further increase the negative impact of climate change. The RCP 4.5 predicts that by 2050, a rise in seasonal mean temperature, up to +1.2°C for each season. While by 2070, the increase could reach up to +2°C except for winter when the increase is lower, around+1.5°C. By 2100, the projected seasonal mean temperature could rise up to +2°C, in winter, exceeding +2.5°C, for the other seasons with a maximum of +2.6°C in summer. For the RCP 8.5, the difference among the seasons is more important. The seasonal projected mean temperature rise is between +1.1°C in winter and +1.6°C in summer by 2050. In 2070, it ranges between +2°C in spring and 2.6°C in summer. The seasonal projected mean temperature evolution until 2100 is the highest, where it may reach +3.2°C in winter and +4.3°C in summer.

Projected seasonal precipitation is **likely** to be more substantial during the rainy season (Figure 4.16). The RCP 4.5, projects that precipitation is expected to decrease during summer by nearly 10% by 2050, thus affecting a time of the year where the precipitation values are close to zero. This explains the projected chances of summer precipitation by 2070, which presents no decrease in rainfall, compared to the reference period. For the other seasons, the decrease is more substantial in 2070, with an important loss during the rainy season (around -20%) in autumn and around 16% in winter. In 2100, the seasonal projected precipitations decrease does not change significantly, except for summer with a decrease of 16%.

The RCP 8.5, predicts that in summer, seasonal projected precipitations are **likely** to increase by 2050 and then it stabilizes at around 10%. In autumn, the decrease exceeds 22% by 2050 and reaches 35% by 2100. The seasonal projected precipitation changes in spring and winter rainfall are gradual and reach respectively -16% and -25% by 2100, and thus precipitation falls dramatically during the rainy season.

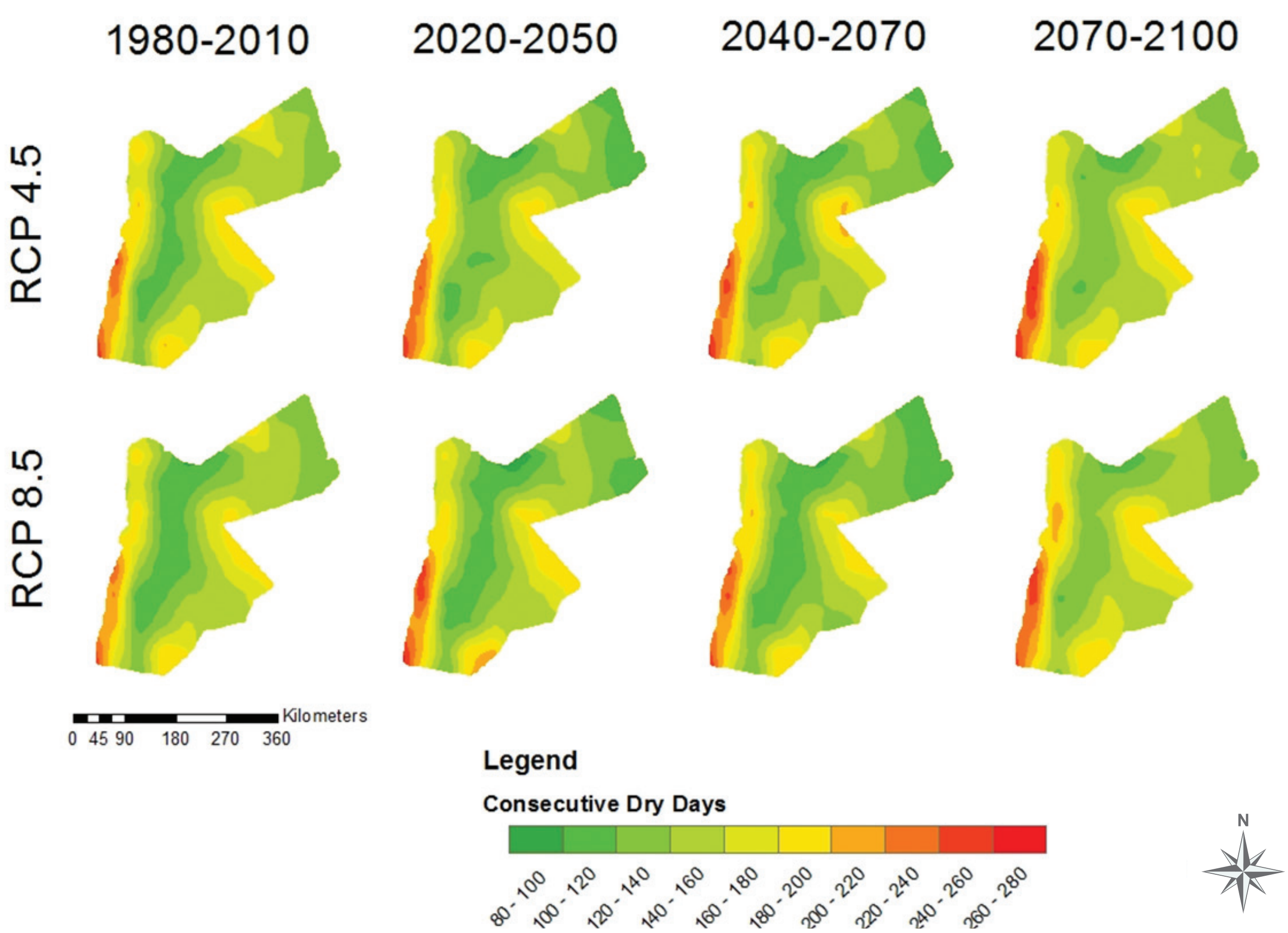
Figure 4.15: Projected changes in seasonal mean temperature (°C) over Jordan for 2035, 2055 and 2085 times-horizons and for RCP 4.5 (left) and 8.5 (right) using median of multi-model ensemble



CONSECUTIVE DRY DAYS

Dynamic projections predicts that consecutive dry days are **likely** to increase over time till the middle of the 21 century especially at the southern region close to Aqaba and it is **likely hood** is magnified at the end of the 21st century. For RCP 4.5, the geographic magnitude is very significant and tends to increase over time and may reach to around 30-40 days especially in the southern highlands. This increase is stronger for RCP 8.5 where the increase in the maximum number of consecutive dry days is **more likely** to occur at the western region with more focusing on ZRB and the southern regions (Figure 4.17).

Figure 4.17: Projected annual consecutive dry days in Jordan using the reference model, for 2035, 2055 and 2085 times-horizons and for RCP 4.5 and 8.5



HEAVY PRECIPITATION DAYS

The nature of climate models and the low frequency of climate extremes make it difficult to assess the long-term variability of weather extremes. The analysis of heavy annual precipitation days (>10 milimeters) does not reveal a clear signal (positive or negative), nor a trend or a clear spatial distribution of events. Since the absolute values are low and range from 0 to 6 millimeters a day, given the aridity of Jordan, the models were not able to predict extreme heavy rains (Figures 4.18-4.19). However, in all cases the chance to have extreme rainfall events is still possible especially at northern highlands and southern highlands as indicated by Figure (4.19), which shows that at least could occur 1-2 days per year. In some exceptional years and during a month, the mean total precipitation of the country could reach 90 to 100 millimeters. Depending on the spatial and temporal distribution, those extreme months are responsible for huge flood events, witnessed during the last period especially in the southern region.

Figure 4.19: Projected number of precipitation days >10 mm over Jordan using the reference model, for 2035, 2055 and 2085 times-horizons and for RCP 4.5 and 8.5

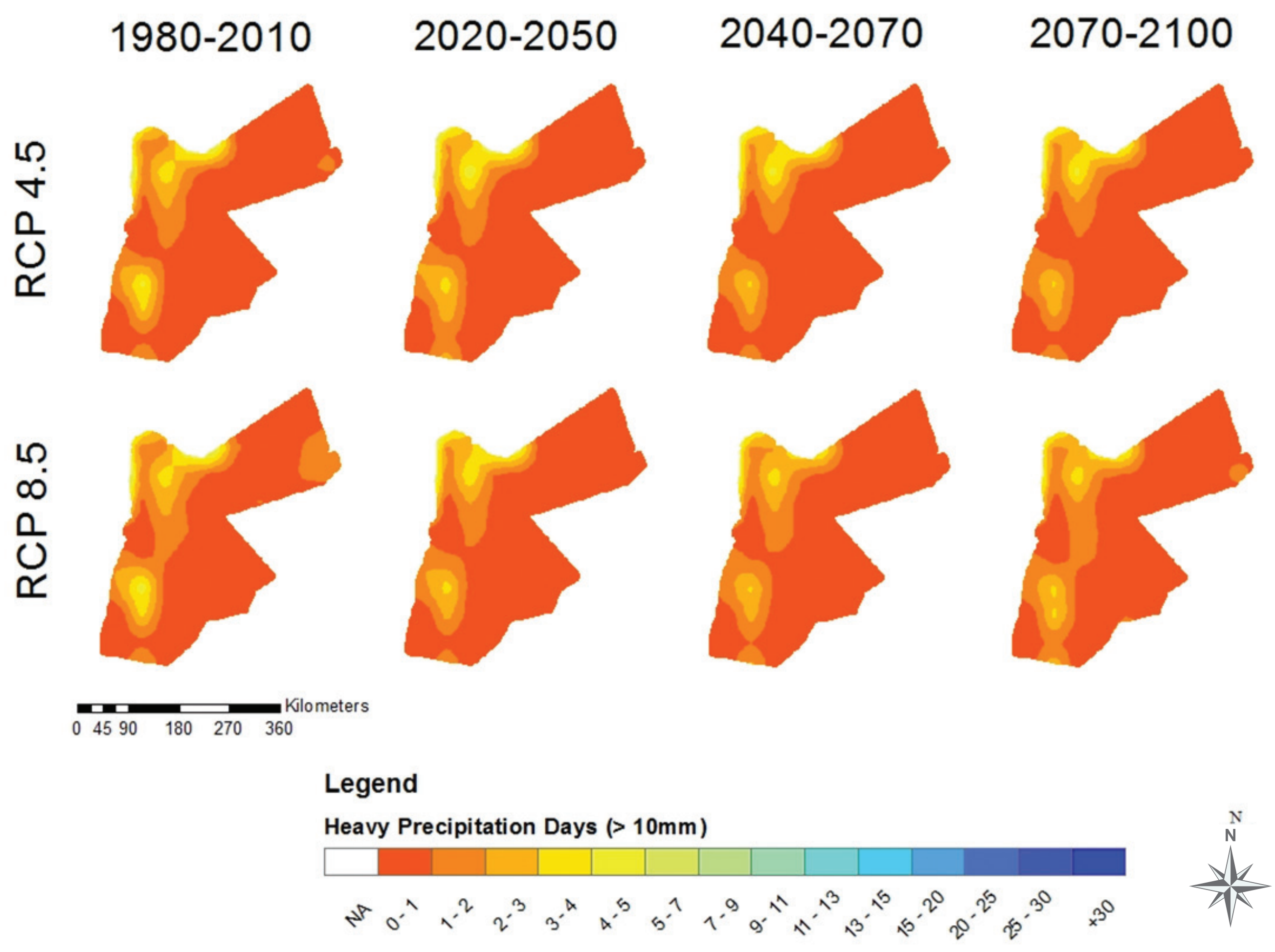
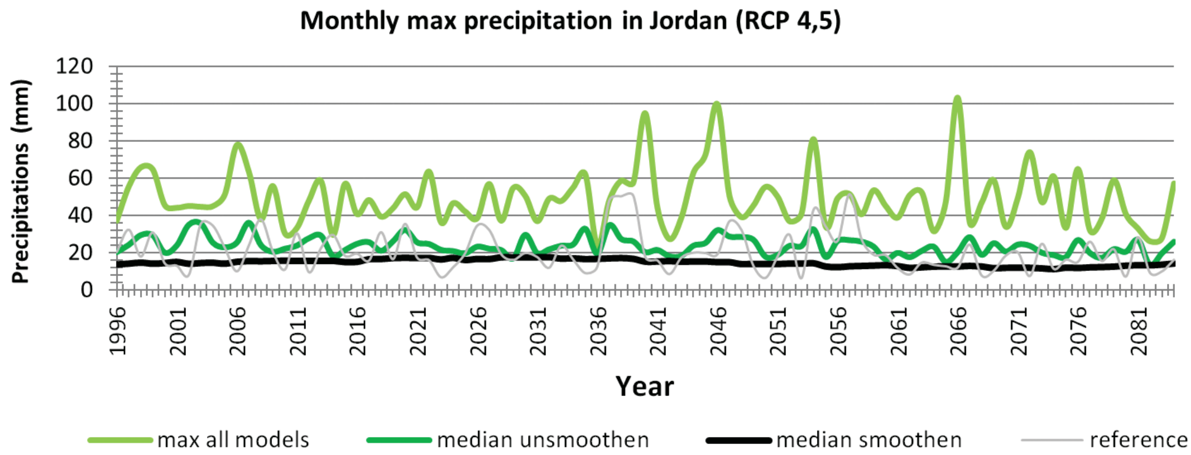
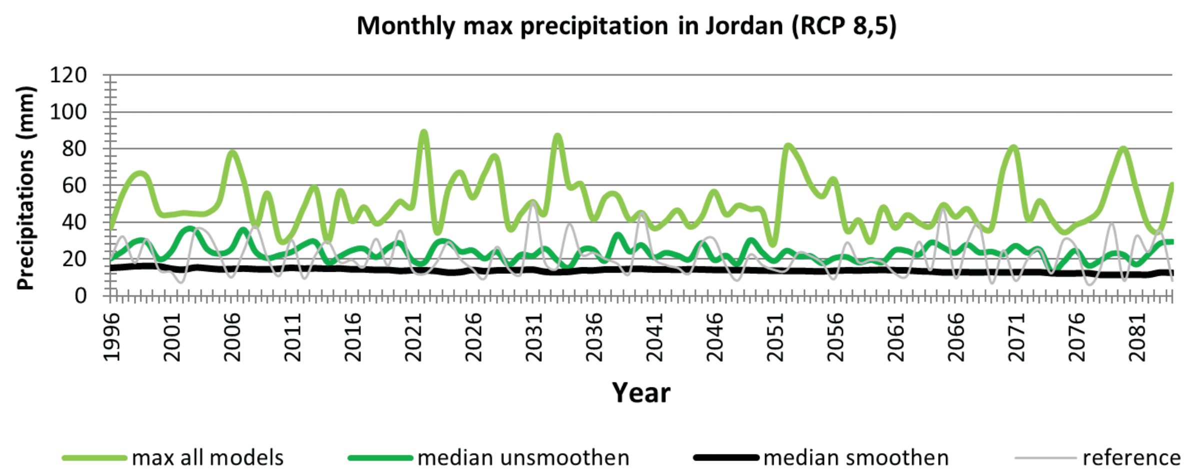


Figure 4.18: Projected changes in number of days of heavy precipitation over Jordan for RCP 4.5 and 8.5





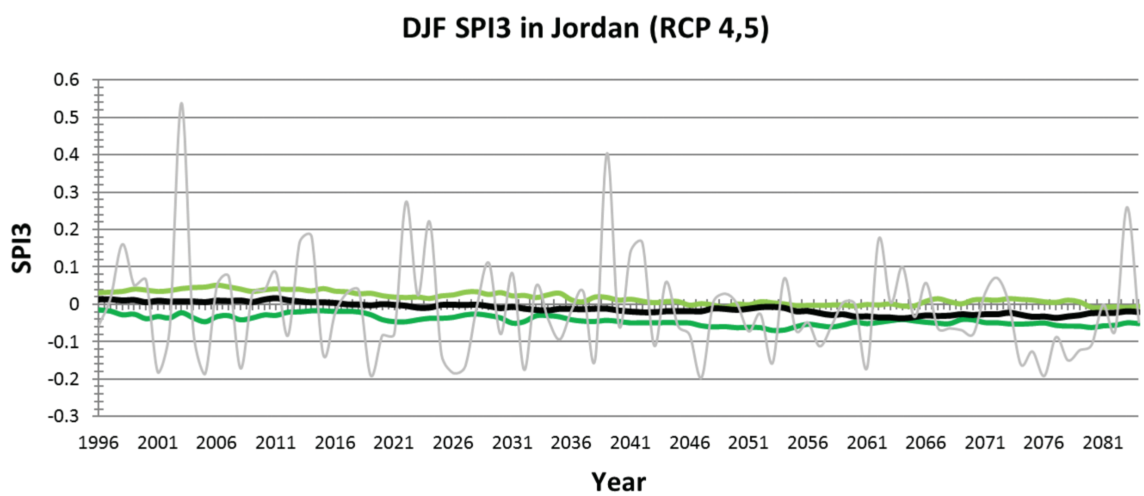
STANDARDIZED PRECIPITATION INDEXES (SPIS)

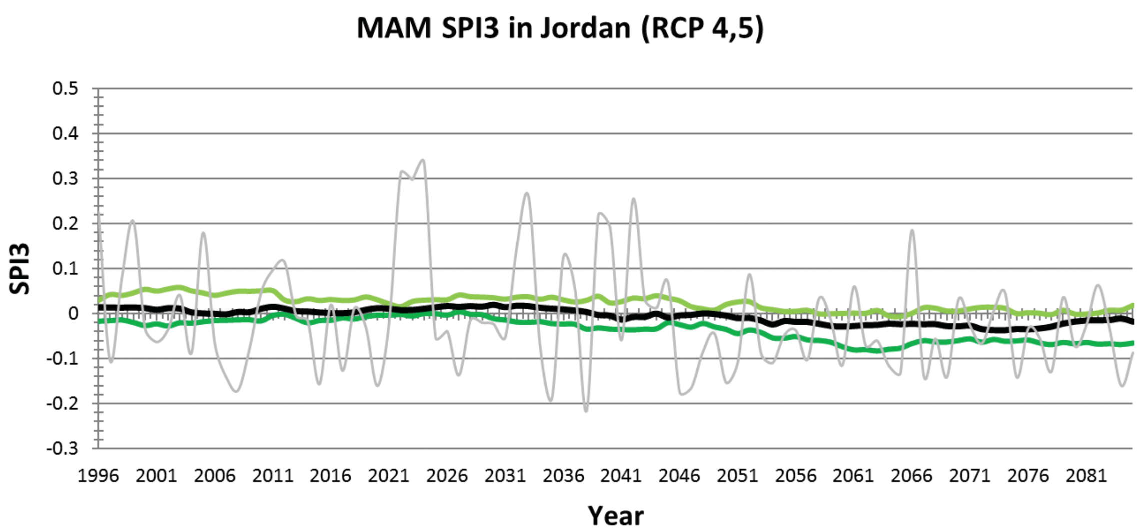
The SPI is an index based on the probability of recording a given amount of precipitation, and the probabilities are standardized so that an index of zero indicates the median precipitation amount. The negative index refers to drought events, and positive for wet conditions. As the dry or wet conditions become more severe, the index magnitude increases.

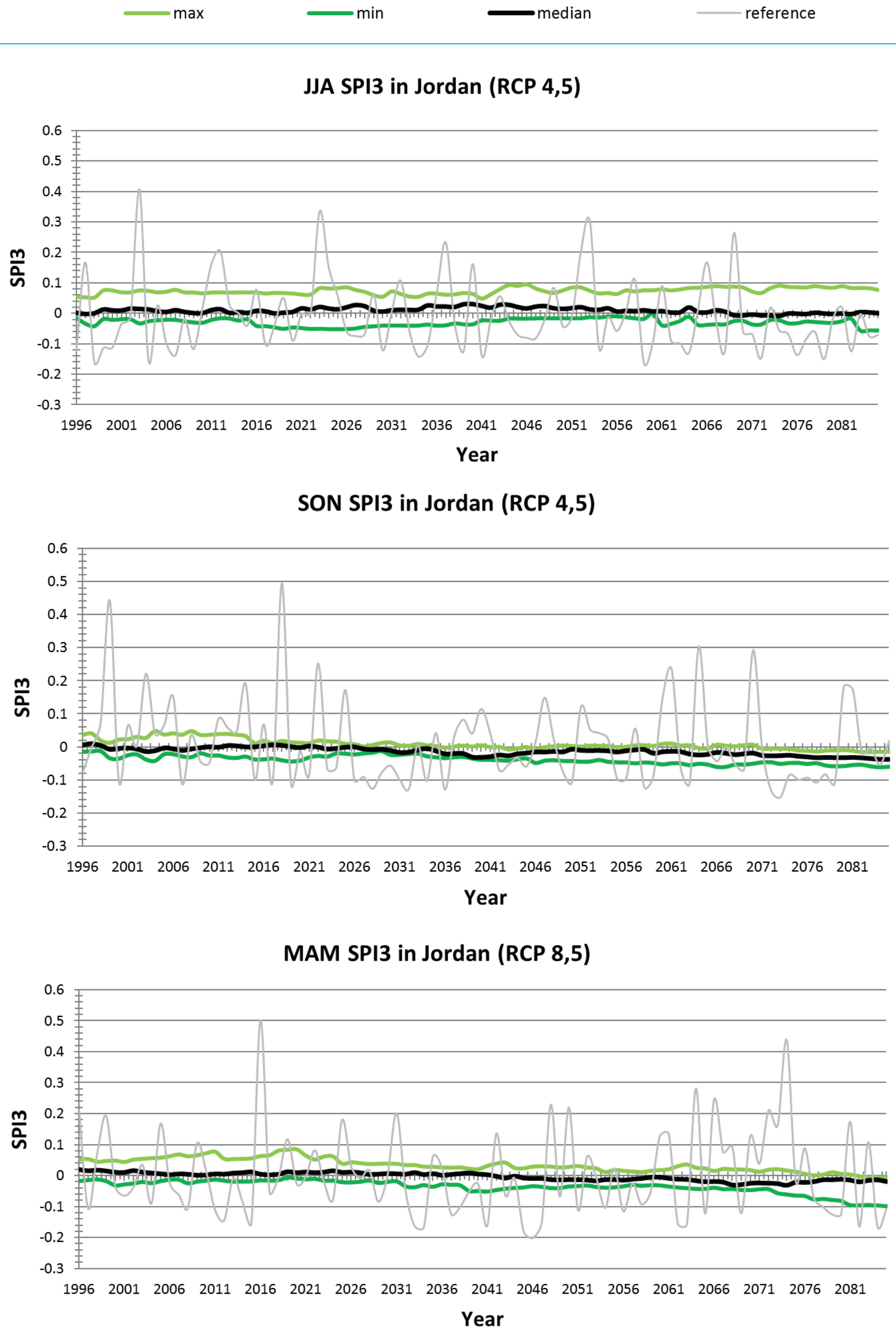
The SPIs were calculated based on the 1980-2100 period (Figures 4.20-4.21). Therefore, given the overall decrease of precipitation over Jordan in this period, the values start above average (i.e. wet years, compared to the 1980-2100 average), while ends below average (i.e. dry years) indicating that it is **extremely likely** to experience more drought. The SPI maps suggest progressive trends towards an intensification of droughts, especially in winter (DJF) and spring (MAM) as compared to autumn (SON). The droughts are **more likely** to be intense in RCP 8.5. Similarly, the consequence of these droughts are **likely** becoming more frequent, 3-4 years and thus impacting the water balance significantly.

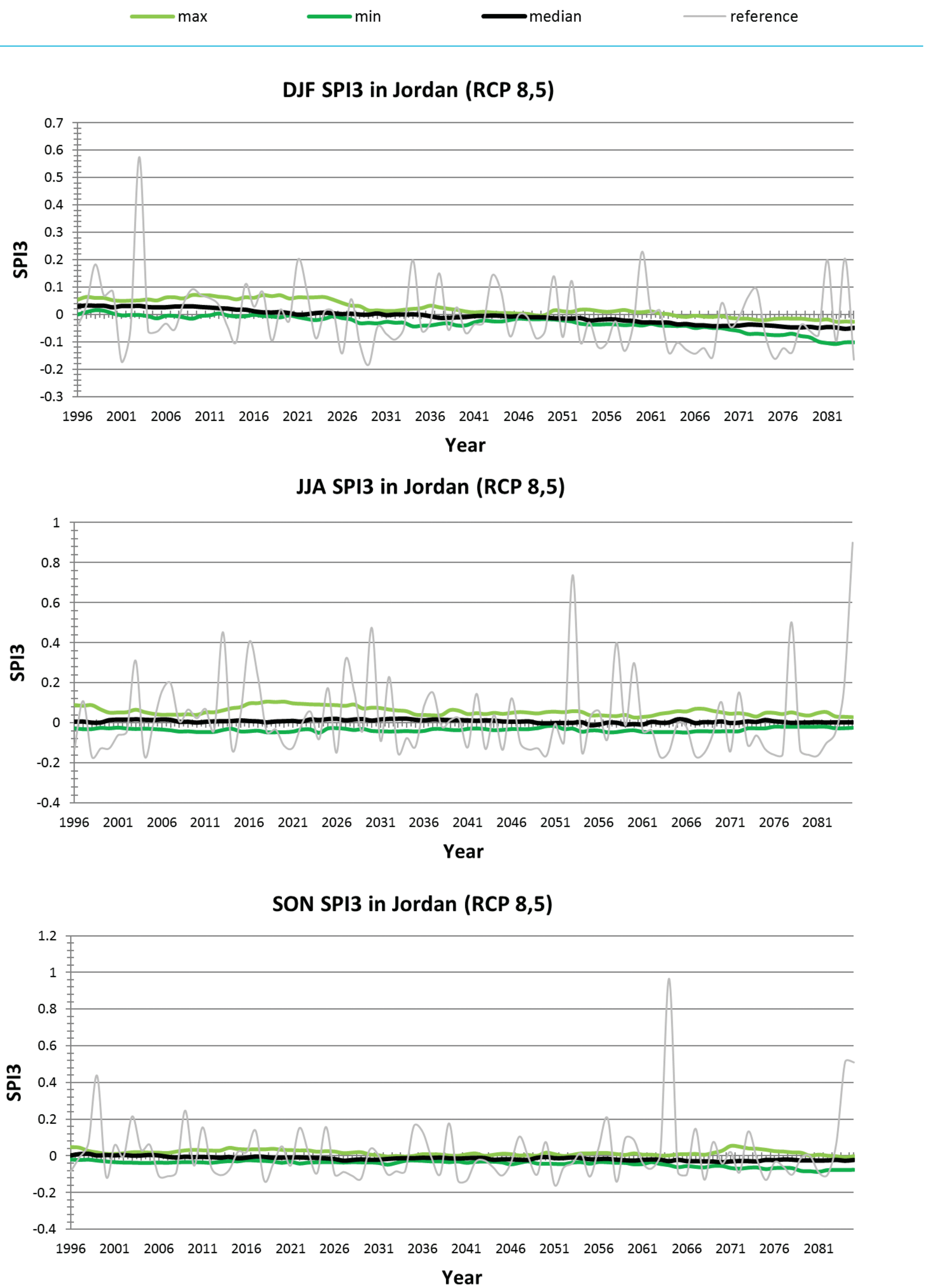
On the other hand, wet years and seasons are increasing, indicating that it is **likely** to witness wet years above the average with high values that may generate flood events. Although the frequency is once every 10-15 years, its occurrence is more frequent in autumn (SON) compared to winter (DJF) while the magnitude is higher winter (DJF) compared to autumn (SON).

Figure 4.21: Projected Seasonal SPI for RCP8.5 across Jordan





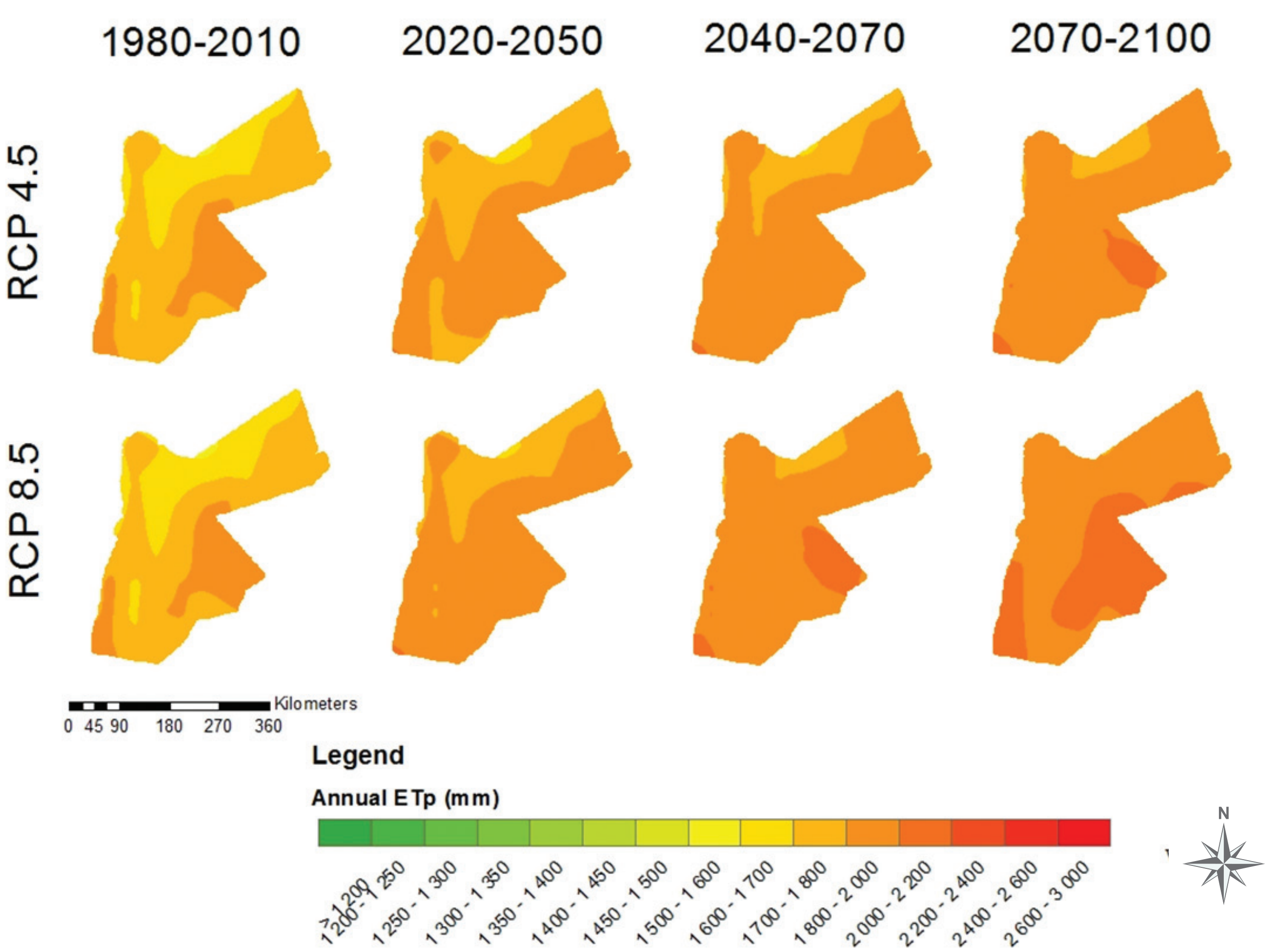

max
min
median
reference
JJA SPI3 in Jordan (RCP 4,5)
SPI3
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1996 2001 2006 2011 2016 2021 2026 2031 2036 2041 2046 2051 2056 2061 2066 2071 2076 2081
Year
SON SPI3 in Jordan (RCP 4,5)
SPI3
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1996 2001 2006 2011 2016 2021 2026 2031 2036 2041 2046 2051 2056 2061 2066 2071 2076 2081
Year
MAM SPI3 in Jordan (RCP 8,5)
SPI3
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1996 2001 2006 2011 2016 2021 2026 2031 2036 2041 2046 2051 2056 2061 2066 2071 2076 2081
Year


max
min
median
reference
DJF SPI3 in Jordan (RCP 8,5)
SPI3
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1996 2001 2006 2011 2016 2021 2026 2031 2036 2041 2046 2051 2056 2061 2066 2071 2076 2081
Year
JJA SPI3 in Jordan (RCP 8,5)
SPI3
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
1996 2001 2006 2011 2016 2021 2026 2031 2036 2041 2046 2051 2056 2061 2066 2071 2076 2081
Year
SON SPI3 in Jordan (RCP 8,5)
SPI3
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
1996 2001 2006 2011 2016 2021 2026 2031 2036 2041 2046 2051 2056 2061 2066 2071 2076 2081
Year

Potential Evapotranspiration (PET)

The projected PET is **likely** to increase gradually over time as indicated by the two CPs. By the end of the 21st century, the PET will **likely** increase to 250 millimeters, especially in the southern region and more concentrated in Aqaba (Figure 4.22). The country will have an average increase of about 70-100 mm by the year 2050, and 150 millimeters by the year 2100. For the two RCPs, the PET will **likely** increase up to 2000 millimeters and more in the southern region, while the far eastern frontier will be even more intense.

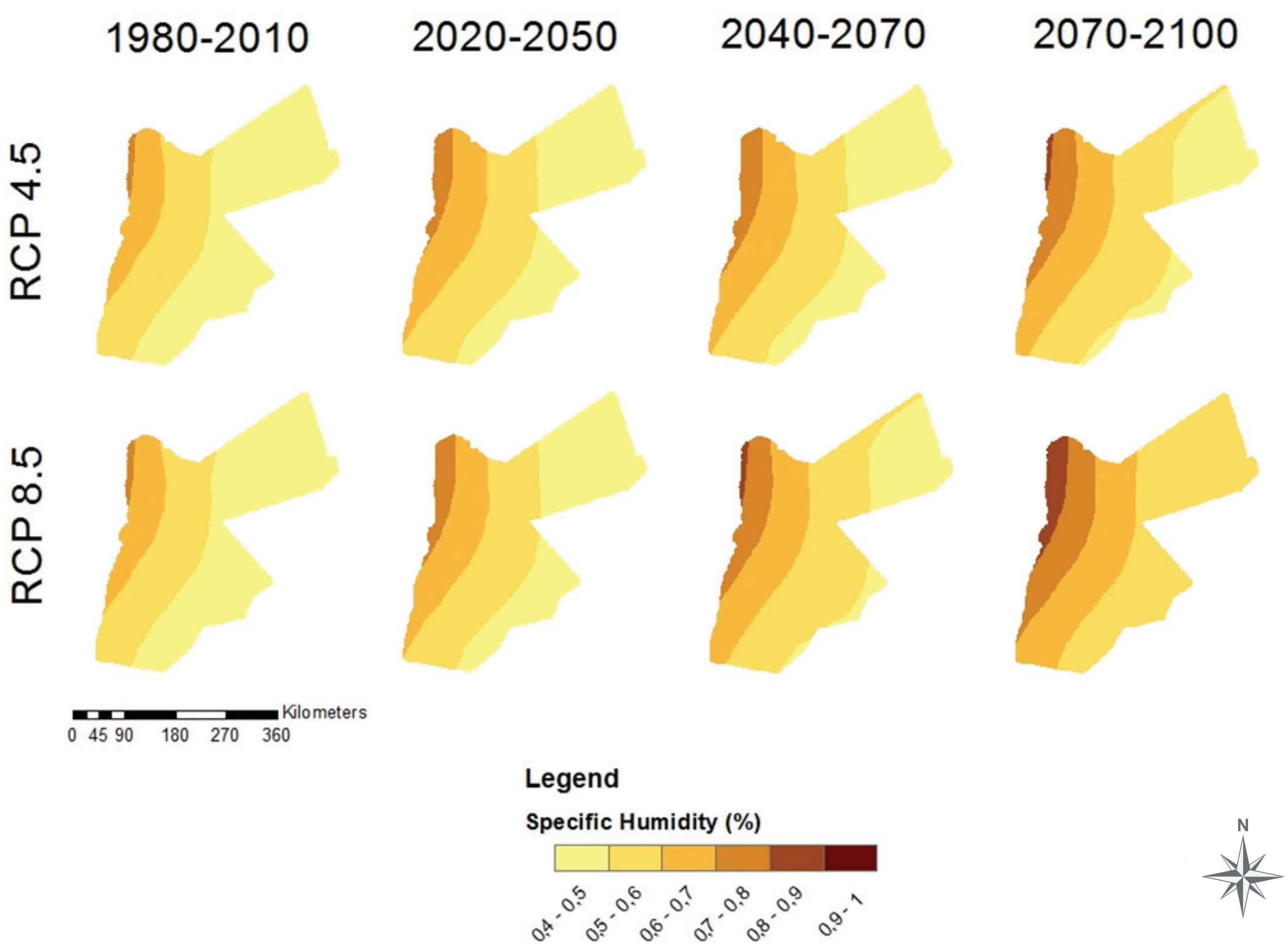
Figure 4.22: Projected potential annual evapotranspiration (mm) over Jordan using the reference model, for 2035, 2055 and 2085 times-horizons and for RCP 4.5 and 8.5



SPECIFIC HUMIDITY

The two RCP projects regarding specific humidity, is **likely** to increase by 0.05% (i.e. the relative may increase up to 5%) by the end of 2050. On the other hand, the increase is more focused in the northern highlands where it may reach up to 0.2% (i.e. RH of 20%), for RCP 8.5. The two RCPs show an increase in specific humidity, this is more important for RCP 8.5. Both absolute values (represented in maps) and deltas are higher in the western part of the country, with a gradient form northwest to southeast (Figure 4.23).

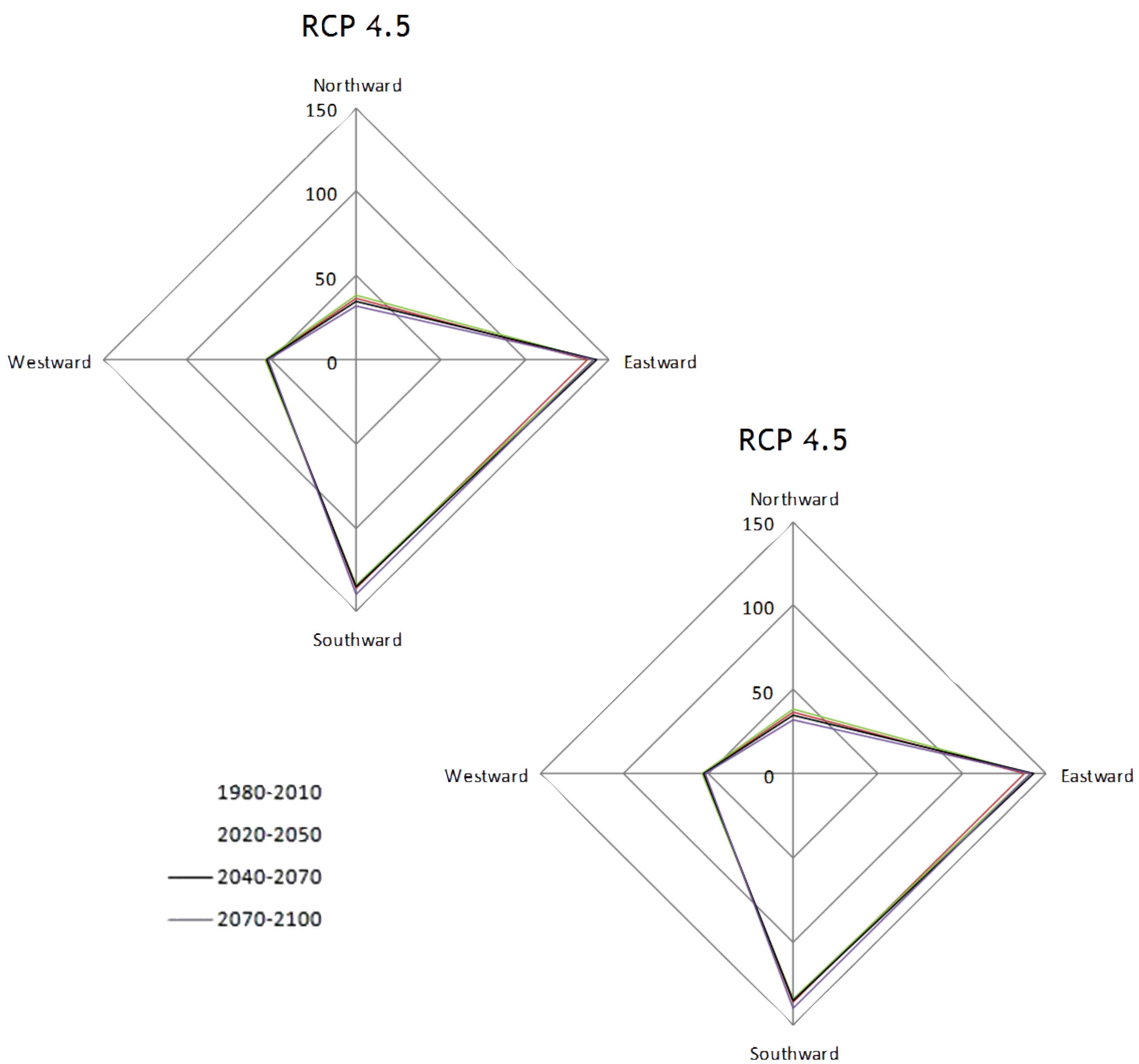
Figure 4.23: Projected Relative air humidity (%) over Jordan using the reference model, for 2035, 2055 and 2085 times-horizons and for RCP 4.5 and 8.5



WIND SPEED AND DIRECTION

The maximum wind speed and gust projection for the two RCPs predicted that there are no significant changes over time. The intensity was predicted to be around a median of 23 m/s in the whole country and it is **unlikely** that wind speed will increase over time. The inter-annual variability is low until 2060 and globally ranges between 21 and 25m/s. However, for the two RCPs, the main projected wind directions are **extremely likely** to be dominated at eastward and northward orientation however there might have some minor inter-annual changes that varies spatially and temporally (Figure 4.24).

Figure 4.24: Number of windy days for each direction in Jordan using reference model



Key messages from the dynamic downscaling study:

Table below shows the main messages that can be interpolated from the comprehensive climate change projections exercise conducted in the TNC. The trends described below indicate the expected future of the climate in Jordan until 2100.

Table 4.11: key messages for climate projections in Jordan

Trend	Details
A warmer climate	All models converge that the temperature will increase. AFRICA CORDEX results are consistent with the IPCC projections. For the 2070-2100 period the average temperature could reach according to RCP 4.5 up to +2.1 °C [+1.7 °C to +3.2°C] and +4°C [3.8-5.5] according to RCP8.5
A drier Climate	Compared to the SNC that used CMPI3 results, CMPI5 results coupled with regional climate models in CORDEX give a more consistent trend towards a drier climate. In 2070-2100 the cumulated precipitation could decrease by 15% (- 6% to 25%) in RCP 4.5, by -21% (9% to - 35%) in RCP 8.5. The decrease would be more marked in the western part of the country.
Warmer summer, drier autumn and winter	The warming would be more important in summer. The reduction in precipitation would be more important in winter and autumn than in spring, as for instance median value for precipitation decrease reaching - 35% in autumn of 2100
More heat waves	The analysis of summer temperatures monthly values and the inter-annual variability reveals that some thresholds could be exceeded. A pessimistic but possible projection for the summer months predicts that the average of maximum temperatures for the whole country could exceed 42-44° C
More drought, a contrasted water balance	The maximum number of consecutive dry days would increase in the reference model to more than 30 days for the 2070-2100 period. In contrast annual values still show possible heavy rainy years at the end of the century. More intense droughts would be (partly) compensated by rainy years in a context of a general decrease in precipitation. Evapotranspiration would increase. The occurrence of snow would strongly decrease. This will complicate water management.
No trend for intense precipitation or winds	The number of days with heavy rain (more than 10 mm) does not evolve significantly nor does the maximum wind speed or the direction of winds

4.3 VULNERABILITY & ADAPTATION OF THE WATER SECTOR

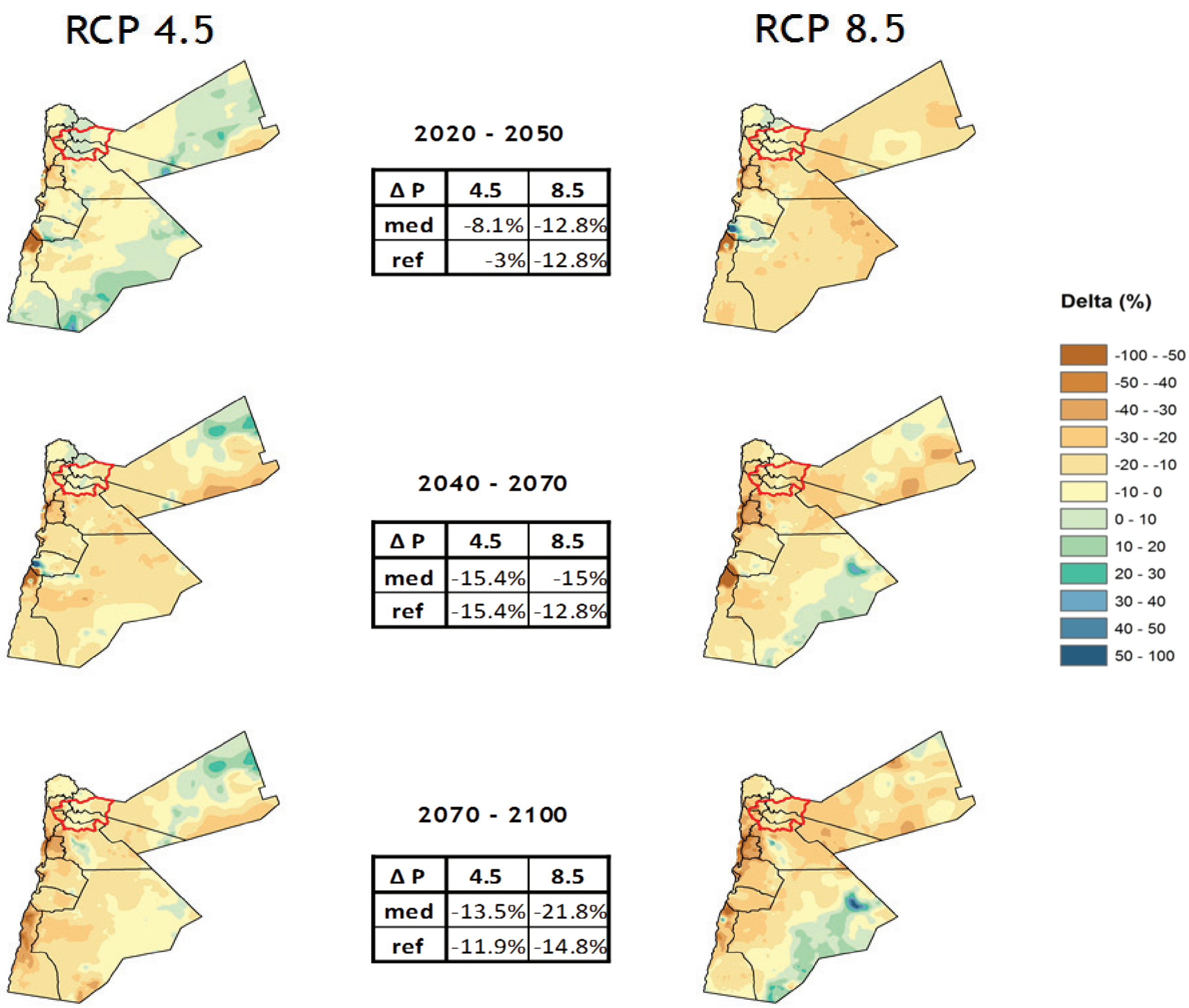
Water resources in Jordan are vulnerable to climate change. Previous studies, strategic documents (i.e. Jordan's SNC (2009) and National Climate Change Policy (2013)) have identified scarcity of water resources as one of the major barrier facing sustainable development in Jordan; a situation that will be magnified by Climate change.

Expected reduced precipitation, maximum temperature increase, drought/dry days and evaporation are the main determinants of climate change hazards. The impact of the increased evaporation and decreased rainfall will result in less recharge and therefore less replenishment of surface water and groundwater reserves. In the long term, this impact will extend to cause serious soil degradation that could lead to desertification, exacerbating future conditions and worsening the situation of the agricultural sector due to the lack of sufficient water that will affect the income of the agriculture sectors. Low income will ultimately reduce the ability to the adaptation to climate change with families unable to respond to the pressing needs for replacing traditional water supplies with new methods that require more spending (purchasing drinking water from tanks)

In addition to climate change the increased demand for water in Jordan during the last decade has contributed significantly to reducing per capita shares. The natural growth of economic activities and population increase has been exacerbated by the continuous flow of refugees from Syria in particular and thus increase the demand for water (see chapter 1).

