National Environmental and Economic Development Study for Climate Change

Jordan National Report

Submitted to the United Nation Framework Convention on Climate Change

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Acronyms and Abbreviations

AF	Adaptation Fund
BAU	Business as Usual
CDM	Clean Development Mechanism
CO_{2eq}	Carbon Dioxide Equivalent
COP	Conference of Parties
CEA	Country Environmental Analysis
CERs	Certified Emission Reductions
CFC	Chlorofluorocarbons
CIS	Climate Information System
CSIROMK3	Commonwealth Scientific and Industrial Research Organization
DOS	Department of Statistics
DSSAT	Decision Support System for Agrotechnology Transfer
DSWLF	Domestic Solid Waste Landfill
ECHAM5OM	The 5th Generation of the ECHAM General Circulation Model
ENPEP	Energy and Power Evaluation Package
ETc	Crop Evapotranspiration
EU	European Union
FAO	Food and Agriculture Organization
GAM	Greater Amman Municipality
GCMs	Global Climate Models or General Circulation Models
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GWP	Global Warming Potential
HADGEM1	Hadley Center Global Climate Model
HFCs	Hydrochlorocarbons
HFO	Heavy Fuel Oil
INC	Initial National Communication
IPCC	Intergovernmental Panel on Climate Change
JD	Jordanian Dinar (1 JD = 1.5 US$)
JMD	Jordan Metrological Department
JOMET	Department of Meteorology
LPG	Liquefied Petroleum Gas
LULUCF	Land Use Land Use Change and Forestry
MEMR	Ministry of Energy and Mineral Resources
MMA	Ministry of Municipal Affairs
MMT	Monthly Maximum Temperature
MoA	Ministry of Agriculture
MoEnv	Ministry of Environment
MoH	Ministry of Health
MOPIC	Ministry of Planning and International Cooperation
MoT	Ministry of Transport
MP	Maturation Ponds
MSL	Mean Sea Level
MWI	Ministry of Water and Irrigation
NERC	National Energy Research Center
NG	Natural Gas
PEE	Public Environmental Expenditure

PMU	Project Management Unit
PV	Photovoltaic
RCMs	Regional Climate Models
RJGC	Royal Jordanian Geographic Centre
TNA	Technology Needs Assessment
TT	Technology Transfer
SNC	Second National Communication
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nation Framework Convention on Climate Change
WHO	World Health Organization
UNEP	United Nations Environmental Program
V&A	Vulnerability and Adaptation
WEAP	Water Evaluation and Planning System
WWTP	Wastewater Treatment Plant
YRB	Yarmouk River Basin
ZRB	Zarqa River Basin

National Environmental, Economic and Development Study (NEEDS) for Climate Change

Executive summary

Since the entry of the UNFCCC into force in 1994, Jordan started working to fulfil its obligations to the convention. The fulfilment of the national obligation to UNFCCC implies that Jordan should have the human, organizational, institutional and financial resources for developing the required tasks and functions on a permanent basis.

The Hashemite Kingdom of Jordan stands at a critical juncture. The country has accumulated a wealth of knowledge and expertise in the climate domain. Through various initiatives the government of Jordan has attained a clear assessment of the challenges posed by climate change and has also identified the measures needed to address these challenges. However, implementation has been lagging partly due to lack of financial resources, technical capacity and weak linkages with national plans.

As part of its commitment to international environmental conventions, Jordan initiated with the support of UNFCCC A National Economic and Environmental Development Study (NEEDS) for Climate Change. NEEDS initiative aims at identifying financing needs to implement adaptation and mitigation measures. Furthermore, the imitative will identify linkages with financial and regulatory instruments that will support the implementation of adaptation and mitigation measures. Eventually, the initiative should provide opportunity for inputs into the national development plan.

The NEEDS study was performed in two stages, namely stocktaking and consultation. In the stocktaking stage the GHG inventories, previous adaptation and mitigation works, national development strategies and institutional frameworks were documented and reviewed. On the other hand, during the consultation process various stakeholders were involved. This included national stakeholders, high level experts and sectoral level experts. Based on the findings of the stocktaking and consultation the NEEDS study report was developed.

The current report is presenting the findings of the National Environmental, Economic and Development Needs Study (NEEDS) for climate change in Jordan. The study funded by the UNFCC Secretariat. It is focusing on the identification of financial needs to implement adaptation and mitigation measures in key sectors. Therefore, the main objective of the NEEDS study is to provide information on the financing needs to implement climate change mitigation and adaptation measures in Jordan, as well as to provide information on financial and policy instruments available to support these measures.

For the mitigation measures, two key sectors were identified, namely energy and waste sectors, while under adaptation, water resources and agriculture were identified as the main key sectors.

Constraints, gaps and related financial, technical and capacity needs to incorporate the climate change mitigation and adaptation issues into national police were identified. These included the low level of knowledge on the national level, lack of financial resources, as well as the absence of the national policies that address the climate change issues.

In terms of financial resources needed to integrate the climate change into national policies, it has been estimated that until the year 2020 about 3.345 billion US$ will be needed for mitigation and 1.564 billion US$ will be needed for adaptation. Up to the year 2050, it has been estimated additional 4.5 billion US$ for mitigation and 5 billion US$ for adaptation projects and programs will be needed.

Therefore, it is recommended to take actions to build the capacity and to seek financial resources to conduct studies and implement adaptation and mitigation projects, and to strengthen the nation legal and institutional frameworks in such a way that they will reflect the climate change aspects.

1. Overview

Jordan is located about 80 km to the East of the Mediterranean Sea, between 29°11'- 33°22' N and 34°19'–39°18'E with an area of 88,778 km^2. The climate of Jordan is predominately of the Mediterranean type; it is characterized by a hot dry summer and rather cool wet winter, with two short transitional periods; the first starts around October and the second around mid of April. The rainy season starts by October and ends by May. Therefore, the rainy season comprises two fiscal years, for example the rainy season 2005/2006 comprises October, November and December of 2005 and January, February, March and April of the year 2006.

The country has a unique topographic nature that might not be found anywhere else. According to the geographic and topographic characteristics, Jordan can be divided into three main climatic regions (Figure 1): the first one is the Jordan Valley or the Ghore Region (the Ghore means low land); the second is the Highlands Region; and the last is the Badia and Desert Region. The Western part of the country is the world lowest valley that lies north – south between two mountain ranges with a length of about 400 km and a width varies from 10 km in the North to 30 km in the South and elevation between 170 – 400 m below Mean Sea Level. Jordan River passes through this valley from north to south down to the Dead Sea. Jordan River is the main source of irrigation in Jordan Valley. Because of its warm climate in winter and the availability of irrigation water, the valley is considered as the vegetable and fruits basket of Jordan. Just to the east of the Jordan Valley the North – South mountain range reaches about 1150 m above MSL in the Northern parts and about 1500 m above mean sea level (MSL) in the Southern parts of the kingdom having a highest peak of 1854 m in the extreme Southern region. About 88% of human settlement of Jordan lives in this region. To the East of this mountain range a semi desert plateau extends to cover approximately 80% of the total area of the country. Most of Jordan (90%) is arid and semi arid areas that characterized by remarkable rainfall variation with total annual rainfall averages less than 200 mm.

Given the fact that Jordan is located in the Mediterranean region, which is considered among the driest areas of the world, Jordan is highly vulnerable to the impacts of climate change. As a result, the country has witnessed noticeable adverse impacts that rendered it to become the fourth water poorest country in the world. The per capita share of 150 M^3/capita.year from water resources is located far below the internationally identified water poverty line of 1000 M^3/capita.year.

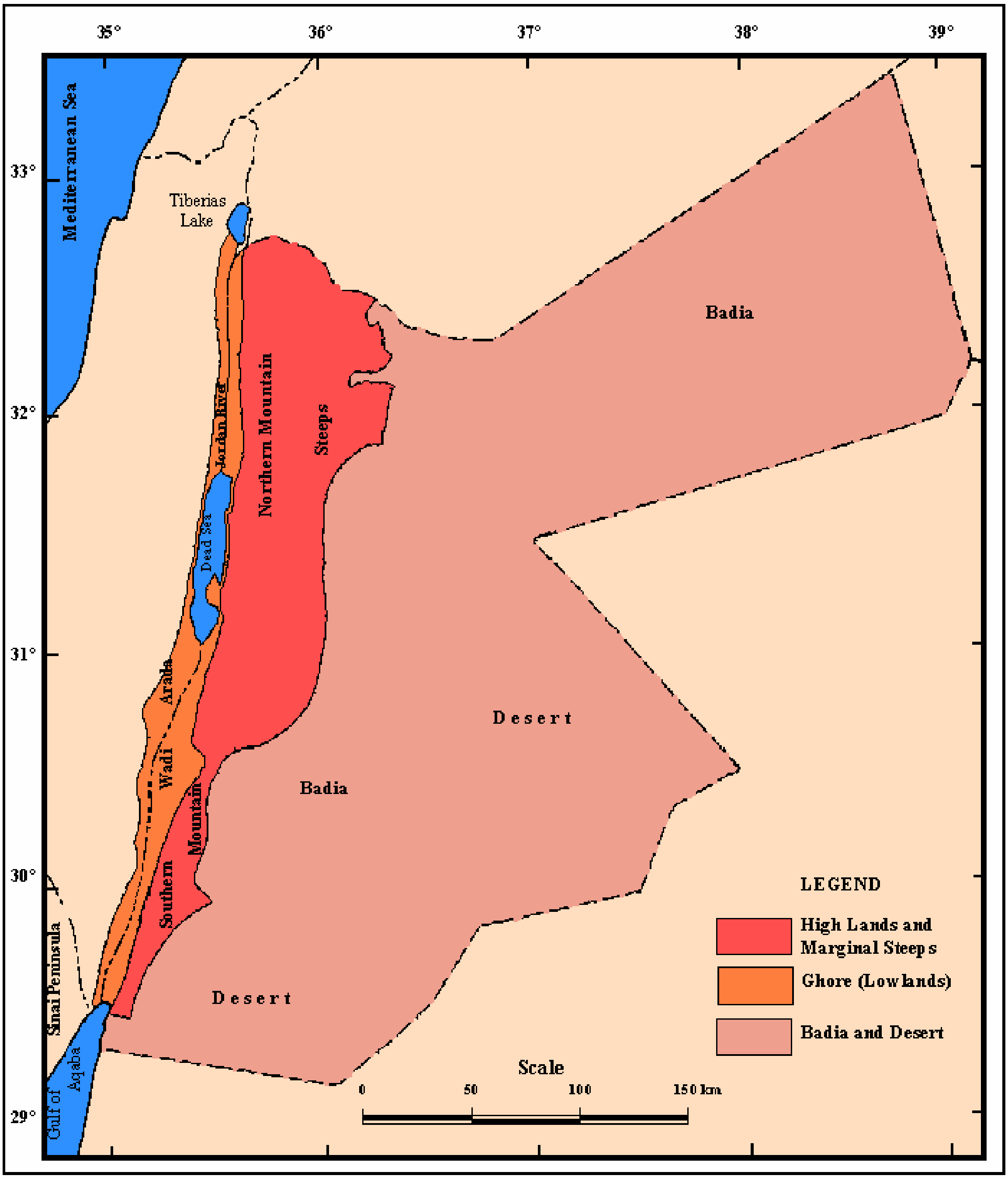

Figure (1) Main climatic regions of Jordan (INC, 1997)

On the other hand, the country does not have indigenous energy sources, which makes the country fully dependent on the imported fossil fuel. Unless immediate actions taken, on both international and national levels to face the adverse impacts of climate change, Jordan will face serious challenges in the near future.

