THE HASHEMITE KINGDOM
OF JORDAN

JORDAN'S 4TH NATIONAL COMMUNICATION ON CLIMATE CHANGE

Submitted To
The United Nations Framework
Convention on Climate Change (UNFCCC)

global
environment
facility
INVESTING IN OUR PLANET

UNDP

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Jordan’s Fourth National Communication on Climate Change

4NC

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“Climate Change cannot be addressed in isolation. No geographical region, no economic sector can protect itself from the impact of global threats. To achieve the future we seek, there must be comprehensive, collective, sustainable global action - action that gets results.”

His Majesty King Abdullah II Ibn Al-Hussein

21st Conference of the Parties – Paris

30 November 2015

Forward

Jordan’s Fourth National Communication Report on Climate Change represents years of diligent and painstaking work by Jordan’s foremost experts on climate change and national stakeholders who have committed to the ongoing process of producing the most accurate and thorough National Communication thus far. The report comes at the perfect time, following the ambitious update of Jordan’s Nationally Determined Contributions, the recent launch of Jordan’s National Climate Change Policy 2022-2050, the National Adaptation Plan, and most importantly, the royal vision that has produced the Economic Modernization Vision of Jordan with climate change at its forefront. This report will provide a substantial evidence base for stakeholders to undertake the most critical challenge of our generation in the upcoming years, enabling the implementation of the recently published national policies and strategies and a response to climate change commensurate with the danger it poses to our nation.

We are proud to announce that the Fourth National Communication Report was developed exclusively through national efforts and expertise and relied on capacitating national institutions to develop the data required, as well as the contribution of representatives from all national institutions under a technical working group that insured that the report was aligned with national policies and strategies and that national ownership was guaranteed on every level.

As the impact of climate change becomes exponentially more apparent in Jordan, exacerbated by the influx of refugees from the region, and as Jordan’s natural resources are continuously stressed, it becomes imperative that an adequate approach to adapting to climate change is identified, and the information identified through the report will prove to be invaluable as this approach is honed in the coming years. On the other hand, the report also focuses on the important need for mitigating the causes of climate change, even though Jordan only contributes 0.06% of global emissions, the nation is determined to implement mitigation actions under the principle of common-but-differentiated responsibilities and respective capabilities.

In conclusion, I want to express my gratitude to the national experts and stakeholders for their valuable expertise and input that greatly contributed to the successful completion of this document. The achievement of this forward-thinking report was made possible by the support of GEF and the UNDP, as well as the collaboration of all national governmental institutions involved.

Dr. Muwaieh Al-Radaideh

Minister of Environment

Explanatory Note

Jordan signed the United Nations Framework Convention on Climate Change in 1992 and ratified the Kyoto Protocol in 2003. Under these agreements countries are expected to provide information to assess the progress of efforts to address climate change; the National Communication is one such document that provides greenhouse gas (GHG) inventories, measures to mitigate and to facilitate adequate adaptation to climate change, and other information, with Jordan publishing the first, second, and third National Communications in 1997, 2009, and 2014, respectively.

The Fourth National Communication was developed relying solely on national expertise and efforts, with experts working directly with focal points from line ministries and sectoral institutions. Data collection was completed in close partnership with government institutions, and the climate change projection was developed in the offices of the Meteorological Department through their servers and with the department's staff, who received the required capacity-building. The data was shared with all government entities for input and verification. Discussions were held prior to the formulation of the technical working groups, and sector specific discussions took place to identify areas of importance for the report in addition to the validation of the data. This approach guaranteed the avoidance of duplication in national reports and the alignment with Jordan's priorities. The mitigation section's recommendations were aligned with Jordan's recently published National Climate Change Policy 2022-2050, allowing both documents to build upon each other and ensure the compatibility of their implementation.

4NC Governance & Preparation Team

The governance structure formulated to prepare the Fourth National Communication Report can be described as representative, transparent, and collaborative. The National Climate Change Committee represented the supreme decision-making and guidance platform. National technical working teams representing governmental and non-governmental stakeholders concerned with climate change, were formulated to provide sector-specific input under the direct guidance and mentorship of lead experts for each sector. This report was prepared collectively by national lead experts in collaboration with the national technical teams.

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List of Acronyms & Abbreviations

4NC	**Fourth National Communication**
a.s.l.	Above Sea Level
AAWDCP	Aqaba Amman Water Desalination and Conveyance Project
ACCBAT	Adaptation to Climate Change through improved water demand management in irrigated agriculture by introduction of new technologies and best agricultural practices
ACI	Airports Council International
ACTED	Agency for Technical Cooperation and Development
ADC	Aqaba Development Corporation
AFD	Agence Français de Développement
AFOLU	Agriculture, Forestry, and Other Land Use
AICS	Italian Agency for Development Cooperation
AIG	Airport International Group
Al_2O_3	Aluminium (III) Oxide
AMR	Aqaba Marine Reserve
AMRMP	Aqaba Marine Reserve Management Plan
ASEZA	Aqaba Special Economic Zone Authority
AWC	Arab Water Council
b.s.l.	Below Sea Level
BAU	Business As Usual
BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMZ	German Federal Ministry for Economic Cooperation and Development
bpd	Barrels per day
BRCCJ	Building Resilience to cope with Climate Change in Jordan, through improving water use efficiency in the agriculture sector
BREEAM	Building Research Establishment Environmental Assessment Method
BRT	Bus Rapid Transit
BTRs	Biennial Transparency Reports
BURs	Biennial Update Reports
C/y	Celsius/year
CAEP	Climate Action Enhancement Package
CBD	Central Business District
CBD	Convention on Biological Diversity
CBJ	Central Bank of Jordan
CBOs	Community-Based organizations
CC	Climate Change
CCAC	Climate and Clean Air Coalition
ccGAP	Climate Change Gender Action Plan
CCP	Climate Change Policy
CCIVA	Climate Change Impacts, Vulnerability and Adaptation
CCV	Climate Change Vulnerability
CCVA	Climate Change Vulnerability Assessment
CCVIA	Climate Change Vulnerability and Impact Assessment
CDM	Clean Development Mechanism
CEHA	Regional Centre for Environmental Health Action

CH_4	Methane
CLEER	Clean Energy Emission Reduction
CMIP6	Coupled Model Inter-comparison Project, version 6
CO_2	Carbon Dioxide
CO_2eq	Carbon Dioxide equivalent
COP	Conference of Parties
COPD	Chronic Obstructive Pulmonary Disease
CORDEX	Coordinated Regional Climate Downscaling Experiment
CRVS	Civil Registration and Vital Statistics
CSA	Climate-Smart Agriculture
CSBC	Construction and Sustainable Building Center
CSO	Civil Society Organization
CSP	Concentrated Solar Power
CSR	Corporate Social Responsibility
CVA	Comprehensive Vulnerability Assessment
CWS	Center for Women Studies
DAE	Direct Access Entity
DEG	Deutsche Investitions Und entwicklungs gesellschaft
DEM	Digital Elevation Model
DHS	Department of Health Services
DIAPOL-CE	Policy Dialogue on Low Emission Strategies
DLDD	Desertification, Land Degradation and Drought
DMS	Data Management System
DNA	Designated National Authority
DOS	Department of Statistics
DP	Displaced Persons
DQC	Data Quality Control
DRR	Disaster Risk Reduction
DTU	Technical University of Denmark
EbA	Ecosystem Based Adaptation
EBRD	European Bank for Reconstruction and Development
EDAMA	Association for Energy, Water and Environment
EDP	Executive Development Program
EE	Energy Efficiency
EF	Emissions factor
EIA	Environmental Impact Assessment
EIP	Expanded Immunization Program
EMEP/EEA	European Monitoring and Evaluation Programme
EMIS	Environmental Management Information System
EMRC	Energy and Minerals Regulatory Commission
ENPI CBC Med	European Neighborhood and Partnership Instrument Cross-Border Cooperation for the Mediterranean Area
EPD	Environmental Planning Directorate
EPF	Environment Protection Fund
EPI	Expanded Program of Immunization
EQM	Empirical Quantile Mapping
Eqn.	Equation
ESAP	Environmental and Social Action Plan
ESGF	Earth System Grid Federation
ESHS	Environment, Social, Health and Safety

ESHSM	Environment, Social, Health and Safety Management
ESIA	Environmental and Social Impact Assessment
ESTs	Environmentally sound technologies
ETc	Crop Evapotranspiration
ETF	Enhanced Transparency Framework
ETp	Evapotranspiration
EU	European Union
EWE	Energy, Water and Environment
FAB	Functional Agrobiodiversity
FAO	Food and Agriculture Organization
FBUR	First Biennial Update Report
FDI	Foreign Direct Investment
FES	Friedrich Ebert Stiftung
FNC	First National Communication
FSI	Food Security Index
GAM	Great Amman Municipality
GCEP	General Corporation for Environment Protection
GCF	Green Climate Fund
GCM	General Circulation Models
GDP	Gross Domestic Production
GEF	Global Environment Facility
GEP	Government Executive Programme
Gg	Gigagrams
GG-NAP	Green Growth National Action Plan
GGGI	Global Green Growth Institute
GGR	General Guidance and Reporting
GHG	Greenhouse Gas
GIEP	Government Indicative Executive Program
GIS	Geographical Information System
GOA	Gulf of Aqaba
GoJ	Government of Jordan
GR	Growth Rate
GSP	Global Support Programme
GSPA	Gas Sales and Purchase Agreement
GW	Groundwater
GWP	Global Warming Potential
GWP	Government Work Plan
ha	Hectares
HCST	Higher Council for Science and Technology
HEC-RAS	Hydrologic Engineering Centre's – River Analysis System
HEIS	Household Expenditure and Income Survey
HFCs	Hydrofluorocarbons
HGVs	Heavy Goods Vehicles
HIS	Health Information Systems
HUDC	Housing and Urban Development Corporation
ICFVA	Impact Chain Framework Vulnerability Assessment
ICRI	International Coral Reef Initiative
ICT	Information and Communication Technologies
ICZM	Integrated Coastal Zone Management
IEA	International Energy Agency

IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IHR	International Health Regulations
IIP	Inventory Future Improvement Plan
IKI	International Climate Initiative
IMF	International Monetary Fund
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IRENA	International Renewable Energy Agency
ISWM	Integrated Solid Waste Management
ITS	Intelligent Transport Systems
IUCN	International Union for the Conservation of Nature
IWRM	Integrated Water Resources Management
IYCF	Infant and Young Child Feeding
JEF	Jordan Environment Fund
JEU	Jordan Environmental Union
JGBC	Jordan Green Building Council
JGBG	Jordan Green Building Guide
JICA	Japan International Cooperation Agency
JMD	Jordanian Meteorology Department
JNBC	Jordanian National Building Council
JNCCC	Jordan National Committee on Climate Change
JOSCO	Jordan Oil Shale Company
JOSE	Jordan Oil Shale Energy Company
JOTC	Jordan Oil Terminals Company
JPFHS	Jordan Population and Family Health Survey
JPRC	Jordan National Petroleum Company
JREEEF	Jordan Renewable Energy and Energy Efficiency Fund
JRP	Jordan Response Platform
JSF	Jordan's Strategy Forum
JTB	Jordan Tourism Board
JUH	Jordan University Hospital
JV	Jordan Valley
JVA	Jordan Valley Authority
JWPC	Jordan Wind Project Company
KAH	King Abdullah Hospital
Kc	Crop Coefficient
KEMAPCO	Kemira Arab Potash Company Ltd
KEXIM	Korea Export-Import Bank
KFW	KFW Banking Group (German Development and Investment Bank)
kgoe	Kilogrammes of oil equivalent
KHIA	King Hussein International Airport
KIO	Karak International Oil Company
KP	Kyoto Protocol
LCAP	Local Climate Action Plan
LCoY	Local Conference of Youth
LEAP	Long-range Energy Alternative Planning System
LEED	Leadership in Energy and Environmental Design
LFG	Landfill gas

LNG	Liquified natural gas
lpcd	Liter per Capita per Day
LTM	Low Thermal Mass
LTO	Landing and Take-Off
LTS	Long Term Strategy
LULC	Land Use Land Cover
LULUCF	Land Use, Land-Use Change and Forestry
MAB	Man and Biosphere
m.s.l.	Maximum Sea Level
MCDA	Multi-Criteria Decision Analysis
MCM	Million Cubic Metres
MDGs	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
MEMR	Ministry of Energy and Mineral Resources
MENA	Middle East and North Africa Region
MIT	Massachusetts Institute of Technology
MMcfd	Million Cubic Feet per Day
MMSCF/d	Million standard cubic feet of gas per day
MOA	Ministry of Agriculture.
MoE	Ministry of Education
MoEnv	Ministry for Environment
MoH	Ministry of Health
MOPIC	Ministry of Planning and International Cooperation
MoPWH	Ministry of Public Works and Housing
MoSD	Ministry of Social Development
MoT	Ministry of Transport
MoTA	Ministry of Tourism and Antiquities
MoU	Memorandum of Understanding
MPG	Modalities, Procedures and Guidelines
MRP	Market Readiness Proposal
MRV	Monitoring, Reporting and Verification
MSL	Maximum sea level
MSW	Municipal Solid Waste
MToe	Million tonnes of oil equivalent
MW	Megawatts
MWI	Ministry of Water and Irrigation
N_2O	Nitrous Oxide
NA	Not applicable
NAMAs	Nationally Appropriate Mitigation Actions
NAP	National Adaptation Plan
NNPA	National Network of Protected Areas
NBS	Nature Based Solutions
NCCC	National Climate Change Committee
NCCP	National Climate Change Policy
NCDs	Non-Communicable Diseases
NCSA	National Capacity Self-Assessment for Global Environmental Management
NCSCM	National Center for Security and Crisis Management
NDA	National Designated Authority
NDC	Nationally Determined Contribution
NE	Not evaluated