The downscaled climate data on Jordan in general and on the study area in particular suggest that the long-term temperature and precipitation averages, for the periods 2020-2050; 2040-2070; 2060-2100 show a slight increase in temperature with slight decrease in precipitation (Fig 4.25 and 4.26).

Figure 4.25: Projected annual precipitation using RCP 4.5 and RCP 8.5 over Jordan for the periods 2020-2050; 2040-2070; 2060-2100



2020 - 2050

Δ P	4.5	8.5
med	-8.1%	-12.8%
ref	-3%	-12.8%

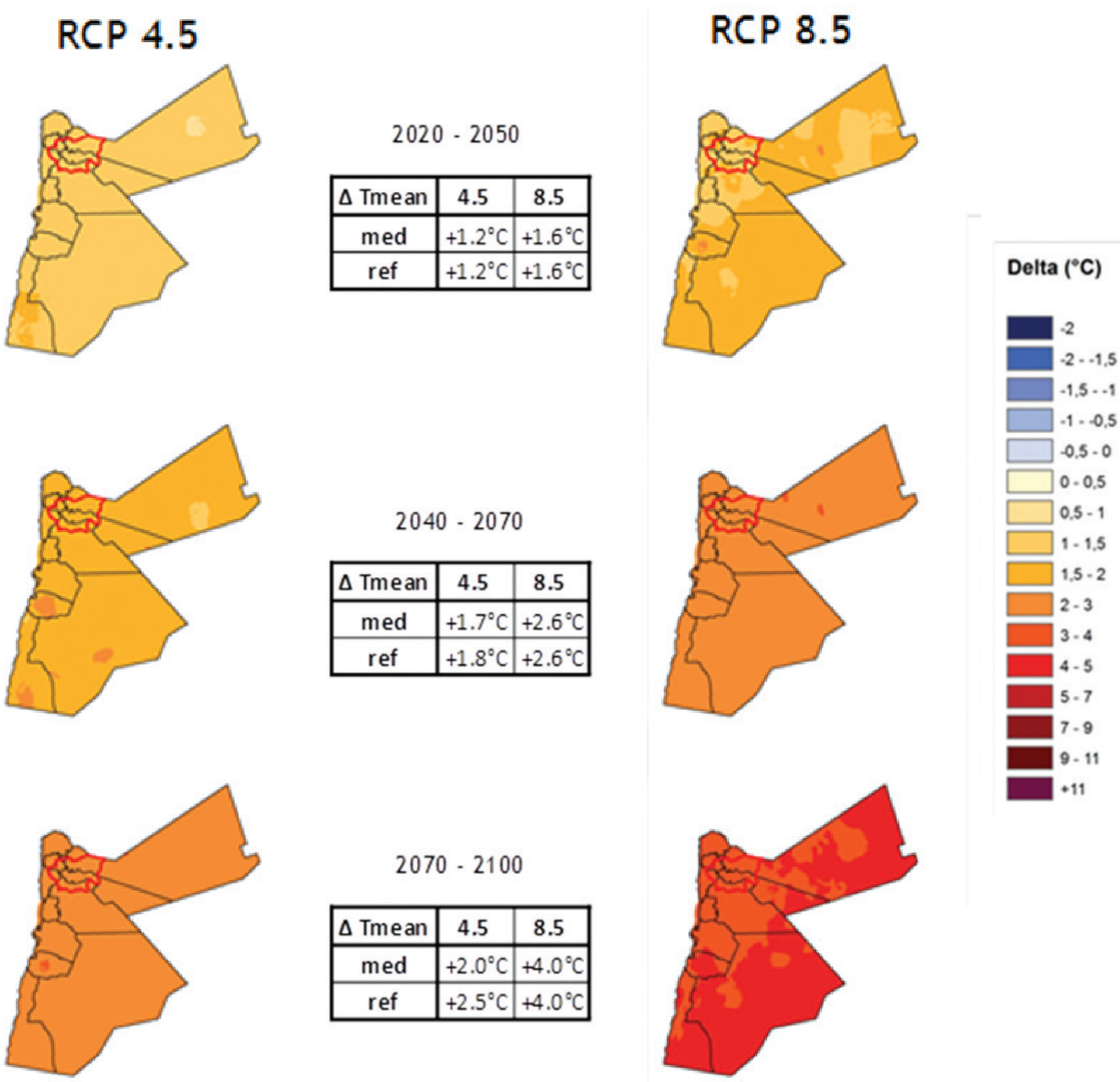
2040 - 2070

Δ P	4.5	8.5
med	-15.4%	-15%
ref	-15.4%	-12.8%

2070 - 2100

Δ P	4.5	8.5
med	-13.5%	-21.8%
ref	-11.9%	-14.8%

Figure 4.26: Annual mean temperature over Jordan for the periods 2020-2050; 2040-2070; 2060-2100



2020 - 2050

Δ Tmean	4.5	8.5
med	+1.2°C	+1.6°C
ref	+1.2°C	+1.6°C

2040 - 2070

Δ Tmean	4.5	8.5
med	+1.7°C	+2.6°C
ref	+1.8°C	+2.6°C

2070 - 2100

Δ Tmean	4.5	8.5
med	+2.0°C	+4.0°C
ref	+2.5°C	+4.0°C

Assessment of exposure

Table 4.12 shows the average exposure values based on the three components (likelihood, geographical magnitude and confidence level) for the two RCPs used in this study, which shows that the main climate hazard on water resources is the increase in temperature. The methodology for determining the final results of the average exposure is fully explained in the sectoral report on water vulnerability & Adaptation in the CD of resources attached to the TNC report.

Table 4.12: Average exposure in water sector scoring results

Climate change hazards	RCPs	Average assessment of hazard exposure	Total exposure score
Precipitation decreased	RCP 4.5	3.67	4
	RCP 8.5	4.33	
Temperature increased	RCP 4.5	5	5
	RCP 8.5	5	
Drought	RCP 4.5	3.67	4
	RCP 8.5	4.33	
Evaporation	RCP 4.5	3.67	4
	RCP 8.5	4.33	
Average		**4.5**	

Climate data pooled from eight models for three periods (2020–2050, 2040–2070, and 2070–2100) suggest that there is significant increase in temperature and hence in evaporation. Also, the data suggest reduced precipitation and hence, drought. Therefore, the study focused on the four parameters mentioned above. Figure 4.26 shows a pictorial representation for the minimum, maximum and median and for the reference model for RCP 4.5 and RCP 8.5. This significant change in the potential evaporation will apply further stress in the availability and distribution of the water resources in Jordan as well as in the study area. In conclusion, Jordan's water sector is extremely vulnerable to climate change, especially to temperature increase, decrease in precipitation and increase of evapo-transpiration in the area of study.

Similarly, the changes in precipitation predicted by the same models indicate significant reduction in the rainfall amounts during the three periods (Fig 4.28).

Based on the analysis of exposure, the three listed methods indicate an overall average exposure of 4.5, which is considered serious level of exposure.

Assessment of climate sensitivity of water sector

Selected sensitivity indicators have been examined. These indicators include groundwater level decline, groundwater quality deterioration, stream flow reduction,

Figure 4.27: Predicted Potential Evaporation

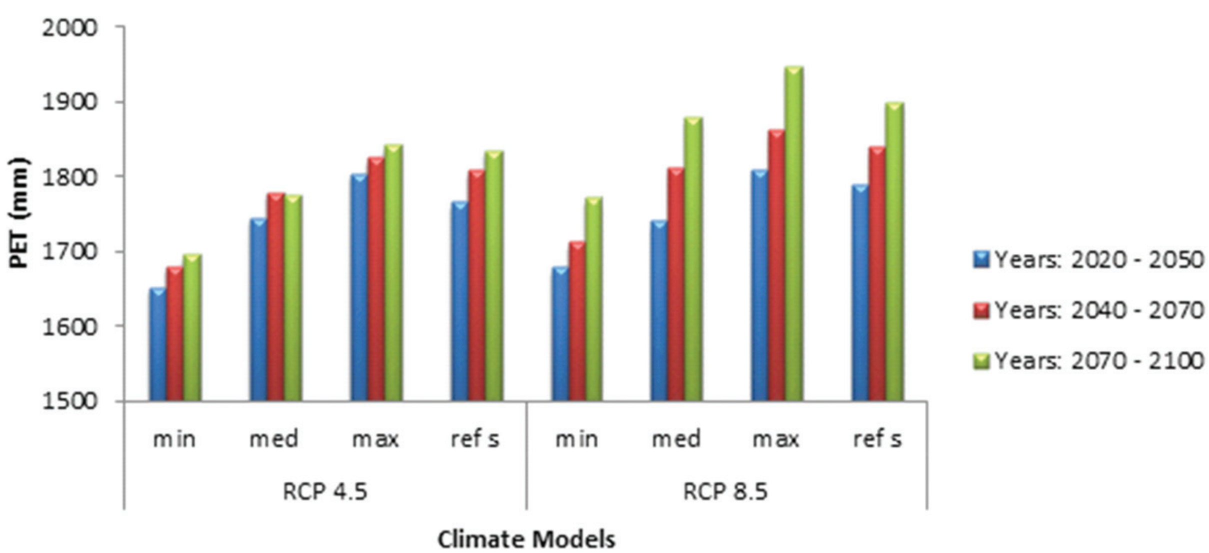
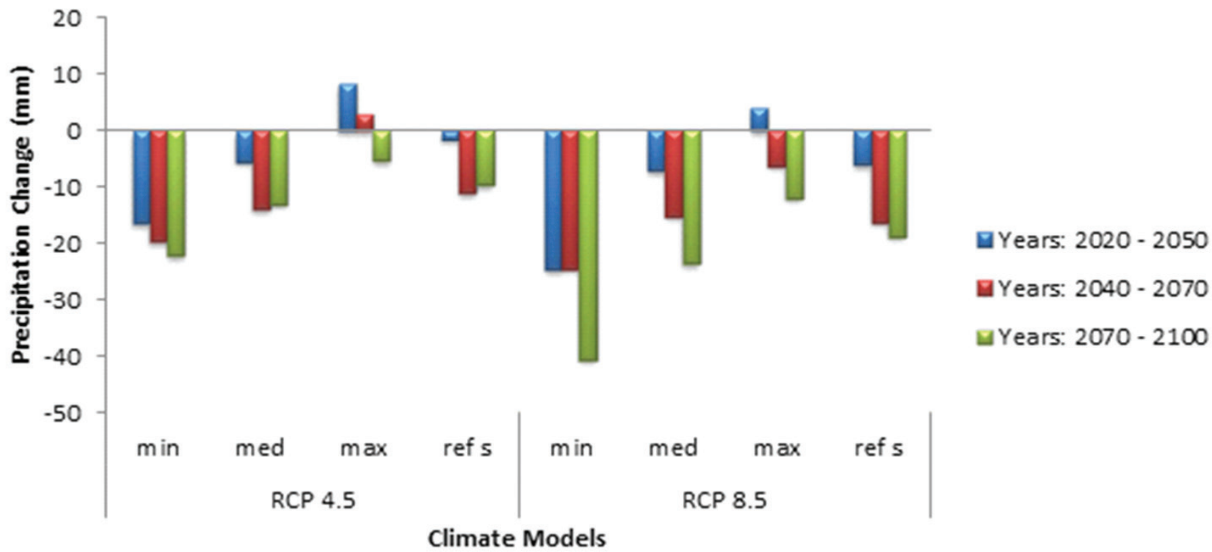


Figure 4.28: Predicted changes in precipitation



less groundwater recharge and increased water demand. Impacts include groundwater depletion and salinization, surface water contamination, soil erosion, desertification, disappearance of small springs, significant reduction in the discharge of major springs, violations and vandalism, land abundance, social conflicts and economic stresses.

The sensitivity factors are evaluated using a combination of socio economic information, expert judgment and hydrologic modeling. For example, the developed models are used to quantify the hydrologic response (sensitivity) of stream flow and groundwater levels to future variations in temperature and precipitation. For this purpose, the following scale with different scores is proposed:

Percentage	Changes
< 2%	Insignificant
2 – 10%	Minor
10 – 25%	Moderate
25 – 50%	Major
> 50%	Catastrophic

Lumped models are calibrated and validated using monthly precipitation, evaporation, stream flow and groundwater levels during the period 1981 – 2010. The calibration period is 20 years (1981 – 2000) and the validation period is 10 years (2001 – 2010).

Once the models are calibrated and validated, future monthly precipitation and evaporation form RCP 4.5 and RCP 8.5 are used to predict future stream flow and groundwater levels at two points within the study area. Afterward, the results are compared and evaluated. For example, when stream flow quantities are reduced by 2-10% due to the decrease in precipitation based on RCP 4.5 or RCP 8.5, the sensitivity of stream flow to the reduction in precipitation is evaluated as minor and its score is 2. Nevertheless, the modeling effort assumes minimal anthropogenic influences on surface water and groundwater flows. The overall conclusions are presented in Table 4.13.

Assessment of sensitivity showed that the average sensitivity level is 3.71 and can be classified as high. That indicates how the system can be adversely impacted by the investigated climate change hazards.

Table 4.13: Sensitivity factors and associated levels in water sector

Climate change hazards	Sensitivity factors	Sensitivity level					Average
		Insignificant	Minor	Moderate	Major	Extreme	
		1	2	3	4	5	
Precipitation decreased	Groundwater level decline				4		3.67
	Groundwater quality deterioration			3			
	Stream flow reduction				4		
Temperature increased	Less groundwater recharge			3			3.50
	Stream flow reduction				4		
Drought	Increased water demand				4		4
Evaporation	Stream flow reduction				4		4
Average Score							**3.71**

Impacts of climate change on water resources sector

Impact of climate change was determined after identifying exposure and sensitivity. The following table (4.14) presents the results of the impacts level assessment.

The potential impacts of climate change, evaluated based on the above four climate hazards, seems to be serious ranging from high to very high especially the ones related to temperature increase. Also, the impact seems serious for both RCP 4.5 and RCP 8.5.

Table 4.14: Results of the impacts level assessment on water sector

Climate Change Hazards	Sensitivity Factors Indicators	Exposure level		Sensitivity level	Impact level	
		RCP 4.5	RCP 8.5		RCP 4.5	RCP 8.5
Precipitation decrease	Groundwater level decline Groundwater quality deterioration Stream flow reduction	High (average score = 3.67)	Very High (average score = 4.33)	High (average score = 3.67)	High (average score = 3.67)	High (average score = 4.0)
Temperature increase	Groundwater recharge decrease Stream flow reduction	Very High (average score = 5)	Very High (average score = 5)	High (average score = 3.50)	Very High (average score = 4.75)	Very High (average score = 4.75)
Drought	Increased water demand	High (average score = 3.67)	Very High (average score = 4.33)	High (average score = 4.0)	High (average score = 3.83)	High (average score = 4.0)
Evaporation	Stream flow reduction	High (average score = 3.67)	Very High (average score = 4.33)	High (average score = 4.0)	High (average score = 3.83)	High (average score = 4.0)

Assessment of adaptive capacity of the water sector

Provision of drinking water is the responsibility of the government. Based on the statistics and on frequent interviews with local people in the study area, there is little to no stress on drinking water resources during most of the year, and there is adequate level of satisfaction. However, tremendous pressure on water supply occurs during the summer. This pressure is represented by intermittent water supply, which results in water shortage and in contamination due to corrosion of pipes. During the summer, a significant number of residents tend to buy potable water to meet their household need.

Current adaptive capacities to the shortages in the study area include the installation of additional storage media such as tanks on top of houses to minimize the risk of running out of water between water supply cycles. To avoid water quality problems a significant number of people either buy filtered water or use water purification systems. Moreover, another aspect of adaptive capacity is rainwater harvesting (RWH).

RWH is a common practice in the study over with over 50% of the houses has underground tanks or cisterns with a capacity of 30 cubic meters or more. This particular adaptive capacity is inherited and is socially very acceptable. For irrigation, current adaptive capacities include the application of drip irrigation to reduce the amount of water required, storing water during winter to be used in summer, planting crops that require less water and developing existing springs. Overall, the adaptive capacity levels to various climate hazards are determined based on social surveys that were conducted in the socio-economic section and expert judgment.

Overall climate change vulnerability assessment

Table 4.15 below describes the general climate change vulnerability assessment for water sector, which identifies increase in temperature as the main exposure risk affecting vulnerability.

The overall vulnerability falls in the categories of high and very high. These unpleasant findings are originated from severe level of impact due to high sensitivity and exposure levels. The low levels of adaptive capacities play a role as well.

Table 4.15: Vulnerability Assessment Matrix for Water sector

Climate Change Hazards	Sensitivity Factors Indicators	Exposure level		Sensitivity level	Impact level		Adaptive capacity level	Overall vulnerability assessment	
		RCP 4.5	RCP 8.5		RCP 4.5	RCP 8.5		RCP 4.5	RCP 8.5
Precipitation decrease	Groundwater level decline	High (average score = 3.67)	Very High (average score = 4.33)	High (average score = 3.67)	High (average score = 3.67)	High (average score = 4.0)	1.5	High	High
	Groundwater quality deterioration						1.5		
	Stream flow reduction						2.5		
Temperature increase	Groundwater recharge decrease	Very High (average score = 5)	Very High (average score = 5)	High (average score = 3.50)	Very High (average score = 4.75)	Very High (average score = 4.75)	2.0	Very High	Very High
	Stream flow reduction						2.0		
Drought	Increased water demand	High (average score = 3.67)	Very High (average score = 4.33)	High (average score = 4.0)	High (average score = 3.83)	High (average score = 4.0)	1.5	High	High
Evaporation	Stream flow reduction	High (average score = 3.67)	Very High (average score = 4.33)	High (average score = 4.0)	High (average score = 3.83)	High (average score = 4.0)	1.5	High	High

CLIMATE CHANGE ADAPTATION STRATEGIES AND MEASURES IN WATER:

Nearly all the low cost options for the development of new water resources are challenging in Jordan. Since all rivers and aquifers are highly exploited, few options are left for developing new sources of water for drinking and irrigation. However, a long list of possible opportunities is presented and evaluated in the table 4.16 and a detailed description of six options is given.

1. Rainwater harvesting

Rainwater is the prime source of water in Jordan. The quantities lost to evaporation from temporary open water bodies and soil represent a significant part of the water budget in Jordan. Rainwater is dispersed over a wide area and, if properly collected, could provide a significant addition to the water reserves of the country.

Rooftop water harvesting, simple model indicates that where the average design-rainfall is about 400 millimeters per year and the losses are about 20%. A rooftop of 100 square meters can easily harvest 32 cubic meters per year. On the other hand, flood water harvesting at macro-catchment can collect considerable amounts of water in small dams across intermittent rivers and Wadis. Further, micro-catchment water harvesting is widely implemented in the study area. Example techniques include earth and stone bonds, terraces and pots. Observed storage media include soil, tanks, underground cisterns, small check dams and one large dam which is the King Talal Reservoir (KTD).

At study area level, field visits and consultations with farmers indicate that about 50% of the households have functional rainwater harvesting systems. However, the existing rainwater harvesting techniques need modification/improvements to adapt to the changing climate conditions and to ensure proper water quality. For example, significant increase and improvement in the catchment area will enhance the efficiency of rainwater collection and will improve the quality of the harvested water. In addition, public safety should be improved. Open underground reservoirs could be dangerous, as they may attract people to swim there while some may not be skilled enough. Jordan has a high rate of mortality due to drowning in open water bodies.

2. Wastewater treatment

Wastewater treatment and reuse in the agricultural sector is a feasible option and already in use. Reusage helps meet the demand for freshwater, but the cost of treatment need to be minimized considering water quality and quantity constraints. Centralized wastewater treatment such as AsSamra treatment plants requires technical expertise and massive operation and maintenance costs. Hence, decentralized wastewater treatment is a viable option for farmers. Nevertheless, due to knowledge and financial reasons, few households in the study area own and operate decentralized wastewater treatment units. The capacity of the suggested decentralized wastewater treatment units reaches 200 cubic meters per day.

3. Desalinization

Currently, the economy of Jordan, a developing country, cannot support the full implementation of seawater desalination as a fresh water source due to lack of financial resources and low abundance of energy sources. However, using clean energy such as solar and wind can be used for brackish water desalinization at a local, small scale. Groundwater with high quantity of total dissolve solids and sulphur contents are common in the study area. This unused groundwater source can be utilized by farms or cluster farms.

4. Increasing Efficiency of irrigation technologies

Agriculture is the largest water-using sector in Jordan, making implementation of proper irrigation technologies like sprinkler systems, drip irrigation, subsurface irrigation systems and plastic greenhouses necessary to improve water savings during hot seasons.

5. Grey water Reuse:

Grey water can be reused to partially replace fresh water to flush toilets. Using proper showerheads can reduce demand for fresh water. Moreover, capturing and storing rainwater from roofs can reduce the demand on fresh water for other domestic purposes for example gardening purposes.

6. Public Awareness

Based on the stakeholder consultation conducted in the study area, frequent field visits and casual interviews, a comprehensive program of public educating regarding water issues could help gain their support and assistance in maintaining and best management of water resources for irrigation and domestic purposes as well.

RECOMMENDATIONS FOR ACTION

Filling current knowledge and methodological gaps

There are clear gaps related to levels of public awareness, participation in water protection programs, construction of a comprehensive legal framework for water management and sectoral priorities for water conservation. Additional methodologies for sustainable water solutions are required such as reliable data bank, proper research, funding support and training program.

Table 4.16: List of Prioritized Adaptation Measures in water sector

Climate Change Hazards	Sensitivity Indicators Factors	Overall vulnerability assessment (Average for RPC 4.5 and RCP 8.5)	Adaptation measures	Priority level
Precipitation decreased	Groundwater level decline Groundwater quality deterioration Stream flow reduction	High	Rainwater harvesting Springs rehabilitation Increasing efficiency of irrigation Reduce abstraction Water saving devices Wastewater treatment Reduce irrigation Decentralized wastewater treatment Research programs	1 2 3 4 5 6 7 8 9
Temperature increased	Decline of groundwater recharge Stream flow reduction	Very High	Artificial recharge Conjunctive use Research programs	1 2 3
Drought	Increased water demand	High	Enhance water storage efficiency Plants with low water requirements Awareness programs Desalinization Develop tolerable prediction models Research programs	1 2 3 4 5 6
Evaporation	Stream flow reduction	High	Improve runoff - Catchment treatment Increasing efficiency of irrigation Enhance water storage efficiency Complimentary irrigation Grey water Desalinization Research programs	1 2 3 4 5 6 7

Policy recommendations

The utilization and careful use of water resources requires integrated management policies to ensure sustainability of water and the environment. The existing water policy and by-laws seem to be well focused on the issues. However, there is a lack of enforcement and sustainability.

Other recommendations

1. Intensive rainwater harvesting and assessing the existing rainwater harvesting structures. This action will benefit the farmers, and raise national food security.
2. Desalinization of seawater and wastewater.
3. Employing proper treatment technologies to treat industrial wastewater containing heavy metals.
4. Treated wastewater should be the main source for irrigation. Otherwise, there will be a need to reduce the agriculture activity plans.
5. Maintenance of the water distribution network to reduce the losses of drinkable water and avoid water contamination
6. The involvement of the private sector in running water resources is one option to assist in developing Jordan's water infrastructure and thereby reduce water losses.

4.4 VULNERABILITY AND ADAPTATION IN AGRICULTURE SECTOR

Agricultural production is closely tied to climate, making agriculture one of the most climate-sensitive of all economic sectors. In the study area, the climate risks to the agricultural sector are immediate and an important problem because the majority of the rural population depend either directly or indirectly on agriculture for their livelihoods.

Data of crop production for the period 1995-2010 showed that the total cultivated area in Jordan was 255 thousand hectares, of which 31% was irrigated while the rest was rainfed. The distribution of the cultivated crops was 46% fruit trees, 42% vegetables and 12% field crops.

The country's total yield in 2008 was 212,000 tons of field crops, 349,000 tons of fruits, and 1.4 million tons of vegetables. Data analysis indicated that 95% of the area of vegetables was irrigated, 93% of field crops area was rainfed and 62% of the fruit tree area was rainfed. These figures demonstrated that most of agricultural areas in Jordan were rainfed which made agriculture in Jordan more susceptible to climate change.

The percentage of harvested to cultivated areas in 2008 was 45%, which indicated a high risk associated with rainfed agriculture in Jordan.

The rural poor will be disproportionately affected because of their greater dependence on agriculture, their relatively lower ability to adapt, and the high share of income they spend on food. Climate impacts could therefore undermine progress that has been made in poverty reduction and adversely impact food security and economic growth in vulnerable rural areas.

Poor in rural areas in Jordan are expected to face the most severe consequences of climate change through disruption of livelihood options that depend on natural resource management. The expected impacts of climate change, particularly reduced agricultural productivity and water availability threatens livelihoods and keeps vulnerable people insecure. Poor families and households are the most vulnerable group to the impacts of climate change and deserve the priority the in design of appropriate adaptive measures.

Assessment of climate change exposure in Agriculture:

The major determinants identified are: 1) Temperature increase, 2) Rainfall decrease 3) Droughts and 4) Shift in rainy season. A detailed description of each is shown below:

1- Temperature increase:

Higher growing season temperatures can significantly impact agricultural productivity, farm incomes and food security. Changes in short-term temperature extremes can be critical, especially if they coincide with key stages of development. Only a few days of higher temperature at the flowering stage of many crops can drastically reduce yield.

Crop physiological processes related to growth such as photosynthesis and respiration show continuous and nonlinear responses to temperature, while rates of crop development often show a linear response to temperature up to a certain level. Both growth and developmental processes, however, exhibit temperature optima conditions.

Higher temperatures may be more immediately detrimental, increasing the heat stress on crops and water loss by evaporation. A 2°C local warming could decrease wheat production by nearly 10%. Different crops show different sensitivities to warming. It is important to note the large uncertainties in crop yield changes for a given level of warming because agriculture in many parts of Jordan is already marginal.

2- Precipitation decrease:

Water is vital to plant growth, so varying precipitation patterns have a significant impact on agriculture. As over 70% of total agriculture in Jordan is rain-fed, projections of future precipitation changes often influence the magnitude and direction of climate impacts on crop production. The impact of global warming on regional precipitation is difficult to predict owing to strong dependencies on changes in atmospheric circulation, although there is increasing confidence in projections of a general decrease over the next 50 years. Precipitation is not the only influence on water availability. Increasing evaporative demand owing to rising temperatures could increase crop irrigation requirements by between 5 to 20%, or possibly more, by the 2070s.

Low rainfall causes poor pasture growth and may also lead to a decline in fodder supplies from crop residues.

3- Droughts:

The most immediate consequence of drought is a fall in crop production, due to inadequate and poorly distributed rainfall. Farmers are faced with harvests that are too small to both feed their families and fulfill their other commitments. Where crops have been badly affected by drought, pasture production is also likely to be reduced although output from natural pastures tends to be less vulnerable to drought than crop production.

4- Shift in rainy season:

The timing of rain, and intra-seasonal rainfall patterns are critical to smallholder farmers in Jordan. Seasonality influences farmers' decisions about when to cultivate, sow and harvest. It ultimately contributes to the success or failure of their crops. Delays and below-average rainfall will likely have a negative impact on agricultural production. A successive month of water stress for crops has increased the possibility of below average harvest and a reduction in the planting of cereal and winter crops. Usually shifts or delays in rainfall have caused irregular crop development.

Assessment of exposure

The score for climatic hazards for the exposure components were as follows:

Table 4.17: Hazards' exposure average in Agriculture for the two RCPs 4.5 and 8.5

Climatic indices	Likelihood		Geographical magnitude		Confidence	
	4.5	8.5	4.5	8.5	4.5	8.5
Precipitation decrease	3	4	5	5	3	4
Temperature Increase	5	5	5	5	4	5
Shift in rain season	3	4	4	4	2	3
Drought	3	4	4	5	4	4

The average exposure level score for each projection is calculated and plotted in the vulnerability matrix shown later.

Assessment of climate sensitivity

The major determinants identified are: 1) cropping systems, 2) livestock production and 3) livelihood and food security. A detailed description of each is shown below:

1. Cropping systems:

Climate change impacts on crop yield are different or vary according to the geographic position or kind of crop. There is a general trend toward a yield decrease that ranges from 5%-20% for different crops. The crop yield is more sensitive to the precipitation than temperature. If water availability is reduced in the future, soil of high water holding capacity will be better to reduce the frequency of drought and improve the crop yield. According to the projected climate change scenarios, the growing period will be reduced, and the planting dates needs to be changed to ensure higher crop production.

Climate change can decrease the crop rotation period, so farmers need to consider crop varieties, sowing dates, crop densities and fertilization levels when planting crops.

2. Livestock production:

An increased environmental temperature, decreased precipitation, increased frequency of extreme weather conditions and summer season length has negative impact on productive and reproductive performance of livestock such as increased incidence of livestock diseases and parasitic infestation, decreasing trend of feed and fodder resources.

3. Food security and livelihood:

Food security is defined by the Food and Agriculture Organization (FAO) as a, "situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." The definition involves four aspects of food security, namely, food availability, food stability, food access and food utilization.

Climate change could affect food quality because of the increasing temperature and decreasing crop growth period. Also, it will affect the food quantity and the accessibility to food leading to food insecure communities. Food security is increasingly important for the livelihood of rural communities, where food availability and food quality are major concerns because of climate change impacts.

The sensitivity scale shown below (table 4.18) was used to assess the sensitivity of the agriculture sector to climate change in the study area.

The sensitivity level of the agricultural sectors was minor to moderate (2+3)/2= 2.5. This was calculated based on average impact score for multiple climatic hazards.

The exposure average and the total impact scores are shown below in table 4.19 These were calculated for the different climatic hazards under RCP 4.5 and RCP 8.5.

Table 4.18: Assessment of sensitivity in Agriculture: Sensitivity (consequence) scale (risk case)

5	4	3	2	1	Score
Catastrophic	Major	Moderate	Minor	Insignificant	Qualitative measure
Catastrophic losses of more than 50% of production and/or livestock	Major losses of between 25% and 50% of annual production and/or livestock	Moderate losses of between 10% and 25% of annual production and/ or livestock	Minor losses of between 2% and 10% of annual production and/or livestock	Slight losses of annual production and/or livestock covered by normal contingency allocations.	Description
Livelihood: Near complete collapse	Livelihood: Irreversible depletion	Livelihood: Accelerated depletion	Livelihood: Stressed	Livelihood: Nonstressed	
Phase 5: Catastrophe Food Insecurity	Phase 4: Emergency Food Insecurity	Phase 3: Crisis Food Insecurity	Phase 2: Stressed Food Insecurity	Phase 1: No Acute Food	

Table 4.19: Exposure average in Agriculture under RCP 4.5 and RCP 8.5 and total impact score for the different climatic hazards

Indices	RCP 4.5 exposure average	RCP 8.5 exposure average	Total impact RCP 4.5	Total impact RCP 8.5
Precipitation decrease	3.7	4.3	3.1	3.4
Temperature Increase	4.7	5	3.6	3.75
Shift in rainy season	3	3.7	2.75	3.1
Drought	3.7	4.3	3.1	3.4

IMPACTS OF CLIMATE CHANGE ON AGRICULTURE

Rainfed agriculture

Field crops such as wheat and barley are important crops in Jordan. Barley was found to be more susceptible to climate change impacts than wheat because warmer temperatures tend to hasten development more, thus reducing the time available for assimilation of dry matter. According to Al-Bakri et al. (2010), a 1°C increase in temperature and 10% decrease in precipitation will decrease yield by 7% for wheat and 18% for barley. While a 2°C increase in temperature and 20% decrease in precipitation will decrease yield by 21% for wheat and 35% for barley due to shorter duration of crop growth and lower water availability.

It is anticipated that a 1°C increase in temperature and 10% decrease in precipitation will decrease olive yield by 5%, while a 2°C increase in temperature and 20% decrease in precipitation will decrease yield by 10% due to lower water availability.

Irrigated crops

Climate change will affect growth and production of tuber and root crops, but the possible impact of climate change has not yet been studied for most species of this crop group. Potato yields are particularly sensitive to high-temperature stress because tuber induction and development can be directly inhibited by even moderately high temperature. It is anticipated that a 1°C or 2°C increase in temperature will decrease yield by 5 and 10%, respectively. (Al-Bakri et al. 2010).

Vegetables: For many vegetable crops, high temperatures may decrease quality parameters, such as size, soluble solids and tenderness. It is anticipated that a 1°C or 2°C increase in temperature will decrease vegetables yield by 5 and 10%, respectively.

Orchards: Using the appropriate varieties could help avoid the adverse impacts of temperature increase such as less flower bud induction, higher fruit drop, faster volume growth of fruit, earlier maturation, less total soluble solids and fruit reaches insipid and dry states earlier. Also, planting trees that have high tolerance to higher temperatures such as dates would prevent loss of productivity due to global warming. On the one hand, it is anticipated that a 1°C or 2°C increase in temperature will not have a negative impact on an average year if the right varieties or tree types are used. On the other hand, however, extreme weather could have a rather severe impact.

Impacts of climate change on rangelands

Vegetation change will probably be more closely coupled to changes in soil resources than to immediate physiological responses of plants to CO_2 concentration or temperature.

The increase in evapotranspiration (ET) rate and decrease in precipitation in drier systems such as the arid and semi-arid rangelands of Jordan would reduce productivity.

ASSESSMENT OF ADAPTIVE CAPACITY

The assessment of adaptive capacity was based on the following determinants:

- Economic capability
- Social capital
- Physical infrastructure
- Institutional capacity

More detailed description of those determinants is presented in the socio-economic sector.

Current Adaptive Capacity

Assessing adaptive capacity in Jordan's agricultural sector and in the study area is challenging, because adaptive capacity reflects a wide range of socioeconomic, policy and institutional factors at the farm, local and national levels. Considerations in determining the variation in adaptive capacity across the country include current climatic exposure, social structures, institutional capacity, knowledge and education and access to infrastructure. Specifically, areas under marginal rainfed production will have less adaptive capacity than areas that are more productive and irrigated agricultural land. In addition, financial resources are one of the key factors in determining adaptive capacity, as most planned adaptations require investments. By that measure, Jordan ranks relatively low in overall adaptive capacity in the agriculture sector. Finally, agricultural systems that are poorly adapted to current climate conditions are indicative of low adaptive capacity to future changes in climate conditions.

OVERALL CLIMATE CHANGE VULNERABILITY ASSESSMENT:

The overall vulnerability resulting from impact and adaptive capacity is determined through the following vulnerability assessment matrix for the two climatic projection scenarios RCP 4.5 and RCP 8.5 is determined in tables 4.20 and 4.21.

Table 4.20: Overall vulnerability in Agriculture for RCP 4.5

Climate change hazards	Resulting impact	A. Exposure level	B. Sensitivity level	C. Total impact	D. Adaptive capacity level	E. Overall vulnerability assessment
Shift in rainfall season	Decrease in reliable cropping days and crop failure	Moderate (average score = 3)	Moderate (average score = 3)	Moderate (average score = 3)	Low (average score= 2)	Moderate
Increase in average annual temperature	Increase in causes decrease in agricultural productivity	High (average score = 4.7)	Moderate (average score = 3)	High (average score = 3.85)	Low (average score = 2.5)	High
Decrease in average annual precipitation	Decrease in agricultural productivity and revenue	Moderate (average score = 3.7)	Minor (average score = 2)	Moderate (average score = 2.85)	High (average score = 4)	Moderate
Increase in frequency of droughts		Moderate (average score = 3.7)	Moderate (average score = 3)	High (average score = 3.35)	Moderate (average score = 3.5)	Moderate

Table 4.21: Overall vulnerability in agriculture for RCP 8.5

Climate change hazards	Resulting impact	A. Exposure level	B. Sensitivity level	C. Total impact	D. Adaptive capacity level	E. Overall vulnerability assessment
Shift in rainfall season	Decrease in reliable cropping days and crop failure	Moderate (average score = 3.7)	Moderate (average score = 3)	Moderate (average score = 3.35)	Low (average score= 2)	High
Increase in average annual temperature	Increase in causes decrease in agricultural productivity	High (average score = 5)	Moderate (average score = 3)	High (average score = 4)	Low (average score = 2.5)	High
Decrease in average annual precipitation	Decrease in agricultural productivity and revenue	Moderate (average score = 4.3)	Minor (average score = 2)	Moderate (average score = 3.15)	High (average score = 4)	Moderate
Increase in frequency of droughts		Moderate (average score = 4.3)	Moderate (average score = 3)	High (average score = 3.65)	Moderate (average score = 3.5)	Moderate

Climate Change Adaptation Strategies and Measures in Agriculture:

The key adaptation measure to climate change is setting and implementing a sustainable agriculture policy. Adaptation measures vary horizontally according to the agricultural subsectors and their vulnerability to climate change. These measures vary vertically according to the different actors involved in the development and implementation of this policy.

The Adaptation strategies to a changing climate include:

- Agronomic and crop strategies that are intended to offset either partially or completely the loss of productivity caused by climate change through the application of defense tools with different temporal scales, e.g. short term adjustments and long term adaptations, and spatial scales, e.g. farm, regional or national level adaptation; and
- Socio-economic strategies intended to meet the agricultural costs of climate change.

Generally, the most important adaptation measures for the study area are: modification of cropping pattern, modification of crop calendar including planting and harvesting dates, implementation of supplemental irrigation and water harvesting techniques, improve water use efficiency, use of different crops varieties and modification of policies and implementation of action plans.

a) List of measures

In the following sections, detailed description of adaptation strategies and measures will be discussed. Based on the main findings from this study, the most appropriate measures were proposed to reduce the impacts of climate change on agriculture in Jordan. A list of measures (per climate hazard) is shown below in the adaptation measures matrix.

In irrigated areas: The conversion to drip irrigation decreases water use anywhere between 30-70%, while increasing crop yields from 20-90%. Drip irrigation systems, especially low-head systems, use less energy than surface irrigation by emitting water at or near the root zone (increasing water use efficiency up to 90%).

In Jordan, irrigation efficiency and Water Use Efficiency (WUE) are relatively low. Therefore, shifting from surface irrigation to drip irrigation will increase irrigated areas, since drip irrigation uses less water and will promote more efficient use of fertilizers due to reduced nutrient leaching as well as improving yield and quality of crops such as vegetables.

Rainfed areas: In general, adaptation measures for rainfed agriculture include, but are not limited to, the following:

- Improving soil water storage to maximize plant water availability by maximizing infiltration of rainfall; minimizing unproductive water losses (evaporation, deep percolation and surface run-off); increasing soil-water holding capacity; and maximizing root depth.
- Application of conservation agriculture, which involves minimum soil disturbance and encompasses land preparation techniques that reduce labor, improve soil fertility, manage crop residue and tillage and conserve soil and water.
- Use of supplemental irrigation from harvested rainwater in the critical stages of crop growth.
- Modification of planting and harvesting dates for some crops.

Most of the interventions to upgrade rainfed agriculture can be cost-effective in farming systems, especially where irrigated agriculture is not feasible. For example, supplemental irrigation (the watering of rainfed crops with small amounts when rainfall fails to provide sufficient moisture) has proven to be a drought-proof strategy in most areas.

Increase of water available for supplementary irrigation can be achieved through on-farm rainwater harvesting and management system, i.e. small farm ponds for micro-irrigation using drip or sprinkler irrigation systems. Larger rainwater storage structures can also be constructed to provide supplementary irrigation water to a number of small farms or fields by using the micro-dams.

Conservation agriculture, on the other hand is very efficient, leading to increased crop yield. In this adaptation measure, several techniques are used to enhance soil water storage. Water conservation is usually enhanced through mulching and crop residue retention through zero or minimum tillage, stubble mulch tillage, strip tillage and crop rotation. Conservation agriculture, however, requires extension programs such as training and provision of equipment.

Modifications in planting and harvesting dates are very essential for field crops. Since temperature will increase with time, crop failure may increase. Therefore, early cultivation of field crops will reduce the risk of crop failure.

Other measures include:

Selection of tolerant crop varieties- Shift to cultivating crops that are more tolerant to droughts or lower water requirements, either as a long term change or as climate prediction information might suggest the likelihood of drier seasons. Farmers need to be linked to research institutions and centers such as NCARE to get certified seeds or crop varieties to increase production under changing rainfall regimes. This is essential to improve farmer incomes and adaptation capacity.

Crop diversification- Crop diversification includes integration of different varieties of crops, both food and cash crops which will increase farmer's income. Because of changing rainfall amounts and temperatures, the existing cropping patterns are becoming less productive. Thus crop intensification, through mixed cropping and integration of high-value crops is needed. This can be achieved by adopting the following cropping patterns:

- Low-value to high-value crops (resulting in a price-risk benefit).
- Low-yielding to high-yielding crops (resulting in a yield-risk benefit).
- High water-use crops to water-saving crops with high nutritional values.

Prioritization of measures

The following matrix lists the adaptation measures per climate change hazard and the prioritization of the measures based on discussions and consultations held with the focus group during the results dissemination national workshop.

Table 4.22: Adaptation measures per climate change hazard and the prioritization of the measures in Agriculture

Climate change hazards	Resulting impact	E. Overall vulnerability assessment	Adaptation measures	Priority
Shift in rainfall season	Decrease in reliable cropping days and crop failure	High	Application of conservation agriculture.	2.0
			Modification of planting and harvesting dates	2.0
Increase in average annual temperature	Increase in causes decrease in agricultural productivity	High	Conversion to drip irrigation and increase water use efficiency.	3.0
			Use of supplemental irrigation	2.0
Decrease in average annual precipitation	Decrease in agricultural productivity and revenue	Moderate	Selection of tolerant crop varieties and crop diversification	3.0
Increase in frequency of droughts		Moderate	Integrated watershed management	3.0

RECOMMENDATIONS FOR ACTION

Actions needed at national level:

- Establishment of an integrated drought monitoring and early warning system at different levels.
- Development of policies and creation of institutions that support adaptation at different levels.
- Development and adoption of adaptive technologies and innovations.
- Agricultural agencies, particularly NCARE need to establish and support targeted research programs for agricultural adaptation to climate change.
- Communication about climate risk management and effective adaptation strategies need to be promoted and facilitated among researchers, extension agents, producers and policy makers.
- Researchers need to take advantage of the wealth of knowledge about climate risks and adaptation opportunities in their fields of specialties.

Policy recommendations

Climate change and management options need to be considered in government programs and policies. The question is how to integrate considerations of adaptation into policy and institutional systems at national and regional levels, in a consistent rather than in a fragmented way. This will ensure that government has proactive climate change adaptation strategies, and its initiatives contribute to the reduction of climate-related damages, and encourage timely and effective adaptations in the agribusiness sector.

Agribusiness investment, know-how and technology will be essential to respond to the challenge of adapting to climate change. Such action may not require creating new programs and policies focusing on climate change, but may simply entail having climate change risks and adaptations incorporated, where appropriate, in existing programs or program reviews. Thus, there is a need to incorporate climate change adaptation into the Jordanian agricultural policy of 199 when this document undergoes an updating process Efficiency and cost-effectiveness of measures and win-win policies should be key considerations for policy makers.

Policy integration can be horizontal or vertical. Horizontal policy integration is coordination across sectors and involves responsibilities and actions across multiple agencies, and mainstreaming is an imperative. Many traditional structures exist—ministerial councils, cross-agency task forces, policy units in central agencies, national policies and plans for sustainable development, etc.

4.5 VULNERABILITY AND ADAPTATION IN BIODIVERSITY

The exposure of ecosystems was examined through four major climate indices, 1) change in maximum temperature 2) change in precipitation 3) length of dry season and, 4) evapotranspiration. Full range of nine available RCMs driven by GCMs were analyzed and maximum and minimum values for each indices were considered for exposure under two emission scenarios (RCP 4.5 and 8.5) to extract the exposure of biodiversity both on the overall country and over the pilot area. The actual values of change of the climate indices are illustrated in table 4.23.

All indices were scored from 1 to 5 according to the level of change from current situation happened on geographic scale of Jordan and the pilot area. Total exposure in Jordan ranges from 5 (very high) and 1 (very low) according to results from averaging of indices scores.

Assessment of Exposure:

After compiling the four climate indices (indicators) for Jordan under the RCP 4.5 and 8.5 comparing all the 9 RCMs used in this research the resulting exposure of Jordan came out as follows in figure 4.28 and 4.29 for mean, minimum and maximam exposure, respectively. The RCMs generating the maximum, minimum and mean values depend on the indices and the RCP used case by case and not always the same RCM for each case.

Assessing sensitivity of biodiversity and ecosystems to climate change impacts

Some species will be able to adapt through evolving or moving if local conditions become unsuitable; species with short-life cycles have some potential for evolutionary adaptation in response to climate change (Skelly et al. 2007). On the other hand, many species will not have the capacity to move at rates fast enough and these species will face increased risk of extinction (Midgley et al. 2006). Climate change, however, will not have negative impacts on all species. Generalist species that could be found in wide range of habitats will suffer fewer impacts from climate change due to their high adaptive capacity and species with high dispersal rate and vast geographic range such as birds and insects have less sensitivity to climate change impacts, making them less vulnerable (Hoegh-Guldberg et al. 2008). On the other hand, changing climate may also provide new opportunities for invasive species, both exotic and native to spread in regions where they were never able to reach before (Lovejoy and Hannah 2005). The characteristics list that make species either at risk or not are illustrated in the table 4.24.