The Ministry of Environment (MoEnv) has approached the UNFCCC to fund conducting the NEEDS for climate change in Jordan, consequently, Jordan has been selected by the UNFCCC to conduct the study. NEEDS seeks to provide information on the financing needs to implement climate change mitigation and adaptation measures in Jordan, as well as to provide information on financial and policy instruments available to support these measures.

The purpose of the study is to identify the priority mitigation and adaptation measures by Jordan in line with the country's national sustainable development strategy, and how these measures can be effectively financed through the available finance instruments and sources, such as public and private sector funding, multilateral initiatives, carbon markets and other sources of funding and how to integrate these options in the national development plans.

Therefore, the main objectives of the NEEDS are to support Jordan in:

1. Selecting key sectors for climate change mitigation and adaptation measures, on the basis of priorities identified in the national communications and in national development plans;

2. Assessing the financing required and received to implement mitigation and adaptation measures in the key sectors selected in 1. above and identifying appropriate financial and regulatory instruments to support these measures;

3. Raising awareness and facilitating informed consensus among government agencies on the policy actions required to mobilize finance and investment in mitigation and adaptation measures

1.1 National Development Plans and Priorities in the Context of Climate Change

In 1991, the first environmental strategy in Jordan was prepared through a multi-stakeholder approach. The National Environmental Strategy (NES) was the outcome of an extensive debate by many experts in all sectors of environmental policy formulation. The work, supported by USAID and IUCN, was one of the first environmental strategies to be prepared in West Asia. Jordan had matured regarding environmental thinking and planning, and with the rapid emergence of civil society in the 1990s, Jordan was ready to get into serious environmental planning and policy formulation on the eve of the Earth

Summit (the UN Conference on Environment and Development) in Rio de Janeiro in 1992.

In June 1992, Jordan signed the UNFCCC and ratified it in November 1993, before entering into force in March 1994. After that, intensive efforts were directed towards addressing the climate change issues in Jordan. This was reflected through several programs, projects and activities that were launched.

Until 1995, to take action to preserve the environment the government had to rely on laws that were designed to regulate other sectors, regions, services and activities. There were 187 articles in at least 18 laws and eight regulations dealing with preservation of environmental resources in Jordan. As a result, there were duplication and overlapping between the laws, as well as many gaps with regard to environmental issues. The NES pointed out these legal difficulties and strongly recommended the introduction of special environmental legislation.

In 1995, a new comprehensive environmental law (Environmental Protection Law No. 12, for the year 1995) was enacted by the government that was intended to regulate various activities in the country in an environmentally sustainable way, and which included monitoring and compliance provisions. The law specifically provided for the creation of a central authority (General Corporation for Environmental Protection) to manage Jordan's environment and implement the new environmental legislation.

Another maturation phase in the evolution of Jordan's environmental policy came in 1995, when the National Environmental Action Plan (NEAP) was developed. NEAP focused on moving from rhetoric to action, and formulated a package of environmental and sustainable development projects. The action plan was the result of a multi-stakeholder discussion and exchange of experiences and information.

The stage was set in Jordan for the most comprehensive environmental strategies, and in 1996 the National Agenda 21 project was launched, its goal was to provide the country with a national environmental strategy and action plan for the twenty-first century. In one of the most important sections of the Agenda 21 document, the participants listed around 70 projects covering almost every developmental/environmental area in the country. Project proposals covered such issues as approaches in water-resource management, agriculture, energy, environmental management, biodiversity protection and eco-tourism. However, there were no specific projects related directly to the climate change.

In 1996, Jordan started a GEF funded project (Building Capacity for GHG Inventory and Action Plans in the Hashemite Kingdom of Jordan in Response to UNFCCC Communications Obligations) for Initial National Communication under the UN Framework Convention on the Climate Change (JOR/95/G31/1G/99) with a total budget of 242,000 USD. The main achievement of this project was that Jordan became the first non-annex 1 country that submitted its first national communication in January 1997.

Another component was added to the project and with a target to study the effect of climate change on water resources with a 100,000 USD budget. As the climate change issue became one of the main Environmental issues in Jordan and since the project was in its final stage the cabinet took a decision to change the name of the committee to be a National Committee that is responsible to follow up CC issues in the country.

In 2001, a new Environmental Protection Law (Law Number 1, for the year 2001) was passed which paved the road for establishing the Ministry of Environment (MoEnv) in the country. MOE replaced GCEP and took the role of regulating and monitoring the environmental affairs of the country.

In January 2003, Jordan made an accession to the Kyoto Protocol, One of the flexible mechanisms that Jordan can benefit from is the Clean Development Mechanism (CDM) and with accordance to this mechanism a Designated National Authority (DNA) was established to benefit from the CDM. The Prime Minister took a decision to establish the DNA. The later has a board of directors headed by the secretary general of the Ministry of Environment and has the following members.

1- Secretary General, Ministry of Energy and Mineral Resources
2- Secretary General, Ministry of Water and irrigation
3- Secretary General, Ministry of Transportation
4- Secretary General, Ministry of Planning and International Cooperation
5- Secretary General, Ministry of Agriculture
6- Secretary General, Ministry of Industry and Trade
7- Secretary General, Ministry of Finance
8- Secretary General, Ministry of Tourism and Antiquities
9- Director General of Public Security
10- President of the Royal Scientific Society

The Climate Change Unit within the Monitoring and Assessment Directorate in the MoEnv, acts as a permanent secretariat and a technical back up to review all the proposed projects and can ask for an assistant as needed.

The strategic and policy-oriented plans for climate change could be extracted from the Jordan's National Communication Reports (First and Second reports) to the UNFCCC in 1999 and 2009. Because of the lack of indigenous conventional energy resources, Jordan considered the development of local energy-resources including renewable energy and oil shale and gas reserve. The establishment of the National Energy Research Centre (NERC) in 1998 aimed to undertake scientific research and development activities, transfer of new and renewable energy technologies, and motivate rational use of energy.

Other activities related to implementation of UNFCCC are the national and regional workshops that are usually held to raise the awareness on climate change among the different stakeholders and decision-makers. Also, some of the media programs were funded by GEF and UNDP to increase the public participation in energy and environmental conservation. So far, the issue of climate change was considered in the sectors of energy and environment, but not in the sector of agriculture. The current policy of agriculture does not take the issues of vulnerability and adaptation into consideration. Therefore, several programs are urgently needed to formulate adaptation measures for the vulnerable agricultural sector in Jordan.

Another action at the country level was the launch of National Energy Strategy in 2006. The strategy aimed at enhancing the use of alternative sources of energy and the integration of CDM in the national plans. The main goals of the strategy are to:-

- Diversify the local energy resources.
- Increase the potential contribution of the local energy resources in the total energy mix.
- Reducing dependency on oil imports.
- Enhancing environmental protection.

It is expected that the Ministry of Energy and Mineral Resources (MEMR) will increase the potential contribution of renewable to be 7% by 2015 & 10% by 2020. Figure 2 shows the energy mix in Jordan starting from 2007 up to 2020. It can be observed that by the year 2020 the nuclear energy is expected to contribute 6% into the total energy mix. The MoEnv, on the other hand, is involved in environmental legislation and auditing to ensure that air pollutants are within the Jordanian standards. Also, it is involved in some projects related to the use of biogas and in capacity development for implementing the UNFCCC.

In 2009, Jordan submitted its second national communication report to the UNFCCC. The report provided the latest inventory of greenhouse gases emissions together with vulnerability and adaptation assessment of the country's assessment sectors. The report sets the national priorities for climate change related actions and guide the country's future efforts to be part of the global efforts to combat climate change and ensure the achievement of sustainable development at the national level. The findings of the SNC show how serious and urgent are the challenges Jordan faces in the water sector, agriculture and health sectors. Although information on abatment marginal cost for the mitigation projects was presented, the report has not provided specific cost information for the recommended adaptation initiatives.

The National Water Strategy Plan for the years 2008-2022 has been issued in 2009. The strategy outlined needed actions and polices to overcome the shortage of water without taking into considerations the extra impacts that is induced by the climate change.

In 2010, Jordanian cabinet passed the Renewable Energy and Energy Efficiency Law Number 3, for the year 2010. This law has paved the road for private sector investment in renewable energy projects. According to the law, a Renewable Energy Fund has to be established in the Ministry of Energy and Mineral Resources (MEMR). Article three of the law states that the main goal is to increase the share of the renewable energy in the national energy mix and to increase energy efficiency, so as to improve the national energy security, attract the investment and to protect the environment.