NEEAP	National Energy Efficiency Action Plan
NEEDS	National Environmental and Economic Development Study for Climate Change
NEPCO	National Electric Power Company
NetCDF	Network Common Data Form
NGGP	National Green Growth Plan
NGOs	Non-Governmental Organizations
NHWD	Normalized Heatwave Difference
NIE	National Implementing Entity
NMVOC	Non-Methane Volatile Organic Compounds
NNW	North North-West
NO	Not Occurring
NPC	National Petroleum Company
NPD	Normalized Precipitation Difference
NPRP	National Preparedness and Response Plan
NRP	National Resilience Plan
NSE	Nash-Sutcliffe Efficiency
NSWMS	National Solid Waste Management Strategy
NTD	Normalized Temperature Difference
NUP	National Urban Policies
ODS	Ozone-depleting substances
OEP	Other estimation parameters
PA	Paris Agreement
PAR	Participatory Action Research
PCV	Pneumococcal Conjugate Vaccine
PDTRA	Petra Development & Tourism Region Authority
PFCs	Perfluorocarbons
PHC	Primary Health Centers
PKU	Phenylketonuria
PMI	Partnership for Market Implementation
PMR	Partnership for Market Readiness
PPP	Public-Private Partnership
PPP	Purchasing Power Parity
PSU	Practical Salinity Unit
PT	Public Transport
PV	Photovoltaic cells
QA/QC	Quality Assurance / Quality Control
QAI	Queen Alia International
QAIA	Queen Alia International Airport
QM	Quantile Mapping
R&D	Research & Development
RCM	Regional Climate Models
RCP	Representative Concentration Pathway
RE	Renewable Energy
RE&EE	Renewable Energy and Energy Efficiency
REEEF	Renewable Energy and Energy Efficiency Fund
RES	Renewable Energy Sources
RMS	Royal Medical Services
RMSE	Root Mean Squared Error
RSCN	Royal Society for the Conservation of Nature
RSS	Royal Scientific Society

RWH	Roof-top rainwater harvesting
SACOS	Saudi Arabian Corp for Oil Shale
SAP	Simplified Approval Process
SAR	Second Assessment Report
SBUR	Second Biennial Update Report
SCAs	special conservation areas
SCCF	Special Climate Change Fund
SDC	Swiss Agency for Development and Cooperation
SDGs	Sustainable Development Goals
SEP	Stakeholder Engagement Plan
SF_6	Sulfur Hexafluoride
SFERA	Special Fund for Emergency and Rehabilitation Activities
Sh. Gh	Shamaliyah Gharbiyah (sub-district of Badia)
SLCFs	Short-Lived Climate Forcers
SLCP	Short-Lived Climate Pollutants
SLM	Sustainable Land Management
SMBC	Sumitomo Mitsui Banking Corporation
SME	Small and Medium-Sized Enterprise
SNAP	Supporting National Action and Planning on SLCPs
SNC	Second National Communication
SNE	Single National Entity
SOC	Soil Organic Carbon
SOCER	State Of the Cetacean Environment Report
SOx	Sulfur Oxides
SPI	Standardized Precipitation Index
SPUAR	*Sustainable Production and Utilization of Agro-natural Resources*
SSC	Social Security Corporation
SSD	Self-Sufficiency Degree
SSPs	Shared Socioeconomic Pathways
STI	Science, Technology and Innovation
SVI	Social Vulnerability Index
SW	Surface Water
SWAT	Soil Water Assessment Tool
T&D	Transmission and Distribution
TAPs	Technology Action Plans
TB	Terabit
TNA	Technology Needs Assessment
TNC	Third National Communication
TOE	Tonnes of oil equivalent
TOT	Training of Trainers
TT	Technology Transfer
TT1/TT2	Tetanus toxoid vaccinations
TWW	Treated Wastewater
UHC	Universal Health Coverage
UN-Habitat	United Nations Human Settlements Programme
UNCCD	United Nations Convention to Combat Desertification
UNCT	United National Country Team
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCWA	United Nations Economic and Social Commission for Western Asia
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
UNHCR	United Nations High Commissioner for Refugees
UNRWA	United Nations Relief and Works Agency for Palestine Refugees in the Near East
USAID	U.S. Agency for International Development
UVR	Ultraviolet Radiation
V&A	Vulnerability and Adaptation Assessment
VAF	Vulnerability Assessment Framework
VBD	Vector Born Diseases
WaCCliM	Water Companies for Climate Mitigation
WAJ	Water Authority of Jordan
WASH	Water, Sanitation and Hygiene
WB	World Bank
WFP	World Food Programme
WHA	World Health Assembly
WHO	World Health Organization
WMO	World Meteorological Organization
WUA	Water Users Association
WWF	Worldwide Fund for Nature
WWTP	Wastewater Treatment Plants
YWC	Yarmouk Water Company

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Executive Summary

I. **National Context**

The Hashemite Kingdom of Jordan is located in the Middle East, at the intersection of the continents of Asia, Africa and Europe. According to the 2021 estimates, Jordan's population stands at 11.1 million. Approximately 30% of the population are non-Jordanians and more than 1.3 million are Syrians, with around 89% of Syrian refugees living in host communities, mostly in the capital Amman, and in the northern governorates, making Jordan the largest refugee-hosting country worldwide, when compared to the size of its Jordanian population. Such circumstances put increased pressure on Jordan's limited resources, especially water resources, and impose severe stress upon its public services, including health, education, energy, infrastructure, municipal services, and solid waste management.

Jordan is signatory to the UNFCCC - the government ratified, *inter alia*, the Convention in 1993, the Kyoto Protocol in 2004, and the Paris Agreement in 2016. Jordan joined the Climate & Clean Air Coalition in 2012 and produced several policies, pieces of legislation, and national reports in response to the obligations of the global collective collaboration frameworks. Jordan submitted the Initial, Second and Third National Communication Reports to UNFCCC in 1998, 2009 and 2014 respectively. Moreover, Jordan submitted the First Biennial Update Report (FBUR) to UNFCCC in 2017 and submitted the Second BUR (SBUR) in 2021.

Jordan submitted its first Nationally Determined Contributions (NDC) in Nov 2016 with an approximate GHG reduction target of 14 % by 2030. In 2021, Jordan updated its 1st NDC and increased the ambition of GHG reduction up to 31%.

At the national level, several steps have been taken in response to the global environment obligations to advance the climate agenda and mainstream it into the sectoral development policies, strategies, and programs. In this context, the government of Jordan enacted the Climate Change Bylaw Number 79 of 2019, which established the Jordanian National Climate Change Committee (JNCCC) as the supreme coordination and collaboration mechanism. In 2022, the Ministry of Environment launched the Climate Change Policy (2022-2050).

II. **National GHG Emissions Inventory**

According to the 2006 IPCC Guidelines and the 2019 Refinement to the 2006 IPCC Guidelines, the national GHG emissions were calculated for 2017. The nationwide Inventory was computed using the 2006 IPCC Inventory Software for Non-Annex I Parties. The following sectors and subsectors were considered: Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry, and Other Land Use (AFOLU), and Waste.

Anthropogenic emissions of the direct GHGs of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) were assessed by source and by removal by carbon sinks. Indirect GHG Inventories were prepared on a gas-by-gas basis in units of mass. Estimations were made whenever the activity data were available, using the EEA Guidelines and Methodology. Emissions were estimated in Gigagrams (Gg) for all direct and indirect gases using Gg of CO_2-equivalent (CO_2eq). For the conversion from Gg of different GHGs to Gg of CO2eq, the Global Warming Potential (GWP) values provided in the IPCC SAR were used. Jordan's overall GHG Inventory estimate in 2017 was 32,647 Gg CO2eq. A breakdown of Jordan's total emissions of GHGs by sector indicated that the energy sector was the major emitter releasing around 76% of total national emissions, followed by the waste sector with a contribution of about 12%.

Energy sector

Total emissions from the energy sector were 24,701 Gg of CO_2eq in 2017. Fugitive emissions (from oil and natural gas) were negligible, accounting for less than 2%. Significant emissions resulted from the Transport and Energy Industries and subsectors within the fuel combustion activities, with a share of 38% and 37%, respectively. Emissions resulting from "Manufacturing Industries and Construction" and "Other sectors" (Residential, Commercial, and Agriculture) accounted for 8% and 12% of the total, respectively.

Industrial processes and product use (IPPU) sector

Emissions from the industrial processes sector were 3247 Gg of CO2eq, accounting for 10% of Jordan's total GHG emissions in 2017.

The industrial processes sector was a source of NMVOC emissions, accounting for 33.21 Gg in 2017. In addition to CO_2 and NMVOCs, the industry generated HFC emissions with 942.38 Gg of CO2eq in 2017.

Agriculture, forestry, and other land use change sector

The GHG emissions of AFOLU activities accounted for around 2% (652 Gg of CO2eq) of Jordan's total GHG emissions in 2017. The emissions were composed of methane and nitrous oxide and were generated by various subcategories.

Waste sector

GHG emissions from the waste sector reached 4046 Gg of CO2eq, accounting for 12% of Jordan's total GHG emissions in 2017. Most of the emissions were generated by domestic solid waste disposal, which accounted for around 94% (3792 Gg CO2eq) of total waste emissions in 2017, while wastewater handling accounted for 5% (193 Gg CO_2eq) of total waste emissions.

GHG Inventory by gas.

The share of carbon dioxide was the largest, with a contribution of 25227.5 Gg accounting for 77% of all GHG emissions, followed by CH_4 and N_2O accounting for only 15% and 4%, respectively,

In 2017, most carbon dioxide emissions resulted from the energy sector accounting for 24062 Gg, followed by 2035 Gg from the IPPU sector. Methane emissions were highest in the waste sector, followed by the AFOLU sector, with contributions of 77% and 14%, respectively. Nitrous oxide emissions were highest from AFOLU then, followed by the IPPU sector and energy and waste sectors (60%, 18%, and 11%, respectively).

As expected, the IPPU sector contributed 100% of HFCs, and the NMVOCs emissions were mostly from IPPU and Energy.

Within the energy sector, the main emissions were in the form of CO_2 (97%). Within the IPPU sector, the key GHGs were CO_2, followed by HFCs, with shares of 63% and 29%, respectively. Within the waste and AFOLU sectors, methane emissions were the highest, resulting from solid waste management, livestock, and land and manure management.

According to the most significant emitters, the energy sector comes first, followed by the waste sector and IPPU, in contrast to the TNC, which placed the energy sector first, IPPU in second place, and the waste sector in third place.

On the other hand, if we consider sector and subsectors, the most significant GHGs sources sectors are, in order: transportation, electricity production, waste, and IPPU. This ranking differs from the TNC, where electricity generation is the first, followed by the transport sector the second, then IPPU and waste, due to the increasing renewable energy penetration in the generation system, as illustrated in the table below.

Ranking of sectors that emit the most greenhouse gases

Categories	Emissions CO_2 Equivalents (Gg)	Percentage of the total
Total National Emissions and Removals	32647	100%
Transport	9465	29%
Electricity Generation	9153	28%
Waste	4046	12%
Industrial Processes and Product Use	3247	10%

III. GHGs Mitigation Analysis

The goal of the GHG Mitigation Analysis is to identify and evaluate potential economic, social, and policy measures and human interventions that could be used in Jordan to reduce anthropogenic emissions of greenhouse gases (GHGs), in various sectors, at the national level, to slow the pace and magnitude of long-term induced global warming. Potential mitigating methods were examined and evaluated for the various sectors according to the timeframe.

Two different sorts of scenarios were created for this purpose: baseline scenarios and mitigation scenarios. The baseline scenario simulates the events assumed to occur without mitigation efforts; in other words, this reflects a future in which there are no policies or programs designed to 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 cost of mitigation options are directly linked to the sound definition of the baseline scenario. The updated baseline scenario in 4NC was constructed for the period 2018-2066 based on the sectorial approved strategies, plans, policies, laws, implementation plans, constraints, and trends prevailing in the Jordanian context during the current time and social and economic variables including the impacts of COVID-19 on the Jordanian economy—moreover, the Economic Modernization Vision was also considered.

The mitigation scenario in 4NC was created according to a set of criteria reflecting Jordan-specific conditions, such as the potential for significant impact on greenhouse gas emissions, direct and indirect economic impacts, consistency with national sustainable development goals, the potential effectiveness of implementation policies and programs, sustainability of an option, data availability for evaluation, and other sector–specific criteria.

In preparing this chapter of Jordan's 4NC, all mitigation projects included in the updated NDC (October 2021) and SBUR (December 2020) have been reviewed and assessed to identify valid and applicable options. The cost-benefit analysis and the CO_2 emissions reduction have been updated for each valid mitigation project. Net present value was used in the financial calculations by converting all current and future revenues and costs over the project's lifetime to a base of today's price. A discount rate of 8% was used in all cost calculations. The discounted unit cost of reduced emissions, the quotient of the discounted cost to the total emissions reduction, was also calculated.

The LEAP model was used to perform the energy mitigation analysis, and the standard calculation tool (IPCC 2006) was used to assess the mitigation potential of GHG in other sectors (IPPU, waste, agriculture, and forestry).

As a result of the in-depth analysis and discussions, it was agreed with all concerned partners to define 37 projects, procedures, and policies in the sectors above as measures to reduce anthropogenic emissions, the details of which are shown in Table (3.31).

The most important results concerning the emissions predicted for the future, can be summarized as follows:

- The total GHG emissions from all sectors in the baseline scenario are 33.556, 35.516, 37.858, and 39.943 million tonnes CO_2eq for 2022, 2025, 2030, and 2035 respectively. Out of which, approximately 77% is from the energy sector, 12% from waste, and 8% from IPPU.
- The ranking from the most significant emitters' point of view is the energy sector first, the waste sector second, and IPPU third. This ranking differs from the TNC, where the energy sector is first, IPPU is second, and the waste sector ranks third.
- In contrast, the total GHG emissions in the mitigation scenario are estimated to be 29.458, 27.757, 28.798, and 29.797 million CO2eq in 2022, 2025, 2030, and 2035 perceptively. The reduction percentages from all sectors for the mentioned years are 12%, 21%, 24%, and 26%. For more details, see Table (3.30).
- According to the analysis of the unit abatement cost and abatement marginal cost curve, energy mitigation measures and projects are the most feasible options. Specifically, from the total reduction of GHG and the unit abatement cost point of view, energy efficiency and renewable energy projects should receive the most attention.
- Implementing these mitigation options will enhance sustainable development by minimizing dependence on imported energy, where costs are redirected to the economy and creating good economic mobility in the local investment sector, especially where projects are located, by creating hundreds of direct and indirect jobs and revitalizing supporting works of different sectors. This will contribute to creating a green economy and associated socio-economic benefits such as revenue from energy generation, stable power supply for commercial operators, improved air quality, and health benefits from improved air quality.

IV. <u>Climate Change Impact, Vulnerability & Risk Assessment</u>

Climate Change Trends and Projections

Regional Climate Downscaling Models, from the Coordinated Regional Climate Downscaling Experiment (CORDEX) were accessed from Earth System Grid Federation (ESGF) global system of federated data centers. Six Regional Climate Models (RCMs) for two Representative Concentration Pathways scenarios (RCP 4.5 and 8.5) were tested, de-biased and calibrated using long historical climate data obtained from Jordan Meteorological Department for the periods from 1950 to 2005, for 28 weather stations distributed across the country. The historical and future data to 2100 for the six RCMs was calibrated and de-biased using the Statistical Downscaling of General Circulation Models followed by three de-biasing techniques (Delta, Quantile Mapping, Empirical Quantile Mapping) and tested using six efficiency criteria (Pearson Correlation, Nash-Sutcliffe efficiency, Spearman Correlation, Root Mean Squared Error, index of agreement, and Mean Absolute Error). Five uncertainty criteria were adopted for selecting the most representative RCM; (1) Root Mean Square Error, (2) Pearson coefficient of determination, (3) the Spearman test, (4) Kendall test, and (5) Nash-Sutcliffe test. The "CYI.NCAR-CCSM4" RCM showed the highest capabilities to represent the local historical weather station data with an accuracy reaching 97% for air temperature and more than 65% for precipitation.