Table 4.23: Scale of Changes in climate indices under different RCPs for the period 2040-2070

Climate Indices	Min.	Med.	Max.	RCP
Change in Precipitation (%)	0.68 -6.97	-15.42 -14.97	-24.18 -26.46	4.5 8.5
Change in Maximum Temperature (°C)	1.58 2.16	1.71 2.56	2.51 3.51	4.5 8.5
Change in Potential annual evapotranspiration (mm)	100 120	140 160	160 200	4.5 8.5
Changes in annual consecutive dry days (%)	-10 -20	10 15	30 30	4.5 8.5

Figure 4.28: Jordan climate change exposure under RCP 4.5 ,for minimum, mean, maximum sensitive RCM for the period between 2040-2070 (average 2055)

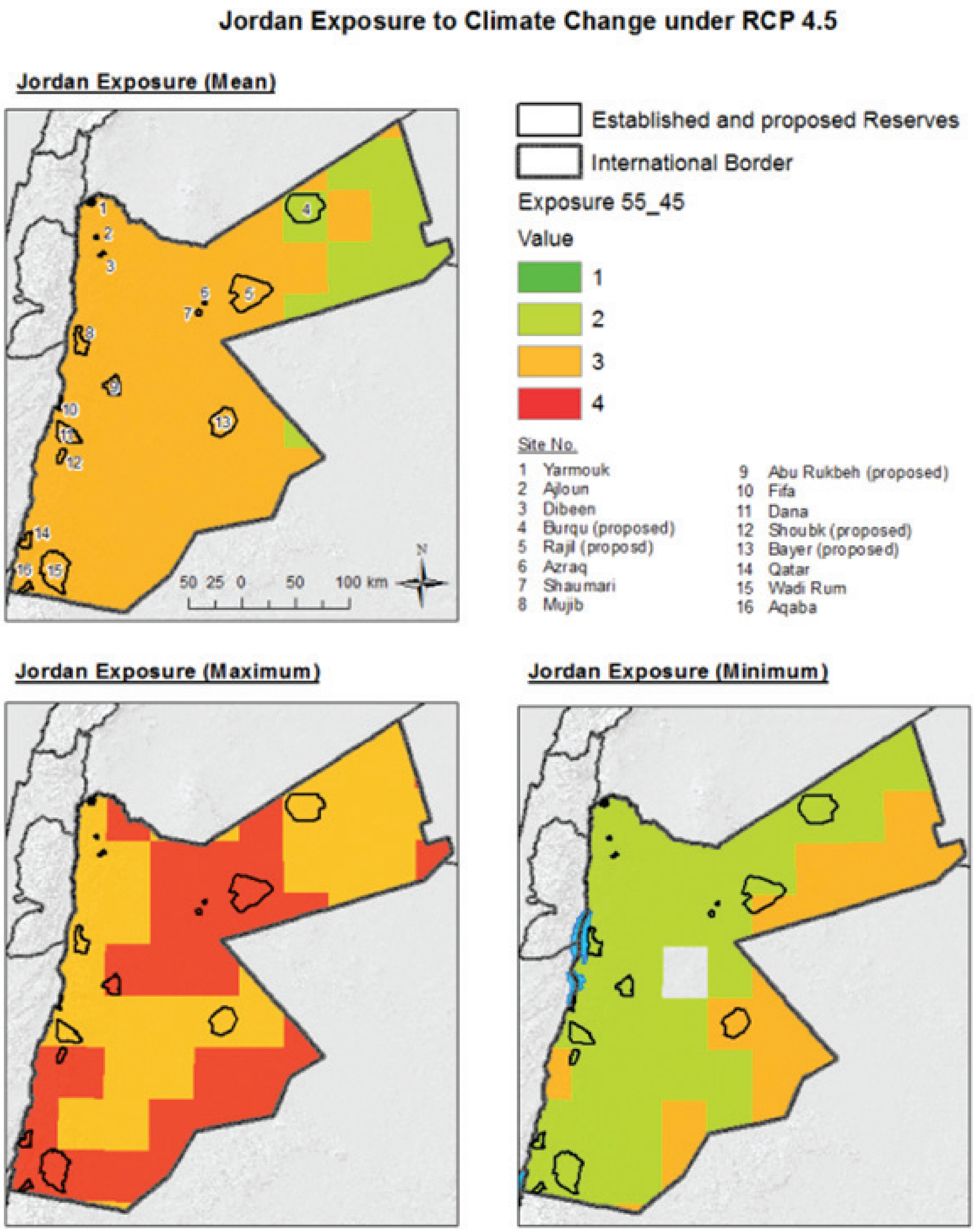


Figure 4.29: Jordan climate change exposure under RCP 8.5, for minimum, mean and maximum sensitive RCM for the period between 2040-2070 (average 2055)

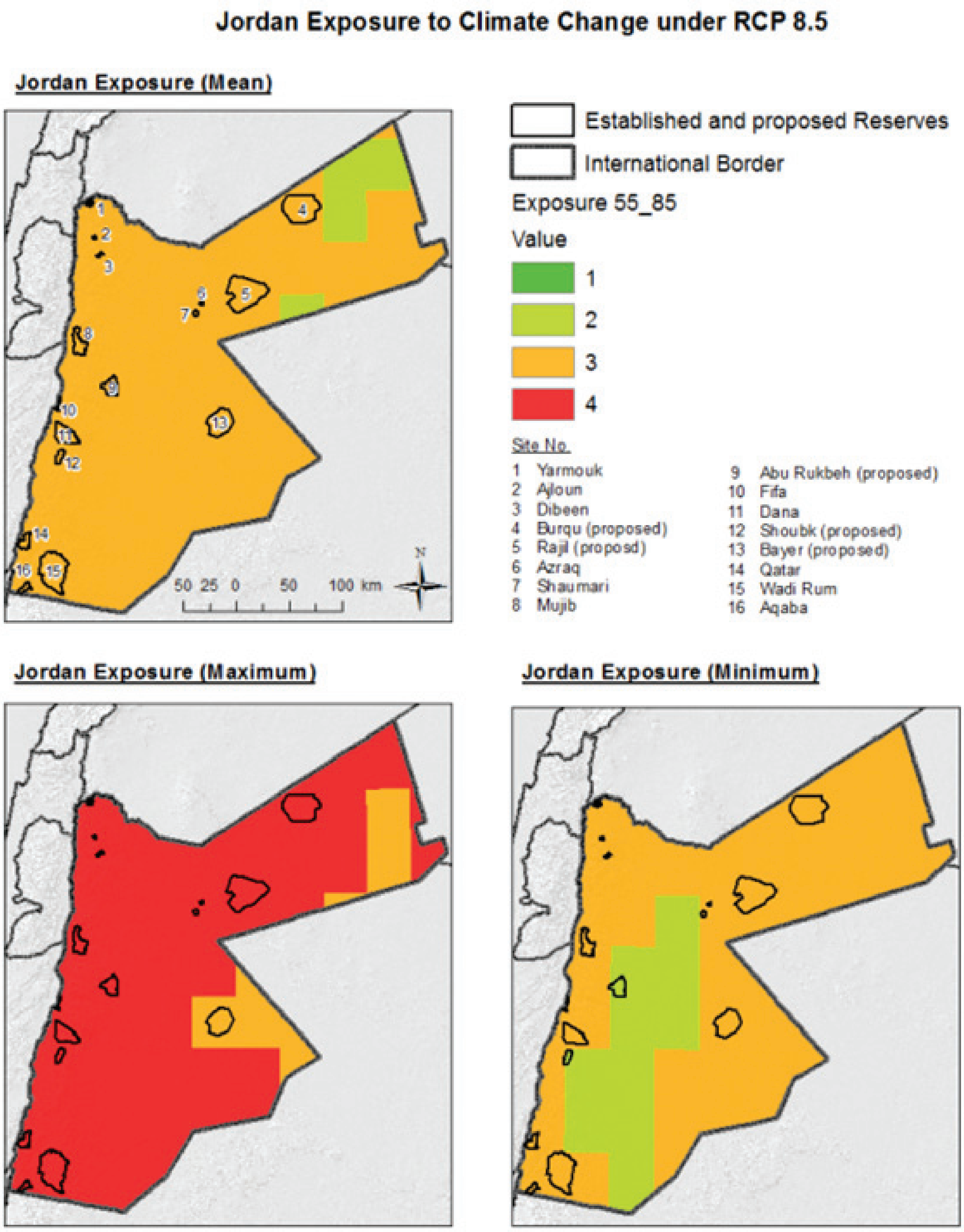


Table 4.24: Major species characteristics that formulate the level of risk from climate change (Foden et al. 2008)

Species least at risk	Species most at risk
Physiological tolerance to broad range of factors such as temperatures, water availability and fire.	Narrow range of physiological tolerance to factors such as temperature, water availability and fire.
High degree phenotypic plasticity	Low phenotypic plasticity
High degree of genetic variability	Low genetic variability
Short generation times (rapid life cycles) and short time to sexual maturity	Long generation times and long time to sexual maturity
High fecundity	Low fecundity
Generalist' requirements for food, nesting sites, etc	Specialized requirements for other species (e.g. for a disperser, prey species, pollinator or photosynthetic symbiotic) or for a particular habitat that may itself be restricted (e.g. a particular soil type)
Good dispersal capability	Poor dispersal capability
Broad geographic ranges	Narrow geographic ranges

Four indicators were used to represent the sensitivity for each ecosystem, 1) moisture dependence, 2) temperature tolerance, 3) geographic range/fragmentation and, 4) other stressors pressure level. Every ecosystem was scored from 1 to 5 for each indicator according to the level of fulfillment for that indicator on geographic scale of the ecosystem based on expert judgment as well as geographic knowledge of the expert like in the case of geographic range/fragmentation indicator.

Assessment of Sensitivity:

The sensitivity of Jordan's ecosystems is illustrated in the figure 4.30 below, the resulting sensitivity ranges from 5 (very high) and 1 (very low) according to results from summation of indicators scores and dividing the result over the number of indicators.

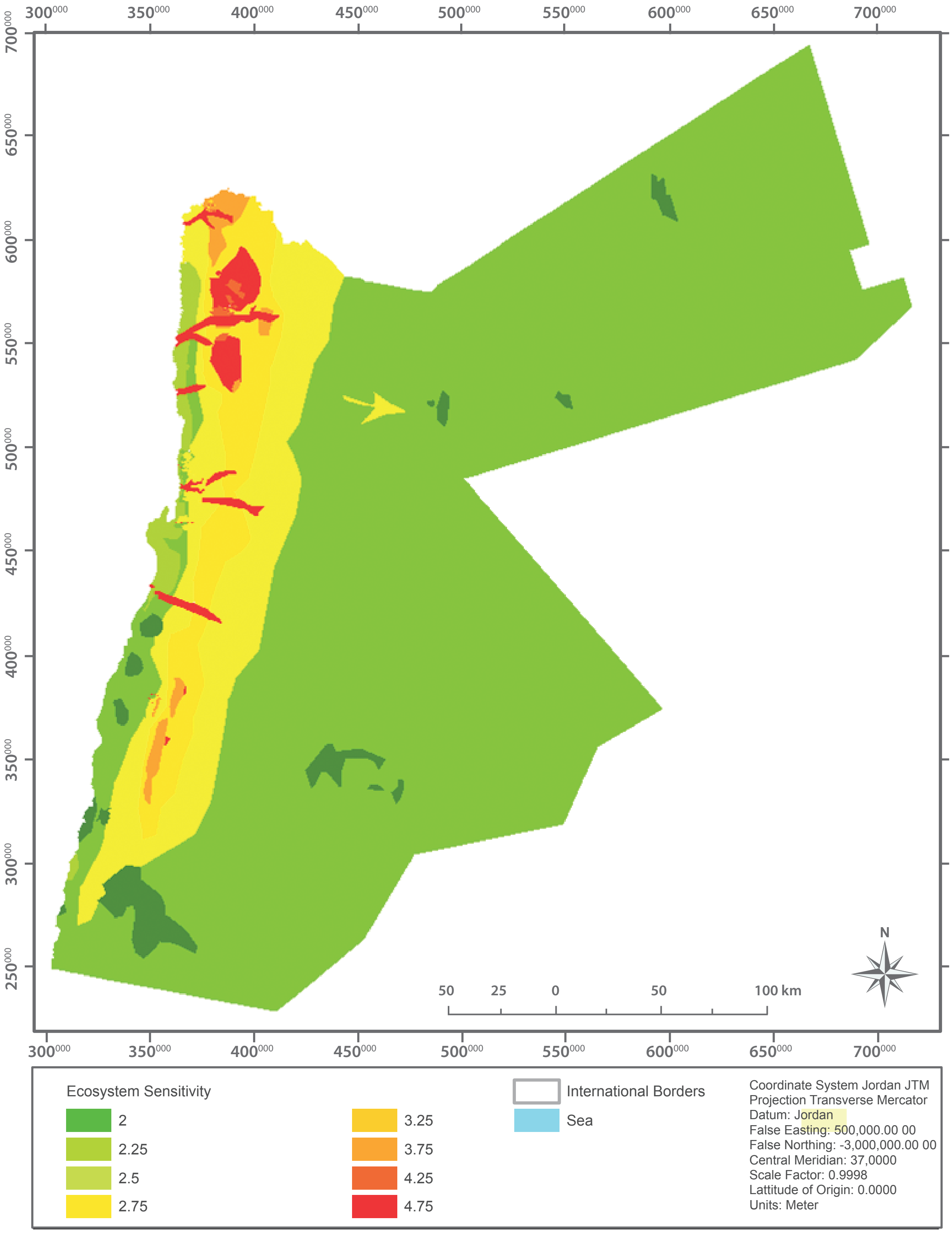
Moisture dependence and other stressors level indicators are reflecting the requirements of each vegetation type for moisture and level of pressure from humans on it respectively, accordingly more water demand and higher human impacts are reflected by higher scores. On the other hand, temperature tolerance and geographic range show the availability of high temperature tolerance characteristics and the extent scale and connectivity level in each vegetation type respectively, accordingly the lower drought tolerance and less geographic range in the vegetation types the higher sensitivity scores allocated.

According to the scoring of indicators, the highest sensitive ecosystems in Jordan are water vegetation in valleys (Wadis) and the forests vegetation in Ajloun and Jarash where big part of the pilot area of this assessment is located.

Assessing climate change impacts on biodiversity and ecosystems

In Jordan, research done by the Royal Society for the Conservation of Nature (RSCN) using LPX dynamic vegetation and fire model, driven by seven projections of regional climates across Jordan in response to mean global warming of 4°C by the end of the 21st century (Harrison, 2010 a), shows that net primary productivity (NPP) and foliar projective cover (FPC) will be decreasing over the country as a whole. Although some regions show a small increase in NPP and FPC initially, there are no parts of the country that show robust increase in productivity by the end of the 21st century. The decrease in woody vegetation is most marked in the east and south of Jordan, while there was a slight increase in the NPP and FPC of woody vegetation in the northwest.

Figure 4.30: Sensitivity of Jordan's ecosystems based on vegetation types prepared by Al Eisawi and modified by RSCN



In contrast, the decline in herbaceous vegetation was most marked in the northwest, although there are only a few areas with a robust increase in herbaceous productivity by the end of the century. The fertilization in CO_2 process plays role in maintenance of woody vegetation in the northwest of Jordan, partially offsetting the deleterious effects of changing climate.

In this study for the TNC climate change impact was estimated at both levels: all country (vegetation types) and pilot area (communities). The results for the impacts on vegetation types are represented in the figure 5.7 for both 4.5 and 8.5 RCP. While the list of impacts on pilot area communities are represented in table 5.3.

The results range between a score of 1-10, as the sum of two 5 point scores. In both maximum and minimum impact cases it was noticed that the highest impacts will be in areas where forest vegetation and water vegetation occurs in general. While it is least noticeable in the eastern and southeastern deserts.

Social potential impacts under maximum and minimum climate change scenarios are presented in the table 4.25

Assessing the adaptive capacity of biodiversity and ecosystems in Jordan

Four indicators were used to represent each ecosystem adaptive capacity, 1) drought tolerance characteristics, 2) short life cycle, 3) high species diversity and 4) percentage covered in PA network.

Every ecosystem was scored from 1 to 5 in each indicator according to the level of fulfillment for that indicator on geographic scale of the ecosystem based on expert judgment as well as numbers known by the expert like in the case of high species diversity and percentage covered in PA network.

Figure 4.31: Climate change impact on ecosystems under RCP 4.5 (left) with least sensitive RCM and RCP 8.5 (right) with most sensitive RCM for the period between 2040-2070 (average 2055)

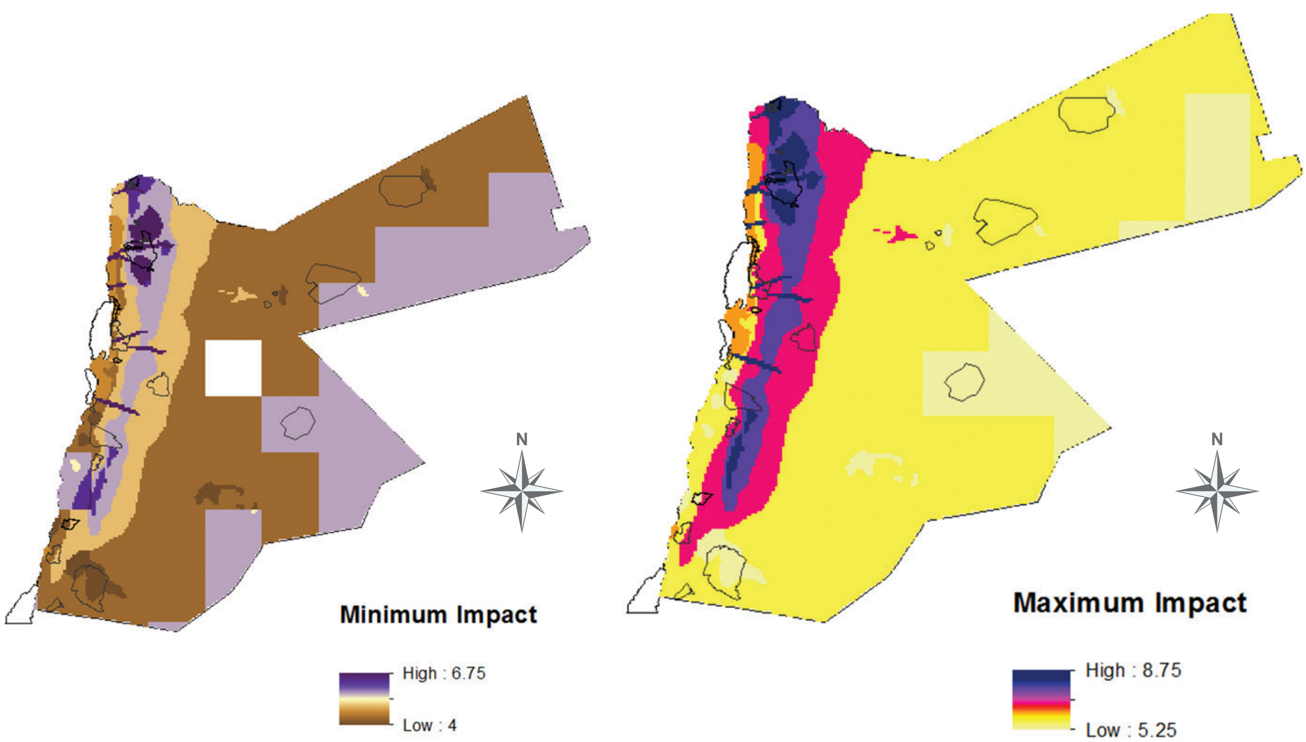
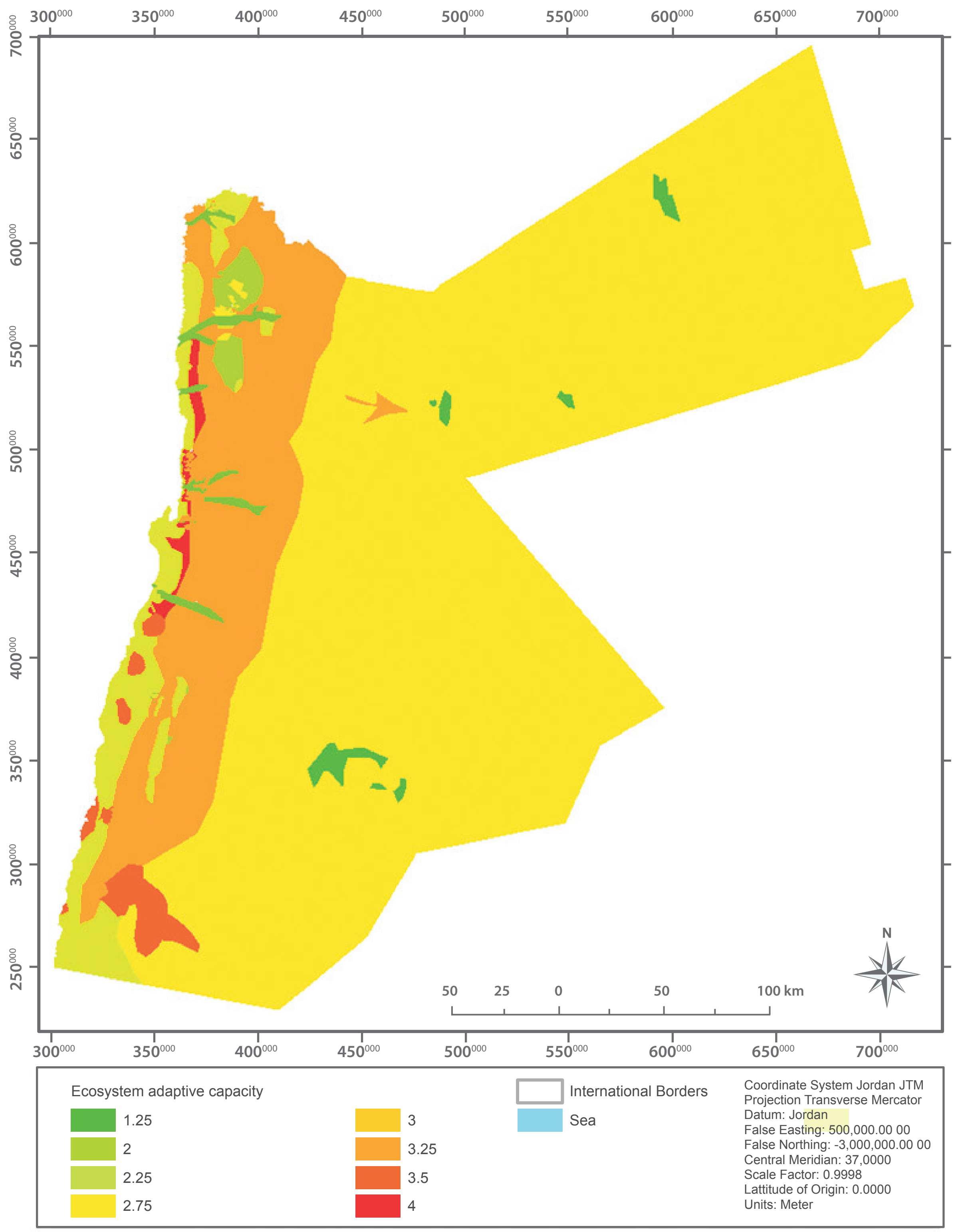


Table 4.25: Climate change impact, social risk and consequences under minimum potential impacts (best case) RCP 4.5 with least sensitive RCM (least change in correspondence to change in GHGs) and maximum potential impacts (worst case) RCP 8.5 with highest sensitive

Vegetation type/Habitat	Effects on Ecology	Environmental Impact	Socio-economic impacts	Impacted Areas	Impact level RCP 4.5	Impact level RCP 8.5
Water vegetation	Reduced growth and reduced growth range due to lower soil moisture	- Reduction in aquatic plants for human use and for livestock grazing, - Reduced water quality and increase in turbidity - Reduction Aesthetic value of the area - Loss of medicinal plants	- Economic losses for livestock owners - Economic losses for farmers - Reduce the chance of tourism activity - Increase expenditure on medicine	Bayoudah Sbaihi Khayouf SCA	Moderate	High
Evergreen Oak Forest	Lower regeneration rate, change in community composition and shrinkage in geographic range	- Reduction of wood resources - Increase risk of fire - Reduced water percolation and purification - Soil degradation - Reduce biomass for livestock grazing - Reduced Aesthetic value of the area	- Increase in energy bill for local community - Reduce tourism activity and income - Losses for farmers - Losses for livestock owners	Rmemien Dibeen PA	Moderate	High
Pine Forest	Lower regeneration rate, change in community composition and decrease in geographic range	- Reduction of wood resources - Increased risk of fire - Reduced water percolation and purification - Reduced Aesthetic value of the area	- Increase in energy bill for local community - Reduce tourism activity and income - Losses for livestock owners - Losses for farmers	Rmemien Siehan Dibeen PA	Moderate	High
Deciduous Oak Forest	Lower regeneration rate, change in community composition and decrease in geographic range	- Reduce of wood resources - Increased risk of fire - Reduction of water percolation and purification - Soil degradation - Reduced biomass for livestock grazing - Reduced Aesthetic value of the area	- Increase in energy bill for local community - Reduce tourism activity and income - Losses for farmers - Losses for livestock owners	Byoudah Dibeen PA Siehan	Moderate	High
Mediterranean non-forest	Reduced growth in lower elevations and shift toward higher elevation with time	- Soil degradation - Reduce biomass for livestock grazing	- Losses for livestock owners - Losses for farmers	Byoudah Siehan Sbaihi	Moderate	High
Steppe vegetation	Lost ground for tropical elements and desert species	- Soil degradation - Reduce biomass for livestock grazing	- Losses for livestock owners - Losses for farmers	Byoudah Sbaihi Khayouf SCA	Moderate	Moderate

Figure 4.32: Adaptive Capacity of Jordan's ecosystems based on vegetation types prepared by Al Eisawi and modified by RSCN



Assessment of Adaptive capacity:

The Adaptive Capacity of Jordan's ecosystems is illustrated in the table below, the resulting adaptive capacity ranges from 5 (very high) and 1 (very low) according to results from summation of indicators scores and dividing the result over the number of indicators.

Drought tolerance, high species diversity and percentage covered in PA network indicators are reflecting the availability of drought tolerance traits, amount of diversity and the level of protection achieved in each vegetation type respectively, accordingly more drought toleration, more diversity in species and higher percentage of vegetation under protection are reflected by higher scores of adaptive capacity. On the other hand, short life cycle reflects the dominant species life cycle length, accordingly the shorter life cycle for the vegetation type the higher adaptive capacity scores it gets.

For the pilot site villages' social adaptive capacity was used based on social determinants including economic capability, social capital, physical infrastructure and institutional capacity. Based on the results obtained and analysis from the socioeconomic study; the adaptive capacity for the pilot areas.

Highest adaptive capacity was noticed to be in desert vegetation, tropical vegetation and to lower extent in marginal vegetation types such as steppe vegetation. On the pilot site the villages show differences in social adaptive capacity with Rmemeen and Seihan having the highest adaptive capacity, while for the ecosystem and biodiversity important sites Dibeen PA and Khayouf SCA poses moderate and low ecological adaptive capacity, respectively.

OVERALL BIODIVERSITY AND ECOSYSTEMS CLIMATE CHANGE VULNERABILITY ASSESSMENT

Vulnerability assessment

The expected impacts from climate change on ecosystems in Jordan according to climate exposure and sensitivity of ecosystems are droughts, forest dieback, community composition change, expansion of drier biomes into marginal lands, habitat degradation and species loss. Taking these impacts into consideration, climate change vulnerability assessment for biodiversity and ecosystems all over Jordan for RCP 4.5 and 8.5 under the least, median and most sensitive RCM runs resulted of differentiation in vulnerability shown in figures 4.33 and 4.34, respectively.

Figure 4.33: Vulnerability of biodiversity and ecosystems all over Jordan for RCP 4.5 under the least (left), median (middle) and most (right) sensitive

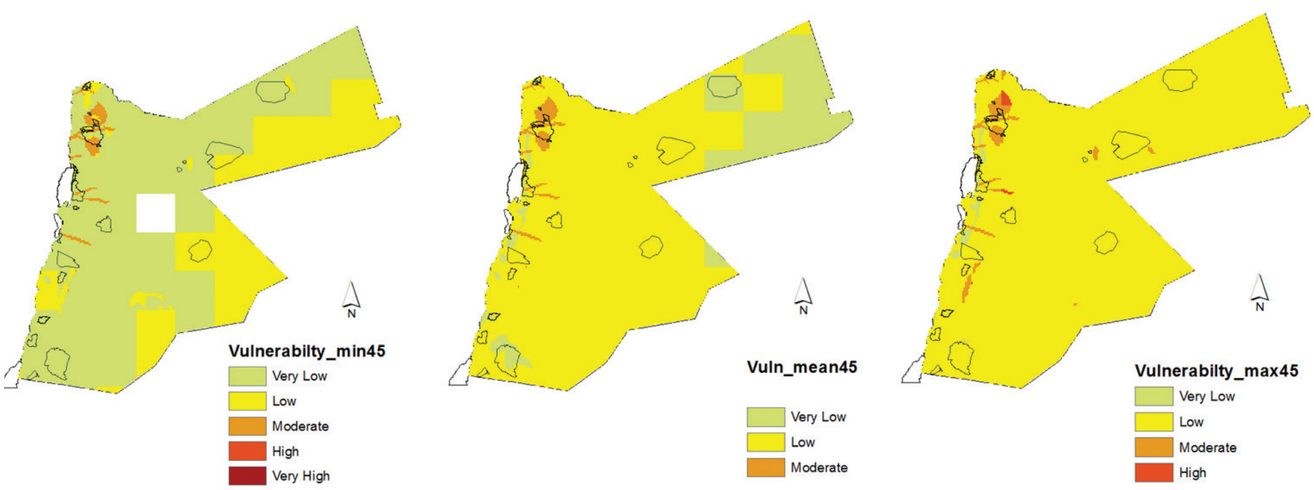
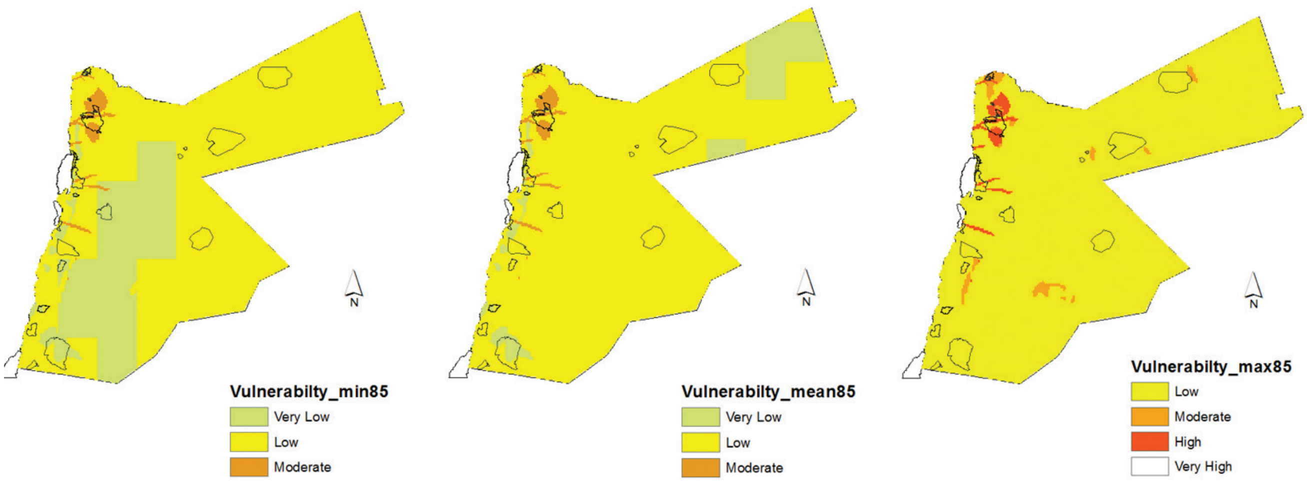


Figure 4.34: VVulnerability of biodiversity and ecosystems all over Jordan for RCP 8.5 under the least (left), median (middle) and most (right) sensitive



For the pilot site it was decided to use the data from socio-economic sector on adaptive capacity and match with Impacts under both RCP 4.5 and least sensitive RCM and RCP 8.5 and most sensitive RCM. The social adaptive capacity was used to cover the interaction between ecosystems in the region and local communities (ecosystem services), since no matter if the ecosystems are resilient, it could be difficult for them to adapt if the local community (with low social adaptive capacity) increases the pressure on the ecosystem (e.g. if community cannot afford buying fuel for heating they will cut wood at higher rates), accordingly adaptation priorities would be defined.

Conclusions

It was noticed that the highest vulnerable ecosystems are forests (especially in the north) and fresh water ecosystems (especially in Jordan rift valley), that highlights the priority to perform adaptation interventions within these two ecosystems. The ecological vulnerability assessment results that covered important biodiversity and ecosystem sites within the pilot area including Dibeen PA having a and Khyouf SCA had high scores of vulnerability that is compatible with the overall conclusion all over the country .It is concluded from the social vulnerability assessment for the pilot site villages under RCP 4.5 and least sensitive RCM that all the villages have moderate vulnerability under degraded ecosystems resulting from climate change while under RCP 8.5 and most sensitive RCM, Subeihi, Bayoudah and Rmemien have high social vulnerability under degraded ecosystems resulting from climate change, while Siehanhas has a moderate social vulnerability since it has moderate adaptive capacity combined with lower impact than Rmemien that has the highest impact scoring (very high).

ADAPTATION STRATEGIES AND MEASURES IN BIODIVERSITY:

In order to achieve sustainable and healthy ecosystems in the future under climate change and other stressors, climate change adaptation (CCA) strategies should be prepared and implemented. CCA typically rely on three concepts: resistance, resilience and transition.

Resistance is the concept that an ecosystem, habitat or species will be able to remain unaffected by changes in climate. Resilience refers to the degree to which an ecosystem, habitat or species' population can recover after a disturbance. From the perspective of climate change adaptation strategies, resilience is needed as changing environmental conditions increase species' stress or cause disturbances (such as fire) to become more frequent or more intense. Transition refers to when it is determined that a species, habitat or ecosystem may not be able to withstand the impact of climate change, and a strategic decision is made to permit the location to change to a new habitat type. This may involve helping the location by, for example, planting species that are expanding into an area after a disturbance, rather than planting native- endemic species.

Adaptation measures and programs that can be adopted in Jordan include:

1. Restoration of degraded forests and encouraging the establishment of community forests to control soil erosion.
2. National wide, using diverse conservation governance forms including Protected Areas (PAs), Hima and Special Conservation Areas (SCAs) that empowers local communities to conserve their Natural resources and improves their livelihoods by improving their adaptive capacity through better availability and access to resources, as well as using diverse conservation techniques including In-situ and Ex-situ techniques through gene-banks and seed-banks.
3. Protecting and enhancing ecosystem services in conservation areas; Improve the access to ecosystem services and improve the quality of such services empowers local communities and increases the resistance/resilience of local communities to climate change impacts. More effective management in the conservation areas increasing carbon sequestration (storage in ecosystems) and improving conservation areas resilience. One of the possible means to achieve that is establishing new PAs and SCAs.
4. Preserving water quality and flows in water catchment areas using buffer zones surrounding PAs and SCAs. Buffer zones should not be with regular shape rather depending on each conservation area circumstances, possible risks, and most importantly consider natural corridors that enhance connectivity and transition between ecosystems.
5. Restoration and protection of rangelands to reduce the vulnerability of livestock to drought. .Adopt water management procedures providing alternative water sources for fauna and avifauna such as retention dams.

Prioritization of adaptation measures was performed during the national vulnerability assessment of the National Consultation Workshop based on the criteria set by the research team beforehand. Scores range from 1 (less achieving) to 3 (most achieving) for each criterion. The criteria and the result of the biodiversity group work are presented in the table 4.26 below:

Table 4.26: Biodiversity group prioritization of adaptation measures exercise scores and final results

Criterion	Adaptation measure number (refer to the list above)				
	1	2	3	4	5
Social equity	1	2	3	2	3
Cost/Benefit	2	3	3	1.5	3
Effectiveness	3	3	3	3	3
Robustness to uncertainty	3	3	3	2	2
Synergies	3	3	3	3	2
Score/15	**12**	**14**	**15**	**11.5**	**13**

According to the prioritization done by the TNC it was found that enhancing ecosystem services provided by conservation areas and empowering local communities is the most important adaptation measure in Jordan followed by diversification of conservation methodologies and governance systems.

General recommendations for future Biodiversity and Ecosystems sector responses to climate change

- **Advance Understanding of Climate Change Impacts on Biodiversity (Research)**

  More research is needed to understand climate change impacts on biodiversity. Jordan's priority research areas should be to predict future distributions of species and track range shifts through species distribution modeling (climate envelope models), identify vulnerable ecosystems (those with high exposure, high sensitivity and low adaptive capacity), developing climate change vulnerability index within conservation areas, monitoring ecosystem conditions and correlating them with meteorological data gathered by the weather station network in and out of the conservation areas, allowing the verification of modeling results and defining the pathway most probable in the future. Allowing the reconsideration of size, placement and number of conservation areas, by considering the shape and orientation of conservation areas, and through conservation management of the buffer zones surrounding the conservation sites. Universities and research institutes in Jordan should be given increased roles and responsibilities.

- **Facilitate Adaptation of Biodiversity to Climate Change by Increasing Resilience (PA Management)**

  Identify key sites to maintain ecological resilience that has the lowest vulnerability that might be the refuge areas under climate change. Identify the most vulnerable sites to help formulate firefighting, patrolling, restoration and ecosystem transition plans. Incorporate climate resilience as an integral part of threat assessments done in any management cycle , and publish guidelines for land managers and planners that inform land uses, defining buffer zones and biodiversity climate change refugia spots. Endorse the ecosystem-based approach at the national level including protected areas as one of the strategies to adapt to climate change. It is highly recommended to include all of them in the National Adaptation Progammes of Action (NAPAs), when prepared for Jordan.

- **Capacity Development (Capacity building and training)**

  Building the capacity of conservation professionals to deal with climate change challenge must be a priority in Jordan, and training programs must be directed towards high-level decision makers, as well as for technical professionals. The RSCN has the capacity and databases that qualify them to provide such trainings in the future for other stakeholders. International conservation Non-governmental Organizations working in Jordan (e.g. International Union for the Conservation of Nature, Birdlife International and others) as well as UN bodies should be involved in the process of capacity building due to their capability of mobilizing expertise from other parts of the world.

- **Outreach and communication**

  Each conservation site in Jordan should prepare a story to tell about climate change emphasizing the possible risks of climate change on their particular ecosystems..They should also highlight the positive role the conservation sites can play in climate change adaptation and mitigation. School curriculum in Jordan should be revised to include more climate change topics and materials. The Royal Society for the Conservation of Nature (RSCN) can participate in the revision of school curricula to explore the possibilities of adding more concepts relating to biodiversity in relation to climate change and how climate change adaptation is going to be important in conserving nature.

4.6 VULNERABILITY AND ADAPTATION IN COASTAL AREAS

Four main determinates were identified:1) sea level rise, 2) extreme rainfall events or droughts in upstream terrestrial areas which are connected to run off and flooding, 3) sea surface temperature and 4) CO_2 concentrations. The following illustrate these determinates in more details.

Sea level rise

Although changes in global mean sea-level could reflect changes in sea-level at the Gulf of Aqaba, the relationship between global mean sea level rise and local sea level rise will depend on a combination of factors, including changes in ocean circulation (which can alter sea-levels at local and regional scales), variations in oceanic levels due to thermal expansion and relative sea-level change associated with land movements (i.e. geological uplift and/or subsidence) (Nicholls and Klein, 2005; Harvey, 2006). The Gulf of Aqaba is an extension of the Levantine or Dead Sea Fault, and part of the Red Sea Rift that are tectonically active leaving the possibility of sea level increase.

Sea level rise is expected to occur at the Gulf of Aqaba, which will bring several consequences including coastal retreat leading to land area loss in the already small area of the Gulf of Aqaba. This could have serious economic and social consequences at local and national level as they will affect tourism and recreational activities on beaches, industries, marinas, as well as ecosystems and biodiversity. The IPCC (2007) stated that certain coastal areas will experience more sea level increases than the open ocean. However, an increase in the sea level of the Gulf of Aqaba may have many implications but there is no model today which accurately represents/models the anticipated and possible implications on the coastline, habitats and species.

Extreme rainfall events or droughts in upstream terrestrial areas which are connected to run off and flooding

Precipitation in Jordan is represented by three extensive rainfall zones, with the highest mean annual rainfall (400-600 mm/yr) occurring in upland areas in the northwestern parts of the country, and lower mean annual rainfall of 250-350 millimeters found in central Jordan and the southern uplands, and the lowest rainfall with less than 170 millimeters per year occurring in the lowland regions of the east and south of the country. Aqaba is located within the last zone with the lowest rainfall with precipitation around 30 millimeters per year (Hashemite Kingdome of Jordan, 2009). Some studies indicated that Aqaba received 32 millimeters per year for periods ranging from 33 to 78 years in years prior to 2000.

Nonetheless, rainfall in adjacent regions of Aqaba influences runoff regimes and drought that has consequences on the Gulf of Aqaba (although most runoff in Aqaba is currently diverted). Altered run-off will cause changes in water salinity, turbidity, temperature and also disruption of microbiological activity and life cycles of flora and fauna. Scavia et al. 2002 stated that this will affect coastal resources due to the impacts on human health, tourism, biodiversity (including phytoplankton and other primary producers) and fisheries. Scavia, et al (2001) stated that any decrease in run-off (lower freshwater delivery) will increase water residence time which will cause several changes including increased salinity, modified stratification, as well as higher residence time of phytoplankton, which causes higher susceptibility to eutrophication (Scavia et al. 2002).

The northern parts of Aqaba are the most vulnerable regions for flashflood hazards since they are located downstream from areas of major wadis (Arabic term traditionally referring to a valley. In some cases, it may refer to a dry riverbed that contains water only during times of heavy rain or simply an intermittent stream) which discharge water into the Gulf of Aqaba. In addition, they contain most of the town residential expansion areas. Despite the establishments of flood diversion channels at the northern parts of the Gulf of Aqaba, floods are still a threat, if rainfall events exceed the thresholds. In 2006, a disaster hit the alluvial fan of Wadi Yutum and caused large-scale sediment-related damage causing five deaths, the destruction of 18.5 km of water pipes and water production wells, and damage to the airport.

Based on the provision of regional climate projections using CORDEX, and for RCP 4.5 that predicts decreases of rainfall by 2050 reaching less than 50% of current rainfall in the North of Aqaba. Until 2100, the decrease of rainfall extends to the whole country, except the northeastern part. In addition, for the RCP 8.5, the precipitation decreases everywhere by 2050 except in two small areas in the mountains and in the rift and the northern parts of Aqaba that are the most affected regions.

Increased sea surface temperature

Implications of sea surface temperature increases play a vital role in coastal dynamics with respect to the interplay between temperature and sea levels. The increase in water temperature will increase the ability of certain alien species to be established at the Gulf of Aqaba. In addition, the warming of the ocean water temperature could impact a variety of population characteristics such as breeding and survival ability, which might lead to the threatening of species and habitats, or even extinction. In addition, increased temperature will increase stratification, change circulation, increase coral bleaching and mortality, limit species migration and increase algal blooms. An increase in mean sea surface temperature will cause changes as sea temperature and CO_2 concentration favor algal blooms in combination with increased nutrient run-off, which could lead to critical changes in ecosystems and species diversity.

In addition, increases in temperature may intensify conditions of poor water oxygenation (lower solubility of O_2) and may promote the spread of diseases. This will consequently stress fish immune systems that combined with higher temperatures could possibly favor toxic algae presence (HELCOM 2007). The increase will certainly affect the coastal resources. If any diseases are transmitted then it will lead to death and the reduction of populations which will result in the migration of organisms to other areas. In addition, an increase in temperature will impact fisheries and coastal production of goods; fish stocks may migrate, and benthos may die due to an extension of dead zones (eutrophication and oxygen depletion). The impacts will affect biodiversity, fishery, human health and tourism. This will also put the already vulnerable coral reef at the Gulf of Aqaba at risk of bleaching.

Warming of the Red Sea waters will also result in increased temperatures within the Gulf of Aqaba. However, rates of future warming in the Red Sea and Gulf of Aqaba are currently uncertain. A study performed in Eilat showed a positive linear trend in temperature in the upper layer of 0.02ºC per year based on analyzing historical observations of water temperature, but this trend is not significant in the 95% confidence interval German and Brenner (2004). However, they found a significant long-term increase in temperature of about 0.03º C per year since 1989 in the lower layer. Changes in temperature at the Gulf of Aqaba should be studied further to understand changes over longer periods of time.

Increased CO_2 concentration in sea water

Increased CO_2 fertilization will lead to decreased seawater pH or "increased sea acidification" which will lead to negative impacts on coral reefs "bleaching" and other pH sensitive organisms. In addition, fertilization will increase CO_2 productivity in coastal systems. Harley et al. 2006 stated that the acidification of seawater will cause a reduction of marine invertebrate's growth and survivorship. Silverman et al, 2009 stated that "by the time atmospheric partial pressure of CO_2 will reach 560 ppm [parts per million] all coral reefs will cease to grow and start to dissolve." The atmospheric CO_2 concentration is likely to reach 560 ppm by the middle of the 21st century under current policy regimes, which are associated with high greenhouse gas emissions. Under low emissions climate change scenarios, 560 ppm of atmospheric CO_2 is reached by the 2070s or 2080s (Meehl, et al, 2007). Nonetheless, the impacts of ocean acidification will vary according to species, with a recent study identifying mixed responses to increases in pH across 18 different marine organisms, with calcification rates falling in some organisms, increasing in others, and remaining unchanged in one case (Ries, 2009).

ASSESSMENT OF EXPOSURE

Table 4.27 shows the average exposure values based on the three components assessed earlier, which were averaged and the following table shows these values. The table illustrates two RCPs used in this study.

The most likely event at the Gulf of Aqaba is sea level rise, and the extreme rainfall or drought events from the upstream areas especially after analyzing the modeling data provided for precipitation rate. Based on the short coastline of the Gulf of Aqaba, the hazard impacts will have a widespread geographical magnitude. However, there is a low confidence in the results due to the current lack of a model, in Jordan, that accurately models the possible impact of climate change on sea level.

Table 4.27: Average exposure results in coastal area in Jordan

Climate change hazards	RCPs	Average assessment of hazard exposure	Average hazard
Sea level rise	RCP 4.5	3	3.5
	RCP 8.5	4	
Extreme rainfall events and drought in upstream terrestrial areas which is connected to run off and flooding	RCP 4.5	2	2.5
	RCP 8.5	3	
Sea surface temperature	RCP 4.5	3	4
	RCP 8.5	5	
CO_2 concentration	RCP 4.5	3	4
	RCP 8.5	5	
Average of all exposure indicators		**3**	

ASSESSMENT OF CLIMATE SENSITIVITY

Three main determinates were found which are: 1) bio-geological features of the coast at the Gulf of Aqaba, 2) state of water basin and 3) ecosystem and biodiversity. The following illustrate each of them in more details.

Bio- geological features of the coast at the Gulf of Aqaba: which will be represented by

- Coastal landform
- Coastal retreat
- Tidal range

Since Aqaba is characterized by a small coastline. Most of the coastline areas are densely occupied and used heavily for different purposes; the major threat will come from the rise in sea level and the extreme flooding events from the upstream areas. However, modeling information showed that flooding is not considered a major threat due to the low precipitation rate expected at Aqaba. Sea level increases will affect the coastal landform, and will cause a loss of land in coastal areas as well as create changes in tidal range. This in turn will affect several sectors such as tourism, a sector that is dependent on the integrity of natural resources, a healthy marine ecosystem. Any loss of corals or associated marine species could result in a reduction in tourist visits to Aqaba. This is true since no other areas in Jordan will serve the purpose of such activities, despite the presence of other areas within the country that can and do serve as tourism destinations.

State of the water basin: will affect the following

- Hydro-geological features of the catchment
- Amount of groundwater storage

Although it's anticipated effect is minimal due to the current climatic data obtained from modeling which showed that Aqaba will receive the lowest amount of rainfall for the coming 50 years. However, effects could be represented by the amount of groundwater reserves, which will have negative consequences on other sectors areas in the Gulf of Aqaba such as agriculture as well as the effects in the hydro-geological features of Aqaba.

Ecosystems and biodiversity: This will result from the increase in sea surface temperature as well as increase in CO_2 concentrations which will affect major ecosystems and species such as the following:

- Coral reef
- Seagrasses
- Fisheries
- Endemic and Threatened species

Coral Reef

The coral reef is considered the most diverse marine ecosystem in Jordan, It is vulnerable to thermal stress, and has a low adaptive capacity. Increases in sea surface temperatures of 1 to 3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatization by corals (IPCC, 2007). Studies have shown that a 1 ° rise in temperature over the seasonal maximum was sufficient to trigger bleaching. (Gitay et al, 2002) At 2° above seasonal maxima, most corals died. Moreover, a recent study performed by Fine et al 2007 indicated that corals will stop producing a skeleton under laboratory conditions of low pH, but they will continue to maintain other life functions, including reproduction, and will start building new skeletons when conditions return to normal.

Seagrasses

Seagrass is predominant in coastal shallow water habitats with a depth of less than 10 meters, this can be found in the northern of Jordan coastline and partially in its southern parts. To date, three species of Seagrasses were recorded from the Gulf of Aqaba: Halophila stipulacea, Halodule uninervis and Halophila ovalis. Seagrasses provide a stable coastal habitat, improve coastal water quality and support fish production, making them one of the most valuable marine resources. The importance of the seagrass systems in Jordan lies not only in the direct food value to wildlife, but also in its value as a habitat for the growth of both commercial and non-commercial fish and invertebrates, and especially as a refuge from predators for juvenile fish. Seagrasses' habitats are influenced by seawater temperature regimes, tidal variations, salinity content, changing water depths as well as ocean carbon dioxide content. Tidal height and tidal range effects on available light, current velocities, depth and salinity distribution, are all factors that regulate the distribution and abundance of Seagrass.

A sea level increase, as it contributes to increased water depth, leads to a subsequent reduction in light available for seagrass growth. One study suggests that the projected 50 centimeter increase in water depth due to sea level rise over the next century could reduce available light by 50%, which in turn may cause a 30-40% reduction in seagrass growth and productivity (Short and Neckles, 2002).

Fisheries

Fishing was practiced in the Gulf of Aqaba for many years as a source of income and a traditional activity. There is an absence of studies that could provide information about the revenues earned from this action in Aqaba, but two fishing community based organizations exist with an approximate number of members of 150. The primary threats to the Fishing at Aqaba are the increased sea surface temperatures, as well as CO_2 concentrations, which will lead to changes in pH and loss of habitat. Increased sea surface temperatures and pH will have an impact on foraging, growth, fecundity and migratory behavior in aquatic species leading to its decrease. This will in consequence lead to the extinction of traditional fishing practices, which is considered a primary income source for many families at the Gulf of Aqaba.