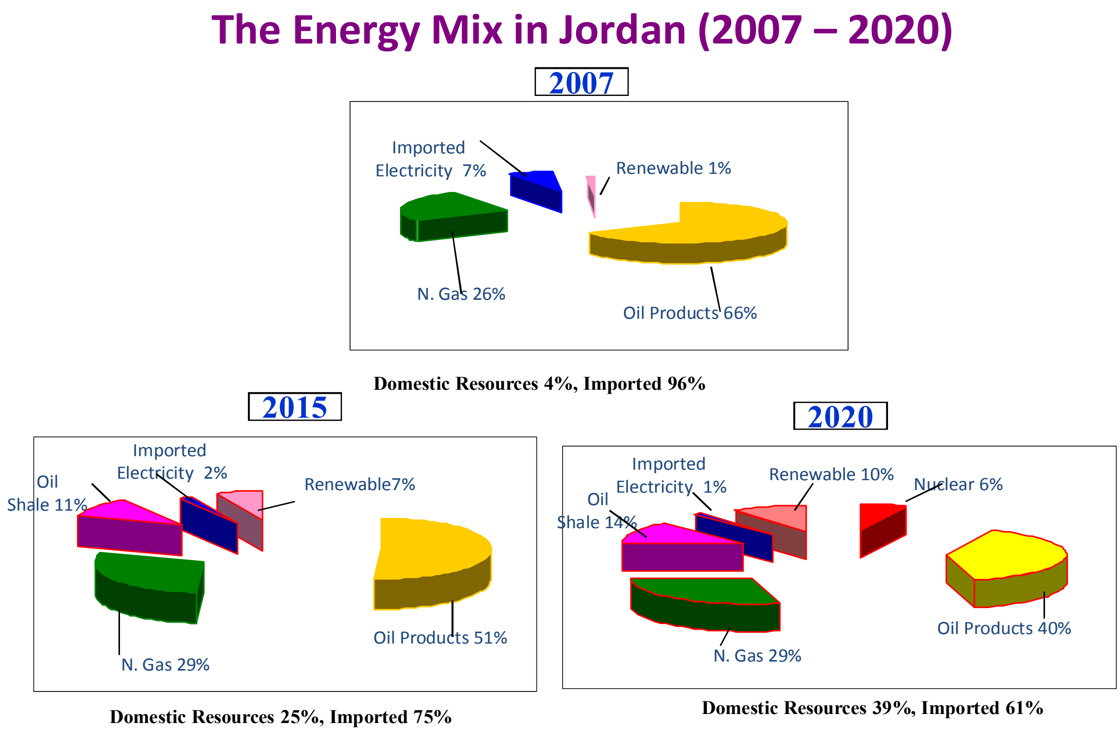

Figure (2) Energy mix of Jordan for the years 2007-2020 according to the National Energy Strategy

1.2 Status of Greenhouse Gas Emissions, Projections and Mitigation Scenarios

Under the national greenhouse gas inventory chapter of the Second National Communication Report, the anthropogenic emissions by source and sink of all GHGs not controlled by the Montreal Protocol were assessed. The inventory took the year 2000 as a base year. According to the inventory, Jordan contributed about 20140 gigagrams (20.14 million tonnes) of $CO_{2\ eq}$ to the atmosphere. About 74% of the total emissions are attributed to the energy sector, while the waste sector is the second emitter with 14% followed by the industrial sector with 8% and the agricultural, land use and forestry is the least sectors with 4%.

On the gas by gas basis, the inventory found Carbon Dioxide emission to be 17047 Gg, which accounts for 84.6% of Jordan's total greenhouse emissions in the year 2000. Methane ranked the second largest emitted gas with 2754 Gg CO_{2eq} which accounts for 13.6% of the total emissions. The solid waste landfills and wastewater are responsible for 91.6% of the total methane emitted in Jordan. The least amount of the emission was attributed to Nitrous oxides that were estimated to be 347 Gg CO_{2eq}, which is 1.7% of the total emissions.

As for the greenhouse gas emissions projections, the second communication report projected the emissions up to the year 2033. The NEEDS study report has made extrapolation to the total emissions from various sectors until the year 2050. Figure 3 depicts the projected amount of the greenhouse gases emitted from all sectors in Jordan. It can be observed that by the year 2033, the projected total emissions will be 70377 Gg (70.377 million tonnes of CO_{2eq}) For the period 2033-2050, the projection was made based on three scenarios of increase in the emissions, namely 1%, 3% and 5% (i.e. upper bound, mid bound and lower bound). Under the lower bound the emissions are expected to increase to 81,000 Gg (81 million tonnes of $CO_{2\ eq}$), while under the mid bound scenario the emission will increase to118,000 Gg (118 million tonnes of $CO_{2\ eq}$) and under the upper bound the emissions will reach 170,000 Gg (170 million tonnes). The mid scenario is based on the assumption that the emissions will continue increasing at the current rate, while the upper bound scenario assumes that the economic growth will take place at a higher rate from the current which will be reflected on the emissions level. The lower bound scenario assumes that the emissions rates will be decreased as a result of economic recession and adoption of mitigation measures.

Despite the initiatives that are taking place in the energy sector to increase the contribution of renewable energy in the total national energy mix and to enhance the energy efficiency, energy sector will remain the highest emitter of greenhouse gases in Jordan. It is expected to emit 58167 Gg (58.167 million tonnes of $CO2_{\ eq}$) by the year 2030, which accounts for 82% of the total emissions as shown in Figure 4.

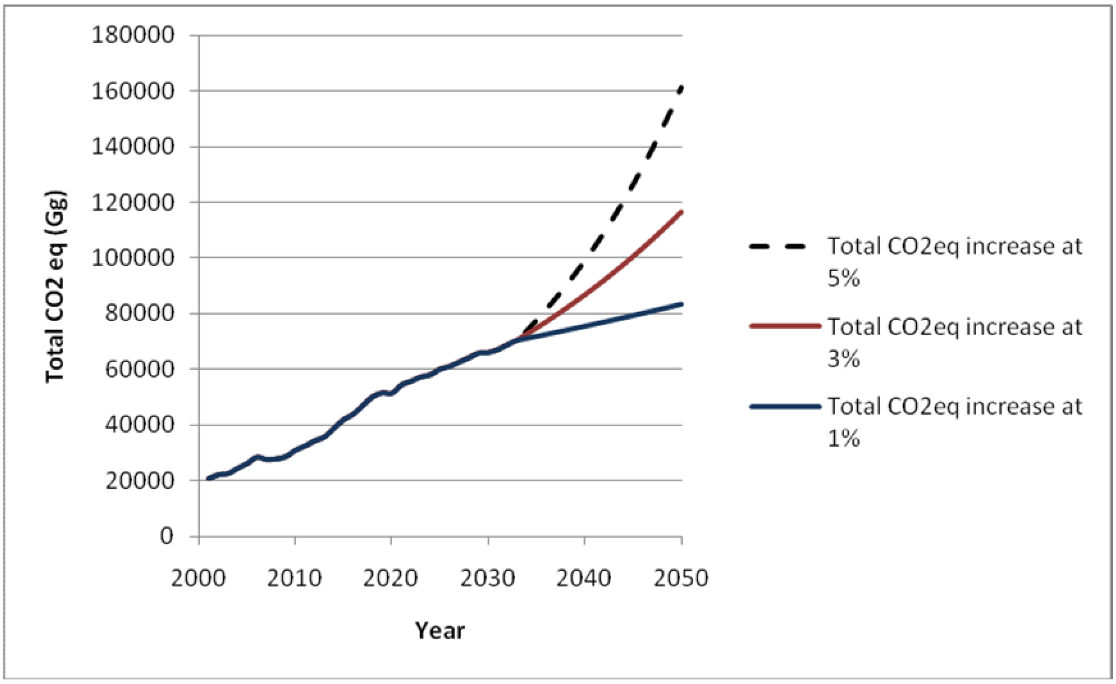

Figure (3) Projected greenhouse gases that will be emitted by all sectors in Jordan up to the year 2050

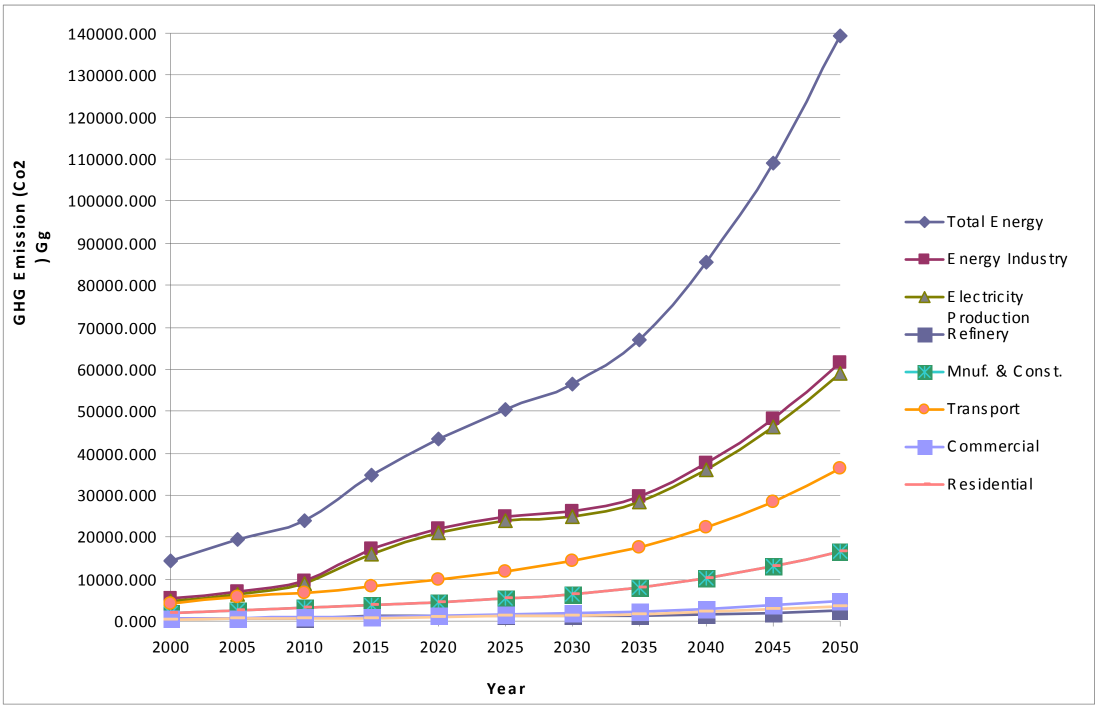

Figure (4) Projected greenhouse gases that will be emitted by energy sector in Jordan up to the year 2050

The SNC report provided analysis of measures to limit and reduce the GHGs emissions, as well as to enhance the GHG sinks. Baseline scenarios for different sectors were constructed based on the trends, plans and policies prevailing in the Jordanian context.