Future climate projections up to the end of the 21st century were achieved using two RCP scenarios within a grid system of 50 km resolution followed by Statistical Downscaling to a 1 km resolution using co-kriging interpolation, a geostatistical technique. Based on temporal historical change trends, the rate of daily minimum temperature increase is about (0.026 C/y) while for the maximum temperature is about (0.007 C/y). The seasonal precipitation is subjected to reduction trends with average rate of 0.6mm per year. Using the reference model, the country is predicted to witness clear climate change exposures. By 2100, the country will witness a warmer climate. By the end of the 21st century, the minimum air temperature is very likely to increase by 1.2 °C [+0.6 °C to +2.9 °C] according to RCP 4.5 and by 2.7 °C [+2.1 °C to +4.5°C] according to RCP 8.5. Similarly, the maximum air temperature is very likely to increase by 1.1 °C [+0.7 °C to +1.7 °C] according to RCP 4.5 and 3.1 °C [+2.6 °C to +3.7°C] according to RCP 8.5.

The country will witness a significantly drier climate by the end of the 21st century, where the precipitation tends to decrease by 15.8% [-7.1% to -31.3%] according to RCP 4.5 and by 47.0% [-23.3% to -57.5%] according to RCP 8.5. The significant precipitation decrease is projected to be most likely in the western part of the country, while a potential increase is predicted to be likely, allocated to the southern arid zones. Standardized Precipitation Index analysis suggests significant future drought probability increase especially in the northern region of the country for both magnitude and duration, reaching a maximum probability of 93% using RCP 8.5 and 50% using RCP 4.5. Expected drought duration is predicted to become longer, with more than 3 consecutive years using RCP 4.5, and more than 5 years using RCP 8.5.

The potential evapotranspiration is very likely to increase by 5.8 % [+4.7 % to +6.9 %] according to RCP 4.5 and by 11.1 % [+8.1 % to +15.3%] according to RCP 8.5. Similarly, the air's relative humidity is likely to decrease by3% [-2.5 % to -3.3 %] according to RCP 4.5 and 7.2% [-6.0 % to -7.8 %] according to RCP 8.5, by the end of the 21st century. On the other hand, wind speed forecasts did not indicate significant changes, although the country is less likely to be subjected to wind gust events exceeding 12 m/s. Also, it is unlikely that the country will face several intense precipitations that varies spatially and temporally across the country. Finally, it is very likely that heatwave events will increase twofold according to the RCP 4.5, and threefold according to RCP 8.5.

CCIVA for Agriculture Sector

Analysis of agricultural sector vulnerability to climate change was carried out for rainfed and irrigated agriculture, livestock, and rangelands. Analysis of the agricultural sector can be summarized as follows:

- Agricultural areas = 400 thousand ha (4.5% of Jordan)
- Irrigated areas = 96 thousand ha
- Main crops produced: Vegetables, Olives, and Fruits.
- Livestock: Sheep (3 million), Goats (0.8 million), Cattle and Poultry.
- Self-sufficiency: Vegetables (144%), Olives, Fruits, Eggs, Milk and Dairy
- Rangelands and feed resources (by products): 31%
- Partial self-sufficiency: Citrus, Chicken meat.
- Direct Contribution to GDP = 3%

Analysis of climate impacts on agricultural sector was carried out using climate projections and agricultural census data from DOS. The tools used for the analysis were AquaCrop and statistical models. Results from this analysis, in terms of climate change (CC) impacts, can be summarized as follows:

1- Impacts on rainfed olives: an overall yield reduction of 20%.

2- Impact on barley cultivated in 200mm rainfall: an increase of 18-25% (Carbon fertilization).

3- Impact on rangelands and feed resources: reduction from 31% to 15%.

4- Impacts on irrigated crops: a possible increase of yield of vegetables by up to 17% (Carbon fertilization).

5- Impacts on crop water consumption: an increase of irrigation depth by 12-30%.

6- Impacts on self-sufficiency degree is summarized in the table below:

Category	% Present	% 2050	% 2070	% 2100
1- Vegetables	144	105	72	39
2- Olives	102	55	34	15

3- Fruit trees	97	63	40	20
4- Field crops	4	2.2	<2	<1
5- Chicken meat	81	37	23	12
6- Mutton and lamb meat	39	18	11	6
7- Goat meat	100	46	29	14

Analysis of DOS data and outputs from CC impact assessment was carried out to derive maps of climate change risk. Maps showed that high risk of CC characterized the high rainfall zones in Jordan and the areas of Middle-North Jordan Valley, northern governorates, Azraq and Al Jizza.

Adaptation measures were prioritized by stakeholders and the top ranked measures are listed, in order, as follows:

1. Integrating climate resilience into the policy and institutional reforms in agricultural sector
2. Enhancing drought management systems including capacity-building on best practices
3. Shifting to water efficient crops (Extension and on-farm capacity-building programs and campaigns) and improving irrigation system efficiency (community-based).
4. Integrating nexus approach to design future, inherently interlinked systems. Planning in a holistic manner, while capturing existing opportunities and exploring emerging ones.
5. Building capacities of hydrological and meteorological (hydromet) agencies to design and deliver better products and services for smallholders.

CCIVA for Water Sector

Analysis of water sector vulnerability to climate change was carried out using data from MWI, research results, studies, and reports. The water sector in Jordan can be summarized as follows:

- Total developed resources = 1,116 MCM (43% GW, 15% TWW, 42% SW)
- Total Consumption = 1,167 MCM (56% irrigation, 42% Domestic, 2% Other).
- Deficit between supply and demand based on all water resources = 265 MCM
- Deficit between supply and demand based on renewable water resources = 422 MCM
- Per capita from renewable freshwater resources = 74 m^3/year

Analysis of climate impacts on the water sector was carried out using climate projections, data from DOS and a SWAT model, which incorporated climate projections with land use to derive impacts on ground and surface water resources. Maps of irrigation and forecasts of irrigated areas, in addition to outputs from AquaCrop, which forecasted the increase in crop water requirements, were also used in the assessment. Results from this analysis can be summarized as follows:

1- Impacts of CC on the surface water: reduction of surface runoff by 18%.

2- Impacts of CC on the groundwater: reduction of groundwater recharge by 16%.

3- An increase of demand for water from 1167 MCM to 2094 MCM in 2050 and 3167 MCM by 2100.

4- A summary of water demand, supply (including national desalination) and deficit is shown in the following table:

Water Demand (MCM)	**Present**	**2050**	**2070**	**2100**
1. Domestic	470	924	1261	1811
2. Irrigated agriculture	658	1072	1097	1201
3. Industrial	32	83	104	125
4. Pastoral	7	15	21	30
Total demand	1167	2094	2483	3167
Total supply	1051	1490	1558	1625
Balance	-116	-604	-925	-1542
Balance (Considering network losses)	**- 265**	**- 835**	**- 1240**	**- 1995**

Climate change vulnerability assessment of the water sector showed that high vulnerability to climate change characterized the basins of Yarmouk, Amman-Zarqa, northern parts of Azraq and middle and western parts of Mujib basins. The impact analysis for Aqaba Coastal Zone, using SWAT and HEC-RAS showed that a destructive flood event would occur every 25-30 years during 2030-2059, and the frequency of flooding would increase after 2059.

Adaptation measures for the water sector were prioritized by stakeholders and the top ranked measures are listed, in order, as follows:

1. Integrating climate adaptation and resilience in the policy and institutional reforms in the water sector (Policy and Management level)

2. Improving contribution of non-conventional water resources to the national water budget (Incentive, extension and capacity building)
3. Improving water demand management and reducing the gap between water demand and supply
4. Improving efficiency in water use for sustainable development (Supply augmentation and demand reduction).
5. Improving the adaptive capacity of water utilities (e.g., Conducting climate-proofing studies for existing water utilities, risk mapping, etc.).

CCIVA for Terrestrial and Marine Biodiversity.

The vulnerability assessment of Jordan's ecosystems was determined, where 13 terrestrial ecosystems were evaluated. The marine environment was considered as one unit, due to the short length of its coastline, which is 27 km.

The exposure trends from the projections of mean annual temperature and the precipitation rate are acceptable, and the exposure trends are unlikely to affect Jordan's ecosystems, except for the very extreme projections of RCP 8.5 in 2100. It is suggested that the anthropogenic threats such as induced fires, land use and water drainage are the main causes of ecosystem loss and deterioration. In order to assess the sensitivity, four indicators have been used which are: size of each ecosystem, level of fragmentation, rarity of the ecosystem in Jordan and the exposure level to anthropogenic pressures. Results of sensitivity showed that forested ecosystems are by far are the most sensitive to climate in Jordan in two directions, since they can be directly affected through several processes, acting at various temporal and spatial scales such as tree growth, reproduction, establishment, mortality, species composition, and stand structure. In addition, forests can be affected indirectly by disturbances such as fire, outbreaks of insects, fungi, and other pathogens, wind, and diseases.

The adaptive capacity of the terrestrial ecosystems has been measured based on a set of criteria. Generally, low adaptive capacity scores have been obtained. The resulting vulnerability has shown that most ecosystems in Jordan would have low to moderate vulnerability except for all forested ecosystems, sand dunes, wetland, and aquatic ecosystems, which will be under high vulnerability toward climate change.

The marine environment is represented in the Gulf of Aqaba, which is the only maritime region in Jordan. The vulnerability assessment was built on the data collected from the Gulf of Aqaba from 2006 until 2020. The data was processed and used to generate parameters per month, depth, and sampling area to quantify the variables for exposure, sensitivity, and adaptive capacity components of Climate Change Vulnerability.

Three exposure parameters were tested including marine temperature, pH, and salinity. In general, exposure projections provide no risks to the Gulf of Aqaba according to the studied parameters until 2100. Sensitivity to current (historical) and future climate change was quantified in reference to the ecosystems at the Gulf of Aqaba. It was assumed that all ecosystems would be the most sensitive to changes in the climate (as reflected in increasing sea surface temperatures, increase in salinity and pH as marine ecosystems inherently climate dependent. Therefore, the sensitivity will be high. The adaptive capacity of marine ecosystems has followed the same set of criteria for the terrestrial ecosystems, where criteria related to asset base, economic resource availability, technology and innovation, infrastructure availability, institutions established, dedicated and actively working in ecosystem conservation. Knowledge and information were assessed based on a scoring system of five categories; 1: very low; 2: low; 3: moderate; 4: high; and 5: very high. Based on the scoring system, the adaptive capacity of ecosystems and biodiversity in the Gulf of Aqaba showed low capacity.

The vulnerability assessment of the marine ecosystems was found to be moderate. The main threat to these ecosystems is derived from anthropogenic activities, thus, continuous effort must be made to prevent and/ or minimize these threats. The establishment of the Aqaba Marine Reserve is a step in the right direction to protect representative ecosystems and the associated species at Aqaba.

CCIVA for Socio-economic Sector

Climate change affects all people regardless of socioeconomic status, and many impacts are projected to worsen as temperatures levels continue to rise, rainfall patterns shift, and some extreme weather events become more common such as drought and heat waves. A growing body of literature focuses on the disproportionate and unequal risks that climate change is projected to have on communities that are least able to anticipate, cope with, and recover from adverse impacts. Climate change impacts on socially vulnerable groups of population are more disproportionate due to multiple impacts.

This study presents the integrated and multi-sectoral socioeconomic measure to address climate change impact, looking particularly at the way in which climate change intersects with social vulnerability. Climate change is often described as a threat multiplier, amplifying other risks and vulnerabilities, including poverty and endowments, food security, agriculture, water and resource scarcity, food security, human security, and social security, which makes it a particular threat in a region that is already facing global changes in economy and experiences resource scarcity particularly food and water.

This report contributes to a better understanding of the degree to which socially vulnerable populations (defined based on income, educational attainment, gender, living standard, residency, and age) may be more exposed to the highest impacts of climate change. The study's objective is to present the interrelationship between climate change and social vulnerability in Jordan, focusing particularly on decline of precipitation, increase of temperature and heatwaves. A range of multi-sectoral and composite indicator indices, using GIS-based mapping at sub-district level, were used to determine hotspots of both climate change and social vulnerability by ensuring that climate risk analyses assign greater weight to social indicators.

A total of 30 indicators, based on over 50 sub-datasets, were used to produce 15 maps for socioeconomic exposure, sensitivity, adaptive capacity, vulnerability, and climate risk. All of the socioeconomic indicators were determined, weighted and aggregated into one index, then normalized and multiplied by assigned weights to derive the overall index. Climate change hazard indicators are used to assess socioeconomic vulnerability in Jordan. The generated hazard maps, represented for three long-term time horizons of 2020-2050, 2050-2070, and 2070-2100, are for precipitation, temperature, and wind speed.

Identifying the most sensitive and vulnerable sub-districts and communities allows the identification of the needs and priorities of these communities and allows for socially inclusive planning by proposing projects based on community needs. The districts/ sub-districts with the highest exposure to climate change are (Irbid Qasabah District, Ramtha District, Badiah Sh.Gh. Sub-District, Karak Qasabah District, Jizah Sub-District and Quaismeh District. The result shows that the sub-districts in the central Governorates (Amman, Madaba, Balqa) and Karak in the south are the most sensitive to climate change.

The socioeconomic indicators for adaptive capacity were also compiled. The sub-districts (Orjan, Sakhrah, Borma, Mraighah, Wadi Araba and Mestabah) and Rwaished, Bsaira, Faqo'e, Kufranjah, Qatraneh and Hasa districts, are characterized by the lowest adaptive capacity. The results show that the most vulnerable sub-districts are (Rwaished, Badiah Sh.Gh., Sakhrah, Irbid Qasabah, Ramtha, Orjan, Borma, Salhiya, Koorah, Bani Kenanah and Mestabah).

In regards to climate change risk and hazard at administrative levels, the Governorates located in the far North-western part of the country – Irbid, Ajlun, Mafraq, and to a lesser extent Jerash and Karak received the highest overall score, meaning the highest average overall climate hazard. One can conclude that some groups of people will likely face greater challenges than others. Climate change may especially impact people who live in remote areas that are vulnerable to decreased precipitation, increase of temperature and drought, and or people who live in poverty, older adults, and immigrant communities. Similarly, some types of professions and industries may face considerable challenges from climate change. Professions that are closely linked to weather and climate, such as agriculture, are likely to be especially affected.