Endemic and Threatened Species

The rate of endemism is considered high among the Red Sea fishes and represents 13.7% of the total fish species recorded with seven species of fishes recognized as endemic to the Gulf of Aqaba (Goren and Dor 1994). More than 20% of mollusks and echinodermata as well as several species of algae occurring in the Gulf may be endemic. These species are considered unique, rare to the area and they are vulnerable to climate change since they need specific conditions and cannot tolerate environmental changes or the introduction of invasive species. In addition, several threatened species inhabit the Gulf of Aqaba and even migrate such as Whale Shark, which could be affected negatively by any climate change and might lead to its extinction.

The sensitivity analysis showed that the threats that are expected to have the most significant impact on ecosystem and biodiversity components including coral reefs are increased sea surface temperatures, and changes in the pH of sea water due to increased volume of CO_2 concentration. However, insignificant threats are expected from extreme rainfall events or droughts in upstream terrestrial areas based on projected data which showed no changes expected to happen. This means that Aqaba precipitation regime is expected to remain the same which will contribute to preserve ecosystems from any increase in nutrients and pollutants transport to downstream ecosystems, and overwhelm the ability of natural systems to mitigate harm to people from these events. Therefore, effects from upstream areas are insignificant but it is significant from the sea area.

Table 4.28: Sensitivity factors and associated levels in coastal areas

Climate change hazards	Sensitivity factors	Sensitivity level					Average
		Insignificant	Minor	Moderate	Major	Extreme	
		1	2	3	4	5	
Sea level rise	Bio- geological features of the coast at the Gulf of Aqaba- Coastal landform				4		4
	Bio- geological features of the coast at the Gulf of Aqaba- Coastal retreat				4		
	Bio- geological features of the coast at the Gulf of Aqaba- tidal range				4		
Extreme rainfall events or droughts in upstream terrestrial areas which is connected to run off and flooding	State of the water basin- Hydro-geological features of the catchment	1					1
	State of the water basin- Amount of groundwater storage	1					
Sea surface temperature and CO_2 concentration	Ecosystems and biodiversity- Coral Reef				4		4.25
	Ecosystems and biodiversity- Seagrasses			3			
	Ecosystems and biodiversity- Fisheries					5	
	Ecosystems and biodiversity- Endemic and Threatened Species					5	
Average Score							**3**

IMPACTS OF CLIMATE CHANGE ON COASTAL AREAS

The impact of climate hazards on coastal areas could have socioeconomic effects, e.g. if sea level rose, or any changes have happened to the sea surface temperature and CO_2 concentration level at the Gulf of Aqaba, then, potential property losses might occur due to the loss of terrain, biodiversity and ecosystems. It could be important to pay attention to the geographical situation of infrastructure such as hotels and factories with respect to the Gulf of Aqaba and seashores as it might be damaged. In addition, other socioeconomic effects might be occurred such as increase risk of diseases, economical losses in means of tourism attraction level due to the loss of biodiversity, ecosystem and its goods and services, loss of fisheries or changing its distribution along the coast of the Gulf of Aqaba.

Impact of climate change was determined after identifying exposure and sensitivity. The following table (4.29) illustrates results.

The potential impacts of climate change due to increase of sea surface temperature, increase of CO_2 concentration and sea level rise, could present a significant challenge to future coastal management at the Gulf of Aqaba. It is anticipated that there will be increasing levels of risk to many coastal communities and assets. This will require an improvement to the standards of protection in high-risk areas.

Table 4.29: Results of Impact level on Coastal Area

Climate Change Hazards	Sensitivity Factors	Resulting impacts	A. Exposure level		B. .Sensitivity level	C. Impact level	
			RCP 4.5	RCP 8.5		RCP 4.5	RCP 8.5
Sea level rise	**1. Bio-geological features of the coast at the Gulf of Aqaba** • Coastal landform • Coastal retreat • Tidal range	1. Erosion 2. Beach migration 3. Flood (from upstream watershed) 4. Changes in run-off due to upstream extreme rainfall events or droughts 5. Inundation (storms and sea level- rise)	Moderate (average score = 3)	High (average score = 4)	High (average score = 4)	High (average score = 3.5)	High (average score = 3.5)
Extreme rainfall events or droughts in upstream terrestrial areas which is connected to run off	**2. State of the water basin** • Hydro-geological features of the catchment • Amount of groundwater		Low (average score = 2)	Moderate (average score = 3)	Very Low (average score = 1)	Low (average score = 1.5)	Low (average score = 2)
Sea surface temperature	**3. Ecosystems and biodiversity** • Coral reef • Seagrasses • Fisheries • Endemic and Threatened Species	1. Increased probability for the invasion of marine alien species 2. Coral bleaching in the Gulf of Aqaba 3. Decrease fisheries production 4. Trophic structure and food web 5. Effects on tourism 6. Increased probability of losing protected areas 7. Sea level rise 8. Increase extinction rate of species 9. Loss of income resources from fisheries	Moderate (average score = 3)	Very High (average score = 5)	Very High (average score = 4.25)	High (average score = 3.625)	Very High (average score = 4.625)
CO_2 concentration	**4. Ecosystems and biodiversity** • Coral reef • Seagrassess • Fisheries • Endemic and Threatened Species		Moderate (average score = 3)	Very High (average score = 5)	Very High (average score = 4.25)	High (average score = 3.625)	High (average score = 4)

ASSESSMENT OF ADAPTIVE CAPACITY OF THE COASTAL SECTOR

Adaptive capacity to climate change is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Any adaptation process should start with an awareness raising process directed to decision makers and public in general regarding the impact of climate change. Climate change is considered an emerging issue in Jordan but is limited to a few academic institutions, especially in Aqaba. In addition, the level of communication and knowledge shared between academic institutions, decision makers and public in general is very low. The lack of institutional capacity to cope with climate change effects is another challenge.

Awareness will be achieved when further data gathering on the vulnerability of the coastal areas is complete and updated on a continuous basis. Generally, the awareness level regarding hazards and climate change impact is limited in the Gulf of Aqaba. This is mainly due to data shortage, weak scientific research on climate change, socio-economic challenges at Aqaba and lack of appropriate methodologies to analyze the impacts. In addition, the current Environmental Impact Assessment performed at Aqaba under ASEZA laws and regulations do not take climate change hazards such as sea level rise or temperature issues into account for future planning.

The lack of awareness regarding climate change and climate change impact, leads to a weak consideration while planning a long-term management plan for coastal areas. Moreover, ecosystem services provided by major ecosystems at the Gulf of Aqaba are vital for the site's economic, social and ecological integrity. Therefore, it has to be protected and included in the land use master plans.

Ecosystem services are very fragile and have low adaptive capacity due to the limited coastal areas at the Gulf of Aqaba with about 27 kilometers and relatively short batches of major ecosystems. In addition, a moderate adaptive capacity is observed for both the economic and social capabilities and infrastructures at Aqaba.

The vulnerability assessment showed clearly that the geographically restricted coastline of the Gulf of Aqaba is vulnerable to climate change impact. The high vulnerability was noticed for main exposure determinants which are: sea level rise, increase of sea surface temperature and CO_2 concentrations. This is true as the Gulf of Aqaba contains sensitive ecosystems and habitats, which are very vulnerable to any changes in sea composition. Despite that modeling showed that precipitation is anticipated to be very low at the upstream areas of Aqaba, but still moderate vulnerability results was obtained due to the high adaptive capacity expected.

Table 4.30: Adaptive capacity assessment for coastal areas in Jordan

Adaptive capacity factors	Very Low	Low	Medium	High	Very High
	1	2	3	4	5
Ecosystem services provided by major ecosystems at the Gulf of Aqaba		2			
Economic and social capability represented by tourism, industries and fisheries			3		
Infrastructure			3		
Institutional capacity- awareness		2			

Table 4.31: Vulnerability assessment matrix for coastal areas in Jordan

Climate Change Hazards	Sensitivity Factors	A. Exposure level		B. .Sensitivity level	C. Total Impact level (A+By2)		D. Adaptive capacity level	C. Overall vulnerability assessment	
		RCP 4.5	RCP 8.5		RCP 4.5	RCP 8.5		RCP 4.5	RCP 8.5
Sea level rise	**1. Bio-geological features of the coast at the Gulf of Aqaba** • Coastal landform • Coastal retreat • Tidal range	Moderate (average score = 3)	High (average score = 4)	High (average score = 4)	High (average score = 3.5)	High (average score = 3.5)	Moderate (average score = 2)	High (average score = 3.25)	High (average score = 3.25)
Extreme rainfall events or droughts in upstream terrestrial areas which is connected to run off	**2. State of the water basin** • Hydro-geological features of the catchment • Amount of groundwater storage	Low (average score = 2)	Moderate (average score = 3)	Very Low (average score = 1)	Low (average score = 1.5)	Low (average score = 2)	High (average score = 3)	Moderate (average score = 2.25)	Moderate (average score = 2.25)
Sea surface temperature	**3. Ecosystems and biodiversity** • Coral reef • Seagrasses • Fisheries • Endemic and Threatened Species	Moderate (average score = 3)	Very High (average score = 5)	Very High (average score = 4.25)	High (average score = 3.625)	Very High (average score = 4.625)	Low (average score = 3)	Moderate (average score = 3.3)	High (average score = 3.9)
CO_2 concentration	**4. Ecosystems and biodiversity** • Coral reef • Seagrassess • Fisheries • Endemic and Threatened Species	Moderate (average score = 3)	Very High (average score = 5)	Very High (average score = 4.25)	High (average score = 3.625)	High (average score = 4)	Low (average score = 2)	High (average score = 2.8)	High (average score = 3)

CLIMATE CHANGE ADAPTATION STRATEGIES AND MEASURES

The aim of adaptation is to use the advantage of any positive opportunities to manage climate risk to an acceptable level. The following table illustrates adaptation measures suggested to cope with climate change impacts.

Table 4.32: Adaptation measures suggested for coastal zones

Climate Change Hazards	Resulting impacts	Overall vulnerability assessment	Adaptation measures	Priority
Sea level rise	1. Erosion 2. Beach migration 3. Flood (from upstream watershed) 4. Changes in run-off due to upstream extreme rainfall events or droughts 5. Inundation (storms and sea level- rise)	High (average score = 3.25)	Awareness campaigns about potential impacts of climate change targeting both individuals and institutions	3
			Prepare disaster reconstruction plans and develop local management plans and get technical expertise support	1
			Revise coastal zone management plan of the Gulf of Aqaba	1
			Training and individual development programs to enhance institutional capacity toward climate change	2
			Sustainable development measures at the coastal areas of the Gulf of Aqaba	1
Extreme rainfall events or droughts in upstream terrestrial areas which is connected to run off		Moderate (average score = 2.25)	Retrofitting of buildings	3
			Increase public awareness of flooding and\ or drought and revise current flood management strategy	2
			Develop and revise current flooding design infrastructure for flood protection	2
			Maintenance of water infrastructures at Aqaba and enhance their capacity	1
			Water resources management at Aqaba and develop a warning system	1
Sea surface temperature and CO_2 concentration	1. Increased probability for the invasion of marine alien species 2. Coral bleaching in the Gulf of Aqaba 3. Decrease fisheries production 4. Trophic structure and food web 5. Effects on tourism 6. Increased probability of losing protected areas 7. Sea level rise 8. Increase extinction rate of species 9. Loss of income resources from fisheries	High (average score = 3.25)	Enhance the monitoring system of ecosystems and species at the Gulf of Aqaba	1
			Understanding fishing activities' impact and reduce its effects if they appeared to be determinant.	3
			Develop a monitoring system for introduced, endemic and threatened species	2
			Increase awareness and knowledge toward the effects of climate change on ecosystems and biodiversity	1
			Rise expertise? of individuals and institutions at Aqaba	2
			Information dissemination/education campaign on climate variability and change and its impacts for decision makers and the public.	1
			Formulation of guidelines and legislation for the implementation of Integrated Coastal Zone Management (ICZM) for the entire coastal areas at Aqaba.	1
			Incorporation of climate change implications in the land-use planning of the coastal areas	1

RECOMMENDATIONS FOR ACTION

Policy recommendations

- Define the department or organizations responsible for coastal protection and climate change adaptation in Aqaba. This body should use a participatory approach and data share with major stakeholders to ensure proper management of climate change effects.
- Adopt a long-term integrated coastal zone management plan, taking into account ecological, social and economic perspectives at the Gulf of Aqaba.
- Include climate change requirements in the Environmental Impact Assessment conditions for coastal development
- Stimulate the proactive involvement of national organizations in climate change adaptation and coastal protection.
- Create a central database that includes potential climate change adaptation strategies, plans, programs and measures applied as well as investments made at Aqaba. This database should be freely accessible by the public and interested organizations.
- Support and assistance should be given to planning authorities through the process of preparation of regional land use plans in order to review the development capacity of undeveloped areas included within coastal settlement boundaries, to ensure that the potential impacts of coastal climate change are taken into account when deciding the future of these areas, and to adjust settlement boundaries where required.

Other recommendations

- Implement resource assessment survey for the Gulf of Aqaba to identify the current situation and impact of climate change on the Gulf of Aqaba.
- Monitor sea level rise along the coast of the Gulf of Aqaba.
- Strengthen the measures to prevent transference of invasive species by trade routes and through the ballast water.
- Avoid marine pollution from land sources in the Gulf of Aqaba in order to reduce the stress on coral reef and make them less vulnerable.
- Conduct site-specific research on the carrying capacity for critical and marine protected areas.
- Develop an education and public awareness campaign related to climate change and its impact on Aqaba coastline.
- Safeguard representative areas as protected area to be included in Jordan's network on protected areas.
- The management authorities shall work toward establishing more conserved areas in the Gulf of Aqaba. This can be done through enhancing enforcement and applying integrated coastal zone management at Aqaba

4.7 VULNERABILITY AND ADAPTATION IN URBAN SECTOR

In overlaying the defined urban areas/built-up areas, from the land cover map , the mean temperature map for 2010 RCP 4.5, showing that most of settlements are within average mean temperature areas of 14-18°C with rainfall between 300-500 millimeters as figures 4.36 and 4.37 show.

In order to make a better representation of climate change impacts on communities, the exposure has been assessed for the pilot area specifically and for the Kingdom to cover the adjacent urban centers; Amman and Salt. The exposure assessment study included: severe winds, increase in maximum temperatures, decreases in minimum temperatures, heavy rain, snow and drought. The overall exposure for the pilot area at RCP 4.5 is low, this is due to the low likelihood of heavy rains, severe winds and snow, low coverage of snow and low confidence for severe winds, heavy rain and snow. As for RCP 8.5 the overall is moderate due to an overall increase either in confidence, geographical magnitude or likelihood.

At the kingdom level, the overall exposure in RCP 4.5 is low and moderate in RCP 8.5, although the exposure is low, the events concentrate in certain geographic areas and thus the kingdom exposure is not the best representation for specific urban areas as Amman and Salt. The main factor, which reduced the exposure score, is the confidence of occurrence due to the large geographic coverage which is not uniform in exposure. For the purpose of better representation of climate change impact on communities, the exposure has been assessed for the pilot area specifically and for the Kingdom to cover the adjacent urban centers; Amman and Salt.

Figure 4.36: Built up areas and mean Temperature 2010

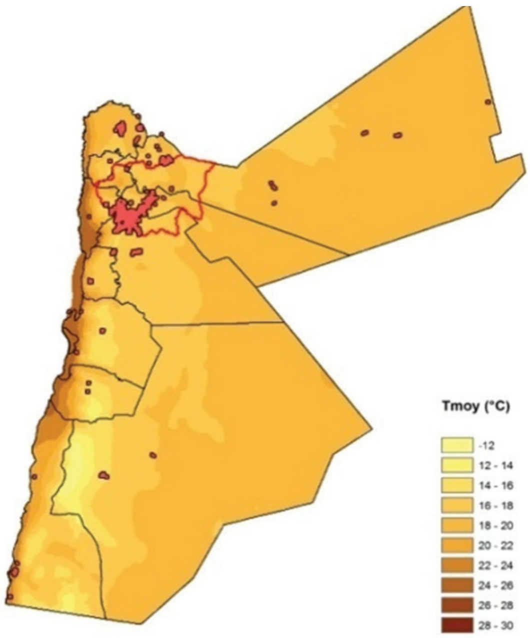


Figure 4.37: Built up areas and rainfall 2010

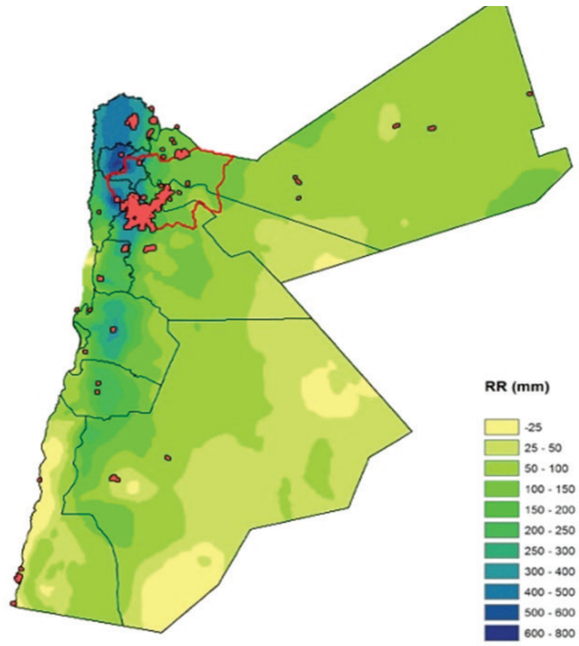


Table 4.33: Climate Exposure Assessment in Urban areas in Jordan

	Kingdom								Pilot							
	Likelihood		Geographical magnitude		Confidence		Scale		Likelihood		Geographical magnitude		Confidence		Scale	
	4.5	8.5	4.5	8.5	4.5	8.5	4.5	8.5	4.5	8.5	4.5	8.5	4.5	8.5	4.5	8.5
Severe winds	2	3	4	5	1	2	2.3	3.3	2	2	4	5	1	2	2.3	3.0
Increase in maximum temperatures	5	5	4	5	3	4	4.0	4.7	5	5	4	5	3	4	4.0	4.7
Decrease in minimum temperatures	3	4	3	4	4	5	3.3	4.3	3	4	3	4	4	5	3.3	4.3
Heavy rain	4	4	1	2	1	2	2.0	2.7	2	3	3	4	1	2	2.0	3.0
Snow	1	1	1	2	1	2	1.0	1.7	1	1	1	2	1	2	1.0	1.7
Drought/ dry days	4	4	4	5	4	4	4.0	4.3	3	4	4	5	4	4	3.7	4.3

ASSESSMENT OF CLIMATE SENSITIVITY

The last snow storm "Alexa" that hit the Kingdom in December 2013 caused widespread electricity outages, thousands of cases of breaks and fractures, difficulty to get gas and other services, cases of people trapped, child births, dialysis, and an initial estimate of 9 million Jordanian Dinars in infrastructure losses.

Sources reported that the majority of air conditioning and fans vanished from the Jordanian market, as a result of the recent heat wave, which raised sales and prices. The value of Jordan's imports during the first six months of this year amounted to JD8.4 million (US$11.8 million), according to preliminary figures issued by the Department of Statistics. Exports of air conditioners declined from JD9.1 million to JD1.9 million due to the growing demand in the local market. The value of imports by the country last year reached JD20.1 million dinars and exports JD14.2 million.

The import value of fans increased from JD2.9 million to JD3.2 million. The director of an outlet owned by the "South Company for Electronics" said, that all air conditioners were sold out within a few weeks, as demand has exceeded expectations, adding that prices ranged from JD319 to JD590.

Table 4.34: Consequences of Snow Storm Alexa (2013) in three different regions

Amman mainly suffered from:	Salt suffered from:	Al Arda suffered from:
• Water flowed on roads not due to exceeding capacity of water collection networks; rather to the disposal of solid wastes that blocks pipes and drives water out to the streets. • Cars got stuck around Amman, creating obstacles for GAM and Civil Defence Directorates response machinery and Tunnel flooding equipment • High rates of car accidents requiring civil defense assistance. • Storm water caused flooding of houses and roads. • 7 million JD loss was the result of damages at Jordan university • Heavy toll on the country's forestry sector with an estimate tree damage of around JD1 million • People were waiting for hours to take taxis or buses on the main roads, residents were forced to walk from their area because most bus drivers refused to go to many parts of Amman. • Ice formation in the mornings preventing residents from reaching their work. • Businesses affected by roads' blockage and slippery conditions.	• Bursting water pipes due to the lack of capacity to accommodate pumping water to houses • Spike in demand for commodities, such as room heaters, in fear of power outage based on previous similar conditions. • Electricity and power outages caused by uprooting of trees as an effect of snow storms. • Closure of main roads for extended periods of time due to landslides • Vehicular mobility restricted due to floods and landslides, blamed on Water Authority excavations • Blocked roads affecting the delivery of basic needs. • Roads closed due to frost formation (black ice), and low visibility due to fog • Motor vehicles swept away by storm water. • Drainage networks unable to cope with the rainfall • Water swept into homes as a result of blockages in water drainage and sewerage networks • Landslides affecting homes and creating high vulnerable areas • Power cuts and residents were unable to reach their homes	• Residents complained that there was no water delivery for three months; infrastructure capacity was not able to accommodate the population growth. Residents forced into purchasing water tanks • Explosion of an electricity transformer affected residents and emergency rooms • Trees falling on homes and roads • Landslides on major highways connecting Al Arda to adjacent urban centers in addition to their significance to the national road network • Outdated infrastructure, most pipes do not exceed 2-in in diameter, affecting water provision especially in the summer. • Flash floods affecting the accessibility of roads and connectivity to adjacent areas. • Flooded cesspit and residents drowning • Flooded houses due to exceeded culvert capacity

Table 4.35: Urban Systems Sensitivity Indicators

Sectors	Indicators	Proxy variables/issues
Energy	Power cuts/ blackouts. Energy consumption. Energy resources.	• Aging grid/ load. • Subject to vandalism/ theft. • Lack of climatic retrofitting. • High electricity prices. • Availability of alternative energy resources/types.
Transportation and mobility	Public transportation. Road infrastructure.	• Availability of public transportation, types. • Proportion of transportation and supply facilities area. • Continuity of transportation methods. • Service times. • Increased travel times. • Dependence on fuel availability and prices. • Centralization of transportation in Salt. • Regional interdependence of road network. • Road conditions (main and agricultural). • Road services (maintenance, lighting ...) • Quality of material used in construction. • Heavy use of roads (transportation vehicles).
Water infrastructure	Water supply.	• Aging network/ leakage. • Pipe/network specifications unresponsive to demand. • Surface networks/ breakage and contamination. • Availability of water. • Irregular/ unresponsive pumping. • Subject to vandalism/ theft. • Water quality. • Lack of knowledge regarding constructing/ maintaining rainwater collection wells.
Sewage and sanitation	Sanitation services.	• Percentage of connections to sewage network. • Lack of knowledge regarding constructing/maintaining cesspits. • High construction/ emptying prices of cesspits. • Dependence on the use of specialized transportation to empty cesspits. • Lack of regulation/ follow up.
Education/ awareness	Efficiency of the educational system.	• Availability of schools/ types. • Accessibility. • Condition of exiting schools and services.
Governance	Governance	• Centralization of services.
Geography/ landuse	Hilly nature, steep slopes. Drought vulnerable area. Flood risk area. Environmental aspects.	• Urban morphology/ expansion. • Distribution of infrastructures/ access. • Water availability/ water infrastructures. • Impact of high temperatures on infrastructures. • Creation of waterways/ flash floods. • Soil erosion, up lifting trees.
Demographic characteristics	Population density	• Population/ total land area.

Assessment of impacts

Impacts of the climate events listed above were less severe and more related to weather conditions, rather than to climate change. Nevertheless, the understanding of climate events still requires further studies, which will allow for better comprehension of possible future changes in climate patterns, whether in duration or intensity. Generally, infrastructures built within Al Arda - as a main component of urban systems- are found to be prone to impacts of climatic events. Such impacts on the livelihood of the local residents are multiplied due to the interconnection and dependence between these built hard and soft infrastructures (social, education, health, etc). Ripple effects may surface as one system shuts down causing disturbances in the flow of other systems, services, economic and social aspects of everyday life, i.e. intense rain may cause the flooding or collapse of cesspits, some of which are not constructed properly thus will cause deteriorations in the quality of both the surface and ground water systems, along with the spreading of diseases, insects and the possible contamination of water used for irrigation.

The indirect regional climatic impact on communities highlights the interdependency of infrastructures on a wider scale and the ripple effect of such interconnection, i.e. the impact of Alexa storm that has hit certain areas of Jordan on December 12th, 2013. Al Arda being connected to Salt, and many of its residents work in nearby cities; the public transportation in Al Arda was completely shut down in addition to many other services following Al Salt, i.e. garbage collection… etc. Although Al Arda itself was not severely affected by the storm like other areas, yet that effect was due to the fact that its urban systems are part of broader regional systems.

CLIMATE CHANGE IMPACT ASSESSMENT

Current knowledge indicates that vulnerability assessments tend to be focused on extreme weather events associated with climate change impacts that can disrupt infrastructure services, often cascading across infrastructures because of extensive interdependencies– threatening health and local economies, especially in areas where human populations and economic activities are concentrated in urban areas. Vulnerabilities increase when infrastructures are subject to multiple stresses, beyond climate change alone; especially those that are located in areas vulnerable to extreme weather events.

In general extreme weather events associated with climate change will increase disruptions of infrastructure services in some locations:

- A series of less extreme weather events associated with climate change, occurring in rapid succession, or severe weather events associated with other disruptive events may have similar effects.
- Disruptions of services in one infrastructure or services will almost always result in disruptions in one or more other infrastructures or services, especially in urban systems, triggering serious cross-sectoral infrastructure system failures in some locations, at least for short periods of time
- These risks are greater for infrastructures that are:
    - Located in areas exposed to extreme weather events
    - Located at or near particularly climate-sensitive environmental features, such as coastlines, rivers, storm tracks and vegetation in arid areas.
    - Already stressed by age and/or by demand levels that exceed what they were designed to deliver

- In large urban areas with interdependent service systems the risk matrix is complicated due to influence of one system shortcoming on other systems thus increasing the vulnerability of the residents of these areas.

Summary of impacts

Regarding implications of climate change for urban systems:

- Urban systems are vulnerable to extreme weather events that are becoming more intense, frequent, and/or longer-lasting due to climate change.
- Urban systems are vulnerable to climate change impacts on regional infrastructures (that are outdated and threatened) on which they depend for daily subsistence.
- Urban systems and services will be affected by disruptions occurring in relatively distant locations due to linkages through national infrastructure networks and the national economy.
- Cascading system failures related to infrastructure interdependencies will increase threats to health and local economies in urban areas, especially in locations vulnerable to extreme weather events.
- Such effects will be especially problematic for parts of the population who have the higher vulnerability because of their limited coping capacities.

Assessment of adaptive capacity

The potential for adaptation will not be consistent throughout various communities and systems. The geography, economy and social structures, as well as many other factors will inevitably influence their resilience and their ability for communities to adapt.

Since adaptive capacity is uneven across and within communities, there is the potential for individuals and groups to have insufficient capacity. In addition, not all communities that have high adaptive capacity are less vulnerable to climate change. An example is the social support system that is existent in rural areas which increases the adaptive capacity of the residents, yet it does not ensure they are less vulnerable to climate change due to other functional and technical service standards aspects.

There are many key factors that drive adaptive capacity and lead to inconsistency across and within communities. These key factors include economic resources, technology, information, awareness, skills, human resources, infrastructure, institutional support and governance.

In the observed pilot area, most of the adaptive actions of the community are reactive responses; meaning that once the problem has occurred then adaptation takes place, and mostly relies on the strong social ties and support system of the community. Below are examples of pilot's areas adaptive responses that were provided by the local community during the focus groups:

- Employees of the public transportation system cooperated with the residents in bad weather conditions; high temperatures or heavy rain, also residents use car sharing to reach their destinations.
- Most houses have water collection wells and they support each other in case of water cuts or shortages.
- In case of heavy rain the residents assist each other to redirect the storm water from properties and farms to avoid flooding.
- The community donates and supports public schools for maintenance, rehabilitation or building additional classrooms.
- Doctors within the community offer their services for free to residents in case they were unable to reach health centers under certain weather conditions.
- The community relies on other natural sources for heating in the cold weather to overcome service cuts and the increased prices of these services.
- The community shares knowledge in areas of water usage conservative methods, cesspits standards and construction techniques, grey water usage for irrigation and energy efficiency practices.

CLIMATE CHANGE ADAPTATION STRATEGIES AND MEASURES

City governments are responsible for decisions and actions related to the delivery of a wide range of services that ensure the well-being of their citizens such as: land use planning and zoning, water provision, sanitation and drainage, housing construction, renovation and regulation, economic development, public health and emergency management, transportation provision and environmental protection. Many of these formal functions position cities well to undertake adaptation, because many services are vulnerable to disruption from climate change impacts, and because planning functions can serve as sources of adaptive capacity and strategies to reduce vulnerability.

Cities can take a major step toward sound development and climate change resilience simply by instituting and enforcing stronger management principles—a very substantial undertaking that does not lend itself to consistently easy solutions. Independent of climate change, many cities face significant obstacles in fulfilling their functions because of long-standing problems with governance, such as corruption, lack of transparency and weak administration. These issues can hinder the achievement of long-term development goals in general (World Bank 2007).

Adaptation measures

Cities can take a major step toward sound development and climate change resilience simply by instituting and enforcing stronger management principles—a very substantial undertaking that does not lend itself to consistently easy solutions. Independent of climate change, many cities face significant obstacles in fulfilling their functions because of long-standing problems with governance, such as corruption, lack of transparency, and weak administration. These issues can hinder the achievement of long-term development goals in general (World Bank 2007).

Cities tend to face two major needs in this area— first, a basic assessment of institutional capacity, and second, development of a shared understanding of roles and responsibilities that different actors can play in executing an adaptation agenda. A city can begin to address these needs by developing an institutional map of the different actors that may be involved in an adaptation effort, how they function in reality, and any capacity gaps that may remain to be filled

a) Types of measures

Adaptation actions can be undertaken by individuals, for their own benefit; or it can consist of actions taken by governments and public bodies to protect their citizens (Adger 2005). Adapting to natural hazards—or in less optimal cases, reacting to them—is not new for many individuals, families, and cities around the world. Protecting livelihoods, assets, and access to such basic services as energy and water is a natural response when dealing with disasters and climate hazards.

The adaptation measures proposed and discussed with the public were on: policy formulation, mechanism and detail for daily use.

b) Prioritization of measures

The different adaptation measures that focused on three different levels; policy formulation, mechanism and detail for daily use were presented to the participants during the national workshop, where the participants discussed the importance and applicability of these measures.

The participants along with the expert ranked each measure in regard to the certain indicators; Social equity, financial cost benefit, effectiveness, robustness to uncertainty and synergies. On a scale of 1-3 and based on the average the final priority results were highlighted in the table 4.36.

RECOMMENDATIONS FOR ACTION

Policy recommendations

Regarding Land use and development, the general base for defining development types or locations is defined by the Jordan land use project of 2007, which is very generic and allows various uses on environmentally sensitive areas. Other sources of regulation are the master plans of the various cities. Below are some policy recommendations to ensure better integration between entities and implementation, it guarantees access to all vulnerable groups and promotes better practices:

- Ensure that land using planning in urban areas considers the impacts of climate change and the need to sustain ecosystem services when considering development proposals.
- Consider a combination of ecosystem-based and traditional engineering approaches to reduce vulnerability.
- Government to co-ordinate and integrate transport, energy, land use, economic development, environment & other policies.
- Guarantee the access of the most vulnerable groups to resources contributing to strengthening their capacity to respond to the impacts of climate change.
- Promote mass transit options: establishing mechanisms to promote investments in high-capacity public transport systems.
- Promote construction of energy efficient buildings.
- Develop policy instruments at all levels of government to implement the National Framework Strategy on Climate Change.

Other recommendations

Town planning influences the level of emissions produced by human settlements by changing fuel and consumption patterns. The Government should encourage intensification and densification with appropriate zoning & mass transit (vertical) instead of horizontal expansion/ sprawl of urban housing projects.

Climate Change Framework should recognize the role of local governments as front-liners in addressing climate change.

There is a need to construct sidewalks and bike Paths to persuade the community to use non-motorized vehicles and walking.

Previous planning and development trends to concentrate on expanding urbanized areas in response to growing demand for development without considering the effects of land use modifications on climate, economy, social stability and cohesion of communities. Recent approaches concentrated on preserving the natural heritage in creating buffers, no development zones, policies and incentives, yet the impact on climate was not the main concentration of these plans.

It is highly recommended to identify urban related and systems indicators to conduct in depth research of the effect of these urban systems on climate change and vice versa, to define the different tools and forms of information required to be the base of indicators.

Table 4.36: Hazards and Adaptation Measures

Hazard	Impacts	Description	Socio-economic consequences
Severe winds	Power cuts	Winds causing tree falls on power lines or power lines cuts due to severe wind	Populations are affected by the cut of power service and other services dependent on energy
Increase in Maximum temperature	Power cuts	High temperatures causes increase demand on energy for cooling devices, including fans and Acs, power cuts due to demand exceeding network capacity affect functionality	Populations are subject to high temperatures due to unavailability of cooling devices
Decrease of minimum temperature			
Heavy rain	Landslides	Heavy rain and flash floods wash away roads and cause disconnection. High precipitation weaken prone areas either due to soil structure or steepness of topography	Residents will be blocked from reaching their employment and some services that are provided by adjacent urban centers (i.e. gas, food …etc)

Vulnerability													
4.5						8.5						Adaptation measure	Priority
Seehan	Bayoudah	Subeihi	Ar Rumaimeen	Salt	Amman	Seehan	Bayoudah	Subeihi	Ar Rumaimeen	Salt	Amman		
Moderate	Low	Moderate	Moderate	Moderate	High	Moderate	Moderate	Moderate	Moderate	High	Very High	Replace electricity poles and wires with underground network to reduce the influence of external forces on the network	3
												Coordination between the Energy and forest authorities to clear tree branches that are affecting electricity lines that can cause hazards during storms.	1
High	Moderate	High	High	High	Very High	High	Moderate	High	High	High	Very High	Introduce climate responsive building techniques and elements to reduce the effect of heat and reduce demand on energy for cooling.	2
												Promote the use of energy saving devices, and raise awareness on the long-term benefits of energy efficiency and saving devices.	1
												Amendments to sector policies and regulations, such as building codes, to reflect climate change risks and direct people towards insulating buildings to reduce energy demand	2
												Introduce renewable sources of energy to help in heating and reduce the dependence on the electricity network	3
												Invest in proper/ contextual infrastructure to build resilience to climate change	1
Low	Low	Low	Low	Moderate	Moderate	Low	Low	Low	Low	Moderate	Moderate	Adopt conservative building techniques that withstand the severe climate indicators and avoid landslide	2
												Preserve natural water courses through planning ordinances, regulations, penalties and incentives	2
												Construct proper storm water network to discharge storm water from built environment	2

Hazard	Impacts	Description	Socio-economic consequences
Heavy rain		Heavy rain causes landslides on buildings and infrastructure	Landslides cause infrastructures and buildings collapse and thus endanger the lives of people or disconnect them from reaching their destinations in case of road network. Weak soil structure creates dangerous zones that are prone to landslides, thus affecting the residents, endangering their lives or disrupting services
	Disease and illness	Poorly constructed cesspits collapse or flood due to heavy rain or flash floods	Flooding or collapsing cesspits contaminate surrounding environment and in most cases the adjacent collection wells or ground water. Also there are some incidents of people drowning due to these circumstances
	Sewage flooding to homes	Storm water capacity that cannot accommodate heavy rain or flash floods fill the roads with pooled/standing water that obstructs mobility	Bad practices of some road officials opening sewage to absorb the excess water that is not drained through the storm water network to facilitate vehicle movements along the road, thus flooding the houses that are in lower areas
Drought	Insufficient water supply	In summer, pipes would rust due to lack of water, and in winter would burst due to inadequate water pressure	Residents receive dirty water not adequate for domestic use or get deprived from the water service due to bursting old lines
Snow storms	Disconnection from adjacent areas (services and employment)	Snow in the pilot area or adjacent areas blocks the roads and thus disconnects the residents from accessing surrounding areas	Residents will be blocked from reaching their employment and some services that are provided by adjacent urban centers (i.e. Gas, food …etc)

<table>
<tr><th colspan="12">Vulnerability</th><th rowspan="2">Adaptation measure</th><th rowspan="3">Priority</th></tr>
<tr><th colspan="6">4.5</th><th colspan="6">8.5</th></tr>
<tr><th>Seehan</th><th>Bayoudah</th><th>Subeihi</th><th>Ar Rumaimeen</th><th>Salt</th><th>Amman</th><th>Seehan</th><th>Bayoudah</th><th>Subeihi</th><th>Ar Rumaimeen</th><th>Salt</th><th>Amman</th><th></th></tr>
<tr><td rowspan="4">Moderate</td><td rowspan="4">Moderate</td><td rowspan="4">Moderate</td><td rowspan="4">Moderate</td><td rowspan="4">Moderate</td><td rowspan="4">Low</td><td rowspan="4">Moderate</td><td rowspan="4">Moderate</td><td rowspan="4">Moderate</td><td rowspan="4">High</td><td rowspan="4">Moderate</td><td rowspan="4">Moderate</td><td>Legislative requirements that every policy or investment must have a climate lens</td><td>3</td></tr>
<tr><td>At the strategy and planning level, activities can include revising master plans</td><td>1</td></tr>
<tr><td>Zoning and development changes to reflect increased vulnerability of specific locations and/or resources</td><td>2</td></tr>
<tr><td>Operational level, climate change considerations can be integrated into day-to-day municipal operations and service delivery</td><td>1</td></tr>
<tr><td rowspan="4">High</td><td rowspan="4">Moderate</td><td rowspan="4">High</td><td rowspan="4">High</td><td rowspan="4">Moderate</td><td rowspan="4">Moderate</td><td rowspan="4">High</td><td rowspan="4">Moderate</td><td rowspan="4">High</td><td rowspan="4">High</td><td rowspan="4">Moderate</td><td rowspan="4">Moderate</td><td>Invest in proper / contextual infrastructure to build resilience to climate change</td><td>1</td></tr>
<tr><td>Municipalities to cooperate with residents in return of the sanitation fees they pay for.</td><td>1</td></tr>
<tr><td>Community awareness in climate change mitigation and adaptation</td><td>1</td></tr>
<tr><td>Set standards and regulations for sewage systems in low density and steep topography areas to educate residents and enforce good construction techniques that would protect residents.</td><td>2</td></tr>
<tr><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td>Invest in proper/ contextual infrastructure to build resilience to climate change</td><td>1</td></tr>
<tr><td>Preserve natural water courses through planning ordinances, regulations, penalties and incentives</td><td>2</td></tr>
<tr><td rowspan="2">High</td><td rowspan="2">High</td><td rowspan="2">High</td><td rowspan="2">High</td><td rowspan="2">Very High</td><td rowspan="2">Very High</td><td rowspan="2">High</td><td rowspan="2">High</td><td rowspan="2">High</td><td rowspan="2">High</td><td rowspan="2">Very High</td><td rowspan="2">Very High</td><td>Decentralization of water services to allow private companies that operate in a way that are more considerate of demand and required pressures at different times of the year</td><td>2</td></tr>
<tr><td>Investment in network upgrading and continuous maintenance</td><td>2</td></tr>
<tr><td rowspan="2">Moderate</td><td rowspan="2">Low</td><td rowspan="2">Low</td><td rowspan="2">Moderate</td><td rowspan="2">Low</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Low</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td rowspan="2">Moderate</td><td>Develop climate change contingence and Preparedness plans at central and municipal level.</td><td>1</td></tr>
<tr><td>Decentralization of services to reduce dependence on adjacent areas that might be severely affected.</td><td>2</td></tr>
</table>

RECOMMENDATIONS FOR ACTION

Policy recommendations

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4.8 VULNERABILITY AND ADAPTATION IN HEALTH SECTOR

Health Situation and services in Jordan:

Jordan has advanced health care infrastructures, where the health system is a complex combination of three major sectors: Public, private, and international organizations providing medical services.

The public sector consists of two major public subsectors: the Ministry of Health (MOH) and Royal Medical Services (RMS). Other smaller public programs include universities such as Jordan University Hospital (JUH) in Amman and King Abdullah Hospital (KAH) in Irbid.

Health sector in Jordan has 106 hospitals with capacity of 12106 beds. MOH hospital represents 38% of the total; there are 92 comprehensive health centers, 372 primary health centers and 211 secondary health centers, also there are 444 MCH health centers and 12 chest health centers.

Total health expenditure in both public and private was estimated at 8.6% of GDP in 2012, public sectors finance

48% of the total healthcare expenditures. Health spending in Jordan is high compared to other MENA. Overall spending has increased in over the past six years

About 82% of the population in Jordan is covered by formal health insurance; the Civil Insurance is the largest health insurer (35%).

Over the years, an extensive network of PHC facilities has been formed, with about 2.3 centers per 10,000 populations, and with an average patient travel time to the nearest center of 30 minutes.

Jordan has 1.8 inpatient beds per thousand population; 14.5 percent of the population is admitted annually to hospitals; hospital lengths of stay average 3 days; and the hospital occupancy rate is 62.3.

Jordan has made considerable progress in reducing the major health risks to infants and children since the Expanded Immunization Program EPI was adopted; Life span 80.18 years An important progress was achieved in lowering the infant mortality from 30 per1000 in 2000 to 17 per 1000 in 2012 and child mortality rates from 34 per 1000 in 2000 to 21 per 1000 in 2013, the maternal mortality rates 63 deaths/100,000 live births (2010).

Climate Change and Health in Jordan:

There is sufficient evidence on climate change variability at a wide range of time scales all over the Middle East. This variability has had and will have important impacts on socioeconomic, environmental and health sectors. Precipitation and temperature varies among sub regions. Although of the variations diversity in data quality and analysis, the variations could be attributed to climate change.

The scale of health impacts from climate change will depend primarily on the size, density and wealth of the population. Exposure to heat or cold waves could have impacts on mortality rates, communicable diseases and non-communicable diseases.

In 2012 the Ministry of Health, and with support from WHO CEHA has developed a National Climate Change and Health Adaptation Strategy and Action Plan. The impact of climate change on six climate-sensitive health issues, namely, air-borne and respiratory diseases, water and food-borne diseases, vector-borne diseases, nutrition, heat waves, and occupational health was identified. The national adaptation and health strategy was built on the basis of the above six themes. The strategy identified major trends in the future impacts of climate change on the health sector in Jordan.

The assessment of climate change burden on respiratory diseases reveals that the most visible effect would be on chronic respiratory diseases including bronchial asthma and COPD. There are no effects on acute infectious respiratory diseases; on the contrary, the assessment illustrates a positive effect of the predicted increase in temperature and decrease in humidity.

The increase in temperature due to climate change is likely to be associated with increased survival and abundance of microorganisms; thus, increased water and food-borne diseases. The expected decrease in precipitation will lead to decreased availability of water, which may lead to the consumption and use of unsafe (contaminated) water for drinking and other uses, causing many water and food-borne diseases. Flooding will cause epidemics of water and food-borne diseases. The spread of these diseases after floods results primarily from contamination of water caused by disruption of water purification and sewage disposal systems. However, the secondary effects of flooding, including crowding and subsequent focal-oral spread of gastrointestinal pathogens, may also contribute to spreading of water and food-borne diseases.

Vector Born Diseases (VBD) risk is expected to increase by increasing temperature. Areas with scarce water like the Eastern Desert will become an area of higher risk due to water harvesting projects. Water projects will certainly have impacts on the intermediate hosts or vectors responsible for the transmission of malaria, schistosomiasis and leishmaniasis.

Access to nutritious food is expected to be reduced; dietary quality and eventually quantity declined, and micronutrient malnutrition (or hidden hunger) increased as indirect impacts of climate change. The expected increase of heat waves due to climate change will cause an increase in a spectrum of disorders such as sunburn and fatigue, heat rash, heat cramps, heat syncope, heat exhaustion, and heat stroke. The most serious of these are heat exhaustion and heat stroke, which can lead to death. In addition, exposure to hot weather may exacerbate existing chronic conditions.

Climate change is expected to alter outdoor workers' exposure to solar ultraviolet radiation (UVR) to cause a range of health impacts. The greatest burdens result from UVR-induced cortical cataracts, cutaneous malignant melanoma, and sunburn. Heat stress due to high temperature and humidity can lead to an increase in deaths or chronic ill health after heat strokes. Both outdoor and indoor workers are at risk of heatstroke. Indoor (chemical industries) workers and farmers may be exposed to higher levels of air pollutants due to increased temperatures.

The health sector can respond to the adverse impacts of climate change with regard to the above-mentioned health issues in a number of ways by preparing for extreme events (e.g. heat waves), surveillance, monitoring, responding to infectious disease, increasing awareness, and by providing extra support for the communities. The adaptation actions/ measures/ interventions for each of these climate-sensitive health issues can be classified into 7 major categories: Regulatory/ legislative; Capacity building; Public education and communication; Surveillance and monitoring; Medical intervention; Infrastructure development; Research and further information.

It was recognized that the lack of detailed time-series data on certain health issues and data on influencing factors other than climate change did not allow for a comprehensive and quantitative assessment of health impacts. Nevertheless, good understanding of current activities and programs, their adequacy with respect to health under climate change scenarios, and a range of adaptation measures, early warning systems, and required supporting research emerged. The outcomes provide a proactive approach to protect the health of communities in Jordan from adverse impacts associated with climate change, and form the basis for future planning and decision-making.

A resilient health sector with adequate infrastructure and widespread access to primary healthcare services is fundamental to reduce the population's vulnerability to the impacts of the changing patterns of diseases due to climate change. Health professionals must be trained to better understand the potential impacts of climate change on health. Improving health systems is a clear "no-regrets" option for adaptation.

One of the most important effects of climate change in Jordan is shortage of water. One of the adaptation measures to cope with water shortage includes reuse of grey or treated wastewater in irrigation of trees or vegetables; this could increase the opportunity for transmission risk of several pathogens through crop contamination with pathogens that could cause outbreaks like Typhoid fever or Hepatitis A if the water is not well treated.

Based on previous studies, Table 4.37 shows the level of impacts expected from climate change in Jordan.

Future health-climatic conditions

Rising temperature due to climate change will increase microorganisms growth; leading to increases in water and food-borne diseases, in contrast flooding which is a result of extreme rainfall through concentrating the annual rainfall in a small interval lead to disruption of water purification and contamination with sewage disposal systems, leading to increase the probability of epidemics due to vector borne "VBDs," water and food-borne diseases.

Increasing temperatures and fluctuations in rainfall can create higher risk areas for VBDs. This will have impacts on the intermediate hosts those responsible for the transmission by emerging new diseases like Hemorrhagic fevers which include West Nile virus fever, Dengue fever or Rift Valley fever, or reemerging diseases that have been controlled from a long time, like Leishmaniasis, Malaria, Schistosomiasis or Typhus. The country could witness appearance of new focus for some diseases which were not known to be endemic to certain regions through changing in the vector and reservoirs home range such as Leishmaniasis in south of Jordan.

Raising the temperature and shifting in the rainy season will lead to decreased availability of safe water, which may lead "as an adaptive measure" to searching for an alternative unsafe source of water to cope with the shortage for human or irrigation uses. This will have impact on water and food-borne diseases by increasing the probability of water-borne epidemics such as, cholera, dysentery, hepatitis E, Giardiasis, bilharzias and poliomyelitis.

Climate change may also influence on the seasonal pattern for respiratory diseases, cardiovascular diseases and mortality. The most visible effect of climate change on respiratory diseases is on chronic respiratory diseases including bronchial asthma and chronic obstructive pulmonary diseases "COPD"; acute infectious respiratory diseases seems that are not going to be directly affected.