Under the mitigation scenario, the mitigation study proposed thirty eight greenhouse gases mitigation projects in areas like primary energy, renewable energy, energy efficiency, waste and agriculture. The cost benefits and CO_2 emissions reduction are analyzed for each proposed project. Table 1 lists the proposed mitigation projects in all sectors.

Table (1) List of the mitigation projects proposed by the SNC

No	Project Title	No	Project Title
1	Awareness program for applying best management practices in irrigated farming fertilization application	21	Al-Karak DSWLF
2	Winter pool/ hotel	22	Maddaba DSWLF
3	Waste heat rec./ hotel	23	Aldulail DSWLF
4	Insulation /Food factory	24	Al-Salt DSWLF
5	Ceramic factories Condensate recovery/	25	As-Samra DWWTP
6	Solar heating /hotel	26	Wadi Arab DWWTP
7	Solar water heaters	27	Baqa' a tertiary DWWTP
8	Electronic ballasts/ Medical factory	28	Ramtha DWWTP
9	Food factory	29	Mining industry/heat exchanger
10	Regenerative burners/ Steel factory	30	Salt DWWTP30
11	VSD in pumps/Paper factory	31	Aqaba tertiary DWWTP
12	Comp. air control system/ Canning factory	32	Al-hareer wind farm
13	Condensing heat exch./Mining industry	33	Kamsha wind farm
14	CF lamps/Residential	34	Aqaba wind farm
15	Demand Side Management	35	Ma'an wind farm
16	Samra power conversion to CC	36	Fujaij wind farm
17	Natural gas network/Amman	37	Ibrahimya wind farm
18	Natural gas network/Aqaba	38	Growing perennial forages in the Badia region
19	Natural gas network/Zarqa		
20	Al-Ekaider DSWLF		

The annual emission reduction as a result of implementing the proposed mitigation projects over the period 2009 to 2033 are shown in Table 2. As it can be observed from the table, in case of executing the proposed projects, the annual emissions reduction was estimated to be 2.761 million tonnes of CO_{2eq}

in the year 2009, and are expected to increase to 12.345 million tonnes of CO_{2eq} in the year 2033.

Currently, there are thirteen projects considered to benefit from the clean development mechanism (CDM). The proposed projects are at different stages in the CDM cycle. Three of the proposed CDM projects are concerned with biogas collection and utilization from landfills and wastewater treatment plant, while the others are concerned with power plants and cement industry.

Table 2 Baseline and mitigation scenarios emissions for the period 2009 -2033

Years	2009	2015	2020	2025	2030	2033
Baseline Scenario (1000 tonnes $CO_{2\ eq}$)	28441	41788	51249	59474	65934	70377
Mitigation Scenario (1000 tonnes $CO_{2\ eq}$)	25679	34451	40012	47878	53899	58031.23
Reductions (1000 tonnes $CO_{2\ eq}$)	2761	7335	11236	11595	12034	12345
Reductions (%)	9.7	17.5	22	19.5	18.5	17.5

1.3 Vulnerability Assessment and Adaptation Scenarios

1.3.1 Climate Change Projections

In Jordan, climate change is expected to affect the quantity and quality of the country's water resources. To assess the impact of climate change on Jordan, it is necessary to construct the future climate change scenarios. Therefore, in the SNC report, outputs of 13 GCMs were analyzed for Jordan and consequently the most comparable 3 GCM models to the observational data were selected to construct climate change scenarios for the projection period 2005 – 2050. These models are: the Australian model CSIROMK3 (Commonwealth Scientific and Industrial Research Organization (CSIRO) Model), the German model ECHAM5OM (The 5th generation of the ECHAM general circulation model) and the British model, HADGEM1 (HADley Center Global Climate Model).

The three models are in good agreement with the observed temperature of the study area. The adjustment statistics (the difference between the GCMs future climate scenarios and the baselines for temperature and the ratios for precipitation) were calculated from the three GCM outputs and the daily GCM climate change scenarios were developed by adding this adjustment to the observed daily values of temperature and by multiplying the adjustment by the observed daily precipitation values. Furthermore, 20 daily incremental temperature and precipitation scenarios were developed for each station in the study area (ZRB and YRB).

All the GCM scenarios show an increase in temperature of less than 2°C. Warming was found to be stronger during the warm months of the year while less warming is projected to occur in the cold months of the year. The climate change scenarios for precipitation are highly variable. The Australian model, CSIROMK3 expects an increase in precipitation over the whole year except the summer months where usually no precipitation occurs in Jordan. The British model, HADGEM1 expects an increase in temperature in the cold and rainy months of the year and a decrease in the rest. While the German model, ECHAM5OM predicts a decrease in precipitation in the cold and rainy months and an increase in the summer hot months.

In conclusion, it can be said that the GCM climate change scenarios estimate a general increase in temperature in Jordan, and that summer warming is more substantial than winter warming. But the GCM climate change scenarios of precipitation do not agree with each other.

1.3.2 Baseline Scenarios

In the SNC (2009), the climate baselines are constructed to cover the period 1961 – 2005. The purpose of selecting a baseline scenario covers the last 45 years of the climatological record in the study area is to construct a projection of climate change scenarios for the next 45 year period, 2005 – 2050.
Previous local studies investigated the weather records showed an increase in the magnitude and frequency of extreme temperatures. Higher temperature and lower precipitation are expected as a result of climate change: The main results of the local climate change studies are:

Temperature: warming trends in annual maximum temperature with accompaniment of the statistically obvious warming trends in the annual minimum temperature result in a remarkable decrease in the diurnal temperature range in the majority of the stations (Figure 4)

Precipitation: decreasing trends in the annual precipitation are apparent evidence to climate change in Jordan (Figure 5).

Relative humidity: significantly increasing trends in relative humidity mainly started to occur at the end of the decade 1970's. The yearly total of evaporation shows significant decreasing trends in all the locations which started to occur in the 1960's and 1970's.

Sunshine duration: most of the stations experienced significant decreasing trends of sunshine duration. The decrease in sunshine hours ranged between 2 and 8% and started in the decades 1960's and 1970's.

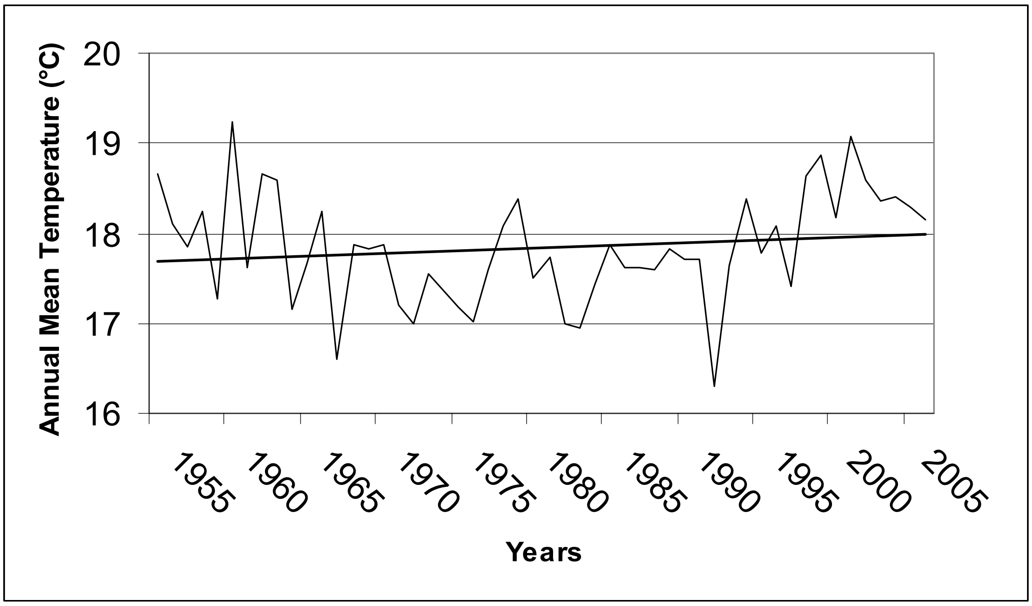

Figure (5) Linear trend of annual mean temperature time series in Irbid for the period 1963-2003 (SNC, 2009)

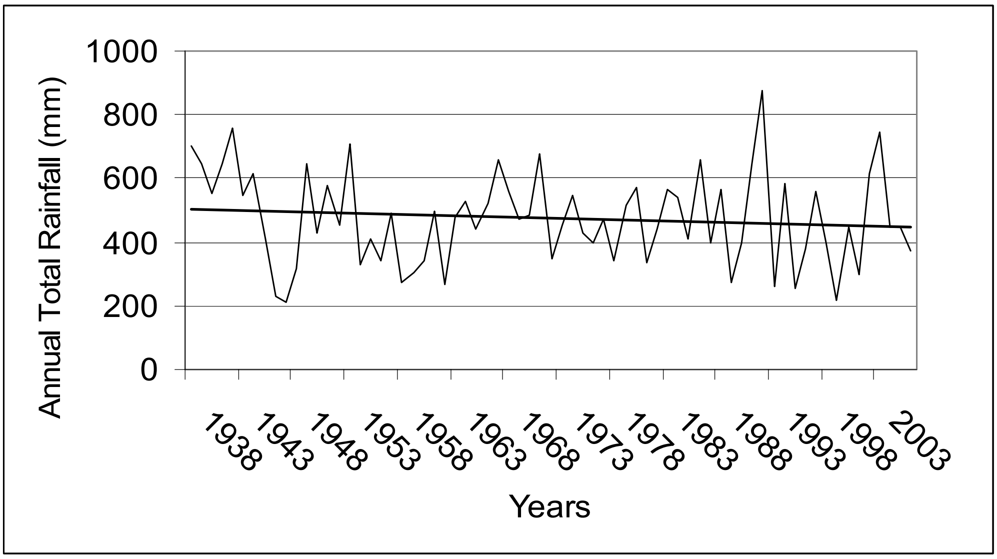

Figure (6) Linear trend of annual total rainfall in Irbid for the period 1938-2003 (SNC 2009)

1.3.3. Sectoral Vulnerabilities to Climate change

The following sectors were identified to be most vulnerable: water and agriculture.