We have identified several factors responsible for differences in local-scale vulnerability to climate change, and accordingly, suggested a number of actions to reduce it.

The proposed adaptation measures are aimed towards poverty alleviation, income diversification strategies and improving access to basic services. They include the promotion of income generating activities and employment and the mainstreaming of gender equality. Concerning resources, the aim is to enhance food security and also improve the nutritional status of vulnerable communities and poverty pockets. Further measures are aimed at reducing rural migration and enhancing endogenous social safety nets.

<u>CCIVA for Health Sector</u>

The health sector in Jordan is influenced and affected by climate change. The climate change risk and vulnerability assessment of the health sector revolves around the assessment of the current and future impact of climate change on health and proposes measures to adapt and mitigate these impacts.

The Ministry of Health (MoH) statistics for 2020 show that there were a total of 1182 primary health centers (PHCs), distributed through Jordan, comprising: 117 comprehensive health centers, 372 primary health centers, 188 secondary health centers (hospitals), and 505 maternal and child health centers. The PHCs include comprehensive health centers, regular health centers, peripheral health centers and 505 maternal and child health centers. In addition, there are over 431 dental clinics in under the responsibility of the MoH. Primary health care (PHC) is the main vehicle through which health care programs are implemented in Jordan**.**

The CCVA in the health sector revealed that climate risks (droughts, dust and sandstorms, flooding, shift in rainy season, increasing humidity, decreasing precipitation, increasing temperature) have both direct and indirect linkages with health risks, and they impact everyone from farmers, consumers of produce, children, and vulnerable populations across the entire country at different levels. The CCVA supports a more comprehensive understanding of the complicated relationship between climate change and health, across various sub-districts in Jordan with their differing adaptive capacities. More specifically, the most visible impacts of climate change on health are as follows:

- Increase in water-borne and food-borne diseases.
- Increased VBD risk with increasing temperature. Areas with scarce water like the eastern Badia 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.
- Reduced access to nutritious food is expected; dietary quality and eventually quantity are expected to decline, and micronutrient malnutrition (or hidden hunger) to increase as an indirect impact of climate change.
- Increase in spectrum of disorders related to the expected increase of heatwaves due to climate change 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 medical conditions.

- Increase in outdoor workers exposure to solar ultraviolet radiation (UVR) is likely 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 expected to be at risk of heatstroke. Indoor (chemical industries) workers and farmers may be exposed to higher levels of air pollutants due to increased temperatures.

The major recommendations of CCVA Assessment are as follows:

- Review and update the Ministry of Health's Strategy, to consider the conclusion of the adaptation and action plan for climate change adaptation in the heath sector.
- Strengthen the dialogue between the health and water sector on climate change impact and adaptation (at the ministerial and research level).
- Ensure the participation of the health sector when planning climate change adaptation in other sectors.
- Ensure that existing public health surveillance systems are adequately comprehensive and sensitive and are easily linked to environmental and meteorological data to be able to detect potential effects of climate change on health.
- Strengthen the surveillance and monitoring of climate change impact on health and implement an early warning system particularly in areas predicted to be at particularly high risk for changing patterns of disease.
- Build the knowledge-base and capacity in the medical infrastructure in Jordan.
- Strengthen public education and communication on health risks caused by climate change and their abatement.
- Further strengthen research on climate impact and adaptation in the health sector; and
- Implement the action plan to protect health from climate change by prioritizing projects and implementing those that will contribute to reducing the impacts of climate change and promote the associated disaster risk reductions (DRR).

CCIVA for Urban Sector

The urban areas of Jordan are more exposed to climate change, as the concentration of citizens, buildings, and economic and industrial activities is within cities. Despite the importance of infrastructure agglomeration within specific areas, urban growth and exacerbation of socio-economic activities pressurize infrastructure and services.

The vulnerability assessment of urban areas was conducted by identifying exposures to climate change, sensitivity, and adaptive capacity. The exposures were analyzed using spatial overlay data using GIS software. The climate change projections of RCPs 4.5 and 8.5 for three main timespans of 2020-2050, 2040-2070, and 2070-2100 were applied to understand patterns at district and sub-district level. Qualitative data analysis from DOS, MoT, and MWI, in addition to 4NC projection results, was adopted for sensitivity and adaptive capacity assessments. Consequently, consultations with experts and stakeholders were conducted to agree on relevant indicators.

The CCVA of urban sector revealed that the most vulnerable districts are in Ajlun Governorate, namely, Orjan Sub-District and Sakhrah Sub-District), followed by, Borma Sub-District and Mestabah Sub-District in Jerash Governorate, in addition to Diesah Sub-District and Wadi Araba Sub-District in Aqaba, and Safi Sub-District and Qatraneh District in Karak.

Drought and Floods were the two key hazards investigated for urban areas. Based on the overall hazard map, the most impacted areas are disseminated between north, central, and central-eastern cities, namely Amman, Ajlun, and Karak. The most affected sub-districts are Al-Jami'ah district, Qasr Sub-District, Ajlun Sub-District, Kufranjah District, Mazar Sub-District, Mujeb Sub-District, Amman Qasabah District, Oran Sub-District, Ghawr Almazra'a Sub-District, and Marka District.

The adaptation measures are aligned with the Updated Climate Change Policy (2022-2050), the National Adaptation Plan, the updated submission of Jordan’s 1st Nationally Determined Contribution (NDC), and the Jordan National Strategy for Disaster Risk Reduction (2019-2022). The adaptation measures are as follows:

- Support urban green infrastructure interventions for climate resilience (e.g. preservation of natural watercourses, use of climate responsive building techniques, integrated land use planning, promotion of rainwater harvesting, establishing recreational parks, and integrating the use of shading elements (native trees) in walkways and streets).
- Improve readiness for climate related disaster risk reduction in urban areas to mitigate the impact of extreme weather events on urban livelihoods.
- Enhance community participation at local urban level for climate change resilience (e.g., implementing existing local organizations and neighborhood networks to identify and respond to climate risks in urban areas, based on participatory consultation, supporting joint actions, and mandating urban municipalities to lead community-based initiatives for

responding to climate risks, through institutional restructuring and capacity development).

- Improve building efficiency for adapting to increased heat in urban centers through enforcement of green building codes and enhancing retrofitting of existing buildings.

1 National Circumstances

1.1 Governance Structure

The Hashemite Kingdom of Jordan is located in the heart of the Arab world; the heart of the Middle East, built around the concept of pan-Arabism. Jordan is based on a modern, progressive constitution and its governing system is a hereditary, parliamentary monarchy. The constitution of Jordan was established on January 8, 1952 and since its establishment, Jordan has become a model of moderation and an evolving democracy in the region.

The King of the Hashemite Kingdom of Jordan, His Majesty King Abdullah II, is the head of state. He sits on the throne of the Kingdom, at the top of three authorities, and also serves as the supreme commander of the armed forces. Executive authority is vested in the King, who exercises his power through the Prime Minister and the Cabinet, or Council of Ministries. 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.

The Constitution of Jordan vests executive authority in the king and in his cabinet. The king signs and executes or vetoes all laws. The king may also suspend or dissolve parliament and shorten or lengthen the term of session. A veto by the king may be overridden by a two-thirds vote of both houses of parliament at his discretion, most recently in November 2009. The king appoints and may dismiss all judges by decree, approves amendments to the constitution, after they have passed by both houses of parliament, declares war and acts as the supreme leader of the armed forces. Cabinet decisions, court judgments, and the national currency are issued in his name. The Cabinet, led by a prime minister, was formerly appointed by the king, but following the 2011 Jordanian protests, King Abdullah agreed to a prime minister selected by and responsible to the Chamber of Deputies on matters of general policy, including the composition of cabinet. A two-thirds vote of "no confidence" by the Chamber can force the cabinet to resign.

The judiciary is completely independent from the other two branches of the government. The constitution provides for three categories of courts—civil (in this case meaning "regular"), religious, and special. Regular courts consist of both civil and criminal varieties at the first level—First Instance or Conciliation Courts, second level—Appellate or Appeals Courts, and the Cassation Court which is the highest judicial authority in the kingdom. There are two types of religious courts: Sharia courts which enforce the provisions of Islamic law and civil status, and tribunals of other religious communities officially recognized in Jordan.

Jordan is divided into twelve Governorates, each headed by a Governor and encompassing a number of districts and sub-districts. Figure 1.1: The Governorates of Jordan. Governors are appointed by the King through the Minister of the Interior, and they are considered extensions of the central government to maintain law and order at the local level in their respective areas. The regional government acts as the executive organ for implementing cabinet decisions at the

[1] CoR - Jordan (europa.eu)

local level. Essentially, these governorates are an extension of the central government. In addition to coordinating public service provision, governors are also in charge of approving local authorities' budgets and expenditures (except in the Greater Amman Municipality).[1] The twelve governorates are: Amman (the capital), Irbid, Zarqa, Mafraq, Ajloun, Jerash, Madaba, Balqa, Karak, Tafileh, Ma'an and Aqaba.

The local level consists of local administrations including municipalities that function as chief town districts, where each municipality is headed by a mayor and 6 to 11 councilors who are all elected for a four-year term. The administration units are controlled by the Ministry of Local Administration.

[1] CoR - Jordan (europa.eu)

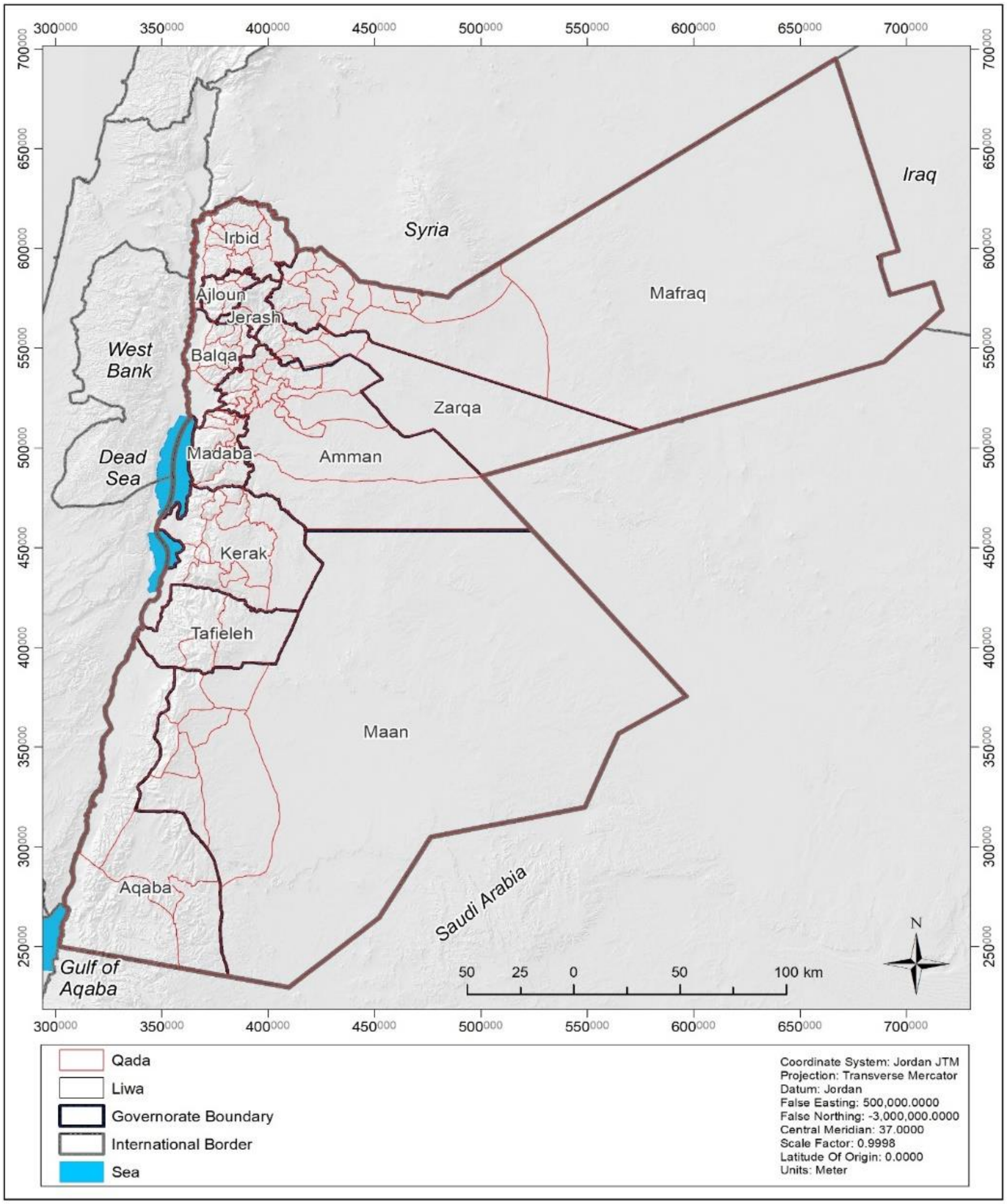

Figure 1.1: The Governorates of Jordan

1.1.1 Climate Change Governance and Institutional Arrangement

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.

In August 2014, the Directorate of Climate Change was established within the Ministry of Environment. The Directorate acts as the institutional hub for coordinating all climate change activities in Jordan in relation to the UNFCCC.

Jordan is signatory to the UNFCCC - the government ratified, inter alia, the Convention in 1993, the Kyoto Protocol in 2004, and the Paris Agreement in 2016. Moreover, Jordan joined the Climate & Clean Air Coalition in 2012 and has produced several policies, pieces of legislation and national reports in response to the obligations of the global collective collaboration frameworks. Jordan started its efforts aiming for building national capacity in documenting national emissions of greenhouse gases and preparing Jordan's national communications to the UNFCCC. So far, Jordan had submitted, with the support of GEF, three National Communication Reports: First National Communication (FNC) (1998), Second National Communication (SNC) (2009) and Third National Communication (TNC) (2014), the First Biennial Update Report (FBUR) (2017), and the Second Biennial Update Report (SBUR) (2021).