Table 4.37: Expected impacts of Climate Change on health in Jordan (compiled from previous studies)

Future climate risks that Jordan could face in the future	Impact description	
	Bio-physical impact	**Health socio-economic impacts**
Drought	• Poor reproduction of livestock • Decrease in crop production	• Malnutrition , skin diseases, high mortality rate. • Food shortages
Dust or sand storms	Air pollution	chronic respiratory diseases including bronchial asthma
Decreasing Precipitation	• Shortage of water, decrease of surface water availability • Use of alternative unsafe source of water (grey or treated wastewater) • Decrease in crop production	• Wash related diseases (Scabies) • Waterborne diseases (Typhoid Fever dysentery, hepatitis A and E, giardiasis, bilharzia) • Conflicts in the use of water
Rising temperature	• Increased microorganisms growth • Extreme heat waves	• food-borne diseases (food poisoning outbreaks) • Increasing diarrhea from bacterial source • Ischemic heart diseases, patients admission
Flooding due to extreme rainfall	• Disruption of water purification (Shortage on drinking water supply) • Contamination with sewage disposal systems • Increasing the birding of diseases vectors	• Epidemics due to water and food-borne diseases • Spread of schistosomiasis • Emerging and remerging of vector borne diseases • Malaria • Hemorrhagic fevers (dengue fever or rift valley)
Shifting in the rainy season	• Decreased availability of safe water, • Decrease in crop production • Changes in the geographical distribution of infectious diseases alternative unsafe source of water	• Malnutrition • Increase in the probability of water-borne epidemics like cholera, dysentery, hepatitis E, appearance of new focuses Cutaneous Leishmaniasis
Increasing humidity	Indoor dampness or Mold	• Dehydration • Heat injury heatstroke • colonize mold and bacteria microscopic airborne particles • Chronic respiratory diseases "COPD"

Assessment of climate sensitivity for health sector

Elderly, children, poor people and mentally or physically disabled people are more sensitive to climate hazards, especially to foodborne and waterborne diseases. (Cutter et al, 2009). The burden of climate change sensitive diseases may be exacerbated for these groups; this exacerbation can be reduced by effectively and timely implementing adaptive interventions.

For respiratory diseases vulnerability is subdivided into innate and acquired. Innate vulnerability may be due to genetic predisposition as broncho-constrictor effects of ozone or to transient incomplete development of normal physiological functions as detoxification processes among young children, acquired susceptibility may be due to socioeconomic status or age. Air pollutants can lead to respiratory diseases such as asthma; children and elderly people are the most vulnerable in Jordan.

Children lungs are not completely developed and they spend more time outdoor, where concentrations of air pollution are generally higher Also children have higher baseline ventilation rates and are more physically active than adults, thus exposing their lungs to more air pollution and higher ventilation rates and mouth-breathing may pull air pollutants deeper into children's lungs.

Immune systems in children are immature; this plays a significant role in asthma. The observed consequences of early life exposure to adverse levels of air pollutants include diminished lung function and increased susceptibility to acute respiratory illness and asthma.

OBSERVED SENSITIVITY TRENDS

Burden of Respiratory Diseases

Globally the disease burden for Acute Respiratory Infections (ARI) is estimated at 94,037,000 DALYs (Disability-Adjusted Life Year) and 3.9 million deaths. ARIs are among the leading causes of death in children under five years but diagnosis and attribution to Climate Change are difficult and uncertain. Another difficulty is that ARIs are often associated with other life-threatening diseases such as measles.

A study done on respiratory infections by the World Health Organization shows that 62% of all deaths are attributable to ARI, but most of these were associated with measles. When measles deaths are excluded the proportion falls to 24%. Better estimates of burden of childhood pneumonia are needed and should be given high priority.

ARI, is considered by health officials to be the leading cause of death among infants in Jordan and the second leading cause of death among children between one and five years of age. According to the DHS97 survey, the percentage of children with ARI was 10.2%, but the current death registry system is not capable of capturing all child deaths due to ARI.

Burden of Diarrheal diseases:

Tens of thousands of Jordanian population, mostly children have at least one diarrhea episode annually, 8% of the total admissions and 15% of children under five years old are due to diarrheal diseases with a mean hospitalization of four days.

The burden includes direct cost of medications, laboratory investigations, absenteeism from school, and parent absenteeism from work.

A study conducted in south Jordan revealed that 40% of admitted children with diarrhea are due to Rotavirus, the annual estimated cost of diarrhea in children less than five years is about $5 million.

The trend of waterborne diseases will rise due to the increase in temperatures, and changing precipitation patterns.

The predicted trend of decreased precipitation, and increased evapotranspiration as a result of temperature increase, combined with other non-climatic stresses, will act substantially to reduce surface water availability leading in shortage of fresh water and searching for alternative sources for irrigation such as treated wastewater reuse as adaptive measures.

The Second National Communication report (2009) stated that "As available freshwater resources become increasingly limited in Jordan, treated wastewater will play an ever more important role in the agriculture sector.

The adopted measures as water conservation, finding additional water sources (desalination and wastewater reuse) and water demand management; will serve as future adaptation measures to climate change, Jordan has defined wastewater reuse as one of the key adaptation measures adopted to alleviate climate change impact on water scarcity.

The agricultural sector accounts for the majority of national water demand, poor water resources lead to searching for new resources of water. Treated wastewater it is an important alternative source, more than 110 MCM of treated wastewater is produced from 24 Treatment Plants, found all over the Kingdom, 72% of it (79.6MCM) is produced by the biggest treatment plant Al-Samra, which is the main supplier for the King Talal Reservoir (KTR).

IMPACTS OF RECENT CLIMATIC SHOCKS

Changing in the pattern of some diseases could be linked with climate change. Here we have two examples to illustrate this.

1- Leishmaniasis

Cutaneous Leishmaniasis CL is an endemic disease in Jordan. The disease is focal in nature and hyper-endemic in the southern part of Jordan Valley, Subeihi and some areas in Karak and Tafileh, recently the trend of CL shows a remarkable increase.

Climate change is one of the multiple potential risks of emergence and spread in new foci. Almost 70% of Jordan's territory constitutes a potential biotope for L. Major transmission and the disease is expected to spread in areas undergoing major population movements and/or environmental changes.

This new foci could be due to climate change as the known reservoir of the disease. The carrier of the disease (Fat Sand Rat) was not known in the southern area, it was believed that the rat immigrated to southern and also northern area as a result of scarcity of a specific plant (Chenopods) that the rat is feeding on.

2- Food borne diseases due to Salmonella and Shigella

In the last decade the number of food poisoning outbreaks significantly increased, it was difficult to attribute the increase to climate change to this as there are many confounders but it is well known that the increase in the temperature increases the microorganism multiplication; the severity of the disease is related to dose response relationship so climate change could indirectly change the pattern of food poisoning.

FUTURE SENSITIVITY

International studies, including reviews by the Intergovernmental Panel on Climate Change, have reported that regions with already scarce water resources, such as the Middle East and North Africa, will suffer even more from water scarcity. Previous regional and local studies of weather records an increase in mean temperatures, and in the magnitude and frequency of extreme temperatures. With decreasing precipitation, the burden of waterborne and food borne diseases is expected to increase (Typhoid Fever, Hepatitis A, Hepatitis E and increasing diarrhea from bacterial source "Salmonella and Shigella").

The burden of non-communicable diseases will also increase; rising temperature and low precipitation will increase the dust and sand storms, this will have effect on respiratory diseases mainly on Bronchial asthma and COPD.

Extreme heat waves will have influence on cardiovascular diseases mainly on ischemic heart diseases, therefore an increase in the number of admitted patients is expecting during the hot season in general and among patients with cardiovascular diseases in particular.

Table 4.38: Climate Sensitivity Scale for the health sector in Jordan

Insignificant	Minor	Moderate	Major	Catastrophic
• Malnutrition	• Wash related diseases	• Chronic respiratory diseases, including bronchial asthma • Ischemic heart diseases, • Patients admission • New focuses Cutaneous Leishmaniasis	• Waterborne diseases like Typhoid Fever dysentery, hepatitis A and E, giardiasis, bilharzia • (Food poisoning outbreaks) • Increasing diarrhea from bacterial source	• Epidemics due to water and food-borne diseases • Remerging malaria • Spread of schistosomiasis • Emerging Hemorrhagic fevers (dengue fever or rift valley • Remerging cholera

The sensitivity of health sector in Jordan is directly or indirectly affected by climate change. The influence scale ranged from insignificant (malnutrition) to catastrophic emerging epidemics (hemorrhagic fevers). Young children and elderly are the most sensitive group mainly to foodborne and waterborne diseases where the admission rate will be increased followed by respiratory diseases where the admission rate and mortality rate will be increased.

ASSESSMENT OF ADAPTIVE CAPACITY ON THE HEALTH SECTOR:

According to their function adaptation measures can be classified into prevention or protection measures; other classifications are:

- Economic capability
- Social capability
- Physical infrastructure and
- Institutional capacity

Also by three main categories:

- Legislative/regulatory, through building guidelines and economic incentives
- Technical/Advisory through Surveillance, supervision, implementing prevention and control programs
- Educational - Cultural and Behavioral through campaign emergency plans, establishing early warning systems

RECOMMENDATIONS FOR ACTION:

- Mitigating the vulnerability due to bronchial asthma (Health output 8) due to decreasing humidity and increasing air pollutants, could be achieved by establishing an early warning system, increasing the Emergency Room capacity and increasing awareness through regular training workshops.
- Mitigating the vulnerability due to food-borne diseases and increasing in the incidence of diarrhea from bacterial source due to temperature increase (Health output 4) could be achieved by establishing an early warning system, enhancing surveillance systems, implementing awareness campaigns and including the climate change concept in the curriculum of schools and universities.
- Mitigating the vulnerability due to increasing the incidence of wash-related diseases and an increase in the incidence of waterborne diseases due to decreasing of precipitation quantity and decreasing amount of fresh water (Health output 3) could be achieved by enhancing the environment, sustaining and improving sanitary conditions andadopting sustainable and green building codes .
- Installation of advanced sanitary systems that separate grey water from black water.
- Mitigating the vulnerability due to the increasing incidence of ischemic heart diseases and patients admission due to increasing of temperature (Health output 5) could be hievedac by increasing the emergency room capacity and increasing awareness through regular training workshops.
- MitThe vulnerability due to increasing the incidence of water and food-borne epidemics diseases as a result of contamination with sewage disposal systems and emerging new vector borne epidemics due to extremes rain fall with flooding health (output 6) could be mitigated by enhancing environment, sustaining and improving sanitary conditions, enhancing intersectorial coordination and regional collaboration.
- The vulnerability due to changes in the geographical distribution of infectious diseases and decreasing in crop production due to shifting in the rainy season and searching for alternative unsafe sources of water (Health output 7) could be mitigated by writing guidelines which include sanitary installation that separate grey water from black water for irrigation to enhance intersectorial coordination.
- The vulnerability due to the increasing of incidence of malnutrition due to increasing drought (health output 1) could be mitigated by strengthening current preventative and curative programs, preparing disaster management plans strengthening surveillance systems, formulation legislations and instruction for reuse of grey water and treated "reclaimed" waste water.
- The vulnerability caused by the increasing prevalence of chronic respiratory diseases including bronchial asthma due to increases of the frequencies of dust or sand storms (Health output 2) could be reduced by allocating economic incentives or sanctions regulating the production of producing pollutant substances, maintaining the green cover and preventing desertification.

Table 4.39: Assessment scale for adaptive capacity in health sector

Climate Change risks	Low	Moderate	High	Very high
Health output 1: Increasing of the incidence of malnutrition due to increasing Drought		Strengthen current preventive and curative programs	Prepare disaster management plans Strengthen Surveillance system.	Legislations and instruction for Reuse of grey water and treated "reclaimed" waste water
Health output 2: Increasing of the prevalence of chronic respiratory diseases including bronchial asthma due to increases of the frequencies of dust or sand storms	Allocate economic incentives or sanctions regarding producing pollutant substances	Maintain the green cover and impedes desertification		
Health output 3: Increasing the incidence of wash-related diseases (Scabies) and increasing the incidence of waterborne diseases like Typhoid Fever dysentery, hepatitis A and E, giardiasis and bilharzia due to decreasing precipitation and decreasing amount of fresh water		Environmental enhancing sustaining and improving sanitary conditions	Adopt healthy buildings Houses building guidelines which include sanitary installation that separate grey water from black water for irrigation	
Health output 4: Increasing the incidence of food-borne diseases (food poisoning outbreaks) And increasing in the incidence of diarrhea from bacterial source due to temperature increase	Adopt policies that have effect in reducing deforestation and encourage using of solar cells application	Establishment early warning system	Surveillance system	Awareness campaign Including the climate change concept in the curriculum of schools and universities
Health output 5: Increasing the incidence of ischemic heart diseases, patients admission due to temperature increase.		Capacity building and increasing awareness through regular training workshops	Increasing the Emergency Room capacity	
Health output 6: Increasing the incidence of epidemics due to water and food-borne diseases as a result of contamination with sewage disposal systems Increasing the emerging new vector borne epidemics like Hemorrhagic fevers (dengue fever or rift valley due to extremes rain fall with flooding.		Environmental enhancing sustaining and improving sanitary conditions		Enhance Inter-sectorial coordination and regional collaboration
Health output 7: changes the geographical distribution of infectious diseases and decreasing in crop production due to shifting in the rainy season and searching for alternative unsafe source of water		Building guidelines which include sanitary installation that separate grey water from black water for irrigation		Enhance Inter-sectorial coordination enhance regional collaboration
Health output 8: : Increasing the prevalence of bronchial asthma due to decreasing Humidity and increasing air pollutions,		Establishment early warning system Increasing the Emergency Room capacity		Capacity building and increasing awareness through regular training workshops

Table 4.40: Vulnerability assessment matrix for health sector in Jordan

Climate change hazards	Resulting risks		Exposure level	Sensitivity level	Total impact level	Adaptive capacity level	Overall Vulnerability assessment
	Bio-physical impact	Health socio-economic					
Drought	Causes poor reproduction of livestock Decrease in crop production	Malnutrition	3.7	3.5	3.6	4	Moderate
Dust and sand storms	Air pollution	Chronic respiratory diseases including bronchial asthma	2.7	3	2.85	3	Moderate
Decreasing precipitation	Shortage of water, decrease surface water availability Use of alternative unsafe source of water (grey or treated wastewater)	Wash related diseases (Scabies) Waterborne diseases (Typhoid Fever dysentery, hepatitis A and E, giardiasis, bilharzia)	4	4	4	4	Moderate
Rising temperature	Increase in microorganisms growth Extreme heat waves	Food-borne diseases (food poisoning outbreaks) Increasing diarrhea from bacterial source, ischemic heart diseases, patients admission	3.7	4.5	4.1	4	High
Heavy rain	Disruption of water purification Contamination with sewage disposal systems Birding of diseases vectors	Epidemics due to water and food-borne diseases Spread of schistosomiasis Emerging and remerging of vector borne diseases Malaria Hemorrhagic fevers (dengue fever or rift valley	2.2	3	2.6	4	Moderate
Shifting in the rainy season	Decreased availability of safe water, Decrease in crop production Change the geographical distribution of infectious diseases Alternative unsafe source of water	Malnutrition Increasing the probability of water-borne epidemics like cholera, dysentery, hepatitis E Appearance of new focuses Cutaneous Leishmaniasis	3.7	2.5	3.1	4	Moderate
Decreasing humidity	Air pollution, dryness	Chronic respiratory diseases	1.7	3.5	2.6	5	Low

PROPOSED ADAPTATION STRATEGIES AND MEASURES:

The following table ranks and prioritizes adaptation measures by the potential of health sector capacity to cope with climate change effects.

Table 4.41: Proposed Adaptation Measures in health sector

Climate change hazards	Resulting impact	E. Overall vulnerability assessment	Adaptation measures	Priority
Increasing temperature	Increasing the incidence of food-borne diseases (food poisoning outbreaks)	High	• Establishment early warning system • Including the climate change concept in the curriculum of schools and universities • Developing water safety plan, awareness camping • Enhancing surveillance system • Adopting policies that have effect in reducing of CO_2	1
Decreasing Precipitation quantity	Increasing incidence of diarrhea from bacterial sources	Moderate	• Enhancing Environmental sanitation, • Sustaining and improving sanitary conditions, • Adopt healthy buildings, through formulation building guidelines which include instructions for advanced sanitary installation that separate grey water from black water.	3
Decreasing amount of fresh water	Increasing the incidence of Wash related diseases (Scabies) and increasing the incidence of Waterborne diseases like Typhoid Fever dysentery, hepatitis A and E, giardiasis, bilharzia	Moderate	• Increasing the Emergency Room capacity • Increasing awareness through regular training workshops • Increasing the green cover and combat desertification	2
Increasing frequencies of dust or sand storms	Increasing the prevalence of chronic respiratory diseases including bronchial asthma	Moderate	• Enhancing Environmental sanitation • Sustaining and improving sanitary conditions, • Enhancing intersectorial coordination and regional collaboration	2

4.9 INTEGRATED VULNERABILITY & ADAPTATION ASSESSMENT OF LOCAL COMMUNITY

Poverty in Jordan is concentrated in rural areas where inefficient agricultural practices use about 60% of the nation's water while generating less about 4% of the countries' GDP (2011). The study went on to give a brief, quantitative and qualitative description of the socioeconomic impacts of climate change on water and agriculture sectors due to their importance in influencing socioeconomic conditions of rural communities. Indeed, the more a community depends on water and agricultural resources, and the worse the condition of their resources, the more sensitive the community will be. It is worth mention that although the contribution of agriculture to the GDP in relative terms has already declined sharply from 1950s to 2011, its contribution in absolute terms has increased (e.g. from 32 million JD in 1964 to 560 JD million in 2010 but with climate change impact the decline will get worse.

The study tends to provide an understanding of socioeconomic adaptive capacity as a crucial step in avoiding the negative impacts of development activities that may sometimes worsen impacts on those who are most vulnerable (''Maladaptation[6]''). The study concluded with a set of prioritization measures that highlighted the close interconnectedness between water and agriculture and local capacities, and the potential for synergistic benefits.

SOCIO -ECONOMIC FEATURES INFLUENCING THE AGRICULTURE SECTOR

Negative impacts on the environment are caused by changes in: flora, fauna, soil, air, water, climate, landscape and human health and safety, or the interaction among these factors. Any alteration in normal circumstances will affect the socioeconomic conditions of the region. In regions suffering from political instability and tensions, climate change is likely to act as a "threat multiplier"—aggravating water scarcity and tensions within and between the nations sharing hydrological resources, geography and political boundaries. For example the Syrian, Iraqi refugees will increase the stress on sustainable use of natural resources and lowering the government ability to improve life standards of certain sectors of the population.

Climatic factors have one of the most important role in the variation of both, water resources and water demand. In spite of the fact that most of agricultural areas in Jordan are rainfed, this sector utilizes about two-third of the available water resources. Water resources are vulnerable to climate change due mainly to changes in precipitation and its distribution both spatially and temporally. The scarcity of water will be more severe under future climatic conditions; this means that adaptation to climate change is a necessity under these conditions. As for the livestock production, its occupies more than 50% of agricultural activities and production in Jordan, the demand for livestock products is expected to increase in the first half of this century, due to the population growth and the rising level of living. The population of Jordan is about 6.2 million at present (Dos 2011) and is expected to double by mid-century especially given the political situation in the neighboring countries.

Agriculture is one of the most sensitive and vulnerable sectors to climate change. Higher temperatures and lower precipitation are expected as a result of climate change. Furthermore, climatic changes may have a high impact on irrigation requirements and in the availability of water resources for irrigation.

Growing populations, increasing urbanization, increasing economic development, and rising standards of living all ultimately have a variety of environmental impacts on the agricultural sector. Such impacts include loss of productive land, particularly in urban areas, degradation of water resources, deforestation and desertification.

The Jordanian labor force was about 1,235,000 in 2010, however, in the sector of agriculture, it has decreased from 32,900 to 25,000 in the same year. This indicates that the contribution of the agricultural sector to employing manpower declined from 3.1% in 2006 to only 2% in 2010.

A gender-based employment gap exists in Jordan as male workers exceed 1 million, compared to little over 200,000 female workers (DOS 2011). Over 90% of pastoralist and agricultural households in Jordan are supported by the male head of household, while women have unaccounted roles through essential contribution in agriculture, animal husbandry and rural enterprises. In 2010, the number of women working as hired agriculture labor was very low compared to the total paid one, as 89.4% were male

6 The IPCC Fourth Assessment Report did not define maladaptation, although the earlier Third Assessment report did, defining it as 'an adaptation that does not succeed in reducing vulnerability but increases it instead' (IPCC, 2001, p. 990). The UNFCCC does not define maladaptation.

and 10.6% female. The composition of its force in the agricultural census of 2007 shows the predominant form of agricultural was family labor, with 77% of the total in rain-fed agriculture being unpaid. While children under 15 years also play a minor role in family farm labor.

THREATS TO SOCIO- ECONOMIC AND GENDER SITUATION WHICH MIGHT LIMIT THE ADAPTIVE CAPACITY TO COPE WITH CLIMATE CHANGE

The potential impact is any effect caused by a proposed activity on the environment including flora, fauna, soil, air, water, climate, landscape and human health and safety, or the interaction among these factors. It includes effects on socioeconomic conditions resulting from alterations to those factors (IPCC, 2007a).

In regions suffering from political instability and tensions, climate change is likely to act as a "threat multiplier"—aggravating water scarcity and tensions within and between the nations sharing hydrological resources, geography and political boundaries. The Syrian, Iraqi refugees will increase the stress on Jordanian government on sustainable use of natural resources and ability to improve life standards.

A study conducted in 2011 in the context of the UN/FAO activities for helping the developing countries towards the achievement of Millennium Development Goals (MDGs) shows for Jordan that Climate change effects impose significant additional stress on ecological and socioeconomic systems. Agriculture, water resources, forestry and ecosystem, are key elements of human development and well being that are all sensitive to climate change. The impact of climate change on these aspects is not uniform.

In summary, the socioeconomic impacts of climate change in Jordan are related to water and agriculture as the most sensitive resource to climate change (See section 4.4):

- Employment in agriculture and forest will increase the demand for certain food and drinks due to high temperature while the agricultural productivity will decrease due to drought.
- This will impact the stability of income from agriculture and leading to income insecurity for full time workers or who depend on agriculture as a main income resource.
- Families who depend on biodiversity species in their food or livelihoods by collecting or marketing medical herbs , will be impacted severely by climate change

SELECTED STUDY AREA

The selected studied communities (Subeihi, Seehan, Bayoudah and Al-Irmemeen) are located in Balqa governorate in the northwestern part of Jordan. It has an area of about 1,119 square kilometers, constituting 1.2% of the total area of the country. Its population is around 428,000 inhabitants (Dos 2012) with density of 321.3 inhabitants per square kilometer. It is divided into uplands and south Jordan valley areas.

The Balqa governorate is distinguished for diversity in its climate and terrain: The Jordan Valley area goes 224 meters below sea level while the mountains and highlands rise to 1,130 meters above sea level. Similarly, the highlands climate is rainy and cold in winter and moderate in summer with annual precipitation rate of 600 millimeters while the lowlands (Jordan Valley) enjoy moderate temperatures in winter and high temperatures in summer with annual precipitation rate of 150–200 millimeters, which gives the governorate a relative agricultural advantage that helps the diversification of cultivated crops around the year.

The highland is considered as a rain-fed area, uses springs for irrigation while the lowlands used the treatment of wastewater effluents as a local source utilized mainly for agricultural purposes. The domestic water network in the governorate covers 98%, and sewage network covers 60%.

1. SUBEIHI COMMUNITY:

The area is considered a resort because of its moderate climate. It is about 500-600 meters above sea level. Average rainfall is 350 millimeters. The soil is sandy-clay making it suitable for farming; olive and almonds that are plentiful as well as vegetable growing.

Most of the Subeihi community incomes depend on farming and government employees' salaries, retirement salaries, farm income comes third so far importance of sources of incomes. Most families own their homes, with 97% homeownership (DOS, 2010). Sources of drinking water come from collecting wells (55.5%) and pipe-water 50.1 % according to the department of statistics (2010).

The area is served by a good road network and drinking water, telephones and communications, comprehensive health centers that provides essential health services also there is in the village government departments and public utilities. As for the educational level and according to the DOS 2010 for Al Arda district, the secondary education among inhabitants is around 19.1%, diploma is 10.4%, BSc holders compose 7.5% and MSc is around 3.8%.

The area is characterized by being part of the Jordan valley. Rainwater is considered the main source for agriculture, in addition to the spring used for irrigation. The main source of water is from Jordan Water Authority (WAJ). Since the area considered as rain-fed agriculture, some water is harvested for farming purposes in order to exploit rainfalls to irrigate the farms, one of the harvesting methods is the collection holes on the farms, and the preparation of the land by plowing, digging of holes and the collection of water for supplementary irrigation purposes, and the construction of stone walls to prevent soil erosions hence the better usage of water from rainfall.

2. SEEHAN COMMUNITY

One Khalid bin Al waleed area is 30 kilometers away from Amman, and it is located in Al-arda district. The total area of the Khalid Bin Al waleed is 30 square kilometers, which includes different areas of topography such as plain lawns, valleys, mountainous areas and plain areas where there were many ways of agriculture depends upon its topography. In addition to that, the land is divided into organization areas, residential areas and agricultural areas.

The village is considered as one of the most beautiful and convenient atmospheres; it has mild winters and warm summers, also green scenic abound where olive and oak trees grows more frequently over large areas on a fresh air free of pollution. Seehan community depends on agricultural cultivation practices.

3. BAYOUDAH COMMUNITY

The Bayoudah community is located at the center of Al-Arda district and 16 kilometers from the city center of Balqa governorate. The village is considered to be warm in the summer and cold in the winter with annual rainfall estimated at 300 millimeters. Bayoudah has its own artesian well 550 meters deep, which serves all Bayoudah's villages and is managed by the Jordan Water Authority (WAJ). The Bayoudah's community used to practice rainfall harvesting, they constructed their own wells near their houses and used the water for drinking and local purposes in order to cope with the water shortage.

The village is served by three secondary schools for girls and boys, Center for Childhood, Motherhood and Health Center, five mosques, municipal building kindergarten, cultural forum, and shops, as well as good primary and secondary transportation systems.

Farming is the main activity especially olives trees which cover the largest areas. While in the past it was popular to farm vegetables, fruits and grains in addition to livestock breeding which formed the main income for the farmers. But these conditions were changed due to climate change, lack of water resources and drought seasons as per local community judgment and community members become more dependent on governmental jobs and their own free businesses.

4. AL- IRMEMEEN COMMUNITY

Al-Irmeen is located in the Zai district with 15 kilometers from the city center of Salt city - Balqa governorate. Al- Irmemeen is considered a rift Jordan valley and one of the important agricultural areas belonging to Balqa Governorate due to its weather conditions which are cold in the winter and moderate temperatures in the summer. The annual rainfall is estimated to be 350 millimeters. Farmers depend on rainfall in addition to the springs as a source of irrigation for crops and watering livestock.

The socio- economic study shows that the main source of water in the community area is two main natural springs, the first one called Al- Saygh spring it covers 300 dunums[7] and the other one called Alrahib spring, and it covers around 80 dunums with irrigation, in addition to rainfall.

ASSESSMENT OF SOCIO ECONOMIC AND GENDER SENSITIVITY

Based on the data analysis from the field survey, the potential sensitivity assessment calculated as a combination of income analysis from resources that are sensitive to climate change and resources that are non-sensitive to climate change, even if there is indirect impact of the climate change on the non-sensitive resources. The table 4.42 below shows the analysis for the study sites.

7 one Dunum = 1,000 Square Meters

Different participatory method of assessing the vulnerability of a community's agricultural sector to the hazards of climate change based on its exposure to climate hazards, sensitivity to the damages that the hazard may bring, and the community's capacity to cope with the adversities. The study builds on VAST-Agro (Vulnerability Assessment for the Agriculture Sector)[8].

The study used the income assessment as a main critical indicator to the sensitivity of local community to the climate change. The importance of these indicators are linked to the impacts of climate change on the yield agricultural productivity at the study site especially that 54.47% of the community income based on agriculture which was considered the most sensitive sector to climate change.

Table 4.42: Communities income diversification as per sensitive resources and non-sensitive resources to climate change

Community	Non Sensitive resources						Sensitive resources	
	Governmental Jobs	Private Sector	Handicraft job	Renting out houses and Shops	Retirement	Other Jobs	Plant Cultivating	Livestock Production
Bayoudah	30.19%	11.60%	0.00%	0.00%	26.62%	10.23%	15.49%	5.86%
Al -Irmemeen	14.29%	0.00%	0.46%	5.86%	10.42%	0.00%	41.41%	27.56%
Seehan	18.32%	2.86%	0.00%	2.72%	2.23%	2.73%	44.26%	26.88%
Subeihi	5.84%	16.20%	2.46%	6.81%	6.68%	11.36%	32.07%	18.58%
Grand Total	**16.63%**	**7.55%**	**0.78%**	**4.06%**	**11.35%**	**5.94%**	**33.63%**	**20.06%**
	45.53%						**54.47%**	

To incorporate the socioeconomic system and ecosystem's ability in adapting to climate change hazards, a scoring was undertaken to assess the level of sensitivity which helped to analyze the real impact for each sector, taking into account the combination of biophysical sensitivity and socio-economic sensitivity. As shown in table 4.43 below, the results show that socioeconomic potential sensitivity is high (score 4).

This is determined by the percent of income dependent on sensitive resources (agriculture), and the diversification in income from other resources. However; since the loss in income linked to the poverty line in case of 10% decrease on the yield productivity as a result of climate change on agricultural resources. (See agricultural sector for more information). Experts judge that this may imply a loss between a 10% to 20% loss in income.

The study indicated also that the average Annual Current Income of Household by Source, from all sources of income was reported at 7135.1 JD at Balqa governorate with an average monthly household income of 594.5917 JD. However, as it was calculated at 1384.10 JD per month from the results of our survey analysis.

Table 4.43: Socio Economic Potential Sensitivity Scoring

Community	A. % of household engaging in other non sensitive income resources	B. % of household engaging in Agriculture and other sensitive income resources	A*B/100% SE potential sensitivity
Bayoudah	68.41%	21.35%	14.61%
Al - Irmemeen	31.03%	68.97%	21.40%
Seehan	26.13%	71.14%	18.59%
Subeihi	37.99%	50.65%	19.24%
Total	**73.84% = High (Score 4)**		

8 Asia-Pacific Network for Global Change Research (APN). (2013)

ASSESSMENT OF CURRENT ADAPTIVE CAPACITY OF THE SOCIO ECONOMIC AND GENDER SECTOR FROM THE STUDY AREA

There is a general consensus within the social science community about some of the major factors that influence socioeconomic vulnerability. These include: lack of access to resources (including information, local knowledge, and technology); limited access to political power and representation; social capital, including social networks and connections; beliefs and customs; building stock and age; frail and physically limited individuals; and type and density of infrastructure and lifelines (Cutter, 2001a; Tierney, Lindell, and Perry, 2001; Putnam, 2000).

For these purposes the four communities' representatives drew their village social -environmental map showing the types and location of natural resources that they depend on, community infrastructure and services, areas where key social and economic activities take place, and areas impacted or threatened by climate hazards. A rainy calendar exercise was used to understand the potential of social and natural impacts from changes in seasonal events, and how communities used to deal with them, in addition to raise awareness and shared the same position on climatic history.

These elements provide a solid foundation on which to analyze the situation in the selected communities, taking into account the gender disaggregated data and focusing on the circumstances facing communities and their prospects for adaptation measures in relation to different sectors as well as vulnerable groups among communities. The discussion of focus groups that follows the collecting of samples questionnaire builds on the adaptive capacities factors as indicated in the table 4.44 below using the Community Based Risk Screening Tool for Adaptation and Livelihood (CRiSTAL).

Table 4.44: Adaptive Capacity Indicators used by CRiSTAL tool

ADAPTIVE CAPACITY FACTORS	Low 1	Slight 2	Moderate 3	Good 4
AWARENESS OF HOUSEHOLDS TO CLIMATE CHANGE	Awareness among local community regarding to their natural resource situation and CC impact	Local community is aware regarding their natural resources with capacities to identify their problems related to CC	People are aware of problem & have the ability to rank priorities	Local community has capacity & skills to manage their natural land resources with different impact of climate change
USE LOCAL KNOWLEDGE AND ABILITY TO MAKE NECESSARY CHANGES TO COPE WITH CC	Dominant group have access according to the community decision making	Rights & roles of different community groups are addressed	Local community accountability toward respect the right for the social group "women group, poor, ----".	Group accountability to government authorities for respecting their rights especially for women toward their natural land resources
COMMUNITY LEADERSHIP	Address individual leaders among local community	Identify potential groups to promote a collective work "voluntary work"	Organized groups can promote voluntary work & advocate rights	Responsible leadership activities accepted from local community
EQUITABLE ACCESS TO RESOURCE	Organized group includes dominant sector only	Identify various social groups in forming organized groups especially for women and youth	Consider social diversity within organized group "women group, poor, ----"	Organized group have the ability & capability claim benefits for different groups mainly women and youth
CURRENT LIVELIHOOD AND INCOME DIVERSITY OF HOUSEHOLD	Depends on one major resource	Depends on different resources to improve livelihoods but not sensitive to climate change	Depends on different resources to improve livelihoods but sensitive to climate change	Depends on different resources to improve livelihoods and both sensitive & non sensitive to climate change

ASSESSMENT OF CURRENT ADAPTIVE CAPACITY

Semi structured interviews[9] are mostly discussion sessions with targeted local communities that were held informally through a conversational way, structured by using a list of key issues or themes and some questions that prepare in advance. In this case, the themes were accompanying according to the results of the CRiSTAL focus groups. As a result of these meetings, the experts scored the community adaptive capacity as shown in table 4.45 below.

Table 4.45: Adaptive capacity score per each community

Village	AWARENESS OF HOUSEHOLDS TO CLIMATE CHANGE	USE LOCAL KNOWLEDGE AND ABILITY TO MAKE NECESSARY CHANGES TO COPE WITH CC	COMMUNITY LEADERSHIP (ABILITY TO RECOGNIZE)	EQUITABLE ACCESS TO RESOURCE	DIVERSITY IN INCOME	ADAPTIVE CAPACITY FACTOR
Subeihi	2	1	2	3	3	**2.2**
Seehan	3	3	3	2	2	**2.6**
Bayoudah	3	2	3	3	4	3
Al-Irmemeen	3	3	3	3	2	**2.8**

FUTURE IMPACTS AND ADAPTIVE CAPACITY

The assessment of the possible future adaptive capacity scenarios builds into two factors: income diversification and local knowledge on agricultural experiences.

The scenario expects that, the diversification in income with emphasis on knowledge transfer from elder groups to younger, the more adaptive capacity to face the impacts of climate change in different socioeconomic contexts. Moreover, the National Poverty Reduction Strategy in Jordan 2002 indicated that households exit poverty when their incomes rise sufficiently to cover their expenditures and allow them to either save or invest in a sustained manner. On the income side, this happens either through wage increases, employment in higher-wage sectors, or through diversification in income (rents or profits generated through their own investments). Incomes that rise above the poverty line nominally shift the household from a poor to non-poor category, but the household remains vulnerable to external shocks or income fluctuations that can swing the household back into poverty unless the household has a buffer either in terms of own-savings or a social security system that allows it to withstand short-term financial difficulties. The National Climate Change Policy 2013 provides special attention to the importance of the climate change impacts on socioeconomic like poverty, employment, social welfare and gender, and the new Poverty Reduction Strategy integrates climate change vulnerability in the proposed plans and measures in order to combat poverty.

Results shows that based on the proposed factors above:

- Communities with less agricultural experiences such as Subeihi and Bayoudah will suffer severe effects due to climate change and it is expected that they will lose 10% or 20% of their income due to the decrease of their crop yields' productivity.
- It is well noticed that farmers above 60 years are less affected than others by external factors. This explains the importance of local knowledge and experience in agricultural practices.
- Seehan community will suffer an insignificant impact as the community scored the highest level in agricultural experiences.
- Because of diversification of their income sources, Seehan will not suffer major impacts on their livelihoods.
- Al-Irmemeen was an exception among the other communities where younger farmers (between 20-

9 Semi-structured interview is a qualitative research method and open questions.

40 years) have reported higher income level from agriculture compared with older age groups. The reason behind this is that the dominant production system is irrigated agriculture and farmers used modern technology and protected agriculture.

Adaptation Measures

The ability of socioeconomic contexts to adapt to climate change is determined by the strength of the economy, the quality and coverage of health services, and the integrity of the environment. The aim of adaptation measures stated below is to support decision makers in using positive opportunities to manage climate risk for social groups bringing up to an acceptable level.

For adaptation measures to be effective and sustainable, it is very important to consider the dimension of equity in the planning and implementation of activities particularly for women. Equal involvement of men and women in adaptation planning is important not only to ensure that the measures developed are actually beneficial for those who are supposed to implement them, but also to ensure that all relevant knowledge, i.e. knowledge from men and women, is integrated into planning (Osman-Elasha, 2009).

1. Building on social capital and using of farmers indigenous knowledge and tradition to adapt to climate change:

Local knowledge within a community may be highly differentiated between men and women and among other groups such as; elders, religious leaders and individuals with different roles within the community. People need to feel that they are competent and have the right skills (knowledge, technology) and means to carry out activities leading to sustainable management of natural resources. Under changing socioeconomic and environmental conditions indigenous knowledge might become less appropriate and needs to be adapted through participatory research and appropriate training to document their knowledge and encouraging its use.

2. Awareness raising:

Programs used local leaders to raise awareness related to climate change impacts and for improving women rights. Women can act as agents of change at different levels of the adaptation process. They often possess a deep understanding of their immediate environment, their experience in managing natural resources (water, forests, biodiversity and soil) and their involvement in climate-sensitive work, such as in the areas of farming, forestry and make them valuable as adaptation decision makers and as key adaptation implementers.

3. Building public-private partnerships to improve the income diversification:

Enhancing the cooperation between public and private sectors may have several potential advantages over traditional public sectors in providing jobs and creating income generating opportunities and sources that have indirect impact on climate change.

4. Active involvement of local communities by creating cooperation networks and strengthening local associations and societies with due consideration given to gender aspects:

Support the development of local conventions, natural resource agreements and other mechanisms to share in solving related problems in a healthy and economically efficient way. E.g. food production at the family level, and improving local control over ecosystem services in order to increase the resilience capacity for locals to cope with climate change impacts.

5. Awareness campaigns to accompany the implementation of adaptation and mitigation measures to target all relevant stakeholders, including communities, decision-makers and the private sector:

Conduct awareness campaigns for communities to raise awareness on climate-related risks to their environment and livelihoods, and also on the possible adaptation responses. This could be conducted through effective communication from scientists, experts and other CSOs.

Table 4.46: Possible impacts of losing in income and scoring the adaptation measures based on community and experts judgment

Climate change impacts	Resulting impacts Based on analysis and community consultation	Adaptation measures	Priority
Loss of income due to the high dependence on resources sensitive to climate change	• Livelihoods stressed • Stress in increasing households below poverty line • Increased probability for the food insecurity • Shifting from agricultural work to non- sensitive financial resources • Increase in illiteracy rate especially women • Excessive consumption of natural resources -such as wooding • Increase in possibility of violence to women especially in land tenure • Decrease in the ability of women to improve agricultural productivity as income resources • Increase in women's work load, leaving less time to participate in awareness campaigns, trainings, developmental programs that address women's rights • Due to women's traditional role of taking care of family health, their workload will increase as well as probability of catching infections	Building on social capital	3
		Use of farmers' indigenous knowledge and tradition to adapt to climate change	3
		Identify and design effective, context - specific strategies to promote gender equality	2
		Building Public- private partnership to improve the income diversification	2
		Awareness raising programs and used of local leaders in related to climate change impacts and on enhancing women rights	3
		Active involvement of local communities by creating cooperation networks and strengthening of local associations and societies with due consideration given to gender aspects.	3
		Creation of income generating opportunities	3
		Awareness campaigns to accompany the implementation of adaptation and mitigation measures to target all relevant stakeholders, including communities, decision-makers and the private sector.	3

RECOMMENDATIONS FOR ACTION

- It is a key message of the present work that building knowledge on the expected impacts of climate change at the household level has to be systematically promoted. Such options include both practices that promote a more efficient use of available resources and inputs (i.e. climate-smart agriculture practices) along with the promotion of developmental objectives (e.g. education, awareness and local knowledge).
- It is clear that Jordan has taken large steps during the last years, and has come a long way regarding economic and social policies and legislations that contributed to the improvement of women's life in Jordan in all fields, especially to ones relating to education.
- Jordan Climate Change Strategy 2013 expressed that the socioeconomic impacts, including cross-cutting issues, are best addressed by sectoral climate change strategies and action plans. However further assessments are required, including detailed social surveying at individual level, baseline socioeconomic scenarios, detailed statistical analysis, downscaling scenarios based on population and gross domestic product (GDP), participatory rural appraisals and participatory mapping and sustainable development indicators.
- Increase women's skill-development and capacity building opportunities through training in community and political participation skills and link them to general literacy and education initiatives
- Take measures to increase the labor productivity of rural women through improved access to training, extension services and technology.
- National governments must prioritize inclusive economic growth that, rather than excluding the rural poor, improves their well-being and reduces rural poverty.
- Mainstream the role of media in climate change and support NGOs and community based organizations (CBOs) are well placed to spearhead awareness raising efforts in different community segments, and in their climate change media-targeting activities.
- A pilot study on vulnerability to food security due to climate change using a multilevel approach, including an analytical and relatively comprehensive chain of logical events regarding the impacts of climate change for farm households is needed. This approach is needed to address climate change constraints on household food security and to promote climate-smart adaptation practices and to integrate climate change-relevant policies effectively into agriculture sector strategies. Adaptation strategies identified at household level need to be based on developing income opportunities that are less dependent on natural resources.
- National level strategies need to be multi-sectoral including developments in education, health, transport, investment climate and particularly empowerment of rural communities.

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MEANS OF IMPLEMENTATION 5

This chapter aims to provide a description of the current and proposed enabling environment for the implementation of the TNC and other national activities related to UNFCCC framework and climate change in general, as well as how Jordan is integrating climate change and national communications findings in sustainable development programmes. It will also provide some recommendations at the national level for enhancing the legal, institutional and technical quality of climate change governance system to maximize the capacity of Jordan to address the challenges of climate change, actively engage in global efforts to combat climate change and benefit from the opportunities for sustainable development present in the UNFCCC framework. It will also address the issue of using the results of the NC report in order to assess new projects and to implement new climate change/green development national policies.

5.1 TECHNICAL GAPS AND CONSTRAINTS FOR PREPARING NCS

The process of the preparation of the TNC has revealed some gaps and constraints that should be addressed adequately in order to ensure the successful implementation of future national communications and other reporting systems including the Biennial Update Reports (BURs). The main gaps and constraints are discussed below.

5.1.1 GHG Inventory

The process of the GHG inventory is a "project based" activity that is conducted once the NC is required. These results were achieved even though they lacked a sustainable system to collect, process, archive, monitor and report on the sources of GHG emissions and their sinks.

The nature of the activity data required for the GHG inventory is complex and it is not categorized under "pollutants" identified in national standards and regulations. The greenhouse gases are not required to be monitored by the Ministry of Environment (MoEnv). With the absence of a national system to guarantee and facilitate the production, exchange and analysis of such data any GHG inventory will take a lot of time and effort to be implemented. Moreover, in order to comply with the current developments within the UNFCCC negotiations, including the proposed Biennial Update Reports (BURs) to be provided by all parties to the UNFCCC each two years, the GHG inventory process should be institutionalized and well documented.

In general, institutional structures under existing national process are mostly built around individual arrangements and exchanges between the MoEnv and stakeholders generating GHG emissions. While data availability is the backbone of every inventory, modalities for data accessing are mostly based on informal arrangements, with very little reporting obligations or methodologies by key stakeholders who generate the data. Improving data access and quality, as well as the technical quality of national GHG inventories can be very beneficial since reporting major sources and sinks of GHGs with high confidence is important for identifying not only the most appropriate mitigation measures but also for determining appropriate national mitigation strategies and also for developing low carbon development policies. These should also be conducive to setting up a legal structure that will ensure the continuity of the NC process and its outcomes.

Moreover, to ensure the quality of the GHG inventory data reported in the NCs it is very important to carry out specific calculations and process the raw primary data generated by the activity sources. This is why certain capacities should be developed within the MoEnv and other key stakeholders to be able to process the data into the required reporting format using Emission factors and other working sheets from the IPCC and not only documenting initial data.

Working protocols and guidelines are developed within the GHG inventory process including the quality assurance/quality control plan that provides a detailed description of all technical steps required for data collection and processing. The possibility of developing a legal tool for reporting of GHG emissions from key sources to the MoEnv should be also explored.

The only way to address this gap in information management is by creating a sustainable system for the collection and processing of GHG inventory data on a sustainable level. This system should go beyond personal arrangements and relationships, to one that is grounded in statutory requirements, memoranda of understanding

(MoU), institutional mandates and possible legal structures. Data quality and format for the new national system should be designed such that the GHG inventory will be perceived more as a national activity with benefits for national development.

The GHG inventory system shall be modeled as Single National Entity (SNE) with the Ministry of Environment (MoEnv) being the designated national GHG inventory entity. The planning, preparation and compilation of sector inventories will be led by MoEnv and involve a network of stakeholders who generate activity data in the five main sectors of GHG inventory (energy, industry, transport, agriculture, landuse and waste).

The development of a sustainable system for GHG inventory should be the main ingredient for the eventual development of a national Monitoring, Reporting and Verification (MRV) system that adheres to international guidelines.

The TNC suggests to following steps to create, institutionalize and sustain a national GHG inventory system:

1. Create a single entity at the newly-established climate change directorate in the Ministry of Environment to act as a hub to collect, process, archive and report GHG inventories.
2. Conduct an intensive training program on the development of a GHG inventory including detailed use of IPCC guidelines and data sheets and calculations. This will widen the base of national experts.
3. Prepare Jordan's First Biennial Update Report (FBUR).
4. Identify all sources of data, their measurement units and sources that are required by an GHG inventory using 2006 IPCC guidelines and arrange for a sustainable flow of information from source to MoEnv.
5. Develop a legal structure that "requires" activity data producers to submit information to the MoEnv.
6. Exploring the potential to develop national emission factors for major GHG sources like energy, waste and industrial processes based on available capacities.

5.1.2 GHG Mitigation Assessment

Data required for mitigation assessment is more readily available than the one required for GHG inventory and vulnerability and adaptation. Most of the initial data are derived from the GHG inventory and baseline sectoral statistics in energy, transport, waste, agriculture and other sectors that are collected by public planning and documentation processes.

The GHG Mitigation analysis however, suffers from influential gaps in data collection and processing. As such data gaps can be fixed and improved, other external factors provide negative impacts on the quality and reliance on long term planning. The following are the main gaps in the mitigation analysis:

1. Limited experience in mitigation model analysis. Only model used is ENPEP and experience is not spread to many stakeholders and professionals. There is a need to increase national capacities in more recently developed models like LEAP.
2. Influence of external factors such as energy supply and security, waste management policies, lack of a suitable infrastructure for public transport and reduced agricultural productivity which all contribute to increasing the levels of uncertainty in future planning.
3. Fluctuating policies in renewable energy development and energy efficiency plans which reduce investment opportunities and blur the distinction between baseline and mitigation scenarios in the assessment.
4. Unclear linkages between sustainable energy plans and projects in Jordan with mitigation and low carbon options. Renewable energy and energy efficiency programmes in Jordan are based on developmental objectives and priorities and should be linked with mitigation at levels of planning and execution. Moreover, Climate Change mitigation should be mainstreamed in other mitigation sectors such as transport, waste management and industrial processes.
5. The "complex" and "uncertain" landscape of mitigation actions and initiatives that are being developed and implemented within the UNFCCC. The various potentials and features of CDM, NAMAs, LEDs, PMRs, INDCs and other mitigation tools make it difficult for a holistic planning perspective in climate change mitigation. The TNC mitigation chapter should be used as a main reference for developing future mitigation project concepts under any of the initiatives mentioned above.

The TNC suggests the following steps to be undertaken for addressing gaps in mitigation assessment:

1. Expand the expertise base and the knowledge capacity for conducting mitigation analysis through an extensive training program on LEAP for energy

and other tools or methodologies targeting major stakeholders in Jordan.
2. Reduce the uncertainty in mitigation planning through more stable policies and plans especially in the energy sector.
3. Engaging globally and regionally to have a more concerted and effective mitigation path for developing countries where resources can be allocated with the highest efficiency and direct outcome.