Vulnerability of Water Sector to climate change

In the vulnerability assessment of the water resources sector to climate change, the Water Evaluation and Planning System (WEAP) hydrological model was applied to the ZRB and YRB using the climate scenarios described above.

The analysis of 20 incremental scenarios had shown that the increase in precipitation and temperature will highly affect the amounts of monthly surface runoff. The surface runoff amounts will be increased by about 21% in ZRB and 12% in YRB when the precipitation assumed to be increased by 20%, and mean temperature to be increased by one degree. The percentages becomes 20% and 4.8% when the mean temperature increased four degrees for ZRB and YRB, respectively. For both basins, it was noticed that the surface runoff amounts will be decreased when the precipitation kept unchanged and the mean annual temperature increased by one, two, three and four degrees. It was noticed that surface runoff decreased in some scenarios more than 60% as a result of increasing the mean temperature four degrees and keep precipitation unchanged. It was also generally noticed that the most vulnerable scenarios to climate change impact on water resources are those when temperature will be increased by more than two degrees and precipitation will not be increased. Even in some scenarios, the increase of precipitation about 20% doesn't compensate the increase of temperature two degrees.

The results from analyzing GCM scenarios hold different results for both watersheds. For Zarqa Basin, the CSIROMK3 results show that the amount of surface runoff will decrease for the rainy season which extends from October to February. The highest decrease is expected to take place in January (about 25%) which is the rainiest season of the year. While the other two models show no or very little impacts of climate change on surface runoff.

For Yarmouk Basin, CSIROMK3 model shows that here will be a slight increase in the surface runoff amount during the rainy season. While ECHAM5OM simulation results show that there will be no change on surface runoff resulted from precipitation in January, and there will be a decrease in the other months.

The HADGEM1 simulation predicated a major increase in surface runoff values in March and a decrease in October and November. While the other months shows no change in surface runoff values. The three models shows slight or no change on surface runoff values for January, February, May and October.

Vulnerability of Agricultural sector to climate change

Agriculture in Jordan is one of the most vulnerable sectors to climate change, as the available water and land resources are limited and most of the country's land is arid and used as open range. Zarqa and Yarmouk rivers' basins were selected as the main study areas to analyze baseline situation and to predict the effects climate change on agriculture under the different future scenarios. The impact of climate change on rainfed agriculture was investigated using a Decision Support System for Agrotechnology Transfer (DSSAT) model on two main crops, wheat and barley. The twenty incremental scenarios of future climate change and three GCM scenarios were used to modify 27-years of climatic data for Irbid station and to predict the average yield under the different scenarios.

The results of the vulnerability assessment for agricultural sector showed that climate change could have significant impacts, in particular on rainfed agriculture. Field crops and fruit trees were the main rainfed crops. Adverse impacts of climate change on rainfed cultivation and the arid and semiarid rangelands were identified as the most significant impacts on the sector of livestock and the overall production of the country's food. Data for the governorates within both study areas showed no obvious correlation or similar trends between rainfall and yield of wheat and barley, except in year 1999 when rainfall amounts and yield were extremely low.
Analysis of crop data also showed differences between cultivated and harvested areas for all rainfed crops and emphasized that rainfed cultivation was the most sensitive sector that might be affected by adverse climatic impacts. The average ratio between harvested and cultivated area was 0.52 for wheat and 0.45 for lentil. The lowest ratio (0.28) was for barley, which was mainly cultivated for hay.

Results from DSSAT model for years 1996-2006 showed that it was able to capture the trend over the years realistically well. The model predicted an average yield of wheat of 1176 kg/ha which is rather close to the Department of Statistics (DOS) average of 1173 kg/ha. Also, the average predicted yield of barley was 927 kg/ha, while the DOS average was 922 kg/ha. The DSSAT had been rerun for 27 years during the period 1970-2005 to simulate the impact of the different climate change scenarios on barley and wheat. Results showed variations in response between wheat and barley. For both crops, however, it has been found that the reduction of rainfall by 10 to 20% had a negative impact, while the increase in rainfall by 10 to 20% had a positive impact on grain yield for both barley and wheat at the different temperature regimes. Generally, the increase in rainfall amount would not compensate for the adverse impacts of the temperature increase on barley. The trend for wheat was different from barley, as the increase of temperature was more advantageous for yield if rainfall would increase.

2. Key Findings on Costs of Implementing Mitigation and Adaptation Measures

2.1 Cost of Implementing Priority Mitigation Measures

For mitigation projects that are proposed by the second national communication report, abatement marginal cost analysis was carried out. Figure 7 shows the results of analysis. It can be observed that based on the unit abatement cost, the most feasible options are the energy efficiency projects, where unit costs ranges from – 61 to -245 JD/t $CO_{2\ eq}$ (- 91.5 to – 367.5 US$/ t $CO_{2\ eq}$). Therefore, the priority should be for implementing such projects by securing the required finance. Second on the priority scale is the demand side management with abatement unit cost of -28 JD/t $CO_{2\ eq.}$ (- 42 US$/ t $CO_{2\ eq}$), followed by fuel switch and landfill biogas utilization with abatement unit costs of -25.5 JD/t $CO_{2\ eq}$ (- 38.25 US$/ t $CO_{2\ eq}$) . and -5.5 JD/t $CO_{2eq.}$, (- 8.25 US$/ t $CO_{2\ eq}$) respectively. On the other hand, the methane recovery from wastewater projects and renewable energy projects such as wind farms are less attractive options with positive abatement costs. After the passage of the renewable energy and energy efficiency law, such projects will be more attractive due to the incentives that are offered by the law.

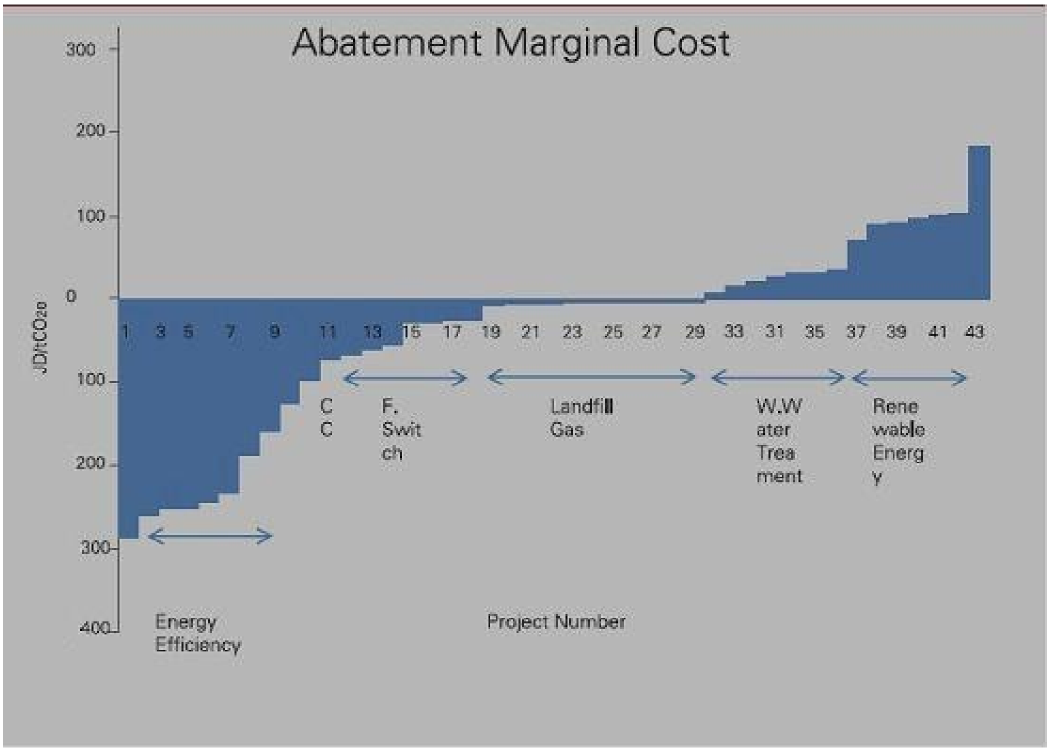

Figure (7) Abatment marginal cost for the mitigation projects proposed by the SNC (1 JD = 1.5 US$)

Tables 3 and 4 are presenting the costs of the mitigation projects for energy and waste sectors, respectively. From the tables, it can be observed that the total cost for energy projects up to the year 2020 is 8.265 billions US$ and the incremental cost is 3.22 billion US$. On the other hand, the total baseline cost for the waste sector is 250 million US$ and the total incremental cost is 125 millions US$.

Energy Sector

The total cost of the proposed projects for energy sector were obtained from the Jordanian public budget and from the governmenbt strategic plan. On the other hand, the the incremental costs were calculated for energy sector based on comparing the cost and carbon emissions of alternative energy sources (natural gas, wind energy, solar energy) to basline scenario of using fuel oil. The detailed methodology followed in calculating the incremental cost of the energy projects is presented in Annex 2. It should be noted that for some projects the total cost is equal to the incremental cost. This is because these projects are will be totally implemented to mitigate the climate change impact.

Waste Sector

In the long term planning, the Ministry of Municipal affairs is thinking to close the exsisting scattered municipal waste landfills and operate only three regional centralized landfills (Inaddition to the already exsiting Al Ghabawi Landfill that serves the central region, another two central landfills will be implemented for Northern and Southern regions).

The baseline project cost (landfill cost without biogas plant) was estimated based on the constructon cost of the third landfill cell which is currently under construction at Al Ghabawi landfill Site in Amman. The contract price for the cell excavation and lining is about US$ 3.6 millions. Since the landfill consists of 9 cells, the total cost for the landfill cells construction is US$ 32.4 millions. If we add the cost of infrastructure of about US$ 5 millions and the annual operation and maintencce of US$ 1.5 millions for 15 years , the total cost will become US$ 60 millions.