The National Climate Change Policy (2013-2020)[2] was issued by identifying the national priorities for adaptation to climate change and mitigation of greenhouse emissions. The policy provides guidance to sector strategies from a climate change perspective, and it provides a framework for coordination of climate change activities at the national level. The MoEnv has updated the Climate Change Policy (2021-2050)[3] as an overarching document for guiding the mainstreaming of climate change in all sectoral policies, strategies and action plans. Taking into a consideration the foundation on a Theory of Change, the new policy is not prescriptive but only serves to provide strategic orientations for Jordan to build a low-carbon and climate resilient society, while also supporting the implementation of UNFCCC requirements. In short, all sectors will be called upon to use the CCP 2021-2050 as the framing document to mainstream climate change in their long-term strategic plans, which in turn will be used to inform updates to the Nationally

[2] moenv.gov.jo/ebv4.0/root_storage/en/eb_list_page/national_climate_change_policy_jo.pdf

[3] National Climate Change Policy of the Hashemite Kingdom of Jordan 2022-2050 | United Nations in Jordan

Determined Contributions (NDCs). For ease of use, all policy orientations are given in tabular form.

In 2019 the Climate Change Bylaw (No. 79, 2019) was enacted to provide a regulatory framework for climate-related actions. The Bylaw establishes the climate change institutional arrangement in Jordan through the National Climate Change Committee (NCCC), being responsible for oversight and coordination. Pursuant to its provisions, the National Climate Change Committee is chaired by the Ministry of Environment and consists of the 16 secretary-generals from the line ministries. Serving as a national focal point for the United Nations Framework Convention on Climate Change (UNFCCC) and its Protocols and Funds, the Ministry of Environment is the government agency responsible for preparing and tracking all related climate changes issues and reporting to the UNFCCC Secretariat, developing the National Adaptation Plans and any other documents in accordance with the international obligations in this regard. The Ministry is responsible for establishing and managing the Measurement, Reporting and Verification Registry System, and for coordinating with the relevant authorities to develop the National Climate Finance Plan, tailored to benefit from relevant market mechanisms/instruments to enable its viability, based on the national circumstances.

Jordan succeeded in developing the first NDC in 2015[4] under the coordination of the Ministry of Environment, as the Chair of the National Climate Change Committee. The Ministry at that time adopted the participatory approach to convene the governmental institutions, the private sector and other non-state actors. In October 2021, The GoJ updated submission of the Jordan's first nationally determined contribution (NDC)[5]. The updated NDC document enhances its commitment to the international climate change governance system by raising its macroeconomic GHG emission reduction target from 14% to 31% as compared to Business as Usual (BAU) scenario. The new GHG emission reduction target is based on a combination of national policies, programmes and actions as well as international support and finance.

Finally, the MoEnv launched the National Climate Change Adaptation Plan (NAP) of Jordan in 2021[6]. The NAP provides a clear vision for adaptation and identifies measures to be addressed in various sectors to guide institutions from different sectors such as governmental, academic, CBOs, and private sector entities to implement adaptation initiatives, develop partnership relations and synergies with each other, to reach the required adaptation goals.

[4] Fehler (unfccc.int)
[5] Microsoft Word - Final Jordan's updated NDC 26OCT (31%)-Clean version (unfccc.int)
[6] final_draft_nap-2021.pdf (moenv.gov.jo)

1.2 Geography and Climate

Jordan is one of the countries in the Mediterranean Region; located about 80 km to the East of the Mediterranean Sea, between 29°10'- 33°45'N and 34°55'–39°20'E. This gives the country a unique topographic nature with predominant Mediterranean climate; hot and dry summers and wet and cool winters.

Jordan is a relatively small country situated in the north of the Arabian Peninsula and in West Asia with an area of 89,213 square kilometers, and it shares borders with five states; the Kingdom of Saudi Arabia from to the south, the Syrian Arab Republic to the north, the Republic of Iraq to the east and the occupied Palestinian territories to the west, in addition to the maritime border it shares with Egypt in the Gulf of Aqaba.

Despite the relatively small area, Jordan has a diverse terrain and landscape, demonstrating a variety usually found only in large countries, that is shaped by its geography, history, geopolitics and scarcity of natural resources.[7]

Although Jordan is a small country (89,320 km²) and three-quarters of its territory is desert, the landscape reveals great diversity within short distances. Five main physiographic regions of Jordan extend in a north–south alignment and comprise: tropical desert in the central Ghor or rift valley, escarpments and mountain highlands east of the Ghor, arid plains, the Badia and the Azraq and Wadi Sirhan depression. These five physiographic regions correspond to five major morphological zones[8].

1.2.1 The Jordan Valley and the Wadi Araba Rift (Ghor)

The Jordan Depression running from Wadi Araba to the Dead Sea is a very distinctive landscape; it forms part of the rift valley, that extends from North Syria down to East Africa. This linear feature runs north-south with significantly lower elevations than the Highlands to the east, and extends about 360 km from Lake Tiberias to the Gulf of Aqaba. The depression gradually rises from the Gulf of Aqaba over a distance of about 80 km up to about 250 m above sea level, and then drops gently towards the Dead Sea (419 m below sea level), and then rises in elevation from 419 m below sea level to 210 m below sea level at Lake Tiberias. Most of the depression is on average 15 km wide.

This region is the lowest on earth (with the Dead Sea at 419 metres below sea level) and includes the Jordan River, flowing through the Jordan Valley, which is considered to be the food basket of Jordan. The Jordan Valley (with its dams) and the Southern Ghor (with its surface water) are among the most important agricultural areas, since there is a permanent supply of water from

[7] About Jordan | King Abdullah II Official Website – accessed 16 June 2021.
[8] Atlas of Jordan - Topography and Morphology - Presses de l'Ifpo (openedition.org)

the Yarmouk River. Due to high temperatures and their location below sea level, these two regions are the most important areas for producing winter vegetables. The Ghor has approximately 34,000 hectares of farming land, all of which is irrigated **(Figure 1.1: Jordan Five Main Morphological Units).**

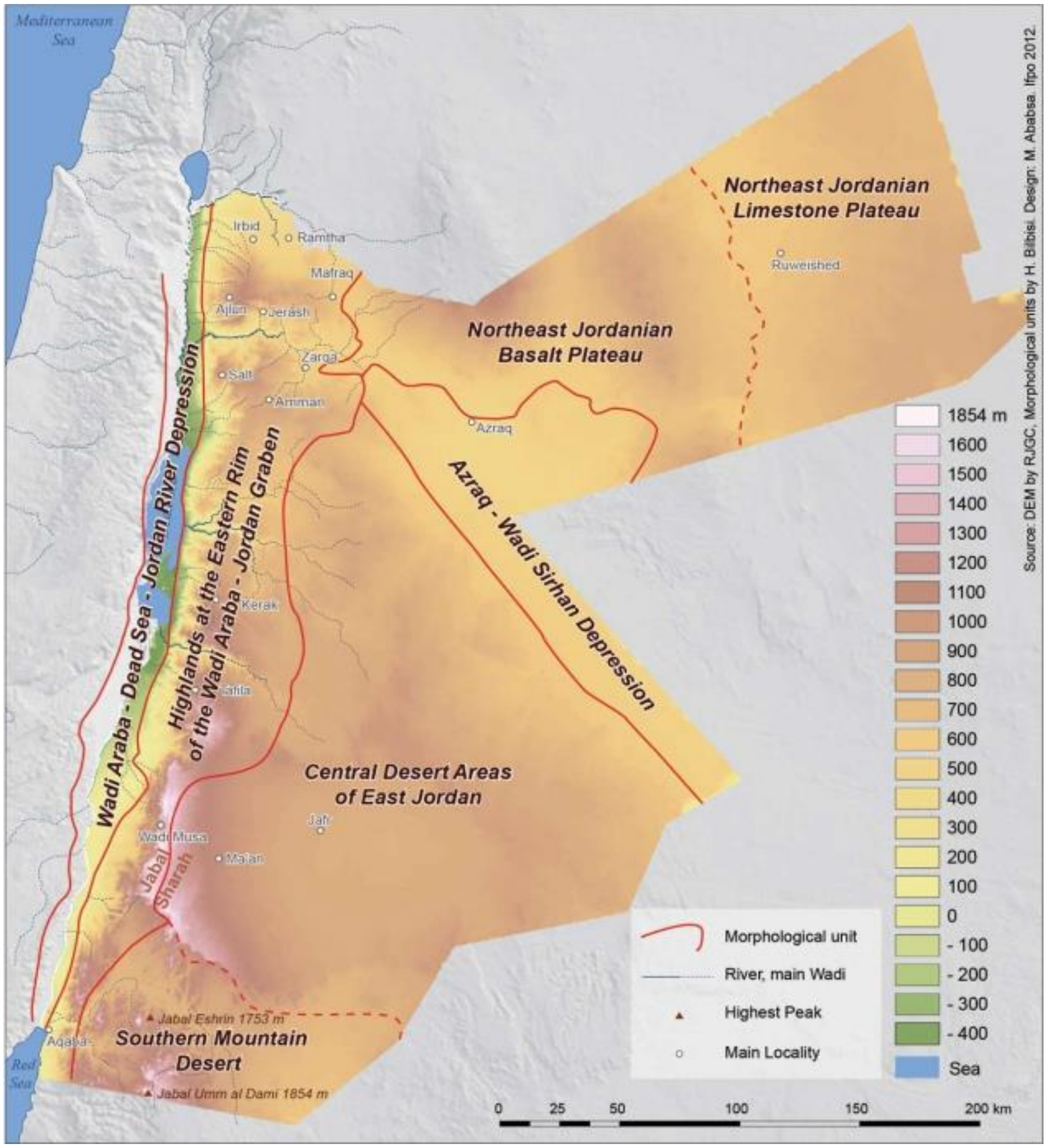

Figure 1.1: Jordan Five Main Morphological Units[9]

[9] [9] AL-BILBISI, Hussam. *Topography and Morphology* In: *Atlas of Jordan: History, Territories and Society* [online]. Beyrouth: Presses de l'Ifpo, 2013 (generated 14 décembre 2021). Available on the Internet: <http://books.openedition.org/ifpo/4859>. ISBN: 9782351594384. DOI: https://doi.org/10.4000/books.ifpo.4859.

1.2.2 Highlands at the Eastern Edge of the Wadi Araba-Jordan Graben

This zone, referred to both as the Mountain Ridge and the Northern Highlands, east of the rift and the Transjordanian Plateau, slopes gently towards the central plateau in the east, and drops steeply towards the Dead Sea Rift in the west. Tectonic activity and structural movements within and in the vicinity of the Graben have until recent geological times continually lowered the base level of the wadis and perennial rivers draining to the west. The relatively high surface runoff has caused excessive active erosion (Figure 1.2).

The northern Highlands extend from Umm Qays in the north through the Ajlun Mountains, the hills of Amman and Moab, and the Edom Mountains. This region is intersected at several points by deep wadis such as the Wadi Mujib and Wadi Yabes, which are shaped like canyons. The southern Highlands are higher than those in the north, but with less variety and density of vegetation. Of special interest are the Wadi Rum and Rum Mountain, the highest mountain in Jordan (with Jabal Umm al Dami at 1,854 m.) and Um Eshrin Mountain at 1,753 m. The highlands are home to the Kingdom’s natural forests, which make up less than one percent of the total surface area.

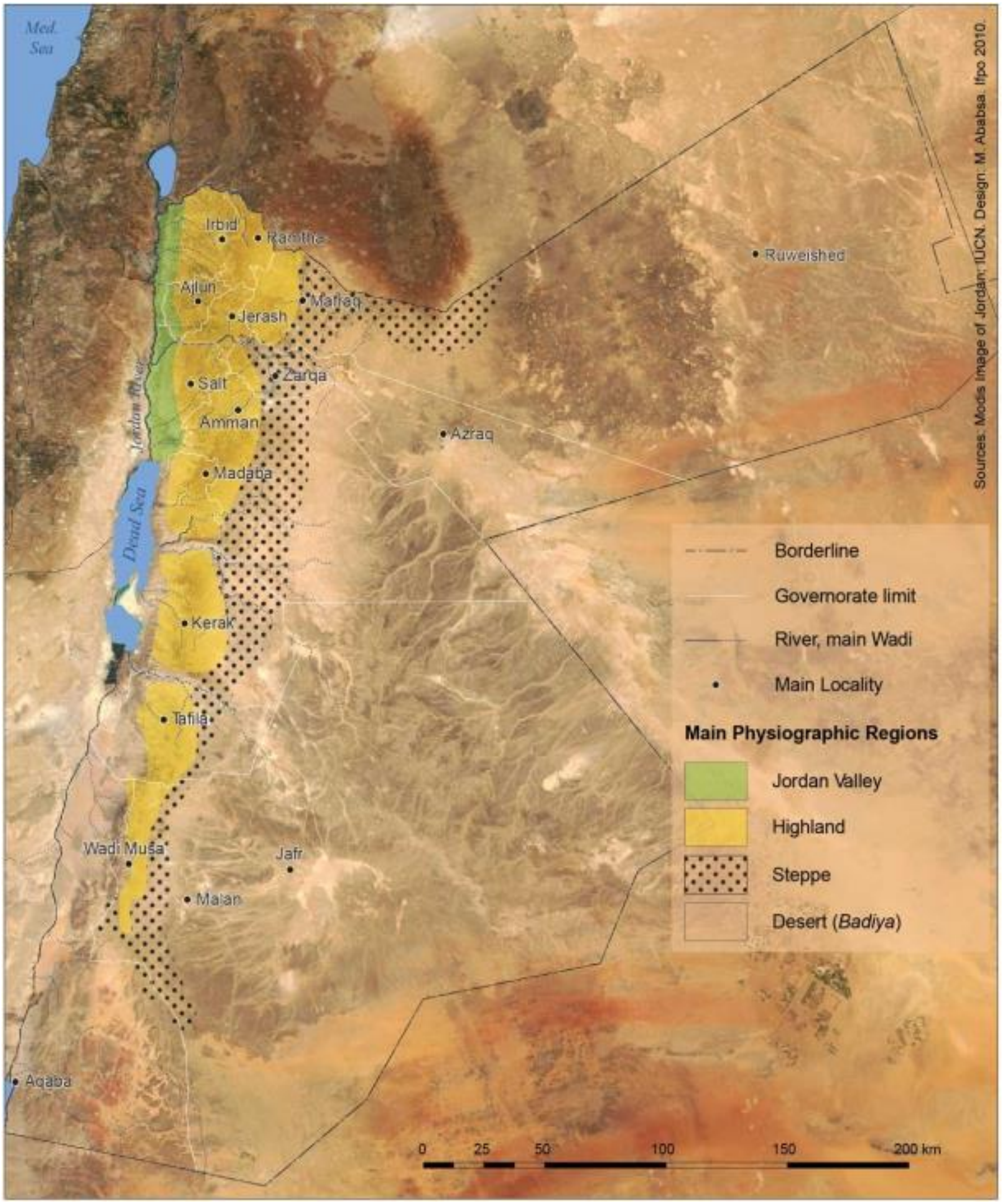

Figure 1.2: Jordan Four Main Physiographic Regions[10]

[10] AL-BILBISI, Hussam. *Topography and Morphology* In: *Atlas of Jordan: History, Territories and Society* [online]. Beyrouth: Presses de l'Ifpo, 2013 (generated 14 décembre 2021). Available on the Internet: <http://books.openedition.org/ifpo/4859>. ISBN: 9782351594384. DOI: https://doi.org/10.4000/books.ifpo.4859.