5.1.3 Vulnerability & Adaptation

Vulnerability and Adaptation assessments are the most complex in a National Communication report as they entail a detailed analysis of the previous climate records, predicted future climate, identified impacts on various sectors with a high level of certainty and proposed proper adaptation measures that respond directly to identified risks/impacts. The TNC project strived to address all gaps and constraints and to develop new methodologies for V & A assessment that are described in details in Chapter 4. However, certain gaps and future challenges remain for the upcoming NCs and sectoral studies on V & A:

Meteorology and Climate Data:

Historical meteorological data has been inconsistent and sometimes absent altogether, creating some gaps in the flow of climate measurements. There is missing data in both the records and time series of the Meteorology Department (MD) and the Ministry of Water and Irrigation. This is hard to correct and will continue to throw a shade of inconsistency over historical data.

The availability and accessibility of meteorological data has improved during TNC project implementation. The TNC project has facilitated the development and adoption of an Understanding (MoU) between the National Meteorology Department (MD) and the Ministry of Environment. This MoU will regulate the flow of data from MD to the Ministry and other stakeholders and provides MD with the required capacity building programmes and activities that will enhance its ability to collect data by expanding the scope of indices and the distribution of stations.

Climate Projections:

During the TNC a paradigm shift was achieved from statistical downscaling through reliance on local data to dynamic downscaling based on the CORDEX system, GCM and relating the results to various RCPs. The expertise for achieving such an endeavor is still lacking in Jordan. The downscaling exercise was conducted by a European consultancy firm but with close cooperation with the national team who prepared the V & A chapter.

National experts were acquainted with the CORDEX methodology and downscaling software at certain levels and are now ready to undergo an extensive and in-depth training programme for conducting the downscaling exercise at the local level.

Climate Impact and Response:

The TNC has introduced a new methodology for identification and quantification of climate exposure, risk, impact and response that was not used before in Jordan. The national team of experts who worked on the methodology have gained considerable knowledge that should be transferred to other stakeholders in the future in order to enhance the number and knowledge base of national experts in climate risk, impact and adaptation planning. However, there is a need to develop a more in depth cross sectoral assessment/ integrated analysis.

The development of a baseline for socio-economic and other sectoral data was difficult to the complexity and interchangeability of measurements related to socioeconomic conditions especially income, livelihood practices, gender disaggregation of data and other factors

The TNC suggests the following activities to address the gaps in the Vulnerability and Adaptation issues in the National Communications:

- Enhancing the capacity of the Meteorology Department in expanding the scope of climate indices recorded and the distribution of monitoring stations and improvement of equipment performance.
- Improving the use of existing meteorological data through the production of maps, datasets and comparative tables that process raw data into policy-oriented knowledge products.
- Expanding the base of national experts trained in conducting climate projections and scenarios using dynamic downscaling and improving access to global climate data and use of various models.

5.2 INSTITUTIONAL ARRANGEMENTS FOR CLIMATE CHANGE

In August 2014 and based on recommendations of the National Climate Change Policy (see section 5.3) the Ministry of Environment has created its first directorate for climate change. The directorate will act as the institutional hub for coordinating and developing all climate change activities in Jordan in relation to the UNFCCC and the global climate change governance system and initiatives.

According to the recently approved institutional setup, the overall objective of the Climate Change Directorate is to follow up and strengthen implementation of provisions of United Nations Framework Convention On Climate Change (UNFCCC) and its Kyoto Protocol (KP) and any related legal instruments that the conference of the parties (COP) may adopt and Jordan ratifies.

This directorate will incorporate both the high-level policy making/decision taking level as well as the executive level, and will facilitate the involvement of all relevant stakeholders in developing response actions/strategies and their implementation. It will also strengthen the internal capacity of the Ministry of Environment for climate change to address its existing and new tasks under the Climate Change Policy.

Main other tasks identified by the directorate mandate are:

- To develop, revise and continuously update national policies, strategies, action plans, programmes and projects that aim at facing the challenge of climate change, considering all aspects of the problem, (vulnerability and adaptation, mitigation, technology transfer and finance and other aspects);
- To work in this regard as the official National Focal Point to the (UNFCCC); the Designated National Authority (DNA) for the purpose of facilitating Jordan's participation in Clean Development Mechanism (CDM); and the official entity representing the country in the meetings of the Conference of Parties (COPs) and climate change negotiations process before the international community to reach commitment periods and a shared vision and long-terms global goals.
- To function, through the Director, as the national secretariat to National Focal Point for the UNFCCC as well as the national secretariat for the DNA;
- To serve, through the Director, as the Secretariat and providing secretarial services to the Jordan National Committee on Climate Change (JNCCC), which is headed by the Minister of Environment;
- To supervise the implementation of The National Climate Change Policy Of The Hashemite Kingdom Of Jordan in full collaboration and coordination with the JNCCC and monitor the implementation process;
- To create or supervise the establishment/ implementation of education, scientific, research, training and awareness programmes on climate change, consistent with Article 6 of the Convention, among various stakeholders and guiding public participation.

It is hoped that the new directorate will have a positive and direct impact on organizing the national efforts on climate change and manage to maximize the benefits from various activities for a concerted and visionary approach.

The National Committee on Climate Change:

The national platform for the integration of multi-stakeholder dialogue and planning on Climate Change is the National Committee on Climate Change (NCCC), which was established in April 2001 based on a decision by the Prime Minister and it includes many stakeholders directly associated with Climate Change sectors in Jordan. The current members of the NCCC constitute 10 line ministries, 3 public institutions, 4 research and academic organizations and 4 NGOs.

The Committee is headed by the Minister of Environment or who the Minster delegates at the Ministry of Environment, which is the national administrative body for the secretariat of the UNFCCC. The Ministry of Environment is responsible locally for calling the meetings of the committee and preparing and distributing all pertinent documents before and after meetings. The committee establishes its specialized thematic legal and technical groups on permanent and/or ad-hoc basis, according to the subject of the discussion theme. Thematic groups are composed of principal country expertise on the needed topics of advice.

The main responsibilities of the JNCC are:

- Supervises and supports implementing the UNFCCC in Jordan in accordance with national interests.
- Supervises and ensures the development and execution of needed legal, regulatory and institutional arrangements and frameworks
- Acts as a national advisory body by providing overall institutional and technical guidance
- Leads climate change adaptation and mitigation efforts and ensures the integration of adaptation within other national development strategies and plans and enhances the integration of gender dimension in these strategies
- Overviews and provides opinion and feedback on climate change programmes and projects in terms of institutional and technical aspects.

Main recommendations for actions in the institutional setup are:

1. Strengthening the capacity of the newly established Climate Change unit at MoEnv through proper organizational management, enhancing human resources and developing roles and mandates.
2. Expanding and enhancing the role and mandate of the national climate change committee, and facilitating the flow of data and processed information between committee members.
3. Strengthen the linkages with other national committees on biodiversity and desertification to synergize and harmonize policies and strategies as they are already interlinked

5.3 CLIMATE CHANGE MAINSTREAMING IN DEVELOPMENT POLICIES

Since the launch of the SNC in 2009 Jordan has vastly improved its policy framework in relation to Climate Change. In 2009 and previously, Climate Change was barely mentioned in any of Jordan's main developmental plans. Currently the country has elaborated a very intricate and useful policy framework that should be utilized for improving national capacities for addressing the challenge of Climate change in all sectors.

One of the main policy and planning tools in Jordan is the Government Executive Programme (GEP) 2013-2016 which is based on the National Agenda of 2005 and was developed by the Ministry of Planning in 2013. In this planning document Climate Change has been integrated as one of four pillars of the Environment sector.

The GWP focuses on Adaptation to Climate Change with GEP particular emphasis on integrating climate change dimensions in all new projects and programmes, developing a legal framework to regulate national activities regarding climate change and enhancing the capacities of national institutions and experts to address issues of Climate Change.

National Climate Change Policy:

In January 2013 a milestone was achieved in Jordan with the launch and adoption of the first national policy on climate change in the country and in the region. The policy was a result of an extensive multi-stakeholder dialogue process that involved all active organizations from various sectors in Jordan. The policy was drafted to accommodate all national climate change priorities for action and to provide a highly flexible policy reference point upon which further strategies and sectoral policies can be based.

The long-term goal of the Climate Change Policy is to achieve a pro-active, climate risk-resilient Jordan, to remain with a low carbon but growing economy, with healthy, sustainable, and resilient communities, sustainable water and agricultural resources, and thriving and productive ecosystems in the path towards sustainable development.

The policy includes comprehensive recommendations for all climate change building blocks (mitigation, adaptation, awareness, technology transfer, education, capacity building, financial resources, etc.) based on a summarised description of the state of each sector.

Mitigation Policy:

No policy instruments are adopted in Jordan that define or determine the effort for GHG mitigation in Jordan, such as a national GHG emission targets. At the moment, GHG mitigation is the result of sector policies, driven by other objectives, such as energy efficiency. Effort-defining instruments are, however, introduced at a sector level in the form of targets, in particular the target for renewable energy and energy efficiency. Jordan intends to promote the mitigation measures that are supported by other objectives than climate change, such as economic benefits (cost-effective under current national conditions, increase security of supply, contributing to the competitiveness of the economy), social (reducing energy expenses, increasing availability to energy services), environmental or other sector-specific objectives, as adopted in other non-climate policies.

The main recommendations for climate change mitigation stipulated in the policy were:

- Strengthen the promotion of renewable energy and energy efficiency in Jordan, which will have a large impact on reduction of GHG emissions in the country;
- Complete the policy and legal framework for renewable energy and energy efficiency and strengthen the development, implementation and enforcement of existing regulation, e.g. green buildings codes;
- Develop and adopt in the transport sector strategies that promote energy efficiency and low carbon transportation modes, and that also facilitate transfer of low carbon transport technologies;
- Integrate the climate change perspective in solid waste and waste water policies, strategies and action plans;
- Improve forest and rangelands management to increase the capacity to store GHG;
- Promote the access to national and international financing for low carbon energy and environmental technologies and projects; and
- Promote technology R&D and technology transfer for mitigation in Jordan.

Synergy in Mitigation Landscape:

Like many other developing countries, Jordan is striving to engage with the international community in the global efforts to address climate change through nationally based mitigation measures. This pursuit however is hindered by both the short supply of financial resources and the complex structure of the global mitigation structure.

Nationally Appropriate Mitigation Actions (NAMAs):

An important barrier to successful NAMAs is the ability of countries to put the appropriate national policy framework in place. This is also to be linked to a Measurement, Reporting and Verification (MRV) framework at the national level, which in turn must also be subject to an international level of MRV to demonstrate the avoided emissions in a manner which will qualify for international climate finance. Currently official guidance on MRV of NAMAs is pending.

During the second half of 2011 and early 2012, the Government of Jordan (GoJ) decided to make a contribution to the national, regional and global process of NAMA design and implementation, by:

- Evaluating and prioritizing its national list of GHG mitigation projects in the context of low carbon growth and sustainable development in Jordan, taking into account:
  - Greenhouse gas emissions and mitigation;
  - The design of new partnership arrangements between the public and private sectors, and;
  - Ways to mobilize climate finance in support of such actions/approaches.
- Secondly, from the prioritized list of NAMAs, one would be selected for a further prefeasibility study in order to provide an example of a workable and replicable NAMA.

Based on a consultative stakeholders engagement process Jordan is expected to start developing its first NAMA project proposal that will focus on the introduction of solar power for water pumps in Jordan. The use of fuel oil for water pumping constitutes about 40% of the electricity bill for the Ministry of Water and Irrigation and is a major source of GHG emissions. Replacing fuel with solar power will both benefit developmental needs and reduce GHG emissions.

Clean Development Mechanism (CDM):

Jordan has registered four CDM project thus far and is in need to upgrade its efforts in registering more projects including exploring the opportunity for registering small scale CDM projects.

Low Emission Development Strategy (LEDS):

Jordan will be seeking international partnerships to assist in developing its Low Emission Development Strategy to act an integral element of its mitigation plans. The results of the TNC and its mitigation chapter should be used as a basic reference for any future LEDS.

Partnership for Market Readiness (PMR):

Jordan has submitted its organizational framework to the Partnership for Market Readiness (PMR) in June 2012 and is now in the process of developing its fully fledged PMR proposal. With the recent positive developments at the legal and institutional levels in Jordan the country is now in a very good position to proceed with its PMR pathway.
Intended Nationally Determined Contributions (INDCs):

INDCs are the latest additions to the negotiation landscape in the UNFCCC process but they are still facing much controversy. Jordan, along with all other developing countries is aiming to expand the scope of INDCs to include adaptation, technology transfer, capacity building and financial resources. In the most recent round of UNFCCC negotiations it was agreed that INDCs will include adaptation, mitigation and means of implementation. INDCs need to be designed prior to 2015 agreement and must be considered as a main priority for Jordan.

Adaptation Policy:

The national climate change policy has focused on priority sectors that are directly linked with main developmental challenges in Jordan and present the highest exposure risks; namely water and agriculture. The recommendations and proposed actions contained in the climate change policy have been developed through an extensive consultation process and included the following main items:

Further increase the scientific knowledge of climate change vulnerability and impact on water, agriculture/food production, health, biodiversity, desertification and other relevant sectors, with water and agriculture as the key sectors. This will include the link between climate change adaptation and disaster risk. It is very clear that developing social protection approaches for climate change adaptation requires a rigorous, evidence based and improved understanding of social impacts, policy and implementation processes.

- Develop national and regional capacity to address climate change risks;
- Develop adaptation strategies in all relevant vulnerable sectors and work towards integrations/filling gaps of climate change aspects into relevant sectors' existing adaptation policies and strategies as well as action plans;
- Strengthen the cross-sector approach to adaptation given the strong thematic relation between the sectors, and strengthen the existing national institutional framework, including the National Committee on Climate Change (NCCC) and its advisory bodies with emphasis on climate change research group; and
- Promote access to national and international financing for adaptation projects, including mainstreaming climate consideration in the allocation of national budgets.

As for education, awareness and research the climate change policy proposed the following:

- The Jordan research portfolio on climate change needs to be strengthened. Policy-supporting research should be promoted to bridge the gap between research and policy makers resulting in informed and scientifically justified resolutions by policy makers;
- Awareness campaigns to accompany the implementation of adaptation and mitigation measures, and target all relevant stakeholders, including communities and the private sector where the media to play a key role in this regard; and
- The curricula of vocational training and higher education should reflect the needs for climate change adaptation professionals, as well as professionals in the public and economic sectors that can benefit from green growth.

At the more operational level it is important that Jordan develops its own National Adaptation Action Plan (NAAP) that includes specific, sectoral, time-bound and practical measures for enhancing the country's adaptive capacity to climate change. The methodology, results and knowledge gained from the Vulnerability & Adaptation chapter of the TNC should be the building block for developing the comprehensive national adaptation action plan in the future.

Climate change considerations and priorities for adaptation should be mainstreamed in main sectoral strategies such as water, agriculture, health biodiversity and others to ensure having no regret actions in priority sectors and responding to climate risks in a timely and coordinated manner.

5.4 PUBLIC AWARENESS

The TNC project has conducted the first public opinion survey to find out the state knowledge and perspectives on climate change, in Jordan and beyond, of five sectors of the general opinion. The aim of the survey is expanded to include a suggested communication plan based on the results of the survey.

The full study is available on the CD attached with the TNC report and the main results show the following:

- About 38% of the sample stated they have a "very good" knowledge of the climate change issue.
- Around 78% stated that there is a change in the climate during the past years
- Around 67% stated that they sensed a change in the climate and this change was negative and annoying to them.
- Around 73% stated that climate change was due to anthropogenic activities like industrial activities, energy sector and transportation.
- The sample's knowledge of some climate change terms as "Kyoto Protocol" was weak with a percentage of 41% stating they have no idea what this protocol is about.
- Around 60% stated that they believe that CO_2 concentrations in the atmosphere have hit the highest levels in the history of earth.
- Around 75% of the sample stated that the impacts of climate change at the national levels will be mainly manifested in the form of rise in temperature and 65% stated that climate change will negatively affect levels of precipitation.
- 64% of the sample stated that they think that Jordan has minor contribution in the climate change phenomena.
- 50% of the sample showed positive attitude towards being involved in action against climate change.
- 16% were interested in joining a society or an organization that addresses climate change issues.
- 53% stated they are willing to pay more in climate-friendly products and services.
- Adaptation options priorities according to the sample under study were:
  - Saving water - 69%
  - Plant drought tolerant crops with minimal water requirement - 60%
  - Conservation of biodiversity and natural ecosystems - 50%
- Mitigation options prioritized by the sample opinion were:
  - Use of renewable energy and energy saving and energy efficiency - 61%
  - Use of climate-friendly products and services - 46%
  - Decrease industrial pollution - 57%
- The sample under study stated that the Government has key responsibilities in dealing with climate change issues with a percentage of 50% followed by civil society organisations with 24%.
- The sample under study said that the most preferred tools for communication are as followed: TV and satellite (72%) with highest percentage followed by social media networks (66%) and the least percentage was for workshops and seminars (26%).
- The top priority targeted groups for climate change awareness and communication activities according to the survey were: students and academia (72%), business sector (61%) and households (43%).

TNC Learning and Outreach Plan:

Based on the results of the Public Opinion Survey the TNC project has developed a national outreach plan that aims to respond to the requirements and guidelines in Article 6 of the UNFCCC and also aims to the improvement of national capacities and performance in public awareness on climate change issues.
This plan sets out four outreach objectives that should be achieved within two years, they are, namely:

1. Strengthening the capacity of the Ministry of Environment and its national partners in developing and conducting Climate Change outreach programmes.
2. Promote effective knowledge and awareness of the causes and effects of climate change at the levels of individuals and community and support open access to relevant information.
3. Advocate for the main stakeholders to mobilize and establish partnerships aimed to address the current and projected impacts of climate change in their programmes.
4. Support the mainstreaming of climate change education, awareness and capacity building in all relevant developmental sectors.

These long term goals will be achieved through a set of specific activities, some of which are described as follows:

- Launch a public access portal website for climate change issues in Jordan linked to global dimensions directed towards the general Jordanian public and the developmental community on climate change.
- Develop a directory of organizations and individuals, with details of their experience and expertise relevant to Article 6 activities, with hope to building active networks involved in the implementation of these activities.
- Create social media accounts for the national communications in specific and other climate change programmes/projects to interact with the public, with dedicated accounts for students and their teachers and professors.
- Work with university students to create clubs for climate change advocacy.
- Initiate national competitions on climate change for various target groups.
- Develop attractive smart phone applications that includes climate change and other environmental concerns to be used by youth and kids.
- Seek opportunities to disseminate widely relevant information on climate change. Measures could include translation into Arabic language and distribution of popularized versions of key documents on climate change, including national assessment reports and other reports by the Intergovernmental Panel on Climate Change.
- Promote and enhance the inclusion of climate change information in the school curricula at all levels and across disciplines. Efforts should be made to develop materials and promote teacher training focused on climate change.
- Integrate climate change learning into the curricula of institutions that provide formal education and training at all levels and support non-formal and informal education on climate change, training of trainers programmes and the development of educational, training and public awareness materials in accordance with national circumstances and the cultural context.
- Develop tools and methodologies to support climate change training and skills development through collaborative efforts and provide training programmes for groups with a key role in climate change communication and education, including journalists, teachers, youth and community leaders.
- Preparing "digests" of scientific research about climate change published in Jordan and beyond to be presented to various target groups as source of trusted and verified information on climate change and its impact on society and the environment.

5.5 EDUCATION AND CAPACITY BUILDING

Currently, schools curricula include environmental concepts and national priorities and challenges in general and climate change issues in particular at some degree in certain grades. There is the need to re-evaluate the curricula aiming at improving student's education on climate change issues. Also, in most of the Jordanian Universities, there are special departments teaching environmental sciences and management and issues related directly and indirectly to climate change. Only one specialized graduate programme offering a degree related to climate change was under preparation at the time of preparing this report.

The national climate change policy in Jordan identifies the following main recommendations for education and capacity building:

- Start systematically integrating climate change aspects, emphasizing on provisions of this policy into different grade levels of schools and other relevant components of the academic framework;
- Re-evaluate the curricula aiming at better educating and raising awareness of the students on climate change issues with emphasis on special departments teaching environmental sciences and management and issues related to climate change;
- Mainstream a comprehensive and progressive climate change science and updated information into existing curricula starting with elementary schools up through secondary schools and universities;
- There is the need to build a professional network of climate change adaptation experts for vocational training in higher education, as well as for professionals in the public and economic sectors that could benefit from green growth;
- Support initiatives aiming at improving climate change related education especially those lead by NGOs and the private sector by facilitating all efforts

to securing the required financing and providing technical information available; and

- Consider forming a National Climate Change Education Work Force from MoEnv, MoE, NGOs, academic centres, and educational and vocational training centers to coordinate climate change educational activities and initiatives highlighted herewith, in full coordination with NCCC.

5.6 KNOWLEDGE MANAGEMENT

The process of the preparation of National Communications and other activities in the Climate Change landscape is a data intensive task. It requires a high level knowledge of scientific research, processing, archiving and retrieval of data.

The process of data collection and analysis is also a project-based and once the National Communication report is finished the data remains scattered and not properly utilized despite the fact that it has monetary and scientific value. It is crucial that the MoEnv, supported by its international partners, to create a national hub for climate change data and information system that enhances climate change knowledge management.

The most important step in this context is developing a clearinghouse of GHG inventory, mitigation, vulnerability & adaptation data needed for the national communication. This requires a coordinated strategy to link necessary and relevant data from various entities and activity sources (oil refinery, customs, transport, chambers of industry, commerce, climate data, socio-economic and sectoral ministries). It is envisioned that the MoEnv will host an environmental management data system for CC and national communication that is linked and informed by the National Information Center and relevant entities.

The amount of information that was gained in the TNC process deserves to be available for the use of policy makers, practitioners, civil society, the general public and researchers. A special online platform for climate change information should be developed with clear sustainability and updating plans.

5.7 SCIENTIFIC RESEARCH AND INNOVATION

With the increased pressure on natural resources, growing number of population, and the harder global competition; Jordan is realizing that its prosperity rely on harnessing its human capital and young population to address development challenges. Jordan – despite the low and public sector led research and developmemt spending - has a good network of universities, a high demand and capacity of industry to acquire technology, a growing network of public and private business incubators and accelerators, good emphasis on reform and governance and some successful examples of private sector involvement in development sectors and projects.

The way forward for a country like Jordan seems to be in clustering partners and activities to focus on selected sectors/sub-sectors with high potential for the regional and international competitiveness. Green innovation and entrepreneurship is not yet that common in Jordan. Only a few ideas have been pursued through commercialization. With the growing green economy potential and market this might change and a more developed environment for a clean-tech cluster would evolve.

The green economy potential in Jordan is estimated to generate 50,000 jobs, and over JD 1.3 billion in revenues over a period of 10 years. The result could only be attainable with an integrated and coordinated national system that enables public, private and research players to collaborate horizontally and vertically to address the sectoral challenges.

With the support of UNESCO and under the umbrella of the Higher Council for Science and Technology, Jordan has prepared its national policy and strategy for Science, Technology and Innovation (STI) for 2013 - 2017.

The document prioritized the proposed strategic directions and defined the following five strategic objectives that would guide implementation:

- Completing the legislative framework, coordinating and enacting policies and legislations, and identifying cooperation channels among relevant entities (international models).

- Completing infrastructure, training human resources on various scientific and technology aspects (partnerships, international networking, grants, FDI).
- Supporting the sustainability of higher education and scientific institutions, by mobilizing efforts, and attracting and retaining national talents (government support).
- Enhancing productivity and competitiveness and supporting private sector led R & D (bringing in advanced technologies and working on the development of basic ones).
- Incentivizing innovation and providing financial and moral support (innovation clusters).

The national strategy for STI was prepared through national committees and teams comprising over 160 members from relevant entities. It encompasses many ambitious and interesting projects and activities. Yet there is a need to cascade this strategy into implementation plans and distribute responsibilities and budget among various players. Collaboration across sectors and industries is a major challenge for the successful realization of a national innovation system.

Under the fourth objective, a project on supporting applied research in the fields of water, energy, food and human health was included with a 2.f Million JD budget. Among several ones addressing energy and other technologies, one key activity was identified under that project the "development of technology to reduce GHG emissions". The monitoring and evaluation of this project is with the general secretariat of the Higher Council for Science and Technology (HCST).

Priorities for Climate Change Research:

The following top priorities resulted from a Stakeholders evaluation exercise that was carried out within the context of the UNDP/GEF supported project "Developing Policy relevant capacities for implementation of global environmental conventions that was conducted between 2010-2012.

- Vulnerability and adaptation assessment of climate change on agriculture sector.
- Vulnerability and adaptation assessment of climate change on water sector.
- Observation, monitoring and estimation of CC impacts on agriculture and food security (solutions to limited data availability, lack of models and tools specifically designed for local conditions).
- Observation, monitoring and estimation of CC impacts on water sector (solutions to limited data availability, lack of models and tools specifically designed for local conditions; improve meteorological and water monitoring through modernization of equipment and extension of monitoring networks; Raising technical capacity for monitoring and data collection, data management and updating of basic data sets, and preparation of basic maps and databases.
- Desertification and biodiversity interactions with CC (solutions to limited data availability, lack of models and tools specifically designed for local conditions).
- Ecosystem-based adaptation and cost-effective (enhancing the resilience of ecosystems and natural habitats to the impacts of CC).
- Vulnerability assessment of climate change on socio-economic sector (vulnerable groups with emphasis on the poor).
- Integrate climate change in current legislative and policy framework.
- Enhance public awareness and training in climate change related issues.
- Vulnerability assessment of climate change on socio-economic sector (vulnerable groups with emphasis on gender mainstreaming).
- Promote and incorporate climate change in education
- Obstacles hindering securing and mobilizing national and international financial resources to conduct studies to improve knowledge regarding climate change impacts and adaptation opportunities in Jordan (Securing and mobilizing financial resources to implement priority adaptation projects).
- Increase of the percentage of electricity production from renewable sources (energy supply side).
- Vulnerability and adaptation assessment of climate change on health sector.

5.8 FINANCIAL RESOURCES

According to the NEEDS study published in Jordan in 2010, both mitigation and adaptation measures in Jordan will require substantial financial resources. According to the NEEDS study that was published in 2010 and as an initial estimation, until the year 2020, about 3.5 billion US$ will be needed for mitigation and a minimum of 1.5 billion US$ will be needed for adaptation in Jordan (for major projects in water, industry and energy). With the public budget allocating only 0.5% to projects in environmental sectors (apart from infrastructure investments in water and energy) a considerable amount of fundraising targets are required.

The big majority of financial resources pumped into environmental sectors in Jordan come from donor countries through bilateral agreements that focus on fiscal and developmental challenges in the country. Framework agreements and strategies with major donors like UNDP, USAID, EU, GIZ, JICA and other agencies have been developed and address a variety of sustainable development objectives.

Future financing for mitigation and adaptation can be attracted from different sources, including:

- Internal sources, including the national budget, dedicated national funds (e.g. the Renewable Energy and Energy Efficiency Fund and the Environment Protection Fund, etc).
- International sources, including bilateral and multilateral ODA, funds for mitigation and adaptation under the UNFCCC (Adaptation Fund, Green Climate Fund bilateral supported NAMAs, complemented with local co-financing, CDM or credited NAMAs, etc). Debt financing/loans by national and international banks, and private sector financing.

Jordan must increase CDM projects in the pipeline since only four CDM projects in total have been registered in Jordan, taking into consideration that the demand for Certified Emission Reduction (CERs) has decreased significantly and the corresponding low price does not provide an adequate incentive for mitigation projects.

Jordan must analyze and benefit from Durban's COP 17 outcome, as parties decided to strengthen NAMA development and implementation. Jordan emphasizes the principle that NAMAs are to be nationally appropriate, i.e. tailored to countries' national circumstances and in line with the Convention's principle of common but differentiated responsibilities. They are to take place in the context of sustainable development, which means they are to be embedded in the country's broader sustainable development strategies and priorities.

In 2012 and as per the Renewable Energy and Energy Efficiency Law, the MEMR created the JREEEF that – just like the Environment Fund – lacked the needed financial and administrate autonomy to be able to carry out its mandate effectively and efficiently. To date, the JREEEF is still inactive and this has impacted its credibility and suitability for receiving grants and other financial products to be channeled to beneficiaries. JREEEF and MEMR require a number of technical, management and financial competencies and expertise to be able to manage the fund. More importantly, there is a need for a transparent and effective governance structure that puts JREEEF as the best choice for green financing.

EBRD has recently commenced its operations in Jordan and is exploring financing ideas in the energy sector especially for SMEs. It has initiated a study in cooperation with AFD to assess need and options for setting up a credit facility/ financial product that would increase SWHs penetration in the residential and commercial sectors.

Financing institutions and the banking sector are interested in entering this new sector. Several green loans and programmes are being established, green suppliers and manufacturers are growing in number, however, the market lacks proactive marketing and public outreach.

Jordan does not have a national policy to encourage green investment in particular. Nevertheless, several sectoral strategies and decisions are inclined to provide some incentives for green projects, although in an ad-hoc manner. Realizing the importance of such incentives in promoting green development and attracting Foreign Direct Investment (FDI); the Ministry of Environment conducted a comprehensive study on the mechanisms to incentivize the financial sector in order to scale up financing of green investment in Jordan. The study analyzed various incentive mechanisms and recommended interventions to overcome green financing barriers.

In addition, the study proposed the following options , based on best international practices that would contribute to the institutionalization of the green economy and green financing endeavors.

- Create a unit within an influential "convening" government entity (such as the MoPIC) to coordinate government action and provide political leadership on, and clear political commitment to, green economy issues;

- Establish a platform for dialogue between the public and private sector (including the financial sector);
- Reduce subsidies, especially in the energy and water sectors, and replace them with targeted interventions aimed at helping the most vulnerable households;
  - Improve the enforcement of green legislation;
  - Support R&D in the green economy;
  - Improve the collection of statistics in relation to the green economy.

Jordan Competitiveness Program funded by USAID has just been awarded to DAI. It includes a full component on cluster development with one of three focus areas being the clean-tech cluster. This would aim to support the green businesses growth and boost the green economy agenda.

Potential For Green Economy in Jordan:

Jordan recognizes climate change mitigation and adaptation as an integral part of the much broader strategy for green growth. There is the need to develop a National Green Growth Plan for Jordan. Jordan's reliance on energy imports, coupled with its low energy efficiency, is also a particular concern. Jordan to pursue green growth plans where there are substantial opportunities for the country, most notably in renewable energy and energy efficiency and in water supply/demand and productivity. To realize green growth opportunities, significant investment will be required in the near term. The private sector, and in particular the Jordanian financial sector, have a key role in financing this investment.

Jordan has started preparing its entry to the green solutions market and has identified clean energy and green investments as new clusters to boost economic development, provide green jobs and sustain natural resources. As the first country in the MENA region to conduct a national green economy scoping study, Jordan has identified several opportunities to kick off the green clusters including renewable energy and energy efficiency, water and wastewater management, solid waste, green buildings, eco-tourism, transportation etc. However, mainstreaming the green economy potential into those sectors is still limited. It is through building an effective regulatory and governance framework and bringing together public and private sectors as well as civil society organizations; that Jordan will establish its competitive edge in the green economy world.

With over 70% of its population under 30 years of age, Jordan's big investment needs to be in its talent. Mainstreaming the green economy market needs into the education and vocational training systems will enhance the green clusters competitiveness and ensure socio-economic benefits.

In total, investment in environmental conservation could generate an estimated 50,000 jobs, and over JD 1.3 billion in revenues over a period of 10 years, as is shown in the UNEP Green Economy Scoping study (2012) In order to achieve such benefits, this study recommends an integrated and coordinated approach that involves all sections of the Government, the private sector and civil society, starting with the production and adoption of the Green Economy Policy Paper.

Neglecting the green economy potential will not only result in tremendous investment and socioeconomic opportunities but also would add to the annual cost of environmental degradation estimated by the World Bank in 2008 to be over 2% of the GDP.

In 2010, The Ministry of Environment has managed to include a strategic objective within it strategy that is dedicated to green economy. As a follow-up on the UNEP scoping study, the MoEnv has also obtained support from other donors like AFD to carry out more detailed studies.

5.9 TECHNOLOGY NEEDS ASSESSMENT AND TRANSFER

The UNFCCC, Article 4, paragraph 5 states that developed countries "shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies (ESTs) and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention"; within this context, the technology transfer is designed to assist developing countries in responding to climate change through the diffusion and use of appropriate climate change mitigation technologies and technologies for adaptation to climate change.

Jordan considers the technology cycle as established in the Cancún Agreement, which includes the research, development, demonstration, deployment and diffusion of technologies, as well as their transfer. The main constraints and gaps for technology transfer in Jordan, as identified by the National Climate Change Policy, are the following:

- Lack of appropriate funding for technology transfer and research;
- Lack of incentives and high taxation and customs on modern technology;
- Routine government procedures and lack of specialized staff in the public sector;
- Insufficient information and training courses allocated to emphasize the effectiveness and the feasibilities of different technological options; and
- Limited expertise in modern technology maintenance and spare parts availability, and special needs for foreign experts to transfer knowledge and experience of the new technologies.

The National Climate Change Policy identifies the following recommendations for technology transfer in Jordan:

- Consider the whole technology cycle in Jordan's technology needs assessment, including weaknesses in the national research and development infrastructure, the current lack of national drivers for innovations and lack of involvement of the private sector;
- Align the national Research & Development (R&D) agenda with Jordan's technology policy, the Green Growth Strategy, and its needs towards technology transfer for climate change mitigation and adaptation;
- Perform dedicated studies considering the research agenda, national technology policy, and setting the right market conditions for technology demand; and
- Take an active approach in developing and participating in the new Technology Mechanism under the UNFCCC, taking into account gender considerations.

Technology Needs Assessment in Mitigation:

The Technology Needs Assessment aims at assisting Jordan in identifying and analyzing priority technology needs to mitigate GHG emissions through country-driven participatory processes and reduce the vulnerability of sectors and livelihoods to the adverse impacts of climate change and to form the basis for a portfolio of Environmentally Sound Technology projects and programmes. TNA aims at providing additional information that responds to concerns, generates new findings for policy reform and shapes action plans for intervention. (UNFCCC, 2007)

Within the TNC process Jordan has developed a Technology Needs Assessment (TNA) study specific for mitigation. The TNA has been undertaken to introduce technologies that could improve Jordan's developmental and environmental integrity. The main objective is to identify and assess environmentally sound technologies that have synergies between reducing the impact of climate change and the rate of GHG emissions and Jordan's national development objectives.

The resulting TNA analysis will be used to identify a portfolio of technologies that have the potential to combat climate change, reduce environmental pollution, and contribute to Jordan's sustainable development. The report will also help to communicate Jordan's climate change technology requirements to the global community as well as facilitate the access to international sources of funding for the implementation of mitigation activities and supports Jordan's position in climate change negotiations in the area of technology transfer. Many existing policies and laws are formulated and adopted at the national level with the aim of:

- In the power sector: promoting rationalization, efficiency and use of clean energy.
- In the transport sector: developing and adopt energy efficiency, low carbon transport technologies and low carbon transportation modes.

A questionnaire was designed and distributed to target sectors that are considered large consumers of energy namely; the energy and transport sectors. The questionnaire was developed to address technical people and experts in these two sectors with the objective of taking their views on ways to reduce consumptions of energy and introduce technologies that assist in mitigate CO_2 emissions. The questionnaire was designed to include all information to fulfill the objective of the study.

The known practice in the assessment process of various technologies is based on maximizing the resilience of the sector to climate change impacts, minimize GHG emissions from the sector, maximize development priority benefits in terms of environmental, social, and economic and to minimize any negative consequences of the technology.

The following prioritization criteria was used to screen and rank the selected technologies:

- GHG reduction potential: Being the main objective of the TNA, this criterion has been given the highest weight of 30%.
- Know-how: The local knowledge and experience of the suggested technology and ability to raise the local capacity building to operate and maintain. A weight of 10% is assigned for this criterion.
- Technical applicability to implement: Is the suggested technology able to be implemented from technical review. A weight of 10% is assigned for this criterion.
- Fuel cost: Since fuel cost constitutes a substantial part of the operational costs of the technologies, and due to the high fuel prices over the last decade at global scale, a weight of 10% is assigned for this criterion for technologies at which fuel switch is needed.
- Capital cost: The cost of selected technologies should be affordable, capable of attracting investments. This criterion has been assigned a weight of 15%.
- Additional operation and maintenance costs: These periodic costs, over the technology lifetime, are associated with running and sustaining emission-reduction measures after initial implementation. They would cover periodic maintenance and repairs, spare parts, plants management fees and others. Fuel costs are not considered as part of this criterion. The weight allocated for this criterion has been set at 10%.
- Option sustainability: Some options can be financially self-sustaining since the GHG emissions reduction can be associated with a drop in operational costs and more appropriate pricing of natural resources. Win-win opportunities are anticipated from some of the recommended abatement options. This criterion has been also assigned a weight of 10%.
- Environmental, social and economic benefits: Several technologies would contribute to the country's environmental, social and economic development by inducing growth in rural areas, creating new jobs and strengthening citizens' participation. Since some of these benefits are partially accounted in the energy saving and options sustainability criteria, hence, a 5% weight has been assigned.

According to the results main mitigation technology options for the energy sector are solar energy, wind energy and biogas to generate electricity. Major mitigation technology options for the transports sectors are Bus Rapid Transit (BRT), hybrid vehicles, Light Rail System and replacement of old cars with modern ones exempted from customs.

5.10 ROADMAP FOR CLIMATE CHANGE ACTION: (2015-2018)

Prior to the preparation of Jordan's Fourth National Communication Report, the following roadmap for implementation of TNC recommendations and climate change action in general is proposed in Table 5.1 based on the availability of adequate capacity, technology and financial resources:

Table 5.1: Suggested measures for the implementation of TNC and development of Climate Change portfolio in Jordan

Item	Actions
1. Technical gaps in National Communications 1.1 GHG Inventory	1.1.1 Create a single entity at the newly-established Climate Change directorate in the Ministry of Environment to act as a hub to collect, process and report GHG inventory and exploring the possibility of creating a National GHG Inventory System 1.1.2 Conduct an intensive training programme on the development of a GHG inventory system, including detailed use of IPCC guidelines 1.1.3 Develop a legal structure that "adheres" activity data producers to submit information to the MoEnv 1.1.4 Prepare Jordan's First Biennial Update Report (FBUR) 1.1.5 Explore the potential to develop national emission factors for major GHG sources like energy, waste and industrial processes based on available capacities
1.2 Mitigation Assessment	1.2.1 Expand the expertise base and the knowledge capacity for conducting mitigation analysis through an extensive training programme on LEAP and other tools.
1.3 Vulnerability & Adaptation	1.3.1 Enhance the capacity of the Meteorology Department in expanding the scope of climate indices recorded and the distribution of monitoring stations and improvement of equipment performance 1.3.2 Improve the use of existing meteorological data through the production of maps, datasets and comparative tables that process raw data into policy-oriented knowledge products. 1.3.3 Expland the base of national experts trained in conducting climate projections and scenarios using dynamic downscaling and improving access to global climate data and use of various models 1.3.4 Undertake and integrated analysis of the country's vulnerability to climate change including local vulnerability maps, taking into account the direct, indirect and cumulative effects
2. Institutional Setup	2.1 Strengthen the capacity of the newly established Climate Change unit at MoEnv through proper organizational management, enhancing human resources and developing roles and mandate 2.2 Expand and enhance the role and mandate of the national climate change committee.
3. Policy Mainstreaming	3.1 Develop a coordinated policy approach for mitigation that integrates CDM, NAMA, PMR, MRV, LEDS and INDCs 3.2 Activate the national policy of climate change through stakeholders' coordination and mainstreaming of CC concepts in sectoral policies. 3.3 Develop a National Climate Change Adaptation Action Plan (NAAP)
4. Public Awareness	4.1 Implement the TNC learning and outreach plan
5. Education and Capacity Building	5.1 Integrate climate change concepts in national curricula 5.2- Develop informal education programmes/plans in climate change issues 5.3- Conduct a national needs assessment exercise for capacity building and responding to resulting priorities
6. Knowledge Management	6.1 Develop a clearing house of GHG inventory, mitigation, vulnerability and adaptation data
7. Scientific research and innovation	7.1 Increase support for scientific research in climate change issues 7.2 Enhance the role of researchers and scientists in the climate change policy making process
8. Financial resources	8.1 Map of all available financial resources in climate change and exploring opportunities for resource mobilization 8.2 Integrate climate change issues in bilateral and multilateral international cooperation programmes in Jordan 8.3 Channel available domestic financial resources into areas of direct connection with climate change
9. Technology Transfer	9.1 Map all available opportunities for technology transfer in climate related issues 9.2 Conduct a national needs assessment exercise for adaptation technologies required

ANNEX A
TABLES FOR MITIGATION ANALYSIS

Table A.1: The actual and projected primary and final energy demand (TOE) for the period 2006-2040

TYPE	SECTOR	2006	2007	2008	2009	2010	2011
1-LPG	Industry	8900	9300	6600	9200	9630	9720
	household	293384	314509	299891	318143	293131	355238
	agriculture	24130	25868	24666	26167	24110	29218
	commercial	25693	27543	26263	27861	25671	31110
Total		**352107**	**377220**	**357419**	**381370**	**352541**	**425285**
2-kerosene	Industry	2100	6700	8000	9000	6000	6500
	household	144000	124300	92000	101000	63000	68300
	agriculture	1000	1000	1000	1400	1000	1100
	commercial	8000	8100	8200	8800	9300	9700
Total		**155100**	**140100**	**109200**	**120200**	**79300**	**85600**
3-Diesel	Industry	328000	341000	305000	337000	322000	342000
	household	232000	200000	165000	167000	135000	136900
	agriculture	124400	127000	105000	107900	103200	104900
	commercial	196000	180700	125000	129000	120000	121700
	transport	902000	965000	819000	867000	818000	813000
Total		**1782400**	**1813700**	**1519000**	**1607900**	**1498200**	**1518500**
4-Gasoline	transport	762000	961900	908800	1063800	1109100	1145900
5-Jet Fuel	transport	245600	216700	223500	244900	298354	226900
6-fuel oil	Industry	507000	351000	337000	280000	217000	137200
7-fuel oil (refinery consumption)	refinery	255000	255000	255000	255000	255000	255000
Total (1) Oil		**4059207**	**4115620**	**3709919**	**3953170**	**3809495**	**3794385**
Fuel Oil	electricity	645000	621000	562000	258000	810000	1284000
Diesel	electricity	105000	9000	16000	18000	102000	960000
N. Gas	electricity	2067000	2396000	2697000	3080000	2282000	848000
Renewable Energy	electricity	115000	118000	123000	127000	134000	141000
Oil Shale	electricity	0	0	0	0	0	0
Nuclear Energy	electricity	0	0	0	0	0	0
Total (2)		2932000	3144000	3398000	3483000	3328000	**3233000**
Total (1+2)		**6991207**	**7259620**	**7107919**	**7436170**	**7137495**	**7027385**

Table A.1 continued: The actual and projected primary and final energy demand (TOE) for the period 2006-2040

TYPE	SECTOR	2012	2013	2014	2015	2016	2017	2018	2019	2020
1-LPG	Industry	10500	10836	11183	11541	11910	12291	12672	13065	13470
	household	324000	334368	345068	356110	367505	379266	391023	403145	415642
	agriculture	53000	54696	56446	58253	60117	62040	63964	65946	67991
	commercial	33700	34778	35891	37040	38225	39448	40671	41932	43232
Total		**421200**	**434678**	**448588**	**462943**	**477757**	**493045**	**508330**	**524088**	**540335**
2-kerosene	Industry	1000	1010	1020	1030	1041	1051	1060	1070	1080
	household	83000	83830	84668	85515	86370	87234	88019	88811	89610
	agriculture	1500	1515	1530	1545	1561	1577	1591	1605	1619
	commercial	10200	10434	10539	10644	10751	10858	10956	11054	11154
Total		**95700**	**96789**	**97757**	**98735**	**99722**	**100719**	**101626**	**102541**	**103463**
3-Diesel	Industry	236000	245912	256240	267002	278216	289345	300919	312956	325474
	household	149000	155258	161779	168574	175654	182680	189987	197586	205490
	agriculture	104000	108368	112919	117662	122604	127508	132608	137913	143429
	commercial	75000	78150	81432	84852	88416	91953	95631	99456	103435
	transport	1121000	1168082	1217141	1268261	1321528	1374389	1429365	1486540	1546001
Total		**1685000**	**1755770**	**1829512**	**1906352**	**1986419**	**2065875**	**2148510**	**2234451**	**2323829**
5-Gasoline	transport	1157000	1212536	1270738	1331733	1395656	1459857	1527010	1597252	1667531
6-Jet Fuel	transport	240200	250048	260300	270972	282082	293366	305100	317304	329362
7-fuel oil	Industry	150000	153450	156979	160590	164444	168391	172432	176570	180455
8-fuel oil (ref. cons)	refinery	255000	255000	255000	255000	255000	255000	255000	255000	255000
Total (1)		**4004100**	**4158272**	**4318875**	**4486325**	**4661081**	**4836253**	**5018008**	**5207206**	**5399975**
Fuel Oil	electricity	1380000	1290000	1313883	39590	0	0	0	0	0
Diesel	electricity	1758000	2441000	236351	110240	110240	110240	110240	110240	110240
N. Gas	electricity	410000	528000	256890	3766760	3969520	4011980	3816690	3716220	3703241
Renewable Energy	electricity	125100	128400	130500	135200	135500	385800	446460	496440	572220
Oil Shale	electricity	0	0	0	0	0	0	579920	565800	1389300
Nuclear Energy	electricity	0	0	0	0	0	0	0	0	0
Biogas	electricity	1540	1540	1540	1540	1540	**1540**	1540	1540	6160
Total (2)		**3674640**	**4388940**	**1939164**	**4053330**	**4216800**	**4509560**	**4954850**	**4890240**	**5781161**
Total (1+2)		**7678740**	**8547212**	**6258039**	**8539655**	**8877881**	**9345813**	**9972858**	**11181136**	**11181336**

Table A.1 continued: The actual and projected primary and final energy demand (TOE) for the period 2006-2040

TYPE	SECTOR	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1-LPG	Industry	13874	14290	14719	15146	15555	15975	16406	16849	17304	17771
	household	428111	440955	454183	467355	479973	492932	506242	519910	533948	548364
	agriculture	70031	72131	74295	76450	78514	80634	82811	85047	87343	89702
	commercial	44529	45865	47241	48611	49923	51271	52655	54077	55732	57179
Total		**556545**	**573241**	**590438**	**607561**	**623965**	**640812**	**658114**	**675883**	**694327**	**713016**
2-kerosene	Industry	1088	1097	1106	1115	1122	1130	1138	1146	1154	1162
	household	90327	91050	91778	92513	93160	93812	94469	95130	95796	96419
	agriculture	1632	1645	1659	1672	1684	1695	1707	1719	1731	1743
	commercial	11243	11333	11424	11515	11596	11677	11759	11841	11924	12001
Total		**104291**	**105125**	**105966**	**106814**	**107562**	**108315**	**109073**	**109836**	**110605**	**111324**
3-Diesel	Industry	337842	350680	364006	377838	391440	405532	420131	434416	449186	464458
	household	213299	221404	229817	238550	247138	256035	265252	274271	283596	293238
	agriculture	148880	154537	160409	166505	172499	178709	185143	191437	197946	204676
	commercial	107365	111445	115680	120076	124398	128877	133516	138056	142750	147603
	transport	1604749	1665730	1729028	1794731	1859341	1926277	1995623	2063474	2133632	2206176
Total		**2412134**	**2503795**	**2598940**	**2697699**	**2794817**	**2895430**	**2999665**	**3101654**	**3207110**	**3316152**
5-Gasoline	transport	1740903	1817503	1897473	1977167	2060208	2146736	2232606	2317445	2405508	2496917
6-Jet Fuel	transport	341878	354869	368354	381615	395353	409586	424331	439182	454554	470463
7-fuel oil	Industry	184425	188482	192440	196482	200608	204821	209122	213723	218424	223230
8-fuel oil (ref. cons)	refinery	255000	255000	255000	255000	255000	255000	255000	255000	255000	255000
Total (1)		**5595176**	**5798016**	**6008612**	**6222338**	**6437512**	**6660699**	**6887911**	**7112723**	**7345528**	**7586102**
Fuel Oil	electricity	0	0	0	0	446819	617709	915950	922740	927590	955720
Diesel	electricity	110240	110240	110240	110234	191318	315500	319000	325000	350000	360000
N. Gas	electricity	3937500	4338330	335200	1202540	1683790	2278962	2647370	2808700	3286600	2770050
Renewable Energy	electricity	572220	572330	572350	572450	572600	572900	573000	573500	573700	573900
Oil Shale	electricity	1508540	1584000	1584000	1389300	1389300	1584500	1695282	1736665	2400298	2400298
Nuclear Energy	electricity	0	0	1541759	1541759	1541760	1541760	1541760	1541760	1541760	1541760
Biogas	electricity	6160	6160	6160	6160	7960	**7960**	7960	7960	7960	7960
Total (2)		**6134660**	**6611060**	**4149709**	**4822443**	**5833547**	**6919291**	**7700322**	**7916325**	**9087908**	**8609688**
Total (1+2)		**11729836**	**12409076**	**10158321**	**11044781**	**12271059**	**13579990**	**14588233**	**15029048**	**16433436**	**16195790**