Considering the alternative project which is the landfill with biogas recovery and electricity generation system. According to the project design document for Al Ghabawi biogas project that submitted to the UNFCCC the total estimated investment cost for electricity production alternative (incremental cost) from AL Ghabawi landfill is about 24 million Euro. (US$ 30 millions) which is about 50% of the baseline cost. Similar approach is applied to calculate the total and incremental cost for the other planned regional landfills in southern and northern regions of the countrywhich are smaller than Al Ghabawi. The results are presented in Table 4. It can be observed that the total cost for the waste sector is 250 million US$ and the incremental cost is 125 million US$.

Table (3) Proposed mitigation projects for the energy sector up to the year 2020

No.	Project/Program Name	Estimated Total Cost (Million US$)	Incremental Cost (Million US$)	Reduced CO_2 emissions quantities (ton/year) Adaptation/Mitigation	Implementing Agency
1	Second Independent Power Producer (IPP) of Qatraneh to Produce 373 MW	449	82.6	866,526	MEMR
2	Third Expansion Project of Samra Power Station to Produce 285 MW	196	65.5	662,090	MEMR
3	Natural Gas (N.G) Distribution Network in Amman & Zarqa	260	260	Infrastructure for supply purpose	MEMR
4	AL-Kamshah Wind Power Project (40MWe)	92	60	230,759	MEMR
5	Fujeij Wind Power Project (80-90) MW	207	135	519,208	MEMR
6	1 MWe PV Project	5.13	4.33	5769	MEMR
7	Supply natural gas to the 2nd Special production electricity project /Alqatranah 373 MW, and to Samra electricity station 285 MW	13.54	13.54	Infrastructure for supply purpose	MOEMR
8	Finance energy efficiency programs in industrial sector	56.4	56.4	Mitigation	MEMR
9	Establishment of wind database	28.2	28.2	Mitigation	NERC and JMD
10	Establishment of Solar radiation database	98.7	98.7	Mitigation	NERC
11	Energy efficiency lamp project	513.2	513.2	Mitigation	NERC
12	National Railway project	5823	1746.9	Mitigation	Ministry of Transport
13	Light railway project between Amman and Zarqa Cities	522	156.6	Mitigation	Ministry of Transport
Total		**8.265 Billions**	**3.220 Billions**		

- Estimated cost were calculated based on fuel oil usage as a source of energy
- Distance from Aqaba to Samra is 393 km, and the cost of pipe line installation per km is 800,000 U $. This cost is distributed among all the power stations that utilize natural gas based on their installed capacities. In addition, a cost of 10 M US$ is added for internal installations for each power station.

Table (4) Proposed mitigation projects for the waste sector up to the year 2020

No.	Project/Program Name	Estimated Baseline Cost (Million US$)	Incremental Cost (Million US$)	Implementing Agency
1	Landfill with biogas plant for the Middle Region of Jordan	60	30	MoEnv and GAM
2	Landfill with biogas plant for Northern Jordan	50	25	MoEnv and MMA
3	Landfill with biogas plant for Southern Jordan	40	20	MoEnv and MMA
4	Rehabilitation of the existing landfills with erection of biogas plants	100	50	MMA
Total		**250**	**125**	

2.2 Cost of Implementing Priority Adaptation Measures

As for the adaptation costs, tables 5 and 6 are presenting the costs of adaptation project for agriculture and water sectors, respectively. It was estimated that the total cost of needed projects in agricultural sector is 308.6 million US$ and the additional cost is 154.3 millions US$. Concerning the water sector, the total cost of the projects and programs was estimated to be 3.53 billions and the additional cost was estimated to be 1.41 billions up to the year 2020. On the long term basis, up to the year 2050, additional 4.5 billion US$ for mitigation and 5 billion US$ for adaptation projects and programs will be needed.

Additional cost estimation for adaptation to climate change in water resources and agricultural sectors

The methodology followed in estimating the additional cost for adaptation to climate change in water resources and agricultural sector can be summarized by the following steps:

1- Review of the vulnerability assessment of the water resources/agricultural sectors to climate change

2- Quantify the potential impacts on these sectors under various climate change scenarios. From this step, the percentage reductions in surface and groundwater quantities due to climate change were estimated.

3- These percentage reductions were applied to the bulk water availability of Jordan as reported by MWI. From this step the future reduction in the availability of surface and groundwater resources due to climate change can be estimated.

4- Obtain costs of potential projects for water resources development from MWI. It is the responsibility of the MWI to proposed future plans to develop the water resources of the country. These plans include many projects and measures that aim to bridge the gap between the supply and demand. This gap is mainly attributed to many causes; among these are the population and economic growths of the country, and climate change.

5- Assign percentage of the total cost as an additional cost. It is reasonable to assign a percentage of the cost of these future projects and program as cost due to climate change (additional cost). Such percentage is assumed to be equal to reduction percentage in the water availability (step 2).

6- Estimate the additional adaptation cost by multiplying the assigned percentage in step 5 by the obtained costs of potential projects/program in step 4

The above six steps were applied to the water resources sector as follows

- Previous studies of climate change impacts on Jordan water resources were reviewed. These studies include the first national communication report to UNFCCC (1997), Jordan SNC to UNFCCC (2009) and other published works by other researchers in the country.

- Previous studies indicated that the surface water will be reduced from 20% to 40% under different climate change scenarios (Abdulla et al., 2008). The percent changes of annual mean runoff as a function of temperature and precipitation changes are shown in Figure 8 (FNC, 1997). The largest change in annual runoff occurred when combining a +4°C temperature change with a –20% change in precipitation. These results are similar to those reported by other researchers in the Middle East. For the most critical incremental scenario (+4°C and –20% precipitation), the mean annual runoff is predicted to decline by approximately 70% of the current level. For the incremental scenarios with temperature change from +2°C to +4°C and precipitation reduced by 10%, the annual runoff is predicted to decease by between 40 to 60%. With decreasing precipitation the effect could be critical, particularly during long and extreme droughts. For incremental scenarios with temperature changes from +2°C to +4°C, and precipitation increased by 10%, the annual runoff is predicted to decrease by between 10 to 30%. For example, for the incremental scenario with +4°C and 10% increase in precipitation, the runoff will decrease by about 30%. The annul runoff in the Zarqa River basin will increase by approximately 20% under the incremental scenario in which the temperature increases by 2° C and precipitation increases by 20%.

The impact will be much more profound on groundwater recharge. A reduction of 10% in rainfall will result in a 32.3% reduction in groundwater recharge if temperature does not change and a 38.9% reduction if temperature increases by 3.5°C. More reduction will be anticipated in both surface water and groundwater recharge with precipitation reduction by more than 20%. All these results indicated that surface and groundwater resources of Jordan are highly vulnerable to climate change and the water availability from these two sources is expected to be reduced by at least 40%.

- The long term average of surface water is 713 MCM and safe yield of renewable groundwater resources is 280 MCM (MWI, 2008). Applying the 40% reduction to both sources due to climate change indicates that the water availability of Jordan will be reduced by about 397 MCM.
- MWI will adopt and implement various measures to bridge the gap between the supply and the demand. These projects are listed in Table 6.
- It is assumed that about 40% of the total cost of these measures should be attributed to the adverse climate change impacts (adaptation cost) and calculated as shown in Table 6

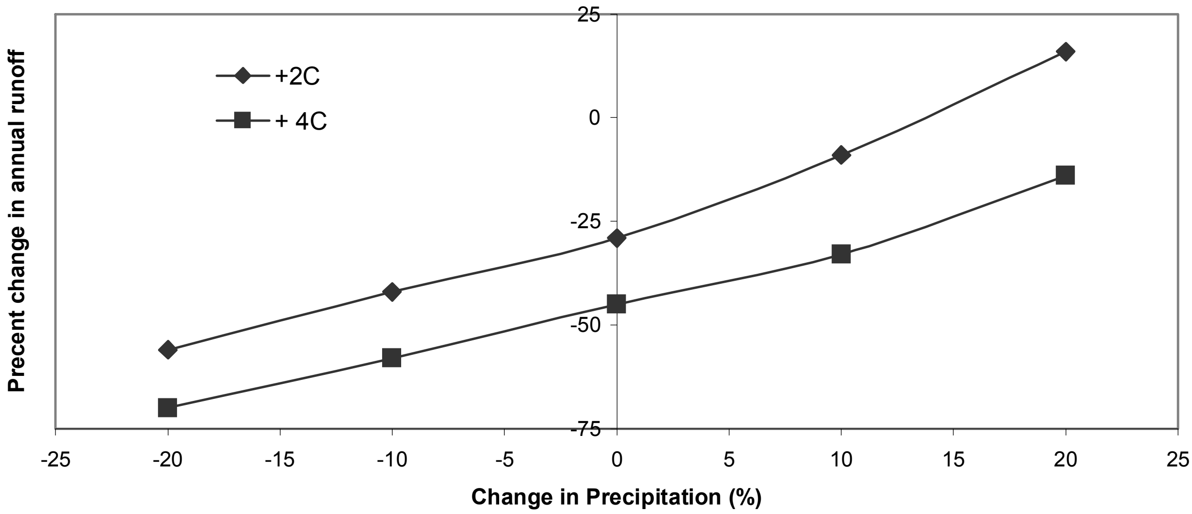

Figure 8 climate change impacts on surface runoff

Most of agricultural land in Jordan is rainfed agriculture. So, this sector will be highly vulnerable to climate change under most of the scenarios. Also, the irrigated agriculture will be affected due to the reduction of the water availability. There are no accurate figures about the degree of climate change impacts on these types of agriculture. The estimated incremental cost of adaptation for this sector should not be less than 40-50% of the proposed cost of agricultural projects.