1.2.3 Central Desert Areas of East Jordan (Arid Plains)

This zone includes the plains between the Badia (semi-desert) and the Highlands. Rainfall ranges between 200 mm in the east and 350 mm in the west. More than 50 percent of arable land is located in this zone. The rain-fed crops are mainly barley (200-300 mm of rainfall), wheat and fruit trees (300-350 mm of rainfall).

The landscape here is distinctive; it is practically flat or gently sloping and is generally covered in sharp-edged chert rock. Chert debris covers hundreds of squares kilometres and the area is known as the flint-strewn desert (in Arabic: *Hammad* land or *Hammada*). In the south it rises to about 850 m towards the Depression of al-Jafr which is a flat, oval, dish-like depression. The centre of al-Jafr Depression is partly mud flats, in Arabic: *Qa'*.

This zone ends southwest of al-Jafr Depression at the escarpment of Ras al-Naqb, with altitudes reaching 1,700 m in some areas. Near Ras al-Naqb, the difference in altitude from base to top of the escarpment is about 600 m.

1.2.4 The Badia Region[11] (North-Eastern Desert)

This extensive region covers about 8,090,000 hectares or 90% of the Kingdom. It meets the Arabian Desert at the borders of three Arab countries: Syria to the north, Iraq to the east and Saudi Arabia to the south. It is a plateau with an elevation of 600 to 900 meters, extending eastwards. This part of the Syrian Badia covers most of Jordan and has diverse characteristics. Most of the Badia region is divided into two broad areas, namely, the Northeast Jordanian Basalt Plateau, and the Northeast Jordanian Limestone Plateau, which is located east northeast of the country.

The Northeast Jordanian Basalt Plateau, frequently referred to in Arabic as *Harrat al-Shaba*, meaning Black Desert, covers an area of about 11,000 km² in Jordan. This Plateau has many isolated hills and long rows of volcanoes. Elevation ranges from between 500 m to 550 m and reaches more than 1,100 m at the NNW of the northern border of Jordan.

The Northeast Jordanian Limestone Plateau is monotonous, flat, stony desert that extends eastward from the Black Desert beyond the eastern borders of Jordan. The land rises in all directions from the eastern margin of the Basalt Plateau, with elevations between 625 m and 800 m. This Limestone Plateau forms a flat, dish-like depression.

Very sparse vegetation and an annual rainfall of less than 200 mm characterize the Badia region. In the past it was only used for grazing, but in the last two decades 20,000 ha have been irrigated, using underground water to grow vegetables (especially tomatoes, watermelon, and potatoes),

[11] Badia region derived its name from the land where Bedouins live and practice seasonal browsing

fruit trees and cereals, especially wheat. The Badia contains two main depressions: Azraq and Jafr.

1.2.5 Azraq-Wadi Sirhan Depression

This is a well-defined morphological area. The axis of the depression gradually rises from 500 m to 700 m in the southeast. This depression collects water from adjacent wadis and was of great importance for nomads in the past. It was an important trade route between the Highlands and the Arabian Peninsula.

Jordan is landlocked except at its southern extremity, where nearly 26 kilometres of shoreline along the "Gulf of Aqaba" provide access to the Red Sea. Aqaba as an ancient city "*Elath or Ayla*", along with Wadi Rum and "Petra", one of the New Seven Wonders of the World, are commonly known as Jordan's golden triangle of tourism. Aqaba city is administered by the Aqaba Special Economic Zone Authority, which has turned Aqaba into a low-tax, duty-free city, attracting several mega projects like Ayla Oasis, Saraya Aqaba, Marsa Zayed and expansion of the Port of Aqaba.

Jordan's climate ranges between a more Mediterranean climate to a desert climate, but the land is generally very arid. Jordan has two long seasons; winter begins in mid-October and lasts until late April, with January the coldest month, and summer is from June to September, with August the hottest month. The two intermediate seasons are short.

The Mediterranean climate prevails in the Highlands region, where summer is moderate and dry and the winter cold and rainy. The desert climate prevails in the Badia; the summer is hot and the winter is cold. The Ghor area has a semitropical climate with a hot summer and warm winter.

Temperatures are very variable depending on the area. Globally, it rises north to south and west to east, but decreases with altitude. Winter temperatures in the southern and northern highlands range between 9-13 °C, while the deserts regions range from 19-22 °C. In the Jordanian Valley, summer temperatures range between 38-39°C, while in the desert regions, they vary between 26-29°C.

Jordan is an arid country with more than 90 percent of the territory receiving less than 200 mm annual precipitation. (**Figure 1.3**). About 75% of precipitation falls during the winter. Precipitation ranges between 50 to 500 mm annually, depending on the location. The amount of rainfall decreases from north to south and from west to east. The annual average in the eastern heights, in the Ajlun Mountains, reaches 400-600 mm, then decreases to 300-600 mm in the Balqa' mountains, 200-350 mm in the Moab mountains, and 100-300 mm in the Sharah mountains. The annual average in the northern part of the rift reaches 300-400 mm but drops to 100-200 mm north of the Dead Sea and 50-100 mm in the Dead Sea area north of Wadi Araba. The southern part of Wadi Araba and the Gulf of Aqaba receive less than 50 mm. Rainfall varies from year to year, while occasional light snowfall is restricted to the highest areas (including Amman).

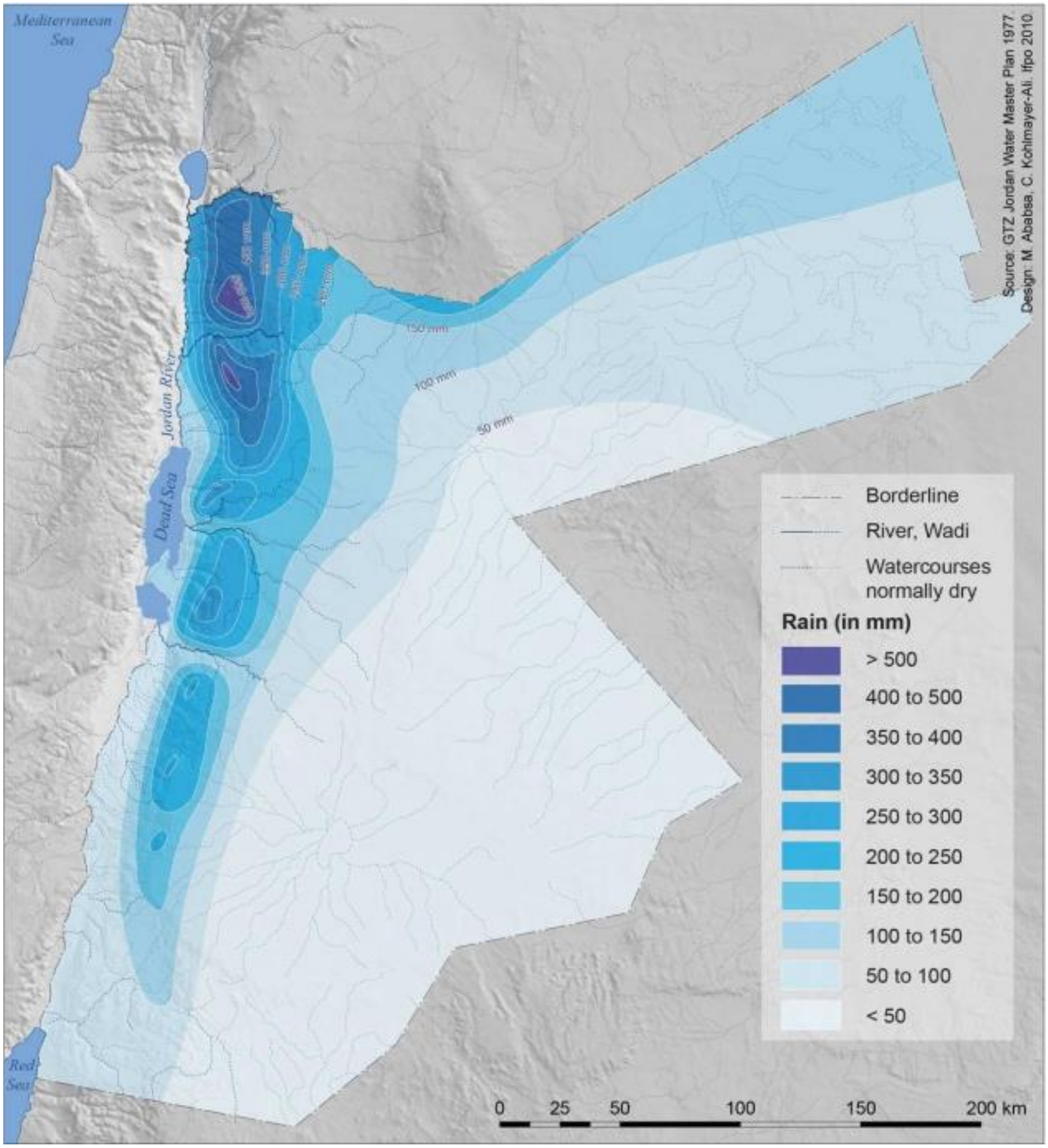

Figure 1.3: Jordan Average Rainfall[12]

[12] ABABSA, Myriam. *Aridity* In: *Atlas of Jordan: History, Territories and Society* [online]. Beyrouth: Presses de l'Ifpo, 2013 (generated 14 décembre 2021). Available on the Internet: <http://books.openedition.org/ifpo/4865>. ISBN: 9782351594384. DOI: https://doi.org/10.4000/books.ifpo.4865.

Depressions, mostly of Mediterranean origin, start affecting Jordan in mid-October and dominate the weather. December and January depressions are frequently accompanied by polar air masses of north European origin. In summer, which is the most stable season, a huge belt of low-pressure forms over North Africa and extends through the Arabian and Indian Oceans to India. This low-pressure belt attracts hot and dry northerly continental tropical air masses from the high-pressure centres over Mesopotamia and Asia Minor. Spring and autumn are the two transitional seasons in Jordan. Spring depressions are called 'Khamsin depressions' or 'Saharian depressions. Jordan's climate is influenced by the Dry Sirocco (Khamsin) winds, which can lead to large temperature anomalies, with increases of up to 15°C. The Shammal Winds are also an influencing factor, blowing from the north and northeast and causing high daytime temperatures.

Average temperatures show a reverse pattern; they increase rapidly from the dissected plateaus to the very low-level graben, increase gradually from the dissected plateau to the eastern margins of the eastern desert, and decrease gradually from north to south in line with increasing altitude. The range of average annual temperatures is 22°C to 25°C in the Jordan Rift area, 18°C to 21°C in the Badia, and 14°C to 18°C in the highlands.

The country's long summer reaches a peak during August. January is usually the coolest month. The fairly wide ranges and differences in temperature during a twenty-four-hour period are greatest during the summer months and have a tendency to increase with higher elevation and distance from the Mediterranean coast.

For a month or so before and after the dry summer season, hot, dry air from the desert, drawn by low pressure, produces strong winds from the south or southeast that sometimes reach gale force. Known in the Middle East by various names, including the Khamsin, this dry, sirocco-style wind is usually accompanied by great dust clouds. Its onset is heralded by a hazy sky, a falling barometer, and a drop in relative humidity to about 10 percent. Within a few hours there may be a 10°C to 15°C rise in temperature. These windstorms usually last a day or so, cause much discomfort, and destroy crops by desiccating them.

The shammal, another wind of some significance, comes from the north or northwest, generally at intervals between June and September. Remarkably steady during daytime hours but becoming a breeze at night, the shammal may blow for as long as nine days out of ten and then repeat the process. It originates as a dry continental mass of polar air that is warmed as it passes over the Eurasian landmass. The dryness allows intense heating of the earth's surface by the sun, resulting in high daytime temperatures that moderate after sunset.

1.3 Demographic and Socio-economic Profile

The total population of Jordan in 2021 reached over 11 million. There are about 2 million households with an average household size of 4.8 persons. The number of Jordanians is around 7.7 million, while the number of non-Jordanians who reside in the country is about 3.3 million, representing 30.6 per cent of overall population. 42 per cent of the population of Jordan live in Amman. Using the recent population statistics published by DOS in 2021, the estimated population in Jordan was 11.034 million persons. Relying on the recent growth rate and the DOS expectation of decreasing growth rate over time, a forecast of the population was performed, as shown in Table 1.

Table 1.1. The population is expected to increase to 12.07 by the year 2025, 13.35 million by the year 2030 and to 14.63 million by 2035. By 2050 the expected population is forecast to be 19.0 million inhabitants.

In March 2014, the National Resilience Plan (NRP) was drafted by the Government of Jordan, in cooperation with United National Country Team (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.

It is worth mentioning that most of the previous strategies, development goals, polices, programs and action plans developed before the population data was revised in 2017, are based on the premise of a 6.6 million population for Jordan in 2015. All publishing strategies and development plans based on the old population figures, have a question mark regarding their validity. All the scenario forecasts indicate an increase in the demand for food and water as the result of many driving forces such as population growth, urbanization, development, economic growth, and sudden influxes of refugees, as well as climate change, including the expected increasing severity of droughts.

Table 1.1: Population by Governorate and Forecast Population

Admin. Divisions	2020	Registered Syrian Refugees 2020[13]	2030	2040	2050
		Population size in millions			
Amman Gov.	4.54	0.1991	5.43	6.30	7.25
Balqa Gov.	0.56	0.0180	0.71	0.87	1.06
Zarqa Gov.	1.55	0.0985	1.94	2.33	2.77
Madaba Gov.	0.21	0.0134	0.27	0.32	0.38
Irbid Gov.	2.01	0.1365	2.54	3.11	3.77
Mafraq Gov.	0.62	0.1685	0.81	1.02	1.27
Jerash Gov.	0.27	0.0093	0.35	0.44	0.54
Ajlun Gov.	0.20	0.0065	0.26	0.33	0.41
Karak Gov.	0.36	0.0086	0.45	0.55	0.66
Tafiela Gov.	0.11	0.0017	0.14	0.17	0.20
Ma'an Gov.	0.16	0.0084	0.21	0.26	0.31
Aqaba Gov.	0.21	0.0038	0.26	0.32	0.37
Jordan	10.80	0.6722	13.35	16.00	19.00

Source: Consultant estimate based on DOS population statistics [14] [15]

The time the population takes to double for Jordan is around 29 years. Most of the population is urban; only 9.7% live in rural areas (Figure 1.4). The social structure of Jordan is complex, and includes about 0.5 million registered Iraqi refugees[16]. Since 2011, more another 1.5 million have fled the civil strife in Syria and are located in border refugee camps.