Table A.1 continued: The actual and projected primary and final energy demand (TOE) for the period 2006-2040

TYPE	SECTOR	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1-LPG	Industry	18251	18744	19250	19769	20303	20851	21414	21993	22586	23196
	household	563170	578376	593992	608248	622846	636548	650552	662913	675508	688343
	agriculture	92124	94611	97165	99789	102483	105250	108092	111010	114008	117086
	commercial	58648	60155	61701	61701	61701	61701	61701	61701	61701	61701
Total		**732193**	**751885**	**772108**	**789507**	**807333**	**824351**	**841759**	**857617**	**873803**	**890326**
2-kerosene	Industry	1169	1177	1184	1192	1199	1205	1212	1215	1218	1221
	household	97046	97676	98311	98950	99494	100042	100592	100843	101096	101348
	agriculture	1754	1765	1777	1788	1798	1808	1818	1822	1827	1832
	commercial	12079	12158	12237	12316	12384	12452	12521	12552	12583	12615
Total		**112048**	**112776**	**113509**	**114247**	**114875**	**115507**	**116143**	**116433**	**116724**	**117016**
3-Diesel	Industry	479321	494659	510488	526824	542628	558907	575675	592945	610140	627834
	household	302622	312306	322300	332613	342592	352869	363456	374359	385216	396387
	agriculture	211226	217985	224961	232160	239124	246298	253687	261298	268875	276673
	commercial	152327	157201	162231	167423	172445	177619	182947	188436	193900	199524
	transport	2276774	2349630	2424818	2502413	2577485	2654810	2734454	2816488	2898166	2982212
Total		**3422269**	**3531782**	**3644799**	**3761432**	**3874275**	**3990503**	**4110218**	**4233525**	**4356297**	**4482630**
5-Gasoline	transport	2576818	2659276	2744373	2832193	2911495	2984282	3049936	3117035	3185610	3249322
6-Jet Fuel	transport	486459	502998	520100	537784	554455	571643	589364	607634	626471	645892
7-fuel oil	Industry	228141	233388	238756	244247	249865	255612	261491	267505	273658	279952
8-fuel oil (ref. cons)	refinery	255000	255000	255000	255000	255000	255000	255000	255000	255000	255000
Total (1)		**7812927**	**8047106**	**8288645**	**8534410**	**8767298**	**8996898**	**9223912**	**9454749**	**9687563**	**9920137**
Fuel Oil	electricity	983670	1008100	1041080	1071150	1092490	1116070	1107080	1117080	1127240	1129740
Diesel	electricity	365000	370500	385000	385000	401000	420000	435000	441000	441000	442000
N .Gas	electricity	2770050	2770050	2770050	2700500	2700500	2700500	2700500	2700500	2700500	2700500
Renewable Energy	electricity	574200	574600	574800	575100	575300	575600	575800	576000	576800	577200
Oil Shale	electricity	2400298	2758550	2758550	3460000	3460000	3460000	3570000	3570000	3570000	3570000
Nuclear Energy	electricity	1541760	1541760	1541760	1541760	1541760	1541760	1541760	1541760	1541760	1541760
Biogas	electricity	9800	9800	9800	9800	9800	**9800**	9800	9800	9800	9800
Total (2)		**8644778**	**9033360**	**9081040**	**9743310**	**9780850**	**9823730**	**9939940**	**9956140**	**9967100**	**9971000**
Total (1+2)		**16457705**	**17080466**	**17369685**	**18277720**	**18548148**	**18820628**	**19163852**	**19410889**	**19654663**	**19891137**

Table A.2: Electricity demand forecast, baseline scenario, 2006-2040

MEDIUM FORECAST

	GENERATED ENERGY	MAX.	GROWTH RATE %	LOAD
YEAR	GWH	DEMAND		FACTOR %
2006(Actual)	11226	1860	8.8%	68.9%
2007(Actual)	12875	2130	14.5%	69.0%
2008(Actual)	14124	2230	4.7%	72.3%
2009(Actual)	14391	2300	3.1%	71.4%
2010(Actual)	15175	2650	15.2%	65.4%
2011(Actual)	16170	2770	4.5%	66.6%
2012(Actual)	17204	2887	4.2%	68.0%
2013	18436	3014	4.4%	69.8%
2014	19787	3237	7.4%	69.8%
2015	21258	3458	6.8%	70.2%
2016	22816	3687	6.6%	70.6%
2017	24458	3926	6.5%	71.1%
2018	26209	4184	6.6%	71.5%
2019	28077	4461	6.6%	71.8%
2020	30059	4755	6.6%	72.2%
2021	32039	5053	6.3%	72.4%
2022	34056	5357	6.0%	72.6%
2023	36143	5671	5.9%	72.8%
2024	38337	5999	5.8%	73.0%
2025	40676	6349	5.8%	73.1%
2026	43079	6706	5.6%	73.3%
2027	45603	7080	5.6%	73.5%
2028	48293	7480	5.6%	73.7%
2029	51080	7891	5.5%	73.9%
2030	54013	8324	5.5%	74.1%
2031	56924	8753	5.2%	74.2%
2032	59773	9185	4.9%	74.4%
2033	61773	9627	4.8%	74.5%
2034	62373	10089	4.8%	74.7%
2035	62873	10553	4.6%	74.8%
2036	63173	11032	4.5%	74.9%
2037	63423	11531	4.5%	75.1%
2038	63673	12036	4.4%	75.2%
2039	63873	12548	4.2%	75.3%
2040	64073	13068	4.1%	75.5%

Table A.3: Actual and predicted annual growth rates (%) of population and GDP at constant price for the period (2007 – 2040)

Year	Population	GDP at constant price	Year	Population	GDP at constant price	Year	Population	GDP at constant price
2007	2.196	8.5	2019	1.984	3.7	2031	1.315	3.0
2008	2.219	7.6	2020	1.88	3.7	2032	1.315	3.0
2009	2.222	5.0	2021	1.776	3.7	2033	1.312	2.9
2010	2.224	2.3	2022	1.675	3.6	2034	1.307	2.9
2011	2.225	2.6	2023	1.58	3.5	2035	1.305	2.9
2012	2.224	2.7	2024	1.491	3.5	2036	1.25	2.9
2013	2.223	3.9	2025	1.407	3.5	2037	1.25	2.6
2014	2.458	3.9	2026	1.389	3.4	2038	1.25	2.6
2015	2.367	3.9	2027	1.37	3.4	2039	1.2	2.5
2016	2.276	3.8	2028	1.348	3.4	2040	1.2	2.5
2017	2.181	3.8	2029	1.323	3.2			
2018	2.085	3.7	2030	1.312	3.2			

Source of population growth data :Higher Council for Population

Table A.4: Domestic landfill sites in Jordan

No.	Site name	Operation date	Governorate	Site area (Dunum)	Quantity (ton/day)
1	Al-Ekader	1980	Irbid	987	1300
2	Husaineat	1986	Mafraq	380	190
3	North Badia	2001	Mafraq	360	70
4	Al-Hamra	1989	Al Salt	267	500
5	Al-Ghabawi	2003	Amman	1947	3000
6	Madaba	1973	Madaba	187	250
7	Dhulil	1991	Zarqa	270	250
8	North Ghor	1989	Irbid	81	100
9	Middle Ghor	1998	Al-Balqa	364	230
10	Ghor Al-Mazra'a	2000	Karak	205	60
11	Lajoon	1996	Karak	885	500
12	Ghor Al-Safi	1996	Karak	200	70
13	Tafilah	1991	Tafilah	454	200
14	Eyil Neimat	1983	Ma'an	274	50
15	Ma'an	1993	Ma'an	598	60
16	Al-Quaira	2000	Aqaba	100	30
17	Aqaba	2005	Aqaba	50	80

Source: Ministry of Municipal affairs letter addressed to MoEnv (No: H/28/9524) dated 2/4/2014

Table A.5: Actual and predicted amounts of generated domestic solid waste for the period (2007 – 2040)

Year	Population (capita)	MSW disposed to SWDS (Gg MSW)	Year	Population (capita)	MSW disposed to SWDS (Gg MSW)	Year	Population (capita)	MSW disposed to SWDS (Gg MSW)
2007	5723000	1,880.01	2019	7586859	2,492.28	2031	9265434	3,043.70
2008	5850000	1,921.73	2020	7737109	2,541.64	2032	9394440	3,086.07
2009	5980000	1,964.43	2021	7885069	2,590.25	2033	9521183	3,127.71
2010	6113000	2,008.12	2022	8030720	2,638.09	2034	9647191	3,169.10
2011	6249000	2,052.80	2023	8174268	2,685.25	2035	9767149	3,208.51
2012	6388000	2,098.46	2024	8315982	2,731.80	2036	9888118	3,248.25
2013	6530000	2,145.11	2025	8456140	2,777.84	2037	10009825	3,288.23
2014	6807835	2,236.37	2026	8594721	2,823.37	2038	10132127	3,328.40
2015	6971656	2,290.19	2027	8731549	2,868.31	2039	10254867	3,368.72
2016	7133294	2,343.29	2028	8867951	2,913.12	2040	10377007	3,408.85
2017	7289783	2,394.69	2029	9001860	2,957.11			
2018	7440785	2,444.30	2030	9134464	3,000.67			

Table A.6: Quantities of wastewater discharged to WWTPs (2006-2012)

Year	2006	2007	2008	2009	2010	2011	2012
	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day	m^3/day
Samra	224175	167190.3	70329	42874.1	20192	0	0
Samra Mech.		61356.7	152587	179407	210414.1	226674.6	240925.5
Aqaba Tertiary	7296	7630.2	8021	10101.8	9845.5	7980.2	8511.3
Aqaba Natural	6229	5515.9	6626	6663.8	6730.6	7001	7220.1
Irbid	6353.8	6363.7	6463.5	8259.9	8132.1	8635.1	8710.7
Salt	4321.9	4481.7	4483.6	4889.3	5290.7	5327	6539.2
Jerash	3312	3391.9	3121	3224.6	3680.8	4224.1	3333.2
Mafraq	1866.4	1990.8	2179	2234.9	2008.8	1915.2	1618.2
Baqa'a	10978	11713.9	10720	11086.3	10208.6	10627.2	11713.3
Karak	1618	1550.5	1205	1611.5	1753.4	1674.3	1852.2
Abu Nuseir	2309	2357.6	2341	2563.6	2570.8	2631.9	2400.6
Tafila	1012.6	1181.1	1167.5	1249.3	1380	1526.8	1575.4
Ramtha	3492	3392.6	3561	3546.6	3488.3	3857.5	4049.9
Ma'an	2644	2416.5	2325	2512.7	3170.8	2517.7	2357.8
Madaba	4584	4711.3	4883	4726.3	5172	5013.6	5259.6
Kufranja	3387	3930.5	2828.2	3518.3	2763	2079.1	2637.6
Wadi Al Seer	2718	3113	3426	3454	3623.8	3554.2	4052.8
Fuhis	1684	1791.6	1860	2056	2221	2036.4	2304.7
wadi Arab	9959.9	10701.4	9922	12190.9	10264	10136.6	10681.4
Wadi Mousa	1669.9	1984.3	2265.8	2508.8	3028.9	2519.4	2536.4
Wadi Hassan	1098.5	964.3	997.6	1049.7	1139.3	1131.8	1237.6
Tall-Almantah	274.1	290.3	298	301	300	321	365
ALekader	2872	3698.8	3376	3437	3907.8	3232.4	2932.4
AL- Lajjoun	502	518	566.3	743.1	853.1	738.4	734.7
AL -Jiza					703.9	569.1	623.9
Al- Maraad						853	2297.1
Shobak						67.2	67.3
AL- Mansourah						15	12.1
Total m^3/d	**306303.9**	**312236.9**	**314086**	**314210.8**	**322840.8**	**316533.8**	**3359924**
Total (MCM) m^3/Yr	**111.092**	**113.83**	**111.527**	**114.687**	**117.83**	**115.423**	**122.637**

Source: MWI annual report (2012)

Table A.7: Influent organic load to WWTPs (2012)

Plant	BOD5 (IN)mg/l
Jerash	1274
Kufranja	671.3
Irbid	685
Madaba	1143
Baqa'a	611
Wadi Hassan	1178
Salt	588.3
Ramtha	888
Fuhais	531
Samra	707
Karak	655
Mafraq	1100
Wadi Arab	904
Tafila	628.3
Wadi Mousa	309.5
Abu-Nusir	729.8
Ma'an	390.6
Wadi Al Seer	595.8
Aqaba Natural	481
Aqaba Tertiary	410
Tall - Almantah	1560
AL - Lajjoun	1500
Al- ekader	1500
AL_ Jiza	430

Source: MWI annual report 2012

Table A.8: Annual productions/extraction/import of the study relevant products and specific national indicators (2006 – 2013)

Year	Cement produced (tons)	Lime produced (tons)	Limestone extracted (tons)	Soda Ash imported (tons)	Nitric Acid produced (tons)	Population (Million)	GDP at constant price (million JD)
2006	4093713.53	2746.0	447537.0	2069.975	71595	5600000	7964.2
2007	4086544.57	12951.0	300450.0	2645.290	66632	5723000	8640.0
2008	4374801.92	15234.0	329782.0	1541.025	69748	5850000	9297.7
2009	3911574.21	7950.0	317154.9	2204.290	15814	5980000	9759.9
2010	2494770.40	14282.0	374539.5	2196.943	69743	6113000	9985.5
2011	3323634.47	16167.0	499681.9	4491.635	84281	6249000	10243.8
2012	2732737.18	11298.0	816519.4	2830.671	72377	6.39E+06	10515.3
2013	3168867.63	3693.0	Not Available	6132.445	71794	6530000	Not Available

Source: Companies annual reports

Table A.9: Annual growth of productions/extraction/import of the study relevant products and specific national indicators (2007 – 2013)

Year	Annual Growth (%)						
	Cement produced	Lime produced	Limestone extracted	Soda Ash imported	Nitric Acid produced	Population	GDP at constant price (million JD)
2007	-0.175	371.6315	-32.866	27.793	-6.932	2.196	8.5
2008	7.054	17.62798	9.763	-41.745	4.676	2.219	7.6
2009	-10.589	-47.8141	-3.829	43.041	-77.327	2.222	5.0
2010	-28.483	79.6478	18.094	-0.333	341.021	2.224	2.3
2011	62.788	13.19843	33.412	104.449	20.845	2.225	2.6
2012	-34.912	-30.1169	63.408	-36.979	-14.124	2.224	2.7
2013	23.102	-67.3128		116.643	-0.806	2.223	

Source: Companies annual reports

Table A.10: Projected productions/extraction/import of lime, limestone, soda ash and nitric acid for the period (2014 – 2040)

Year	Cement produced (ton)	Lime produced (ton)	Limestone extracted (ton)	Soda Ash imported (ton)	Nitric Acid produced (ton)
2014	3269606	10875.2	816519.4	3109.85	84000
2015	3372059	11216.0	842476.6	3207.298	84000
2016	3474502	11556.7	868875.6	3304.735	84000
2017	3578407	11902.3	895272	3403.563	90000
2018	3681913	12246.6	922045.1	3502.011	90000
2019	3786553	12594.6	948715.3	3601.539	90000
2020	3892197	12946.0	975677.7	3702.022	96000
2021	3998766	13300.5	1002899	3803.383	96000
2022	4104233	13651.3	1030359	3903.697	96000
2023	4208481	13998.0	1057534	4002.851	96000
2024	4313503	14347.4	1084396	4102.742	96000
2025	4419335	14699.4	1111457	4203.403	102000
2026	4525156	15051.3	1138726	4304.053	102000
2027	4633081	15410.3	1165993	4406.705	102000
2028	4743070	15776.2	1193802	4511.32	102000
2029	4850335	16132.9	1222143	4613.344	102000
2030	4959759	16496.9	1249782	4717.421	108000
2031	5066765	16852.8	1277977	4819.199	108000
2032	5176081	17216.4	1305549	4923.173	108000
2033	5285089	17579.0	1333716	5026.855	108000
2034	5396261	17948.8	1361804	5132.595	108000
2035	5509717	18326.1	1390450	5240.508	108000
2036	5624044	18706.4	1419684	5349.249	108000
2037	5732307	19066.5	1449143	5452.222	110000
2038	5842654	19433.5	1477039	5557.177	110000
2039	5950743	19793.1	1505472	5659.985	110000
2040	6060832	20159.2	1533323	5764.694	110000

Table A.11: Actual number of livestock in Jordan between (2007-2011)

Type	2007	2008	2009	2010	2011
Dairy Cattle	80.60	76.42	64.00	64.10	66.58
Non-dairy Cattle	2.40	1.34	9.30	1.24	7.10
Sheep	2251.45	2493.39	2070.94	2175.69	2200.00
Goats	569.38	1083.33	919.70	751.73	752.20
Camels	8.49	8.61	8.41	8.33	8.41
Horses	2.98	3.04	3.05	3.01	3.10
Mules & Asses	10.12	10.98	10.50	10.49	10.53
Swine	2.70	2.80	2.70	2.77	2.80
Poultry	172.05	175.49	176.21	176.90	179.12

Source: DOS Annual Reports

Table A.12: Projected number of livestock in Jordan between (2012-2040)

Year	Dairy Cattle	Non-dairy Cattle	Sheep	Goats	Camels	Horses	Mules & Asses	Swine	Poultry
2012	67.58	7.21	2233.00	763.48	8.54	3.15	10.69	2.84	181.81
2013	68.59	7.31	2266.50	774.94	8.66	3.19	10.85	2.88	184.53
2014	69.62	7.42	2300.49	786.56	8.79	3.24	11.01	2.93	187.30
2015	70.67	7.54	2335.00	798.36	8.93	3.29	11.18	2.97	190.11
2016	71.73	7.65	2370.02	810.33	9.06	3.34	11.34	3.02	192.96
2017	72.80	7.76	2405.58	822.49	9.20	3.39	11.51	3.06	195.86
2018	73.89	7.88	2441.66	834.83	9.33	3.44	11.69	3.11	198.80
2019	75.00	8.00	2478.28	847.35	9.47	3.49	11.86	3.15	201.78
2020	76.13	8.12	2515.46	860.06	9.62	3.54	12.04	3.20	204.80
2021	77.27	8.24	2553.19	872.96	9.76	3.60	12.22	3.25	207.88
2022	78.43	8.36	2591.49	886.05	9.91	3.65	12.40	3.30	210.99
2023	79.60	8.49	2630.36	899.34	10.06	3.71	12.59	3.35	214.16
2024	80.80	8.62	2669.82	912.83	10.21	3.76	12.78	3.40	217.37
2025	82.01	8.75	2709.86	926.53	10.36	3.82	12.97	3.45	220.63
2026	83.24	8.88	2750.51	940.42	10.51	3.88	13.16	3.50	223.94
2027	84.49	9.01	2791.77	954.53	10.67	3.93	13.36	3.55	227.30
2028	85.76	9.14	2833.64	968.85	10.83	3.99	13.56	3.61	230.71
2029	87.04	9.28	2876.15	983.38	10.99	4.05	13.77	3.66	234.17
2030	88.35	9.42	2919.29	998.13	11.16	4.11	13.97	3.72	237.68
2031	89.67	9.56	2963.08	1013.10	11.33	4.18	14.18	3.77	241.25
2032	91.02	9.71	3007.53	1028.30	11.50	4.24	14.40	3.83	244.87
2033	92.38	9.85	3052.64	1043.73	11.67	4.30	14.61	3.89	248.54
2034	93.77	10.00	3098.43	1059.38	11.84	4.37	14.83	3.94	252.27
2035	95.18	10.15	3144.91	1075.27	12.02	4.43	15.05	4.00	256.05
2036	96.60	10.30	3192.08	1091.40	12.20	4.50	15.28	4.06	259.89
2037	98.05	10.46	3239.96	1107.77	12.39	4.57	15.51	4.12	263.79
2038	99.52	10.61	3288.56	1124.39	12.57	4.63	15.74	4.19	267.75
2039	101.02	10.77	3337.89	1141.25	12.76	4.70	15.98	4.25	271.76
2040	102.53	10.93	3387.96	1158.37	12.95	4.77	16.22	4.31	275.84

Table A.13: Actual plant production (Gg) from various crops in Jordan between (2006-2011)

Year	2006	2007	2008	2009	2010	2011
Wheat	22.9	23.129	23.36029	23.710694	24.066355	24.307018
Barley	18.4	18.584	18.76984	19.051388	19.337158	19.53053
Clover trefoil	275.4	278.154	280.9355	285.14957	289.42682	292.32108
Lentil	0.3	0.303	0.30603	0.3106205	0.3152798	0.3184326
Vetch	1.1	1.111	1.12211	1.1389417	1.1560258	1.167586
Chick-Peas	1.7	1.717	1.73417	1.7601826	1.7865853	1.8044511
Maize and Sorghum	20.4	20.604	20.81004	21.122191	21.439023	21.653414
Olives	146.8	148.268	149.7507	151.99694	154.27689	155.81966
Palm	3.9	3.939	3.97839	4.0380659	4.0986368	4.1396232
Grapes	32.2	32.522	32.84722	33.339928	33.840027	34.178427
Almond	32	32.32	32.6432	33.132848	33.629841	33.966139
Potato	160	161.6	163.216	165.66424	168.1492	169.8307
Peas	3.25	3.2825	3.315325	3.3650549	3.4155307	3.449686
Bean	11.4	11.514	11.62914	11.803577	11.980631	12.100437

DOS Annual Reports

Table A.14: Projected plant production (Gg) from various crops in Jordan between (2012-2040)

Year	Wheat	Barley	Clover trefoil	Lentil	Vetch	Chick-Peas	Maize & Sorghum
2012	24.67	19.82	296.71	0.32	1.19	1.83	21.98
2013	25.04	20.12	301.16	0.33	1.20	1.86	22.31
2014	25.42	20.42	305.67	0.33	1.22	1.89	22.64
2015	25.80	20.73	310.26	0.34	1.24	1.92	22.98
2016	26.19	21.04	314.91	0.34	1.26	1.94	23.33
2017	26.58	21.36	319.64	0.35	1.28	1.97	23.68
2018	26.98	21.68	324.43	0.35	1.30	2.00	24.03
2019	27.38	22.00	329.30	0.36	1.32	2.03	24.39
2020	27.79	22.33	334.24	0.36	1.34	2.06	24.76
2021	28.21	22.67	339.25	0.37	1.36	2.09	25.13
2022	28.63	23.01	344.34	0.38	1.38	2.13	25.51
2023	29.06	23.35	349.50	0.38	1.40	2.16	25.89
2024	29.50	23.70	354.75	0.39	1.42	2.19	26.28
2025	29.94	24.06	360.07	0.39	1.44	2.22	26.67
2026	30.39	24.42	365.47	0.40	1.46	2.26	27.07
2027	30.85	24.78	370.95	0.40	1.48	2.29	27.48
2028	31.31	25.16	376.52	0.41	1.50	2.32	27.89
2029	31.78	25.53	382.16	0.42	1.53	2.36	28.31
2030	32.25	25.92	387.90	0.42	1.55	2.39	28.73
2031	32.74	26.30	393.71	0.43	1.57	2.43	29.16
2032	33.23	26.70	399.62	0.44	1.60	2.47	29.60
2033	33.73	27.10	405.61	0.44	1.62	2.50	30.05
2034	34.23	27.51	411.70	0.45	1.64	2.54	30.50
2035	34.75	27.92	417.87	0.46	1.67	2.58	30.95
2036	35.27	28.34	424.14	0.46	1.69	2.62	31.42
2037	35.80	28.76	430.50	0.47	1.72	2.66	31.89
2038	36.33	29.19	436.96	0.48	1.75	2.70	32.37
2039	36.88	29.63	443.52	0.48	1.77	2.74	32.85
2040	37.43	30.08	450.17	0.49	1.80	2.78	33.35

Table A.14: Projected plant production (Gg) from various crops in Jordan between (2012-2040)

Year	Olives	Palm	Grapes	Almond	Potato	Peas	Bean
2011	155.82	4.14	34.18	33.97	169.83	3.45	12.10
2012	158.16	4.20	34.69	34.48	172.38	3.50	12.28
2013	160.53	4.26	35.21	34.99	174.96	3.55	12.47
2014	162.94	4.33	35.74	35.52	177.59	3.61	12.65
2015	165.38	4.39	36.28	36.05	180.25	3.66	12.84
2016	167.86	4.46	36.82	36.59	182.96	3.72	13.04
2017	170.38	4.53	37.37	37.14	185.70	3.77	13.23
2018	172.94	4.59	37.93	37.70	188.49	3.83	13.43
2019	175.53	4.66	38.50	38.26	191.31	3.89	13.63
2020	178.16	4.73	39.08	38.84	194.18	3.94	13.84
2021	180.84	4.80	39.67	39.42	197.10	4.00	14.04
2022	183.55	4.88	40.26	40.01	200.05	4.06	14.25
2023	186.30	4.95	40.86	40.61	203.05	4.12	14.47
2024	189.10	5.02	41.48	41.22	206.10	4.19	14.68
2025	191.93	5.10	42.10	41.84	209.19	4.25	14.90
2026	194.81	5.18	42.73	42.47	212.33	4.31	15.13
2027	197.73	5.25	43.37	43.10	215.51	4.38	15.36
2028	200.70	5.33	44.02	43.75	218.75	4.44	15.59
2029	203.71	5.41	44.68	44.41	222.03	4.51	15.82
2030	206.77	5.49	45.35	45.07	225.36	4.58	16.06
2031	209.87	5.58	46.03	45.75	228.74	4.65	16.30
2032	213.01	5.66	46.72	46.43	232.17	4.72	16.54
2033	216.21	5.74	47.42	47.13	235.65	4.79	16.79
2034	219.45	5.83	48.14	47.84	239.19	4.86	17.04
2035	222.74	5.92	48.86	48.55	242.77	4.93	17.30
2036	226.09	6.01	49.59	49.28	246.42	5.01	17.56
2037	229.48	6.10	50.33	50.02	250.11	5.08	17.82
2038	232.92	6.19	51.09	50.77	253.86	5.16	18.09
2039	236.41	6.28	51.86	51.53	257.67	5.23	18.36
2040	239.96	6.37	52.63	52.31	261.54	5.31	18.63

Table A.15: Actual Quantities of Nitrogen applied in agriculture production process from various sources for the period between (2007-2011)

SOURCES OF NITROGEN (KG)	2007	2008	2009	2010	2011
Synthetic fertilizer	13538363	13606055	13742116	13810826	13879880
Animal waste	37360394	37920800	38489612	39066956	39652960
N-fixing crops	19688	19885	20084	20285	20487
Crop residue	23466515	23701180	23938191	24177573	24419349

Source : DOS Annual Reports & Ministry of Agriculture Annual Reports

Table A.16: Projected Quantities of Nitrogen applied in agriculture production process from various sources for the period between (2012-2040)

Year	SOURCES OF NITROGEN (KG)			
	Synthetic fertilizer	Animal waste	N-fixing crops	Crop residue
2012	14088078	40247755	20794.3	24785639
2013	14299399	40851471	21106.2	25157424
2014	14513890	41464243	21422.8	25534785
2015	14731599	42086207	21744.2	25917807
2016	14952573	42717500	22070.3	26306574
2017	15176861	43358262	22401.4	26701173
2018	15404514	44008636	22737.4	27101690
2019	15635582	44668766	23078.5	27508216
2020	15870116	45338797	23424.6	27920839
2021	16108167	46018879	23776	28339651
2022	16349790	46709162	24132.6	28764746
2023	16595037	47409800	24494.6	29196217
2024	16843962	48120947	24862	29634161
2025	17096622	48842761	25235	30078673
2026	17353071	49575402	25613.5	30529853
2027	17613367	50319033	25997.7	30987801
2028	17877568	51073819	26387.7	31452618
2029	18145731	51839926	26783.5	31924407
2030	18417917	52617525	27185.2	32403273
2031	18694186	53406788	27593	32889322
2032	18974599	54207890	28006.9	33382662
2033	19259218	55021008	28427	33883402
2034	19548106	55846323	28853.4	34391653
2035	19841327	56684018	29286.2	34907528
2036	20138947	57534278	29725.5	35431141
2037	20441032	58397293	30171.4	35962608
2038	20747647	59273252	30624	36502047
2039	21058862	60162351	31083.3	37049578
2040	21374745	61064786	31549.6	37605322

Table A.17: Area of natural and forest plantations & No. of non-forest trees in Jordan between (2006-2011)

Year		2006	2007	2008	2009	2010	2011
TREES TYPE		**AREA OF FOREST (KHA)**					
Natural	Evergreen oak & wild olive	20.4	20.4	20.4	20.4	20.4	20.4
	Deciduous oak	4.3	4.3	4.3	4.3	4.3	4.3
	Coniferous (pine and Juniper	8.8	8.8	8.8	8.8	8.8	8.8
	Mixed(oak and pine)	3	3	3	3	3	3
Plantations	Pine & Acacia	50.3	52.8	53	53.1	53.3	53.5
other (private)		10.7	10.9	11.1	11.15	11.2	11.25
NON-FOREST TREES		**NUMBER OF TREES (1000S OF TREES)**					
Olives		8598	6825.395	5977	8886	8674	8607
Grapes		2050	1538	1416	2238	2385	2250
Citrus		2013	1882	1848	2036	2070	2068
Banana		1500	1294	1444	1460	1460	1578
Pome		2823	1665	1623	1682	1521	1657
Stone fruit		1448	1808	1656	1867	2108	2103
Others		769	545	504	578	626	637

Source : DOS Annual Reports & Ministry of Agriculture Annual Reports

Table A.18: Projected areas of forest plantations & No. of non-forest trees in Jordan between (2012-2040)

Year	New Forest Plantations (Pine & Acacia)	Private Plantations	Olives	Grapes	Citrus	Banana	Pome	Stone fruit	Others *
2012	54.04	11.36	8736.11	2283.75	2099.02	1601.67	1681.86	2134.55	646.56
2013	54.58	11.48	8867.15	2318.01	2130.51	1625.70	1707.08	2166.56	656.25
2014	55.12	11.59	9000.15	2352.78	2162.46	1650.08	1732.69	2199.06	666.10
2015	55.67	11.71	9135.16	2388.07	2194.90	1674.83	1758.68	2232.05	676.09
2016	56.23	11.82	9272.18	2423.89	2227.82	1699.95	1785.06	2265.53	686.23
2017	56.79	11.94	9411.27	2460.25	2261.24	1725.45	1811.84	2299.51	696.52
2018	57.36	12.06	9552.44	2497.15	2295.16	1751.34	1839.01	2334.00	706.97
2019	57.93	12.18	9695.72	2534.61	2329.59	1777.61	1866.60	2369.01	717.58
2020	58.51	12.30	9841.16	2572.63	2364.53	1804.27	1894.60	2404.55	728.34
2021	59.10	12.43	9988.77	2611.22	2400.00	1831.33	1923.02	2440.62	739.26
2022	59.69	12.55	10138.61	2650.39	2436.00	1858.80	1951.86	2477.23	750.35
2023	60.29	12.68	10290.69	2690.14	2472.54	1886.69	1981.14	2514.39	761.61
2024	60.89	12.80	10445.05	2730.49	2509.63	1914.99	2010.86	2552.10	773.03
2025	61.50	12.93	10601.72	2771.45	2547.27	1943.71	2041.02	2590.38	784.63
2026	62.11	13.06	10760.75	2813.02	2585.48	1972.87	2071.63	2629.24	796.40
2027	62.73	13.19	10922.16	2855.22	2624.26	2002.46	2102.71	2668.68	808.34
2028	63.36	13.32	11085.99	2898.05	2663.63	2032.50	2134.25	2708.71	820.47
2029	63.99	13.46	11252.28	2941.52	2703.58	2062.98	2166.26	2749.34	832.78
2030	64.63	13.59	11421.07	2985.64	2744.13	2093.93	2198.76	2790.58	845.27
2031	65.28	13.73	11592.38	3030.42	2785.30	2125.34	2231.74	2832.44	857.95
2032	65.93	13.86	11766.27	3075.88	2827.08	2157.22	2265.21	2874.92	870.82
2033	66.59	14.00	11942.76	3122.02	2869.48	2189.58	2299.19	2918.05	883.88
2034	67.26	14.14	12121.90	3168.85	2912.52	2222.42	2333.68	2961.82	897.14
2035	67.93	14.28	12303.73	3216.38	2956.21	2255.76	2368.69	3006.24	910.59
2036	68.61	14.43	12488.29	3264.63	3000.55	2289.59	2404.22	3051.34	924.25
2037	69.30	14.57	12675.61	3313.60	3045.56	2323.94	2440.28	3097.11	938.12
2038	69.99	14.72	12865.75	3363.30	3091.25	2358.79	2476.88	3143.56	952.19
2039	70.69	14.86	13058.73	3413.75	3137.62	2394.18	2514.04	3190.72	966.47
2040	71.40	15.01	13254.61	3464.96	3184.68	2430.09	2551.75	3238.58	980.97

* FIGS, GUAVA, DATES AND POMEGRANATES

ENERGY - Baseline Emissions

Table A.19: GHG emissions of the baseline scenario for energy sector and its subsectors (ton)

Sector	Electricity								Total
GHG	NO_x	CO	NMVOC	METH	METH-CO_2eq	CO_2	N_2O	N_2O-CO_2eq	CO_2-EQ
2006	22339	5356	13	4	92	6516952	234	72540	6589584
2007	23811	6013	7	2	35	6822840	268	83080	6905955
2008	25644	6507	7	2	37	7295242	300	93000	7388279
2009	25900	6765	6	2	33	7200504	559	173290	7373827
2010	25407	6086	14	5	95	7438738	122	37820	7476653
2011	26023	4427	92	33	698	8592113	116	35960	8628771
2012	31438	4538	165	60	1262	10733770	111	34410	10769442
2013	36349	4682	227	83	1744	12659270	101	31310	12692324
2014	35284	4511	220	80	1689	12317110	97	30070	12348869
2015	32207	8253	15	5	98	9011578	414	128340	9140016
2016	31195	8212	15	5	98	8578180	433	134230	8712508
2017	31519	8297	15	5	98	8666191	438	135780	8802069
2018	31423	8252	68	24	506	10099540	423	131130	10231176
2019	30624	8042	67	24	496	9846603	412	127720	9974819
2020	32503	8972	156	54	1136	12430720	420	130200	12562056
2021	34574	9516	167	58	1220	13294240	447	138570	13434030
2022	37811	10368	174	61	1273	14364910	492	152520	14518703
2023	11491	3415	174	61	1273	7205927	116	35960	7243160
2024	13802	4027	170	59	1240	7716152	150	46500	7763892
2025	21923	5873	175	60	1268	10048310	208	64480	10114058
2026	29326	7485	198	69	1442	12569330	277	85870	12656642
2027	35029	8755	208	72	1520	14561740	322	99820	14663080
2028	36515	9124	214	74	1561	15097790	340	105400	15204751
2029	41992	10504	276	97	2040	18265350	401	124310	18391700
2030	38390	9513	277	98	2048	17309350	345	106950	17418348
2031	38679	9744	283	99	2075	17407950	345	106950	17516975
2032	39802	10000	317	111	2331	18632870	350	108500	18743701
2033	40275	10075	320	112	2358	18851760	351	108810	18962928
2034	40010	9981	320	112	2358	18796140	343	106330	18904828
2035	40335	10024	322	113	2369	18909840	344	106640	19018849
2036	40706	10072	323	113	2383	19039720	344	106640	19148743
2037	40756	10067	325	114	2393	19061020	350	108500	19171913
2038	40896	10086	325	114	2398	19109550	352	109120	19221068
2039	40985	10102	325	114	2398	19139430	357	110670	19252498
2040	41016	10106	325	114	2398	19150000	359	111290	19263688

Table A.19: continued, GHG emissions of the baseline scenario for energy sector and its subsectors (ton)

Sector	Transport								Total Transport
GHG	NO_x	CO	NMVOC	METH	METH-CO_2eq	CO_2	N_2O	N_2O-CO_2eq	CO_2-EQ
2006	58997	451255	48137	9132	191772	5830368	149	46047	6068188
2007	66178	563163	53443	9833	206485	6527787	165	51094	6785366
2008	65300	534309	52015	9840	206650	6415814	164	50716	6673180
2009	69545	619740	59206	10205	214310	6964779	171	53081	7232171
2010	71592	645139	64722	10544	221414	7297654	175	54176	7573244
2011	72391	665568	61896	10485	220184	7260804	177	55003	7535991
2012	77632	675792	63223	11463	240723	7681976	193	59706	7982405
2013	81011	707944	66067	11951	250967	8021013	201	62260	8334240
2014	84454	741618	68274	12426	260940	8343380	209	64926	8669246
2015	88135	776914	71353	12955	272054	8712154	218	67710	9051918
2016	91978	813898	74574	13507	283641	9097403	228	70612	9451656
2017	95812	851011	77818	14056	295181	9482751	237	73504	9851436
2018	99809	889813	81203	14628	307194	9884573	247	76517	10268284
2019	103975	930397	84739	15224	319701	10303730	257	79655	10703086
2020	108238	971087	88271	15837	332583	10729630	267	82882	11145095
2021	112546	1013444	91946	16451	345466	11163710	278	86121	11595297
2022	117030	1057650	95777	17088	358857	11615690	289	89491	12064038
2023	121695	1103800	99770	17751	372767	12086140	300	92994	12551901
2024	126453	1149863	103742	18431	387058	12562510	312	96587	13046155
2025	131247	1197737	107868	19109	401298	13046790	323	100180	13548268
2026	136228	1247608	112160	19813	416069	13550050	335	103909	14070028
2027	141296	1297210	116469	20536	431253	14060230	348	107725	14599208
2028	146279	1346183	120746	21246	446165	14563110	360	111467	15120742
2029	151440	1397008	125183	21981	461597	15084190	372	115342	15661129
2030	156783	1449753	129783	22741	477562	15623960	385	119353	16220875
2031	161772	1496123	133968	23469	492859	16124160	397	123141	16740160
2032	166921	1543964	138288	24221	508647	16640370	410	127047	17276064
2033	172235	1593342	142750	24997	524941	17173210	423	131080	17829231
2034	177719	1644300	147357	25798	541760	17723280	436	135241	18400281
2035	182886	1690501	151578	26563	557830	18237420	449	139193	18934443
2036	187995	1733189	155600	27338	574107	18740630	462	143149	19457886
2037	193036	1772054	159408	28124	590595	19231640	475	147101	19969336
2038	198253	1811833	163314	28938	607706	19738560	488	151203	20497468
2039	203422	1852340	167310	29741	624553	20245110	501	155239	21024901
2040	208614	1890299	171178	30563	641828	20748950	514	159340	21550118

Table A.19: continued, GHG emissions of the baseline scenario for energy sector and its subsectors (ton)

Sector	Industry								Total Industry
GHG	NO_x	CO	NMVOC	METH	METH-CO_2eq	CO_2	N_2O	N_2O-CO_2eq	CO_2-EQ
2006	38582	16941	4396	281	5910	2365075	41	12772	2383757
2007	35721	16657	4254	258	5411	2244808	43	13277	2263496
2008	33377	15209	3908	242	5081	2091557	38	11876	2108514
2009	31230	15576	3911	222	4665	2016087	42	13122	2033875
2010	28063	14497	3609	198	4158	1826698	40	12540	1843396
2011	26881	14761	3623	187	3926	1792514	43	13318	1809758
2012	24905	13237	3274	174	3663	1626142	38	11681	1641486
2013	19684	10692	2630	137	2886	1301911	31	9576	1314373
2014	20332	11102	2728	142	2977	1346870	32	9979	1359826
2015	21004	11529	2830	146	3071	1393706	34	10397	1407175
2016	21710	11974	2936	151	3170	1442604	35	10835	1456609
2017	22417	12418	3042	156	3270	1491639	36	11265	1506174
2018	23150	12879	3151	161	3373	1542349	38	11718	1557440
2019	23908	13358	3265	166	3479	1594946	39	12186	1610611
2020	24669	13850	3382	171	3586	1648163	41	12673	1664421
2021	25430	14338	3498	176	3692	1701219	42	13156	1718067
2022	26215	14843	3618	181	3801	1756088	44	13656	1773545
2023	27016	15364	3741	186	3913	1812324	46	14173	1830410
2024	27844	15905	3869	192	4028	1870385	47	14713	1889126
2025	28666	16438	3995	197	4142	1927847	49	15243	1947232
2026	29513	16990	4126	203	4260	1987205	51	15791	2007257
2027	30387	17561	4261	209	4382	2048455	53	16359	2069196
2028	31268	18124	4395	215	4505	2109768	55	16917	2131190
2029	32175	18707	4533	221	4632	2173052	56	17490	2195174
2030	33108	19308	4676	227	4762	2238151	58	18085	2260998
2031	34032	19897	4816	233	4891	2302414	60	18665	2325970
2032	34994	20505	4960	239	5027	2369177	62	19260	2393464
2033	35986	21134	5110	246	5166	2437984	64	19877	2463027
2034	37006	21782	5264	253	5309	2508831	66	20516	2534655
2035	38011	22412	5414	260	5450	2578023	68	21130	2604602
2036	39046	23061	5569	266	5596	2650041	70	21762	2677399
2037	40107	23729	5728	274	5745	2723533	72	22416	2751694
2038	41199	24417	5892	281	5898	2799142	74	23089	2828129
2039	42296	25104	6056	288	6053	2875042	77	23758	2904853
2040	43422	25810	6225	296	6211	2953056	79	24447	2983714

Table A.19: continued, GHG emissions of the baseline scenario for energy sector and its subsectors (ton)

Sector	Commercial								Total Commercial
GHG	NO_x	CO	NMVOC	METH	METH-CO_2eq	CO_2	N_2O	N_2O-CO_2eq	CO_2-EQ
2006	426	81	141	19	392	385109	63	19679	405180
2007	441	84	144	19	400	401146	66	20404	421951
2008	446	85	146	19	406	404680	67	20832	425917
2009	465	88	156	21	431	419324	69	21427	441182
2010	469	88	164	21	449	416610	69	21520	438579
2011	491	91	172	22	471	437265	71	21892	459628
2012	499	92	178	23	487	441738	71	22103	464328
2013	433	74	183	23	490	362444	51	15928	378861
2014	445	76	186	24	497	375730	54	16594	392821
2015	458	79	188	24	504	389510	56	17289	407303
2016	472	82	190	24	512	403927	58	18014	422453
2017	485	85	192	25	518	418336	60	18740	437594
2018	499	88	193	25	525	433111	63	19490	453126
2019	513	92	195	25	532	448451	65	20268	469251
2020	528	95	198	26	540	464428	68	21077	486045
2021	540	98	199	26	545	476719	71	21880	499143
2022	557	102	201	26	553	496461	73	22711	519725
2023	573	105	203	27	561	513298	76	23572	537431
2024	589	109	205	27	568	530711	79	24468	555747
2025	604	112	206	27	574	547643	82	25349	573566
2026	620	116	208	28	581	565151	85	26266	591999
2027	637	120	209	28	588	583296	88	27209	611093
2028	653	124	211	28	595	601203	91	28133	629930
2029	670	128	213	29	603	620188	94	29087	649878
2030	687	132	214	29	609	639183	97	30079	669872
2031	704	135	216	29	616	657666	100	31040	689322
2032	721	140	218	30	624	676931	103	32039	709593
2033	739	144	219	30	631	696617	107	33058	730306
2034	754	147	221	30	636	712715	110	34116	747466
2035	768	151	222	31	641	728373	113	35142	764156
2036	783	154	223	31	647	744397	117	36193	781236
2037	799	158	225	31	652	761007	120	37284	798943
2038	814	162	225	31	656	777841	124	38400	816896
2039	829	166	226	31	660	794675	127	39513	834847
2040	845	170	227	32	664	812092	131	40663	853419

Table A.19: continued, GHG emissions of the baseline scenario for energy sector and its subsectors (ton)

Sector	Household								Total Household
GHG	NO_x	CO	NMVOC	METH	METH-CO_2eq	CO_2	N_2O	N_2O-CO_2eq	CO_2-EQ
2006	3276	337	2509	338	7106	1871520	68	21080	1899706
2007	2982	324	2172	298	6254	1814746	65	20150	1841150
2008	2450	293	1618	233	4896	1646001	61	18910	1669807
2009	2623	306	1773	252	5283	1727130	63	19530	1751943
2010	1931	255	1119	171	3584	1449911	55	17050	1470545
2011	2113	278	1214	182	3821	1606569	58	17980	1628370
2012	2324	284	1466	209	4398	1645257	58	17980	1667635
2013	2310	280	1478	211	4439	1609780	58	17980	1632199
2014	2361	289	1494	215	4516	1660633	61	18910	1684059
2015	2413	299	1510	219	4594	1713241	63	19530	1737365
2016	2467	308	1527	223	4674	1767611	66	20460	1792745
2017	2522	318	1543	226	4755	1822782	68	21080	1848617
2018	2576	328	1558	230	4834	1878682	78	24180	1907696
2019	2632	338	1574	234	4914	1936345	80	24800	1966059
2020	2690	349	1589	238	4997	1995971	93	28830	2029798
2021	2746	359	1604	242	5077	2055162	97	30070	2090309
2022	2804	370	1618	246	5158	2116118	101	31310	2152586
2023	2863	381	1632	250	5241	2179028	104	32240	2216509
2024	2923	392	1647	254	5327	2242906	106	32860	2281093
2025	2981	403	1660	257	5407	2304472	109	33790	2343669
2026	3040	415	1673	261	5489	2368010	113	35030	2408529
2027	3100	426	1686	265	5574	2433455	118	36580	2475609
2028	3161	438	1700	269	5658	2499190	122	37820	2542668
2029	3224	450	1713	274	5744	2566890	133	41230	2613864
2030	3287	463	1726	278	5831	2636479	136	42160	2684470
2031	3351	475	1739	282	5917	2706214	140	43400	2755531
2032	3416	488	1752	286	6004	2778037	147	45570	2829611
2033	3483	501	1766	290	6094	2851885	151	46810	2904789
2034	3549	514	1779	295	6186	2923225	155	48050	2977461
2035	3612	526	1790	299	6269	2993929	158	48980	3049178
2036	3674	539	1802	303	6355	3063315	1262	391220	3460890
2037	3738	551	1813	307	6442	3134411	166	51460	3192313
2038	3796	564	1820	310	6519	3201382	170	52700	3260601
2039	3824	569	1825	311	6541	3235398	173	53630	3295569
2040	3854	574	1831	313	6564	3270118	177	54870	3331552

Table A.19: continued, GHG emissions of the baseline scenario for energy sector and its subsectors (ton)