Table (5) Proposed adaptation projects for the agricultural Sector up to the year 2020

No.	Project/Program Name	Estimated Total Cost (Million US$)	Additional Cost (Million US$)[a]	Implementing Agency
1	Introduce water harvesting techniques in rangeland	3.3	1.65	MoA
2	The protected crops project	15	7.5	MoA
3	Water harvesting	25.4	12.7	MoA
4	Enhancement of irrigation efficiency by using fertilized irrigation	42.8	21.4	MoA
5	Rehabilitation of Desert lands	167.8	83.9	MoA
6	Program for development of Desert Projects	9.0	4.5	MoA
7	Rehabilitation and development of forest and rangeland areas	37.8	18.9	MoA
8	Agricultural sustainability of Petra Region	7.5	3.75	MoA
Total		**308.6**	**154.3**	

[a] incremental cost is assumed as 50% of the total cost

Table (6) Proposed Adaptation projects for the water sector up to the year 2020

No.	Project/Program Name	Total cost (Million US$)	Additional Cost (Million US$)[a]	Implementing Agency
1	Disi Water Conveyance Project	190.35	76.14	MWI
2	Red-Dead Project	2820	1128	MWI
3	Millennium challenge project MCC/service water tender to study the value of technical and environmental aspect for rebuilding and re habitation of the water system in Zarqa city p1-A and P1-B	4.23	1.69	MWI
4	Repair and rehabilitation project (RRF) for Water Supply network for Jeresh/Balela, Abu Eiat,Sakeb,Bani Obead,Alrmtha, and Bani Kenanah	42.09	16.84	MWI
5	Water loss reduction project (WLRP) for Northern Governorates	31.82	12.73	MWI
6	Rehabilitation of water conveyance system for northern governorates (Hofa-Alzatari conveyance	45.12	18.05	MWI
7	Water resources management program WRMP (Water Loss Reduction in the middle and northern parts of Jordan, reuse of treatment waste water in Northern Jordan Valley, reduce water loss in Amman city	122.67	49.07	MWI
8	Water Loss reduction project for Karak city	42.24	16.90	MWI
9	Water loss reduction project in Northern governorates	31	12.41	MWI
10	Improvement of water supply in Zarqa city 2nd stage	21.15	8.46	MWI
11	Improvement the mechanical services to farmers	5.5	2.2	MWI
12	Wastewater system collection (sewer network) project	58.23	23.29 M	MWI
13	Enhancement of Monitoring systems	2.93	1.17	MWI
14	Irrigation improvement projects	13.1	5.24	JVA
15	Dam construction program: Ibn Hammad Dam, Khaled ibn Alwaleed dam, Al-whihdee Dam, Al-Karak Dam, Kufranja Dam etc.	86.74	34.7	JVA
16	Operation and Maintenance Program for King Abdullah Canal (KAC)	15.09	6.03	JVA
17	Early Warning System for Floods	6.0	6.0	JMD
Total		**3.59 billions**	**1.47 billions**	

[a] Incremental cost is assumed to be 40% of the total cost.

3. Key Findings on Financial and Policy Instruments

3.1 Financial and Policy Instruments

According to the Country Environmental Analysis (CEA) of Jordan that conducted by the World Bank in 2009, Jordan's public expenditure on environmental protection is significant. A review of the public environmental expenditure (PEE) that conducted for the first time in Jordan in the context of CEA, shows that total PEE during the period 2002-2006 amounted to an average of 0.8% of Jordan's GDP at real prices, and 2.3% of total government spending (see Table 7). It can be noticed that the government spending on the environment has increased from 0.61% of GDP in 2003 to 1.23% of GDP in 2003, after which it started declining down to 0.72% in 2006.

Table (7) Total public environmental expenditure proportion in GDP and total public expenditure

Variable	2002	2003	2004	2005	2006
GDP at Market Prices (JOD bn)	6.879	7.354	8.32	9.231	10.409
Inflation rate as measured by % change in GDP deflator	0.9	2.1	3.1	3.2	5.18
Deflated GDP (JOD bn) using GDP deflator	6.818	7.203	8.070	8.945	9.896
Total PEE at Market Prices (JOD bn)*	0.042	0.090	0.071	0.076	0.075
Deflated PEE (JOD bn)	0.042	0.088	0.068	0.074	0.072
% of PE of the GDP (%)	0.61%	1.23%	0.85%	0.83%	0.72%
Total Government Expenditure at Market Prices (JOD bn)	2.396	2.810	3.181	3.539	3.912
Deflated Government Budget (JOD bn)	2.375	2.752	3.085	3.429	3.720
PEE as % of Gov. spending	1.7%	3.2%	2.2%	2.2%	1.9%

** PEE includes central Government finance, public independent institutions, municipalities, and Greater Amman Municipality.*

Global Environment Facility (GEF) financially supported Jordan in executing the following climate change activities:

- Preparation of the Initial National Communication (INC), executed by General Corporation for Environment Protection (GCEP) (later became Ministry of Environment (MoEnv)), 1996-1997.
- Vulnerability and adaptation to climate change, carried out by MoEnv in the year 2000 as completion to the INC.
- Establishing a pilot biogas facility at Russifa domestic landfill site, executed by Greater Amman Municipality, commissioned in the year2000.
- Technology needs assessment (TNA) and technology transfer (TT), executed by MoEnv, (2004-2005).
- National Capacity Self Assessment for Global Environmental Management (NCSA). This project was implemented to assess the capacity constraints and potentials for implementing the three international environmental conventions on Biodiversity, Climate Change and Desertification, executed by MoEnv, 2005.

- Enabling Activities for the Preparation of Jordan's Second National Communication to the UNFCCC, executed by MoEnv , 2006- 2009.

The mentioned projects have been executed with UNDP support, and technical support from other United Nations organizations including UNEP and UNFCCC. In addition, National Communication Support Programme (NCSP)- which is a UNEP/UNDP programme- has provided technical support during the preparation of Jordan's SNC through training workshops, provision of guidelines and guidance materials, review of studies and reports and provision of online support and tele-conference calls. Jordan's contribution in these projects is in the form of in kind costs including human resources, office space and furniture, communications, and the associated costs.

The Jordanian National Agenda, which is a ten–year program of action for the country that covers years 2006-2015, embodies a developed vision of Jordan, one that responds to the demands of modernity, and the consequences of competition and regional and international integration. Although many of the programs recommended by the agenda may lead to indirect mitigation of climate change impacts, there was no programs that addressed the climate change.

By reviewing the current national sectoral policies and strategies in Jordan for energy, water and agriculture, it was concluded that the climate change issues were not directly addressed. As for the solid waste sector, the national strategy is not yet developed.

As part of the SNC a preliminary adaptation action plan was proposed as an initial step to develop a multi-sectoral action plant. The MoENV is considering obtaining high level commitment and endorsement of this plan to help in integrating the climate change issue into the national strategies and plans of the relevant sectors.

3.2 Available Financial Mechanisms

Jordan needs financial resources in order to meet its obligation to the UNFCCC. Previously GEF funded most of the projects and programs related to the CC. Table 8 presents the amount the projects and the amount of funsd allocated by GEF. The finance will enable the country in addressing the causes and consequences of the climate change. Therefore, it is important to identify the financial instruments through which the financial resources can be mobilized.

The financial instruments identified under the NEEDS study are comprising three main categories, namely local instruments, regional instruments and international instruments. Under the local category, the following sources were identified:

- National public budget

- Renewable energy fund

- Privatization fund
- Private sector

As for the regional financial instruments, the following were identified:

- The Arab Fund
- Islamic Bank

On the international level, the UNFCCC funds that created by the COP were identified as major sources of funding. These include,

- Special Climate Change Fund,
- Adaptation Fund.

In addition, the Global Environmental Facility (GEF), the World BANK, the United Nation Development Program (UNDP) and The United Nation Environment program (UNEP) were among the funding sources identified. The Clean Development Mechanism (CDM) is another window of finance that identified. The millennium Development Goal Fund of Spain is currently supporting a national project in Jordan, which focuses on enhancing the country adaptive capacity in meeting the millennium development goals. The amount of fund is 4.4 million US$. Copenhagen Green fund is another potential source identified by the stakeholders.

On the multilateral and bilateral levels, European Commission (EC), European Investment Bank (EIB), USAID, Canadian International Development Agency (CIDA), Japan International Cooperation Agency (JICA) are among the potential sources of funding.

Table 8. Climate change projects and programs funded by GEF

No.	Project /Program	Amount of Fund (1000 US$)	Year
1	First National Communication	242	1996
2	Vulnerability Assessment	100	1999
3	Construction of Pilot Biogas Facility at Russaifa Landfill	2500	1996
4	Capacity Building in Climate Change	100	2004
5	National Capacity Self Assessment (NCSA)	200	2006
6	Second National Communication	405	2008
7	Developing Policy-Relevant Capacity for the Implementation of Global Environmental Conventions in Jordan	500	2009

4. Lessons Learned

Undertaking the NEEDS study in Jordan revealed to be a useful exercise in identifying the available opportunities and challenges facing the country in integrating the climate change issues into the national development plans. The participatory approach followed in conducting the study was effective in obtaining the needed information and eliciting the opinions and thoughts of various stakeholders.

The NEEDS study identified the priority sectors that need more attention under both mitigation and adaptation actions. In addition, the needs of various Jordanian agencies to enhance their capacities in the context of climate changes were also assessed and associated costs were estimated.

There are several funding windows that were identified which can be approached to fund the climate change initiatives and programs. Those are available mainly on the international and bilateral levels, while on the national and regional levels there are few financial instruments available.

One of the main challenges identified, was the low level of knowledge and awareness of the climate change issues among the national stakeholders. This has led to the absence of climate change aspects from most of the national strategies and policies. Another challenge identified was the absence of financial resources to address the climate change

The NCSA process was conducted in a participatory way and facilitated a national dialogue that resulted in a robust package of suggested strategic capacity building activities in the form of the NCSA capacity building action plan. The constraints were classified at institutional, legislative, financial and technical levels. Proposed projects were formulated within a logical frame analysis (LFA) to alleviate these constraints.

Challenges and gaps and related financial, technical and capacity needs identified through the preparation of the SNC are presented hereafter.