The percentage of the population in the age group (65 years and over) increased from 3.2% to 3.7%, i.e., by half a percentage point between 2004 and 2015. A detailed examination shows that the percentage of Jordanian population in this category is higher than that of the non-Jordanian population in Jordan, i.e., 4.2% and 2.5%, respectively. This increase is due to the significant change in the age structure of Jordanians and the high life expectancy at birth from 71.7 years in 2004 to 73.2 years in 2015.

[13] https://data2.unhcr.org/en/situations/syria/location/36
[14] DOS, "Population Statistics. ," Department of Statistics, Amman, Jordan2019, Available: http://dosweb.dos.gov.jo/ar/population/population-2/.
[15] DOS, "Population Projections for the Kingdom's Residents during the Period 2015-2050," Department of Statistics, Amman, Jordan2016.
[16] UNHCR estimates

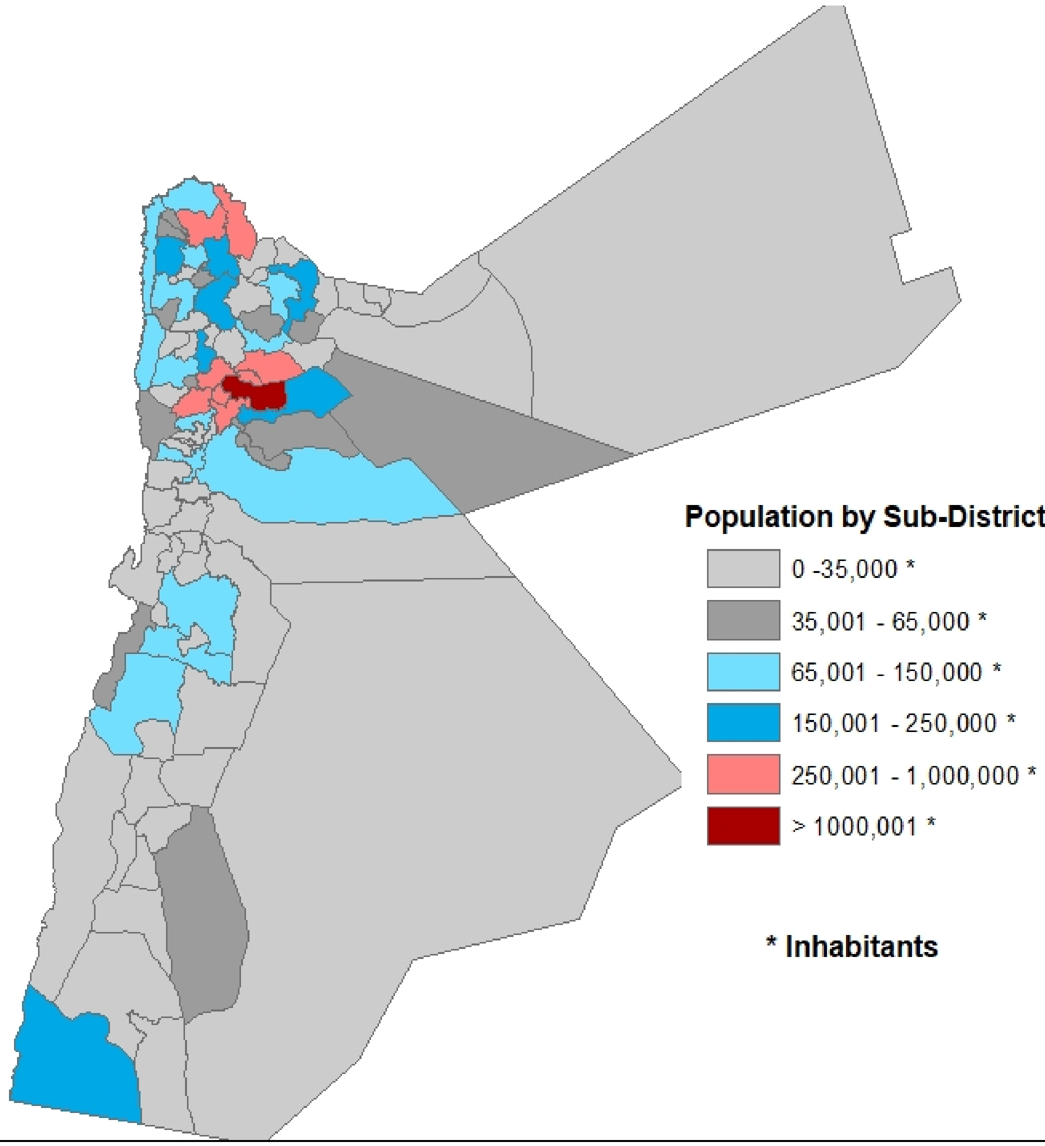

Figure 1.4: Jordan Population by district level

Below are some of the main indicators from the 2015 census:

- Total population of the Kingdom is 9,531,712.
- The population of the Kingdom has multiplied more than 10 times over 55 years.
- The largest absolute increase was during the last decade, especially since 2011.
- The population of Jordanians in the Kingdom is 6,613,587; accounting for 69.4% of the total population
- The population of non-Jordanian in the Kingdom is 2,918,125, constituting 30.6% of the total population. About half of these are Syrians (1.3 million). Out of the Syrians, 34% are concentrated in the Amman Governorate (436 thousand)
- Total number of households is (1,977,534).

- Average household size is (4.8 persons).
- Population of the Governorate of Amman in 2015 has exceeded four (4) million.
- Percentage of married males (aged 13 years and above) is 54% and 57% for females.
- Average marriage age of Jordanians is 25.5 years for males, compared with 21.2 years for females
- Prevalence ratio of functional difficulties "severe or absolute disability" among the population aged five years and above stood at 2.7%.
- Relatively, the governorates of Irbid, Mafraq and Ajloun have the highest ratios concerning “severe or absolute disability”, exceeding 3%
- Percentage of individuals who suffer from any degree of functional difficulties (simple to the absolute inability to perform) is around 11% of the total population aged 5 years and above
- The economic participation rates vary between males and females, notably 71% of males are economically active, compared to only 21% of females.

1.3.1 Family Characteristics

Demographic, social and economic factors play an important role in pressuring Jordan's housing environment and conditions, Jordan's population increased by 86.8% during the period 2004-2015, with a population of 5,103,639 in 2004, rising to 9,531,712 in 2015, of whom 5,046,824 were male and 4,484,888 females (Table 1.2). This unexpected rise is due to several reasons, the most important of which is the emigration resulting from the political circumstances in the region.

Table 1.2: Distribution of Population in Jordan by Governorate and gender, 2015

Governorate	Male	Female	Total
Amman	2,151,568	1,855,958	4,007,526
Balqa	263,984	227,725	491,709
Zarqa	721,601	643,277	1,364,878
Madaba	99,985	89,207	189,192
Irbid	914,634	855,524	1,770,158
Mafraq	283,533	266,415	549,948
Jerash	123,245	113,814	237,059
Ajloun	90,626	85,454	176,080
Karak	165,421	151,208	316,629
Tafiela	50,391	45,900	96,291
Maan	75,401	68,681	144,082
Aqaba	106,435	81,725	188,160
Total	5,046,824	4,484,888	9,531,712

Jordan is characterized by the unbalanced distribution of the population in its geographical areas, where two thirds of the population is concentrated in three governorates, namely Amman, Irbid and Zarqa, which covers only 15.7% of Jordan's area, Amman is the largest governorate in terms of population, with a population of 4,007,526 inhabitants in 2015, with an area of 7,579 km^2, or 8.5% of the Kingdom's area, with a population density of 529 people / km^2, while Ma'an is the largest governorate in the Kingdom with an area of 32,832 km^2, with a population of 144,082 and density of 4.4 individuals/km^2

The unprecedented increase in the population growth rates in Jordan is due to Jordan's exposure to migration, resulting from the political situations in the region, and the waves of labor coming from neighboring countries. At the same time, the annual increase in number of houses of 102,676 dwellings exceeded the annual increase in the number of households of 91, 975 households. It is worth noting that buildings and households are concentrated in three main governorates, Amman, Irbid and Zarqa, where 61% of the Kingdom's total buildings were located in 2015 (Table 1.3).

Table 1.3: Number of Buildings, Houses and Households in Jordan by Governorate, 2015

Governorate	Number of buildings	Number of houses	Number of households
Amman	247,904	1,072,559	843,558
Balqa	70,016	121,953	99,695
Zarqa	118,062	312,170	279,703
Madaba	25,660	46,273	38,118
Irbid	174,910	400,103	355,007
Mafraq	86,449	118,974	106,367
Jerash	34,244	54,413	46,735
Ajlun	24,623	41,638	34,931
Karak	45,248	71,595	63,413
Tafila	16,426	24,637	19,211
Ma'an	23,475	35,328	28,429
Aqaba	21,011	50,847	38,027
Total	888,028	2,350,490	1,953,194

1.3.2 Gender

The gender issues in Jordan are evidenced by highlighting indicators that monitor the status of women in Jordan compared to men, based on data provided by the General Population and Housing Census, 2015. These indicators are highlighted in order to draw the attention of policy-makers and decision-makers to the importance of examining these issues, in order to reduce the gap between males and females wherever they exist. The study included three main issues: Work and challenges that face women, women's access to economic resources and early marriage. The main results are as follows:

In 2015, the percentage of economically active females was 20.7%, while the percentage of economically active males was 71.2%.

- The percentage of female-headed households, indicate that a woman headed one out of every eight households.
- Results showed that 38% of the economically active Jordanian females were aged 25-29.
- The higher the level of education for females the higher the rate of their economic participation. More than half of the Jordanian female workers in 2015 are university graduates, compared with 23% males.
- 11% of Jordanian females work in fixed jobs,
- From the households headed by women, who are working, 21% comprise of only one individual.
- The larger the household, the smaller the percentage of female workers heading their households.
- From the household's headed by women, who had children under 6 years of age, 76.4% of the female heads of households did not seek work (i.e., economically inactive).
- From the households in Jordan headed by a man, 62.9% had ownership of houses in 2015, while the ownership rate of houses by female-headed households was 60.2%.
- More than half of the non-Jordanian, female-headed households live in rented houses.

Demographic literature indicates that the gender rate of births in any population is on average, 105 males per 100 females. This rate did not differ much for the Jordanian population, ranging between 107 and 103. According to the results of the General Population and Housing Census 2015, the ratio for Jordanian gender was 103.8 compared to 135.5 for non-Jordanians, which confirms that the majority of non-Jordanians are males. The overall rate of the population in the Kingdom was 112.5 males for every 100 females.

1.3.3 Internal Migration

Internal migration reflects the spatial movement of individuals and groups between one place of residence and another for permanent residence. Internal migration contributes to a high rate of population growth in the reception area, while reducing the size of the population in the sending area. According to the results of the General Population and Housing Census 2015, the internal migration rate among Jordanians based on current and former residence was 2.04%, and only about 5.4%of Jordanians have moved away from their mother's residential area, at the time of their birth, to live elsewhere. This data indicates that there is population stability among Jordanians, with availability of services of various types contributing to this stability.

The rates of internal immigration, i.e., entering and leaving governorates, according to place of current and former residence and place of residence of the mother, currently and at the time of the individual's birth, were analyzed. Aqaba recorded the highest rate of in-migration and out-migration with 7.6% and 19.9% respectively. According to the current and former residence place, Tafila recorded the highest migration rate, which reached 4.2%, while the lifetime migration rate reached 10.1%. According to the calculation of the net migration rate for governorates, most governorates were losing population according to the place of current residence and the previous place of residence (current (ongoing) migration), except for Aqaba, Balqa and Amman, which were attractive to incoming population. These governorates, in addition to Al-Mafraq, are an attraction to citizens of Jordan, according to the lifetime migration method.

1.3.4 Unemployment

The unemployment rate in Jordan was 19 percent in 2020 and increased to 24.8% in 2021[17]. These figures show a marked increase from the 2014 value, which was 12 per cent. The percentage of Jordanians 15 years or older who were employed reached 36% 2010, and decreased to 33% in 2019; around 35% of youth, 15-24 years old are unemployed, and overall, 14% of the labour force are unemployed.

The Department of Statistics issued its quarterly report on the Unemployment Rate for the Second quarter of 2021; the following are the main results of this survey:

- The results show that the unemployment rate reached (24.8%) during 2021.
- The unemployment rate for males reached (22.7%) during 2021 compared to (33.1%) for females.

[17] https://www.cbj.gov.jo/EchoBusV3.0/SystemAssets/9117847f-9eaf-4c2b-96d1-2651edc831e2.pdf

- The unemployment rate has increased, for males, by 1.2 percent and for females by 4.5 percent compared to 2020.
- The unemployment rate is higher among university degree holders (Bachelor degree and higher, at 31.1%), compared to 24.8 percent for the labor force, for all educational levels).
- The percentage of males with a bachelor degree or higher, who were unemployed, was 31.2%, compared to 83.4% for females of the same educational level.

The unemployment rate during the second quarter of 2021 reached 24.8 percent (22.7 percent for males and 33.1 percent for females), compared to 22.9 percent (21.5 percent for males and 28.6 percent for females) during the second quarter of 2020. The highest unemployment rate was among youth, which reached 58.2 percent for the (15-19) years old category and 47.0 percent for the (20-24) years old category[18]. The refined economic participation rate (the ratio of the labor force to the population of 15 years and over), was 33.7 percent (53.4 percent for males, and 13.9 percent for females).

1.3.5 Urbanization

In October 2021, the population of Jordan reach 11.03 inhabitant (DOS, 2021). Most of the population live in urban areas; only 9.7% live in the rural areas. Jordan has received waves of refugees since World War II, in 1948, 1967, 1975, 1981, 1990, 2003, 2011. Therefore, the social structure of Jordan is complex, and includes about half a million registered Iraqi refugees. More recently another 1,600,000 refugees have fled the civil strife in Syria and are located in cities and border refugee camps.

The trend of urbanization in Jordan is demonstrated by the increase of urban population from 59.9% in 1980 to 78.5% in 2010. The country's biggest city is Amman with 4.0 million inhabitants, which is 42% of the country's total population, followed by the Irbid city with 1.77 million inhabitants and Zarqa with 1.36 million inhabitants (DOS, 2016).

The distribution of population in urban and rural areas varies significantly among Jordan's governorates. In, 2009, Karak and Mafraq had the lowest ratios of urban population (35% and 29.2% respectively), while Zarqa and Amman are the most urbanized governorates with 94.5% and 94% respectively. This obviously illustrated the large variation among governorates; however, the change in the percentage in urban population within each governorate during over 6 years (2003-2009) is negligible with maximum variation of ±0.5%.