Sector	Agriculture								Total Agriculture
GHG	NO_x	CO	NMVOC	METH	METH-CO_2eq	CO_2	N_2O	N_2O-CO_2eq	CO_2-EQ
2006	7631	1659	548	62	1303	448350	15	4650	454303
2007	7793	1694	560	63	1332	460941	16	4960	467233
2008	7032	1529	505	57	1203	419557	14	4340	425100
2009	6629	1441	476	54	1138	404345	14	4340	409823
2010	6342	1379	456	52	1088	390030	14	4340	395459
2011	6451	1403	463	53	1109	401867	14	4340	407316
2012	6396	1391	459	52	1099	399283	14	4340	404722
2013	6667	1449	479	55	1148	418471	14	4340	423960
2014	6985	1518	501	58	1214	495784	16	4960	501957
2015	7281	1583	522	61	1271	519616	17	5270	526158
2016	7885	1714	565	65	1374	554793	19	5890	562057
2017	8200	1782	588	68	1428	575517	18	5580	582526
2018	8527	1853	611	71	1485	596964	19	5890	604339
2019	8867	1927	636	73	1543	619124	20	6200	626867
2020	9202	2000	660	76	1601	641263	21	6510	649374
2021	9551	2076	685	79	1661	664051	22	6820	672532
2022	9913	2155	711	82	1724	687698	23	7130	696552
2023	10288	2236	738	85	1788	712130	25	7750	721669
2024	10658	2316	764	88	1852	736197	26	8060	746108
2025	10916	2374	785	88	1847	756233	27	8370	766450
2026	11436	2486	820	95	1986	786128	28	8680	796793
2027	11824	2570	848	98	2052	811209	29	8990	822252
2028	12225	2657	877	101	2121	837150	30	9300	848571
2029	12202	2652	875	101	2119	841878	30	9300	853298
2030	13044	2835	936	108	2262	890258	32	9920	902440
2031	13460	2926	966	111	2334	917425	33	10230	929989
2032	13890	3019	996	115	2408	945451	34	10540	958400
2033	14333	3115	1028	118	2484	974253	36	11160	987897
2034	14763	3209	1059	122	2558	1002658	38	11780	1016996
2035	15204	3305	1091	125	2634	1031702	39	12090	1046426
2036	15659	3404	1123	129	2713	1061731	40	12400	1076844
2037	16129	3506	1157	133	2794	1092608	41	12710	1108112
2038	16596	3607	1191	137	2874	1123592	42	13020	1139486
2039	17077	3712	1225	141	2957	1155434	43	13330	1171721
2040	17097	3716	1227	141	2963	1164307	43	13330	1180600

Table A.19: continued, GHG emissions of the baseline scenario for energy sector and its subsectors (ton)

Sector	Total Others* (CO_2-EQ)
2006	1305679
2007	1313448
2008	787620
2009	876557
2010	792282
2011	711352
2012	1341723
2013	1648409
2014	1004581
2015	973044
2016	941797
2017	926048
2018	907075
2019	889736
2020	869701
2021	851162
2022	832107
2023	812510
2024	793647
2025	591405
2026	753595
2027	732893
2028	711957
2029	710421
2030	667519
2031	646043
2032	622804
2033	596879
2034	577454
2035	554618
2036	190235
2037	505196
2038	480660
2039	454829
2040	446923

* Emissions from Refinery processes

* Consumptions for Fuel transportation

Table A.19: continued, GHG emissions of the baseline scenario for energy sector and its subsectors (ton)

Year	Emissions of all sectors by Gas								All CO_2-EQ
	NO_x	CO	NMVOC	METH	METH-CO_2eq	CO2	N_2O	N_2O-CO_2eq	
2006	133909	481002	5426942	10021	210439	18716790	578	179168	19106397
2007	139590	593309	5431778	10656	223782	19578950	632	195867	19998599
2008	129887	557766	5429071	9348	196314	19083430	641	198673	19478417
2009	134247	645249	5436514	10024	210514	19692440	698	216423	20119378
2010	129068	666595	5440953	9766	205086	19594490	615	190582	19990158
2011	129033	685189	5438305	9627	202170	20829550	482	149467	21181186
2012	145879	700714	5439962	12167	255502	23857510	512	158729	24271741
2013	152649	731920	5442635	12671	266086	25999420	512	158860	26424366
2014	149902	766732	5444965	13098	275059	25530370	503	155930	25961359
2015	151250	806210	5447958	13560	284769	22716100	781	242110	23242979
2016	154858	843612	5451303	14121	296545	22790630	815	252650	23339825
2017	159794	881268	5454671	14680	308274	23387650	834	258540	23954464
2018	164499	920500	5458236	15280	320886	25349400	835	258850	25929136
2019	168698	961366	5461902	15885	333579	25646450	840	260400	26240429
2020	175677	1003493	5465658	16538	347300	28790730	866	268460	29406490
2021	182889	1046895	5469477	17165	360460	30218290	909	281790	30860540
2022	191474	1092474	5473450	17815	374106	31882140	971	301010	32557256
2023	170699	1132207	5477584	18487	388220	25335340	613	190030	25913590
2024	178674	1179440	5481696	19176	402688	26466930	665	206150	27075768
2025	192365	1229683	5485961	19861	417088	29238160	740	229400	29884648
2026	205798	1281758	5490429	20586	432313	32595230	830	257300	33284843
2027	217525	1333217	5494899	21323	447791	35248400	894	277140	35973331
2028	224954	1383140	5499330	22046	462959	36438240	931	288610	37189809
2029	236583	1435943	5503983	22814	479094	40282960	1011	313410	41075464
2030	239342	1488316	5508742	23585	495292	40026670	976	302560	40824522
2031	245630	1535523	5513087	24326	510840	40784390	996	308760	41603990
2032	252951	1584246	5517599	25101	527117	42690010	1021	316510	43533637
2033	259818	1634345	5522230	25889	543677	43610840	1034	320540	44475057
2034	266144	1685876	5527009	26702	560741	44270730	1057	327670	45159141
2035	272722	1732766	5531392	27479	577052	45061040	1078	334180	45972272
2036	279319	1776169	5535585	28266	593583	45858960	1099	340690	46793233
2037	285556	1815714	5539566	29063	610327	46539980	1120	347200	47497507
2038	292082	1856217	5543644	29889	627678	47262610	1142	354020	48244308
2039	298486	1897436	5547810	30700	644708	47933670	1164	360840	48939218
2040	304886	1936117	5551852	31532	662174	48586380	1166	361460	49610014

WASTE - Baseline Emissions

Table A.20: PGHG emissions of the baseline scenario for waste sector (Gg CO_2 eq)

Year	CO_2 eq emissions in Gg			Total emissions in CO_2 eq Gg
	Landfills	Wastewater	Nitrous oxide	
2006	2796	320	129	3246
2007	2843	214	132	3190
2008	2754	0	135	2889
2009	2814	0	138	2952
2010	2876	0	141	3017
2011	2945	0	144	3089
2012	3015	0	147	3162
2013	3086	0	151	3237
2014	3139	0	157	3296
2015	3140	0	161	3301
2016	3233	0	165	3397
2017	3314	0	168	3482
2018	3386	0	172	3558
2019	3456	0	175	3631
2020	3524	0	179	3703
2021	3594	0	182	3775
2022	3658	0	185	3843
2023	3718	0	189	3907
2024	3777	0	192	3969
2025	3831	0	195	4026
2026	3886	0	198	4084
2027	3934	0	201	4135
2028	3989	0	205	4193
2029	4061	0	208	4268
2030	4154	0	211	4364
2031	4253	0	214	4467
2032	4351	0	217	4567
2033	4450	0	220	4670
2034	4546	0	223	4768
2035	4638	0	225	4863
2036	4731	0	228	4959
2037	4824	0	231	5055
2038	4902	0	234	5136
2039	4981	0	237	5218
2040	5059	0	239	5299

INDUSTRIAL PROCESSES - Baseline Emissions

Table A.21: GHG emissions of the baseline scenario for industrial processes sector (Gg)

Year	N_2O (Giga gram/year)	CO_2 (Giga gram/year)	CO_2eq (Giga gram /year)
2006	0.50	2241*	2550*
2007	0.47	1839	1984
2008	0.49	1973	2124
2009	0.11	1770	1804
2010	0.49	1214	1365
2011	0.59	1625	1808
2012	0.51	1514	1671
2013	0.50	1703	1858
2014	0.59	1761	1943
2015	0.59	1816	1998
2016	0.59	1871	2053
2017	0.63	1926	2121
2018	0.63	1982	2177
2019	0.63	2038	2233
2020	0.67	2094	2303
2021	0.67	2151	2360
2022	0.67	2207	2416
2023	0.67	2263	2472
2024	0.67	2320	2528
2025	0.71	2376	2598
2026	0.71	2433	2654
2027	0.71	2491	2712
2028	0.71	2550	2771
2029	0.71	2607	2829
2030	0.76	2665	2900
2031	0.76	2723	2957
2032	0.76	2781	3016
2033	0.76	2840	3074
2034	0.76	2900	3134
2035	0.76	2961	3195
2036	0.76	3021	3255
2037	0.77	3079	3318
2038	0.77	3138	3377
2039	0.77	3196	3435
2040	0.77	3242	3481

*Source: TNC Inventory 2006, in which N_2O is rounded to 1 Gg

AGRICULTURE AND LULUCF - Baseline Emissions

Table A.22: GHG emissions of the baseline scenario for agriculture and LULUCF sector (Gg)

Annual Emissions Agriculture	CH_4 Livestock (Fermentation +Manure)	CH_4 Agricultural residues	Total CH_4	Total CO_2eq from CH_4	N_2O- Indirect Soil emissions	N_2O- Direct Soil emissions	N_2O- Agricultural residues	Total N_2O	Total CO_2eq from N_2O	Total CO_2eq (Gg) for Agriculture
2007	0.0180	0.0810	0.0990	2.08	3.20	1.03	0.0007	4.23	1311.53	1313.60
2008	0.0180	0.0818	0.0998	2.10	3.23	1.04	0.0007	4.27	1323.04	1325.14
2009	0.0181	0.0821	0.1002	2.10	3.26	1.05	0.0007	4.31	1336.27	1338.38
2010	0.0182	0.0825	0.1006	2.11	3.30	1.06	0.0007	4.35	1349.64	1351.75
2011	0.0186	0.0827	0.1013	2.13	3.33	1.07	0.0008	4.40	1363.13	1365.26
2012	0.0189	0.0839	0.1028	2.16	3.38	1.08	0.0008	4.46	1383.58	1385.74
2013	0.0191	0.0852	0.1043	2.19	3.43	1.10	0.0008	4.53	1404.33	1406.53
2014	0.0194	0.0865	0.1059	2.22	3.43	1.12	0.0008	4.60	1425.40	1427.62
2015	0.0197	0.0878	0.1075	2.26	3.48	1.13	0.0008	4.67	1446.78	1449.04
2016	0.0200	0.0891	0.1091	2.29	3.48	1.15	0.0008	4.74	1468.48	1470.77
2017	0.0203	0.0904	0.1107	2.33	3.53	1.17	0.0008	4.81	1490.51	1492.83
2018	0.0206	0.0918	0.1124	2.36	3.53	1.18	0.0008	4.88	1512.87	1515.23
2019	0.0209	0.0931	0.1141	2.40	3.59	1.20	0.0009	4.95	1535.56	1537.96
2020	0.0212	0.0945	0.1158	2.43	3.59	1.22	0.0009	5.03	1558.59	1561.02
2021	0.0216	0.0960	0.1175	2.47	3.64	1.24	0.0009	5.10	1581.97	1584.44
2022	0.0219	0.0974	0.1193	2.50	3.64	1.26	0.0009	5.18	1605.70	1608.21
2023	0.0222	0.0989	0.1211	2.54	3.70	1.28	0.0009	5.26	1629.79	1632.33
2024	0.0225	0.1003	0.1229	2.58	3.70	1.29	0.0009	5.34	1654.23	1656.81
2025	0.0229	0.1018	0.1247	2.62	3.75	1.31	0.0009	5.42	1679.05	1681.67
2026	0.0232	0.1034	0.1266	2.66	3.75	1.33	0.0009	5.50	1704.23	1706.89
2027	0.0236	0.1049	0.1285	2.70	3.81	1.35	0.001	5.58	1729.80	1732.50
2028	0.0239	0.1065	0.1304	2.74	3.81	1.37	0.001	5.66	1755.74	1758.48
2029	0.0243	0.1081	0.1324	2.78	3.86	1.39	0.001	5.75	1782.08	1784.86
2030	0.0247	0.1097	0.1344	2.82	3.86	1.42	0.001	5.83	1808.81	1811.63
2031	0.0250	0.1114	0.1364	2.86	3.92	1.44	0.001	5.92	1835.94	1838.81
2032	0.0254	0.1130	0.1384	2.91	3.92	1.46	0.001	6.01	1863.48	1866.39
2033	0.0258	0.1147	0.1405	2.95	3.98	1.48	0.001	6.10	1891.43	1894.39
2034	0.0262	0.1164	0.1426	2.99	3.98	1.50	0.0011	6.19	1919.81	1922.80
2035	0.0266	0.1182	0.1448	3.04	4.04	1.52	0.0011	6.29	1948.60	1951.64
2036	0.0270	0.1200	0.1469	3.09	4.04	1.55	0.0011	6.38	1977.83	1980.92
2037	0.0274	0.1218	0.1491	3.13	4.10	1.57	0.0011	6.48	2007.50	2010.63
2038	0.0278	0.1236	0.1514	3.18	4.10	1.59	0.0011	6.57	2037.61	2040.79
2039	0.0282	0.1254	0.1536	3.23	4.16	1.62	0.0011	6.67	2068.18	2071.40
2040	0.0286	0.1273	0.1559	3.27	4.16	1.64	0.0012	6.77	2099.20	2102.47

Emissions LULUCF	Changes in forest and other woody biomass stock	CO_2 Emissions by Soil from Land-Use Change and Management	Total CO_2 (Gg) for LULUCF
2007	415.54	1283.33	867.79
2008	414.42	1283.33	868.91
2009	428.88	1283.33	854.45
2010	430.53	1283.33	852.80
2011	432.42	1283.33	850.91
2012	436.74	1650.00	1213.26
2013	441.11	1650.00	1208.89
2014	445.52	1650.00	1204.48
2015	449.97	1650.00	1200.03
2016	454.47	1650.00	1195.53
2017	459.02	1650.00	1190.98
2018	463.61	1650.00	1186.39
2019	468.25	1650.00	1181.75
2020	472.93	1650.00	1177.07
2021	477.66	1650.00	1172.34
2022	482.43	1650.00	1167.57
2023	487.26	1650.00	1162.74
2024	492.13	1650.00	1157.87
2025	497.05	1650.00	1152.95
2026	502.02	1650.00	1147.98
2027	507.04	1650.00	1142.96
2028	512.11	1650.00	1137.89
2029	517.23	1650.00	1132.77
2030	522.41	1650.00	1127.59
2031	527.63	1650.00	1122.37
2032	532.91	1650.00	1117.09
2033	538.24	1650.00	1111.76
2034	543.62	1650.00	1106.38
2035	549.05	1650.00	1100.95
2036	554.54	1650.00	1095.46
2037	560.09	1650.00	1089.91
2038	565.69	1650.00	1084.31
2039	571.35	1650.00	1078.65
2040	577.06	1650.00	1072.94

OVERALL BASELINE SCENARIO FOR JORDAN FOR THE PERIOD (2007-2040)

Table A.23: Overall GHG emissions of the baseline scenario for Jordan for (2007-2040), (Gg)

Year	Baseline for all sectors- CO_2eq (Gg)					Net for all sectors
	PE	IP	Waste	LULUCF	Agriculture	
2007	19998.60	1984.00	3190.00	867.79	1313.6	27353.99
2008	19478.42	2124.00	2889.00	868.91	1325.14	26685.47
2009	20119.38	1804.00	2952.00	854.45	1338.38	27068.21
2010	19990.16	1365.00	3017.00	852.80	1351.75	26576.71
2011	21181.19	1808.00	3089.00	850.91	1365.26	28294.36
2012	24271.74	1671.00	3162.00	1213.26	1385.74	31703.74
2013	26424.37	1858.00	3237.00	1208.89	1406.53	34134.79
2014	25961.36	1943.00	3296.00	1204.48	1427.62	33832.46
2015	23242.98	1998.00	3301.00	1200.03	1449.04	31191.05
2016	23339.83	2053.00	3397.00	1195.53	1470.77	31456.13
2017	23954.46	2121.00	3482.00	1190.98	1492.83	32241.27
2018	25929.14	2177.00	3558.00	1186.39	1515.23	34365.76
2019	26240.43	2233.00	3631.00	1181.75	1537.96	34824.14
2020	29406.49	2303.00	3703.00	1177.07	1561.02	38150.58
2021	30860.54	2360.00	3775.00	1172.34	1584.44	39752.32
2022	32557.26	2416.00	3843.00	1167.57	1608.21	41592.04
2023	25913.59	2472.00	3907.00	1162.74	1632.33	35087.66
2024	27075.77	2528.00	3969.00	1157.87	1656.81	36387.45
2025	29884.65	2598.00	4026.00	1152.95	1681.67	39343.27
2026	33284.84	2654.00	4084.00	1147.98	1706.89	42877.71
2027	35973.33	2712.00	4135.00	1142.96	1732.5	45695.79
2028	37189.81	2771.00	4193.00	1137.89	1758.48	47050.18
2029	41075.46	2829.00	4268.00	1132.77	1784.86	51090.09
2030	40824.52	2900.00	4364.00	1127.59	1811.63	51027.74
2031	41603.99	2957.00	4467.00	1122.37	1838.81	51989.17
2032	43533.64	3016.00	4567.00	1117.09	1866.39	54100.12
2033	44475.06	3074.00	4670.00	1111.76	1894.39	55225.21
2034	45159.14	3134.00	4768.00	1106.38	1922.8	56090.32
2035	45972.27	3195.00	4863.00	1100.95	1951.64	57082.86
2036	46793.23	3255.00	4959.00	1095.46	1980.92	58083.61
2037	47497.51	3318.00	5055.00	1089.91	2010.63	58971.05
2038	48244.31	3377.00	5136.00	1084.31	2040.79	59882.41
2039	48939.22	3435.00	5218.00	1078.65	2071.4	60742.27
2040	49610.01	3481.00	5299.00	1072.94	2102.47	61565.42

MITIGATION ENERGY

Table A.24: Primary Energy Projects

Year	Loss Reduction in Electricity Transmission and Distribution T&D	Improving Combustion Efficiency in Rehab Power Plant	Combined Cycle Gas Turbine in Risha Plant	Distribution Network of Natural Gas in Aqaba	Demand Side Management	SECOND NUCLEAR POWER PLANT PROJECT
2015	67					
2016	215					
2017	381	27		48	57	
2018	573	27		66	57	
2019	784	27	213	74	57	
2020	1030	27	213	82	114	
2021	1094	27	213	93	114	
2022	1175	27	213	101	114	
2023	1260	27	213	105	426	
2024	1328	27	213	113	426	
2025	1444	27	213	118	426	4050
2026	1444	27	213	119	426	4050
2027	1444	27	213	123	426	4050
2028	1444	27	213	127	426	4050
2029	1444	27	213	131	426	4050
2030	1444	27	213	134	426	4050
2031	1444	27	213	138	426	4050
2032	1444	27	213	142	426	4050
2033	1444	27	213	146	426	4050
2034	1444	27	213	151	426	4050
2035	1444	27	213	155	426	4050
2036	1444	27	213	160	426	4050
2037	1444	27	213	164	426	4050
2038	1444	27	213	169	426	4050
2039	1444	27	213	174	426	4050
2040	1444	27	213	179	426	4050

Table A.25: Energy Efficiency Projects

Year	Ton CO_2							Net Reduction (Ton)	Net Reduction (Gg)
	P1: Ceramic Factories	P2: condensate	P3: insulating Pipes	P4: Replacing lamps	P5: insulating houses walls	P6: Street lighting	P7: regenerative burners		
2017	400.25	0	0	4877	8,534	0	0	13811.25	13.811
2018	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2019	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2020	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2021	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2022	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2023	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2024	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2025	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2026	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2027	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2028	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2029	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2030	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2031	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2032	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2033	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2034	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2035	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2036	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2037	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2038	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2039	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656
2040	400.25	727.63	776.52	4877	8,534	26,954	7,387	49656.4	49.656

Table A.26: Renewable Energy Projects

Year	150 MW Wind Farm	100 MW CSP	PV 1-200 MW	PV 2- 200 MW	300 MW CSP	Biogas power plant- 15 MW	Solar Water Heaters 1-30000 houses	Solar Water Heaters 2-30000 houses	Solar Water Heaters 3-30000 houses	Total CO_2 Emission Reduction
	(Gg)									
2016			176				81			257
2017			176				81			257
2018	198		176	176		17	81	81		730
2019	198	137	176	176		17	81	81		867
2020	198	137	176	176		17	81	81	81	948
2021	198	137	176	176		17	81	81	81	948
2022	198	137	176	176		17	81	81	81	948
2023	198	137	176	176	412	17	81	81	81	1,360
2024	198	137	176	176	412	17	81	81	81	1,360
2025	198	137	176	176	412	17	81	81	81	1,360
2026	198	137	176	176	412	17	81	81	81	1,360
2027	198	137	176	176	412	17	81	81	81	1,360
2028	198	137	176	176	412	17	81	81	81	1,360
2029	198	137	176	176	412	17	81	81	81	1,360
2030	198	137	176	176	412	17	81	81	81	1,360
2031	198	137	176	176	412	17	0	81	81	1,279
2032	198	137	176	176	412	17	0	81	81	1,279
2033	198	137	176	176	412	17	0	0	81	1,199
2034	198	137	176	176	412	17	0	0	81	1,199
2035	198	137	176	176	412	17	0	0	0	1,118
2036	198	137	176	176	412	17	0	0	0	1,118
2037	198	137	176	176	412	17	0	0	0	1,118
2038	198	137	176	176	412	17	0	0	0	1,118
2039	198	137	176	176	412	17	0	0	0	1,118
2040	198	137	176	176	412	17	0	0	0	1,118

Table A.27: Transport Projects

Year	Annual Emission Reduction by Hybrid cars Project (000) Ton CO_2	Annual Emission Reduction by Amman-Zarqa BRT Project (000) Ton CO_2	Total Annual Emission Reduction (000) Ton CO_2
2015	20.4	0	20.4
2016	41.1	85.8	126.9
2017	61.7	87.5	149.2
2018	82.2	89.3	171.5
2019	102.8	91.1	193.9
2020	123.3	92.9	216.2
2021	143.9	94.7	238.6
2022	164.4	96.6	261
2023	185	98.6	283.6
2024	205.5	100.5	306
2025	207.6	102.5	310.1
2026	209.6	104.6	314.2
2027	211.7	106.7	318.4
2028	213.8	108.8	322.6
2029	216	111	327
2030	218.1	113.2	331.3
2031	220.3	115.5	335.8
2032	222.5	117.8	340.3
2033	224.8	120.1	344.9
2034	227	122.5	349.5
2035	229.3	125	354.3
2036	231.6	127.5	359.1
2037	233.9	130	363.9
2038	236.2	132.6	368.8
2039	238.6	135.3	373.9
2040	241	138	379

MITIGATION- INDUSTRIAL PROCESSES

Table A.28: Industrial Processes Projects

Year	Use of steel slag and/ or fly ash to substitute the raw materials needed to produce clinker (Gg/year)	Increase the percentage of Pozzolana in CEM II (Gg/year)	Produce new cement product CEM IV with 45% of Pozzolana (Gg/year)	Use of biomass (MSW or/ and Sewage Sludge) as alternative fuels (Gg/year)	Catalytic Reduction of N_2O inside the Ammonia Burner of the Nitric Acid Plant		Total CO_2eq reduction (Gg/year)
2014	0	0	0	0	0	0	0
2015	0	19.4	0	0	0	0	19.4
2016	13.3	20	0	80.3	0.441	136.7	250.3
2017	13.7	20.6	0	82.7	0.473	146.5	263.5
2018	14.1	21.2	18.4	85.1	0.473	146.5	266.9
2019	14.5	21.8	18.9	87.5	0.473	146.5	289.2
2020	14.9	22.4	19.4	89.9	0.504	156.2	302.9
2021	15.3	23.1	20	92.4	0.504	156.2	306.9
2022	15.7	23.7	20.5	94.8	0.504	156.2	310.8
2023	16.1	24.3	21	97.2	0.504	156.2	314.8
2024	16.5	24.9	21.5	99.6	0.504	156.2	318.7
2025	16.9	25.5	22	102.1	0.536	166	332.5
2026	17.3	26.1	22.6	104.5	0.536	166	336.5
2027	17.7	26.7	23.1	107	0.536	166	340.5
2028	18.1	27.4	23.7	109.6	0.536	166	344.7
2029	18.5	28	24.2	112	0.536	166	348.7
2030	18.9	28.6	24.7	114.6	0.567	175.8	362.6
2031	19.3	29.2	25.3	117	0.567	175.8	366.6
2032	19.8	29.8	25.8	119.6	0.567	175.8	370.9
2033	20.2	30.5	26.4	122.1	0.567	175.8	374.9
2034	20.6	31.1	26.9	124.7	0.567	175.8	379.1
2035	21	31.8	27.5	127.3	0.567	175.8	383.4
2036	21.5	32.4	28.1	129.9	0.567	175.8	387.7
2037	21.9	33.1	28.6	132.4	0.578	179	395
2038	22.3	33.7	29.2	135	0.578	179	399.1
2039	22.7	34.3	29.7	137.5	0.578	179	403.2
2040	23.1	35	30.2	140	0.578	179	407.3

MITIGATION- AGRICULTURE & LULUCF

Table A.29: Agriculture & LULUCF Projects

Year	Forestry		Rangeland		climate-smart Project	Net annual reductions from projects (Ton CO_2)	Reductions in Gg
	Urban	North	P1	P2			
2015	136.5	234	439.2	732	1908	3449.7	3.4497
2016	136.5	429	878.4	1464	1908	4815.9	4.8159
2017	136.5	624	878.4	1464	1908	5010.9	5.0109
2018	136.5	819	878.4	1464	1908	5205.9	5.2059
2019	136.5	1014	878.4	1464	1908	5400.9	5.4009
2020	136.5	1014	878.4	1464		3492.9	3.4929
2021	136.5	1014	878.4	1464		3492.9	3.4929
2022	136.5	1014	878.4	1464		3492.9	3.4929
2023	136.5	1014	878.4	1464		3492.9	3.4929
2024	136.5	1014	878.4	1464		3492.9	3.4929
2025	136.5	1014	878.4	1464		3492.9	3.4929
2026	136.5	1014	878.4	1464		3492.9	3.4929
2027	136.5	1014	878.4	1464		3492.9	3.4929
2028	136.5	1014	878.4	1464		3492.9	3.4929
2029	136.5	1014	878.4	1464		3492.9	3.4929
2030	136.5	1014				1150.5	1.1505
2031	136.5	1014				1150.5	1.1505
2032	136.5	1014				1150.5	1.1505
2033	136.5	1014				1150.5	1.1505
2034	136.5	1014				1150.5	1.1505

Table A.30: MITIGATION- WASTE SECTOR

Year	Project Name										Total
	Dulail landfill	Al Ekadar landfill	AlSalt landfill	KarK landfill	Madabba landfill	Baga'a WWTP	Maddaba WWTP	Ramtha WWTP	Salt WWTP	Wadi Arab WWTP	
2015	0	0	0	0	0	0	0	0	0	0	0
2016	54,988	265,187	109,975	109,975	54,988	19,317	14,081	9,169	10,551	19,637	667,868
2017	56,197	271,021	112,395	112,395	56,197	20,302	14,869	9,866	10,910	20,658	684,811
2018	57,434	276,984	114,867	114,867	57,434	21,337	15,702	10,616	11,281	21,732	702,254
2019	58,697	283,077	117,395	117,395	58,697	22,425	16,581	11,423	11,664	22,862	720,217
2020	59,989	289,305	119,977	119,977	59,989	23,569	17,510	12,291	12,061	24,051	738,719
2021	61,308	295,670	122,617	122,617	61,308	24,771	18,491	13,225	12,471	25,302	757,780
2022	62,657	302,174	125,314	125,314	62,657	26,034	19,526	14,230	12,895	26,618	777,421
2023	64,036	308,822	128,071	128,071	64,036	27,362	20,619	15,312	13,334	28,002	797,664
2024	65,444	315,616	130,889	130,889	65,444	28,757	21,774	16,476	13,787	29,458	818,535
2025	66,884	322,560	133,768	133,768	66,884	30,224	22,994	17,728	14,256	30,990	840,055
2026	68,356	329,656	136,711	136,711	68,356	31,766	24,281	19,075	14,740	32,601	862,253
2027	69,859	336,909	139,719	139,719	69,859	33,386	25,641	20,525	15,242	34,296	885,154
2028	71,396	344,321	142,793	142,793	71,396	35,088	27,077	22,085	15,760	36,080	908,788
2029	72,967	351,896	145,934	145,934	72,967	36,878	28,593	23,763	16,296	37,956	933,183
2030	74,572	359,637	149,145	149,145	74,572	38,759	30,194	25,569	16,850	39,930	958,372
2031	76,213	367,549	152,426	152,426	76,213	40,735	31,885	27,512	17,422	42,006	984,388
2032	77,890	375,636	155,779	155,779	77,890	42,813	33,671	29,603	18,015	44,190	1,011,265
2033	79,603	383,899	159,206	159,206	79,603	44,996	35,556	31,853	18,627	46,488	1,039,040
2034	81,354	392,345	162,709	162,709	81,354	47,291	36,049	34,274	19,261	48,905	1,066,252
2035	83,144	400,977	166,288	166,288	83,144	49,703	36,049	36,049	19,916	51,449	1,093,007
2036	84,973	409,798	169,947	169,947	84,973	52,238	36,049	36,049	20,593	54,124	1,118,691
2037	86,843	418,814	173,686	173,686	86,843	54,902	36,049	36,049	191,636	56,938	1,315,445
2038	88,753	428,028	177,507	177,507	88,753	57,702	36,049	36,049	22,017	59,899	1,172,264
2039	90,706	437,444	181,412	181,412	90,706	60,645	36,049	36,049	22,765	63,014	1,200,202
2040	92,701	447,068	181,412	181,412	92,701	63,737	36,049	36,049	23,539	66,291	1,220,960

Table A.31: Baseline and mitigation scenario and net reductions from all sectors

Year	Baseline Scenario emissions for all sectors- CO_2eq (Gg)	Mitigation Scenario emissions for all sectors- CO_2eq (Gg)	Net Reductions from Mitigation projects for all sectors- CO_2eq (Gg)	Reduction %
2015	31191.05	31089.92	101.13	0.3
2016	31456.13	29964.50	1491.63	4.7
2017	32241.27	30412.30	1828.98	5.7
2018	34365.76	31801.50	2564.26	7.5
2019	34824.14	31687.37	3136.77	9.0
2020	38150.58	34612.58	3538.00	9.3
2021	39752.32	36102.89	3649.43	9.2
2022	41592.04	37818.61	3773.43	9.1
2023	35087.66	30509.82	4577.84	13.0
2024	36387.45	31695.61	4691.84	12.9
2025	39343.27	34507.36	4835.91	12.3
2026	42877.71	38010.90	4866.81	11.4
2027	45695.79	40793.18	4902.61	10.7
2028	47050.18	42111.90	4938.28	10.5
2029	51090.09	46115.34	4974.76	9.7
2030	51027.74	46008.15	5019.59	9.8
2031	51989.17	47012.17	4977.00	9.6
2032	54100.12	49083.43	5016.69	9.3
2033	55225.21	50248.02	4977.19	9.0
2034	56090.32	51072.87	5017.45	8.9
2035	57082.86	52107.34	4975.52	8.7
2036	58083.61	53068.81	5014.80	8.6
2037	58971.05	53742.77	5228.28	8.9
2038	59882.41	54783.55	5098.86	8.5
2039	60742.27	55601.37	5140.89	8.5
2040	61565.42	56389.53	5175.89	8.4

Table A.31: Proposed Mitigation Projects ranked from the highest GHG reduction cost (JD/ton CO_2 eq) to the lowest cost

No.	Project Description	Cost of reduction
1	Rangeland2- New Protected Rangeland Area As Natural Reserve	1922
2	Rangeland1- restoration of Rangeland Areas	1356
3	Reduction by Amman – Zarqa Bus Rapid Transit (BRT)	215.66
4	Reduction by using hybrid cars for public passengers	200.77
5	RE: Biogas Power Plant- 15 MW	58.01
6	Forestry- Introduce new plantations in Northern Area	58
7	Forestry- Introduce new plantations in Urban Areas	56
8	Biogas generation by utilizing the sludge generated from Ramtha domestic wastewater treatment plant	15.47
9	Biogas generation by utilizing the sludge generated from Wadi Arab domestic wastewater treatment plant	13.81
10	Biogas generation by utilizing the sludge generated from Salt domestic wastewater treatment plant	8.49
11	Biogas generation by utilizing the sludge generated from Baqa'a tertiary domestic wastewater treatment plant	8.23
12	Biogas generation by utilizing the sludge generated from Madaba domestic wastewater treatment plant	7.32
13	RE: 100 MW Concentrated Solar Power (CSP)	6.24
14	IP: Catalytic Reduction of N_2O inside the Ammonia Burner of the Nitric Acid Plant	0.9
15	Waste: Biogas collection and utilization from Al-Ekader domestic solid waste landfill	-0.2
16	Biogas collection and utilization from Maddaba domestic solid waste landfill	-0.2
17	Waste: Biogas collection and utilization from Al-Dhulil domestic solid waste landfill	-3.7
18	Biogas collection and utilization from Al-Salt (Hamra) domestic solid waste landfill	-3.95
19	Biogas collection and utilization from Al-Karak domestic solid waste landfill	-3.95
20	PE: Distribution Network of Natural Gas in Aqaba	-5.46
21	IP: Use of steel slag and/or fly ash to substitute the raw materials needed to produce clinker	-12.4
22	RE: Photo Voltaic (PV) 1-200 MW	-13.01
23	IP: Increase the percentage of Pozzolana in CEM II cement	-23.9
24	IP: Produce new cement product CEM IV with 45% of Pozzolana	-24
25	PE: Combined Cycle Gas Turbine in Risha Plant	-19.48
26	PE: Demand Side Management/ introduce actions to reduce overall energy consumption.	-21.31
27	PE: Improving Combustion Efficiency in Rehab Power Plant	-27.94

No.	Project Description	Cost of reduction
28	RE: 150 MW Wind Farm	- 45.7
29	PE: Loss Reduction in Electricity Transmission and Distribution (T&D)	-40.74
30	RE: 300 MW Concentrated Solar Power (CSP)	- 61.98
31	IP: Use of biomass (MSW or/and Sewage Sludge) as alternative fuels	-63.1
32	RE: Photo Voltaic (PV) 2- 200 MW	- 66.09
33	EE: Using Regenerative burners instead of conventional burners in Steel Reheating Industry	-95.56
34	RE: Solar Water Heaters 1-30000 Houses	-104.83
35	Solar Water Heaters2-30000 Houses	-107.01
36	RE: Solar Water Heaters 3-30000 Houses	-109.18
37	EE: Returning Un-returned condensate to the feed water tanks in Food Industry	-124.7
38	EE: Street Lighting: Replacing 125 W Mercury lamps with 70 W high Pressure Sodium lamps	-132.44
39	EE: Replacing Fluorescent lamps fixtures with LED lamps fixtures in commercial buildings	-189.65
40	EE: Replacing High Thermal Mass with Low Thermal Mass (LTM) in Ceramic factories	-229.73
41	EE: Insulating the Un-insulated pipes, fittings and tanks in food industries	-254.09
42	EE: Insulating walls and roofs in 35000 new houses.	-274.77
43	Promoting for Climate-smart agricultural practices in the Jordan Valley	-1335

APPENDIX A: FIGURES

Figure A.1: CO_2 emissions from Electricity

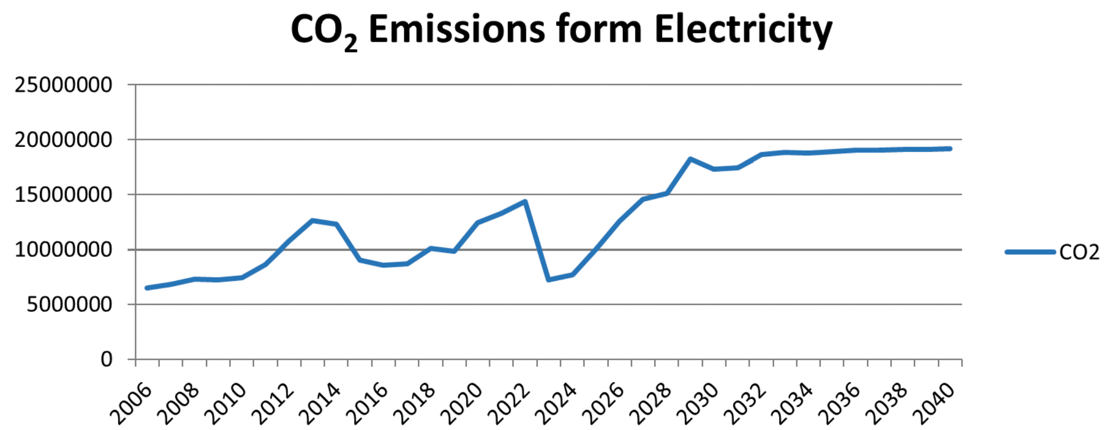


Figure A.2: CO_2 emissions from Transport

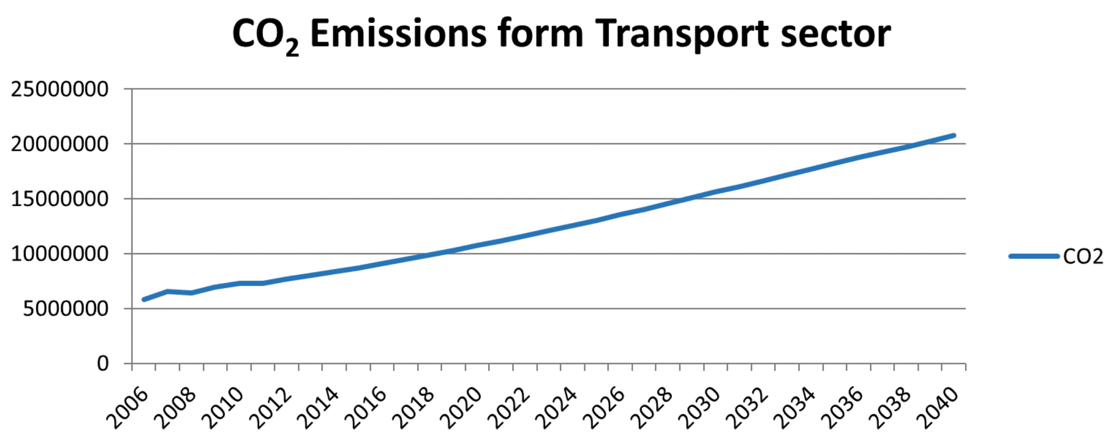


Figure A.3: Overall CO_2 emissions from Energy Sector

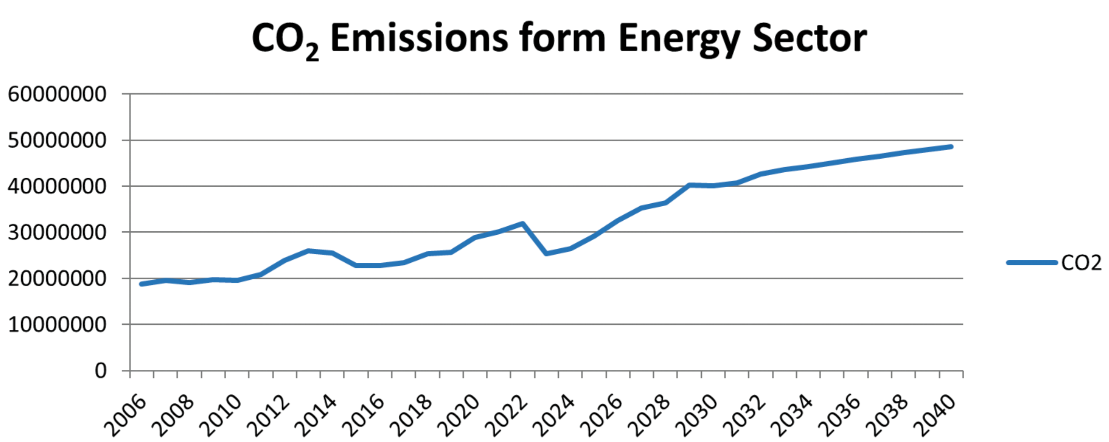


Figure A.4: Primary energy mix for the years 2013, 2020, 2030

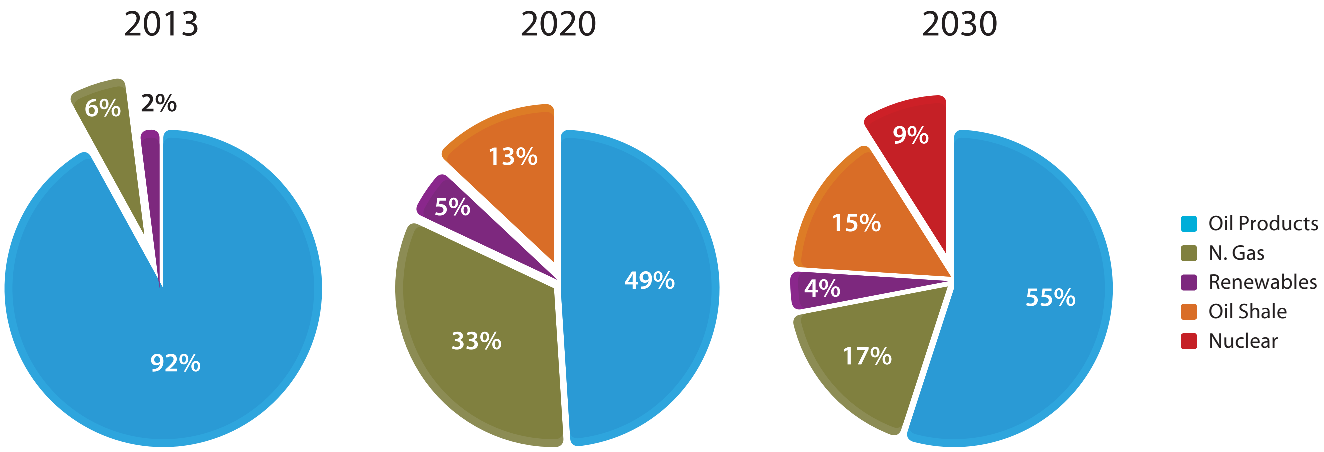


Figure A.5: The contribution of all types of energy in electricity generation

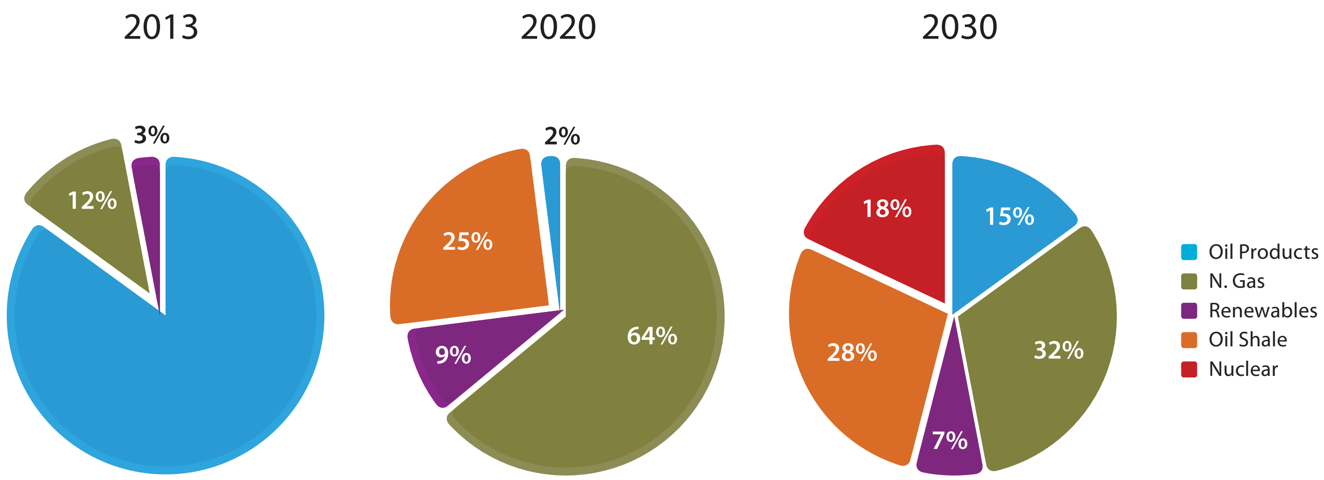


Figure A.6: Primary energy mix for the years 2020 & 2030 with mitigation options

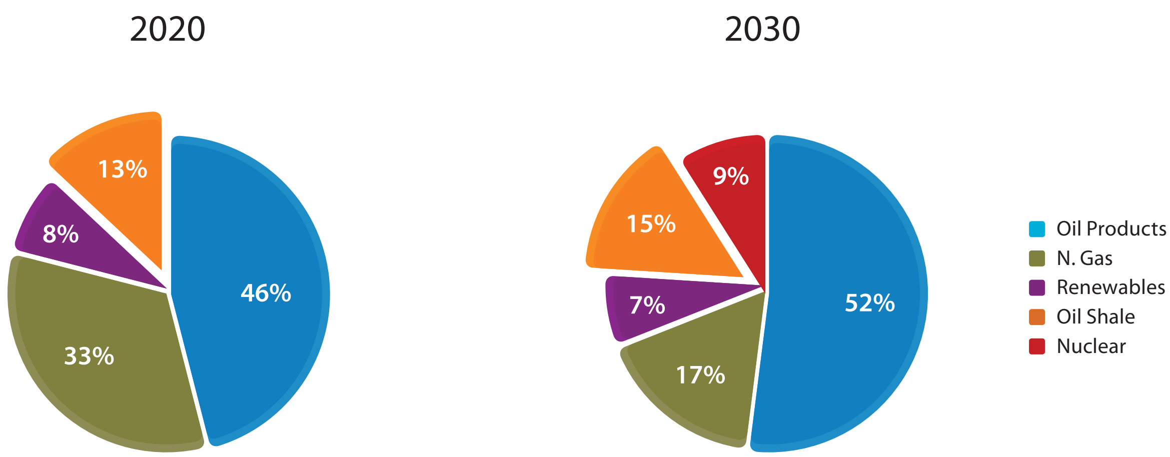
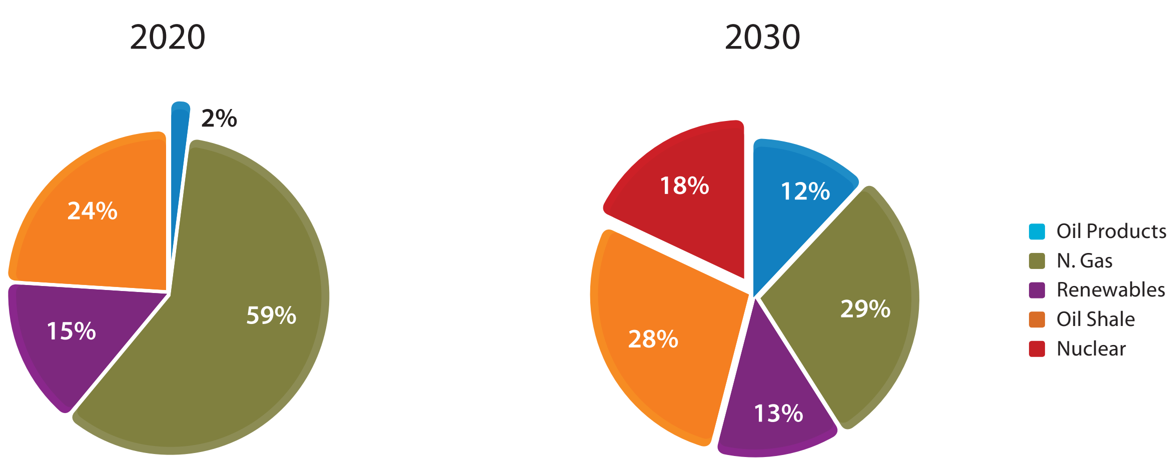


Figure A.7: The contribution of all types of energy in electricity generation for the years 2020 & 2030 with mitigation options



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