4.1 Challenges and Constraints Identified by the SNC

4.1.1 GHGs Inventory

- Data gaps and data availability in the format and quality needed for GHG inventory preparation was one of the main identified problems faced during the preparation of SNC;
    - Lack of institutional arrangements for data collection and data sharing.
    - Data are often available in formats that suit government planning purposes, but do not cover all the information required by the IPCC methodology for inventory.
    - Lack of disaggregated activity data. Specific examples are:
        - LULUCF sector: unavailability of data of forest and on forest annual growth rates, soil types and their carbon content and land-use patterns.
        - Lack of activity data in industrial sector including fuel consumption figures.

- Lack of up-to-date activity data in transport sector including modes of road transportation. In addition, data of local aviation and marine are not available.
- Lack of activity data of use of energy in agriculture, forestry and fishing sub-sectors.

- Unavailability of local emission factors, thus the IPCC default values were used.
- Poor documentation of the inventory of the Initial National Communication and other related studies.

4.1.2 GHG Mitigation Analysis

- Lack of data in sectors other than energy.
- Limited expertise in the energy models.
- Limited technical expertise in some sectors such as transport and agriculture.
- Weak awareness among decision makers on climate change in general and on financial and environmental benefits of CDM.
- Lack of legal and institutional framework to promote energy efficiency and renewable energy options.
- Improper enforcement of existing laws related to energy efficiency and renewable energy.

4.1.3 Vulnerability and Adaptation

- Data availability, consistency and transparency was one of the main identified problems faced during the preparation of climatic scenarios and thematic vulnerability and adaption studies;
  - There are missing data in the daily and monthly climatological time series at the majority of national meteorological stations.
  - There is also a problem in water data availability. The quality of the available data is sometimes inappropriate.
  - The existing climatic and water resources monitoring in the country are facing permanent problems in operation, slow modernization of equipment and reducing of the monitoring network.
  - Health data on climate sensitive diseases are either limited or not readily available. Current records are based on disease groups, for example group one represents all infectious diseases while group nine represents digestive tract diseases.
  - Socioeconomic data are either unavailable or available in inappropriate form. In general, data of some socioeconomic variables are available at the governorate level and not at cities, towns and villages level.

- Coarse spatial and temporal resolution of climate scenarios do not match the requirements of policy oriented applications
- Lack of regional climatic prediction models and downscaling models, thus, Global Circulation Models (GCMs) were used with high spatial distribution. Precipitation modelling using these GCMs models gave poor results.

- Lack of well developed methodologies and tools worldwide for undertaking vulnerability and adaptation studies especially for health and socioeconomic sectors.
- Limited local and international vulnerability and adaptation studies to perform comparisons with the studies conducted during the SNC preparation and to verify the obtained results.
- Lack of financial resources to address needs, conduct research and studies, and implement adaptation measures.

5. Possible Next Steps

To date Jordan does not have a separate "climate change policy" document. Therefore there is a pressing need to develop such a policy. Based on the challenges and problems identified during the preparation of the SNC, the following has been recommended:

5.1 Inventory

- Develop a GHG inventory data system aiming at collecting data in the needed quality and format. This system should include institutional arrangements to facilitate data collection and sharing among the various national institutions. Also, this system should include a legislative framework to obligate private sector to report the required data.
- Conduct surveys, studies and scientific research aiming at developing disaggregated activity data and emission factors needed for the GHG inventory estimation with special focus on key emission sources and sectors with high uncertainty.
- Conduct studies with regional cooperation aiming at developing regional emission factors.
- Develop the local capacities in using the new guidelines, methodologies, tools and software.
- Secure and mobilize financial resources to address the above mentioned needs.

5.2 Mitigation

- Secure funds for the proposed mitigation projects for the energy and waste sectors listed in Tables 3 and 4.
- Develop the local capacities in using GHG mitigation methodologies, tools and software.
- Develop the local capacities in specific areas such as improvement of transport efficiency, assessment of different transport modes and application of transport mitigation methodologies.
- Secure and mobilize financial resources to implement GHG mitigation projects especially small scale CDM projects.
- Formulate legal and institutional framework to promote energy efficiency and renewable energy options as well as enforcement of exciting laws through setting by laws and regulations.
- Raise awareness of decision makers and top management of industrial organizations on the benefits of CDM projects.

5.3 Vulnerability and Adaptation

- Secure and mobilize financial resources to conduct studies and implement adaptation measures for water and agriculture sectors listed in Tables 5 and 6.
- 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 data bases.
- Capacity building is needed in the area of methodologies, tools and guidelines to conduct vulnerability and adaptation studies.
- Conduct studies and research to assess adverse impact and vulnerability to climate change in different sectors specially those that were not included in SNC such as tourism and sea level rise sectors. In addition, studies are needed to geographically cover all potentially vulnerable areas of the kingdom.
- In the field of climate and climate change scenarios there is a need to establish regional models and downscaling models.

- During the preparation of SNC, adaptation measures were proposed by the vulnerability and adaptation team. These measures were formulated into programs and projects and were included in a proposed preliminary adaptation action plan.

  There is a need to further develop the proposed plan into a comprehensive multi-sectoral "National Adaptation Action Plan" through the participation and engagement of the relevant institutions and stakeholders including ministries of environment, water, agriculture and health. This action plan is expected to address all needs in the area of vulnerability and adaptation, and to focus on prioritizing the proposed programs and projects based mainly on the vulnerability of the different sectors. The plan is also expected to identify barriers to implementation of the adaptation measures and put forward programs, projects and mechanisms to deal with them. Such barriers include the problems and constraints mentioned earlier such as; lack of financial resources, lack of awareness, lack of adequate tools, knowledge and methodologies, and lack of incorporation of climate change in developing policies, strategies and plans of climate sensitive sectors.

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Annex 2 Detailed cost calculations for energy projects

Incremental Costs calculations of the Major New & Renewable Energy Projects

Introduction

The following projects will be assessed in terms of their incremental costs and the net avoided emissions of CO_2. Therefore, for the sake of having an idea about those two parameters i.e. incremental cost & the net CO_2 emission reduction, the following factors were used in calculations:

- **Tons CO_2 emissions per ton of Fuel Oil (F.O) as 3.136. this figure is calculated based on the followings:-**

  (I) Fuel Oil consumptions in 2007 as 6,369,260 ton.
  (II) CO_2 emissions (calculated) as 19.974 million ton CO_2.

- **Tons CO_2 emissions per ton of N.G as 2.70.**
- **The needed mass of F.O per MWhr is 210 Kg F.O/M.Whr.**
- **The Load Factor of the Power Generation Station as 85%.**
- **The density of the Natural gas (N.G) as 0.75 Kg/m^3.**
- **By implementing combined cycle process, the needed volume of N.G per KWhr is 8 ft^3/KWhr.**

1. Second IPP Project at Qatraneh to produce 373MW$_e$ by using Combined Cycle & firing N.G:-

Taking into account that the cost of each MW$_e$ installed & produced by firing either N.G or F.O is almost the same.

Thus, the only important revenue that will be saved by using N.G is the Reduction of the CO_2 emissions that will be emitted to the atmosphere. This will be calculated as the difference between:-

- **476,039.16 * 2.70 = 1,285,305.732**
- **686,170.8 * 3.136 = 2,151,831.63 which is:-**
  2,151,831.63 – 1,285,305.732
  = 866,525.898 ton CO_2

The following tables are summarizing the results:-

Table (1)
Net CO_2 Emissions Reductions by using the N.G

Installed Capacity	Ton N.G	Ton F.O	Quantities of CO_2 Reduced (Ton)
373 MW$_e$	476,039.16	686,170.8	866,525.898

Now, to calculate the net cost needed to secure the installation of the N.G line from Aqaba up to the Qatraneh Power Station, taking into account the cost of external-Internal N.G connections then, we need to have an idea about the external cost per KM of the N.G transmission line this is on one hand, the distance from Aqaba to the Qatraneh Power Station, and on the other the cost of internal N.G connections including hot tapping ..etc.

Table (2)
Cost per Diameter & Distance of N.G installation pipeline up To Qatraneh P.S

Cost ($) per KM	Diameter of the Pipeline in inch	Over all Distance (KM) from Aqaba up to Qatraneh Fence Boarder
800,000	36	232

Table (3)
Over all Cost of N.G installation pipeline up to Qatraneh P.S

Cost up to the Qatraneh Boarder (U.S $)	Cost of Internal installations (million U.S $)	Overall Cost (Million U.S $)
185.6 E 06	10	195.6 E 06

The total cost of natural gas pipeline installation is 314.4, distributed among the power stations that will utilize the natural gas based on their installed capacities. The power stations that utilize natural gas are listed below along with their installed capacities:

- **Rehab 360 MW**
- **Samra 500 MW**
- **East Amman 380 MW**
- **Aqaba 660 MW**
- **Qatraneh 373 MW**

2. PROJECT No.(2): Wind Kamsheh Project for Electricity Generation of $40MW_e$:

Taking into account that the present cost of each 1MWe produced from Wind Energy as U.S$2300/KWhr
= U.S$ 2.3 million/1MWe installed.

Avoided quantities of CO_2 emissions will be as:-
= 73584 Ton F.O * 3.136 ton CO_2/Ton F.O
= 230,759.42 ton CO_2.

For the Incremental Cost:-

Each 1MWe costs a total of U.S$ 800,000, then for 40 MWe installed the total cost will be: 40*800,000= US $ 32 millions
So, the Incremental Cost is the difference costs that is:-
= 92- 32
= U.S $ +60 million.

The following table summarizes the results:-

Table (4)
Incremental cost & Net CO_2 Emissions Reductions by using the N.G

Installed Capacity	Ton F.O needed	Incremental Cost in million U.S $	Quantities of CO_2 Reduced
$40MW_e$	73584	+ 60	230,759.42

Project No (3) Electricity generation from PV cells to produce 1 MW_e

Taking into account:-

Cost of 1MWe produced from PV= U.S$ 5.127 million.
Cost of installed 1MWe produced from F.O = U.S$ 800,000.
Then,
The Incremental Cost =U.S$ +4.327 million.

Table (5)
Incremental cost & Net CO_2 Emissions Reductions by using PV cells to produce $1MW_e$

Installed Capacity	Ton F.O needed	Incremental Cost in million U.S $	Quantities of CO_2 Reduced
$1MW_{e\ Installed}$	1839.6	+4.327	5768.98