Urban and rural households have different characteristics and water consumption behavior. For example, rural areas have more individual houses (named as Dar) while urban areas have more

[18] https://www.cbj.gov.jo/EchoBusV3.0/SystemAssets/9117847f-9eaf-4c2b-96d1-2651edc831e2.pdf

apartment buildings. The Dars are normally surrounded by a garden and might have additional facilities, compared with apartments, such as pools, and small economic activities related to agricultural and animal production. Additionally, the number of family members is generally larger in the rural areas, derived from the need to have more family members to help their families in their agricultural activities. Therefore, water demand and consumption behaviors are expected to vary between the urban and rural areas.

The analysis carried out by Salman et al. (2008) concluded that customers residing in a flat or apartment, which are more common in urban areas, consume less water per household and per capita compared to customers residing in individual houses, which are common in rural areas. As households in the rural areas have a garden and some agricultural activities beside the house, it is expected that water consumption and supply with be higher in those areas in comparison to the more urbanized areas. Realizing that such water uses are expected to be higher during summer season.

1.3.6 Disability "Functional Difficulties" in Jordan

A study was conducted by DOS on the proportions of disability in Jordanian society. The objective was to highlight persons with disabilities (functional difficulties) in Jordan aged 5 and above and to reach realistic indicators of disability in Jordan, by identifying the types of disabilities (difficulties) and their prevalence among the population and linking the demographics, social, economic, educational and health characteristics of this vulnerable group of the population, to reach realistic indicators about the prevalence of functional difficulties.

Persons with disabilities (functional difficulties) are defined as any person with long-term impairment of physical, sensory, mental, psychological or neurological functions leading to physical and behavioral barriers, which prevent the person from independently carrying out a major activity of life, or a fundamental freedom, or from exercising a right. Types of disabilities (functional difficulties) are categorized as follows:

- Visual disability (difficulty): Difficult in seeing, even with the use of glasses.
- Auditory disability (difficulty): Difficulty in hearing, even with the use of a speaker.
- Disability (difficulty) of motion: Difficulty in walking or climbing stairs.
- Disability (difficulty) in remembering or focusing.
- Personal care (difficulty): Difficulty in managing personal care such as bathing or clothing.
- Disability (difficulty) in understanding and communicating with others: Difficulty in understanding others when using the regular (traditional) language, such as understanding others, or being understood by others.

Table 1.4, Figure 1.5 and Figure 1.6 summarize the most important indicators in Jordan in the following points:

- The number of Jordanian people with disabilities (difficulties) aged 5 years and over (651,396)
- Of every nine people aged 5 years and over in Jordan, there is an individual with a disability (difficulty), with a percentage of 11.1%.
- The prevalence of disability (functional difficulties) among males is higher than among females, with prevalence rates of 11.5% and 10.6%, respectively.
- The prevalence of disability (functional difficulties) among Jordanians aged 5 years and over is 11.2%.
- The most common disability (difficulties) among Jordanians aged 5 and above is visual impairment (difficulty of vision) which has a prevalence of 6.0%, followed by motor disability (difficulty of walking) at 4.8% and auditory impairment (difficulty of hearing) at 3.1%.
- Al-Aqaba governorate has the highest prevalence rates for visual impairment (difficulty of vision), with 7.1% of the total Jordanian population aged 5 years and over, while Irbid governorate recorded the highest prevalence rates of motor disability (difficulty of walking) at 5.6%, and Ajlun and Tafila governorates recorded the highest prevalence rates in hearing disability (difficulty of hearing) at 3.5%

Table 1.4: Percentage of prevalence of disability (functional difficulties) among Jordanian population aged 5 and above by type of disability (difficulty) and governorate, 2015

Govern-orate	Vision	Hearing	Walking	Remembe ring or Concentra ting	Personal Care	Communi cation	Total
Amman	6.3	3.0	4.6	2.7	2.0	1.6	**11.0**
Balqa'	5.2	3.0	4.6	2.8	2.2	1.8	**10.5**
Zarqa	6.3	3.2	4.9	3.0	2.2	1.8	**11.9**
Madaba	4.7	3.0	4.1	2.7	2.0	1.7	**9.5**
Irbid	6.3	3.4	5.6	3.2	2.4	1.9	**12.1**
Mafraq	4.5	2.9	3.7	2.6	2.0	1.5	**9.3**
Jerash	4.8	3.3	4.2	3.1	2.4	2.0	**10.5**
Ajlun	6.0	3.5	5.2	3.3	2.3	1.9	**11.8**
Karak	5.5	3.3	4.6	2.9	2.2	1.8	**10.8**
Tafila	5.9	3.5	4.9	3.2	2.1	1.8	**11.1**
Ma'an	5.3	3.3	4.0	3.0	2.1	1.9	**10.9**
Aqaba	7.1	2.9	3.9	2.7	1.7	1.6	**11.9**
Jordan	**6.0**	**3.1**	**4.7**	**2.9**	**2.1**	**1.7**	**11.2**

The highest percentage of disability (difficulties) experienced by the Jordanian population at advanced ages, i.e. 65 years and older, is motor disability (difficulty of walking), 37.0%, second is visual impairment (difficulty of vision), 31.0%, and third is hearing impairment (difficulty) at 24.3%, while disability (difficulty) in remembering or concentrating ranked fourth and difficulty in personal care ranked fifth, difficulty in communicating and understanding others ranked sixth, with prevalence rates of 18.9%, 16.3% and 9.9%, respectively. For the younger population, aged from 20 to 64, the highest prevalence is visual impairment (difficulty of vision), followed by motor disability, and then by auditory impairment (difficulty of hearing).

Figure 1.5: Percentage of prevalence of disability among Jordanian population aged >=5 by disability type (difficulty), 2015

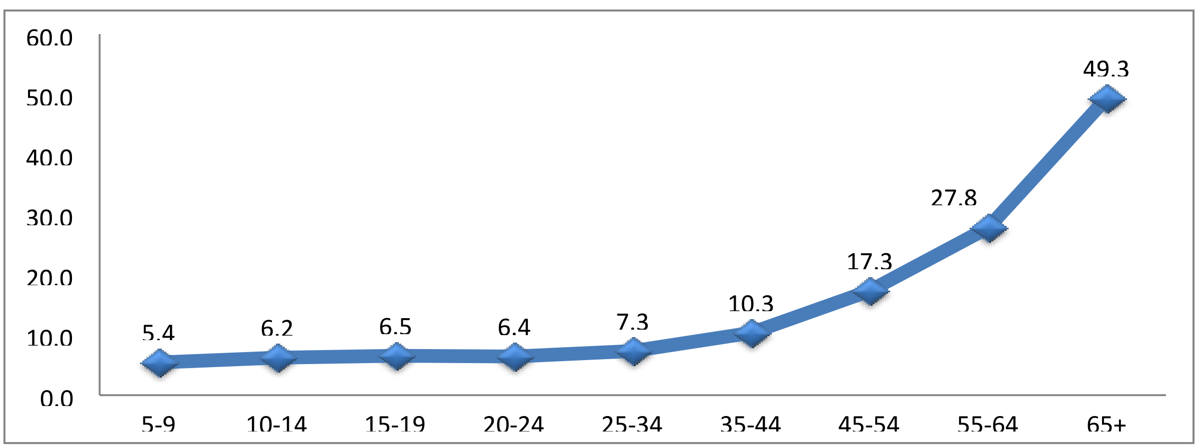

Figure 1.6: Percentage of prevalence of disability (functional difficulties) among Jordanian population aged 5 years and above by age group, 2015

1.3.7 Poverty in Jordan

Poverty is multidimensional. It is associated with the inability to meet multiple basic human needs, or lack of access to them. These needs are defined as sufficient food and nutrition, water and sanitation, basic healthcare, and basic education. Poverty in Jordan is defined as food, non-food and absolute poverty. Absolute poverty is the combination of food and non-food poverty. Food poverty means the amount of money needed to secure sufficient food needs.

About 14.4% of the Jordanian live below poverty line (2010 estimates)[19], inequality is high (the Gini coefficient was 37.7 % in 2006[20]) and poverty is higher in rural areas than in urban areas. The pockets of poverty are mostly rural; some are in isolated and remote areas while others are in areas with a poor resource base and low population density. Water scarcity, climate change and rising food prices are having major impact on food security in Jordan.

One of the main demographics in Jordan is migrants, and thus this is a main political determinant, with development implications. The rapid growth in population and successive influxes of refugees over the decades have imposed additional demands on food, water and energy resources. Jordan is facing substantial problems of water shortage since its establishment (World bank, 1957). All forecast scenarios indicate an increasing demand for food and water as a result of many driving forces such as population growth, urbanization, development, economic growth, and sudden influxes of refugees, which is exacerbated by climate change, which is predicted to increase the severity of droughts.

About 13% of Jordanians live below the poverty line. Inequality in the country is high (the GINI coefficient was 38.8 percent in 2011) with poverty levels higher in rural areas than in urban areas. The rural poor are mostly located in isolated and remote areas with a poor resource base and low population density. A major obstacle to poverty reduction in Jordan is insufficient employment opportunities. Unemployment in Jordan is a particular problem for young people.

According to the latest Household Income and Expenditure Survey carried out by the Department of Statistics (2017-2018). The absolute poverty rate among Jordanians was 15.7%, representing 1.069 million Jordanians, while the rate of hunger poverty (extreme) in Jordan was 0.12%, equivalent to 7,993 Jordanians.

The absolute poverty (food & non-food) line was estimated at 680 JD per capita per year in 2008 at the Jordan level as shown in Table 8. Amman registered the highest poverty line with 703 JD

[19] DOS, 2018. Jordan in Figures. Department of Statistics, Amman, Jordan
[20] DOS, 2018. Jordan in Figures. Department of Statistics, Amman, Jordan

per capita per year[21]. The lowest absolute poverty line was found in Mafraq and Jerash governorates with about 656 JD per capita per year. Because prices differ across the country, the poverty line needs to be adjusted accordingly. For example, a family of 6 living in Mafraq would be considered to be living at the poverty line if they spent JD 263 per month, while the same family would need to spend JD 291 per month to have the same standard of living in Amman (due to higher prices in Amman). Therefore, the general poverty line per capita per month is 56.7 JD or JD 292 per year. For a typical household size with 5.7 members, the general poverty line will be 323 JD per month or about JD 1,665 per year.

The budget for other expenditures was set at the amount spent on non-food expenditures by Jordanians whose food budget was exactly at the poverty line food budget. On this basis, the poverty line non-food budget was JD 32.3 per person per month. Thus, the poverty line budget (including both food and non-food components) was JD 56.6 per person per month for the year 2008 (Figure 1.7).

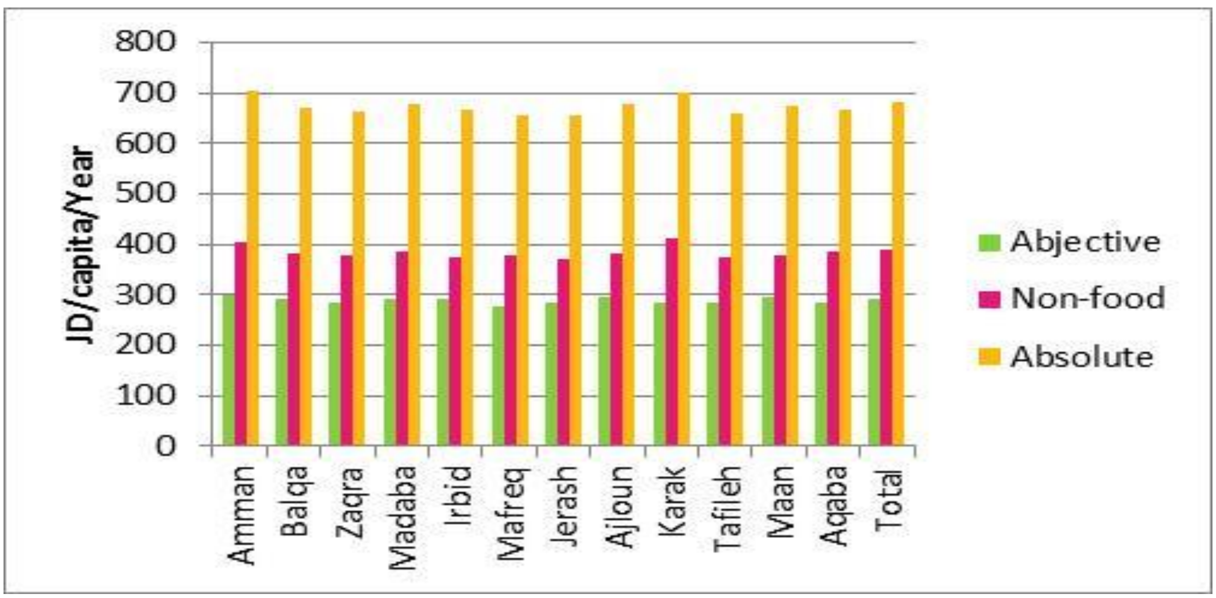

Figure 1.7: Abject and absolute poverty lines by governorate

The poverty ratio (percentage age of individuals whose expenditure is below the poverty line) was 13.3 % in 2008[22] (compared to 14.7 % in 2005 and 14.2 % in 2002). The poverty rate in rural areas was 22.8 % (compared to 18.7 % in 2002). In urban areas, it amounted to 13.1 % (compared with 12.9 % in 2002) (**Table 1.5**).

[21] The population higher council, 2011. The status of Jordanian population. http://www.hpc.org.jo/hpc/tabid/198/ctl/details/mid/580/articleID/140/checkType//Default.aspx

[22] Jordan Poverty Report(DOS 2011) based on analysis of 2008 Household survey results

Table 1.5: Main Poverty Indicators in Jordan in 2008

Governorate	Food Poverty line (JD/c/y)	Non-food poverty line (JD/c/y)	Absolute poverty line (JD/c/y)	Poverty %	% Of Poor Population	% Of Poor households	% Of Poverty Severity
Amman	300	403	703	8.3	24.6	5.7	0.47
Balqa	290	382	672	19.7	8.7	13.9	1.30
Zaqra	285	377	662	11.2	11.7	7.9	0.47
Madaba	293	384	677	14.9	2.6	10.4	0.66
Irbid	292	376	668	14.7	20.5	11.6	0.81
Mafraq	277	379	656	31.9	11.9	25.6	1.96
Jerash	284	372	656	20.3	4.6	16.1	1.67
Ajloun	294	383	677	13.3	2.3	10.1	1.07
Karak	286	413	699	17.1	5.5	12.0	1.25
Tafileh	285	375	660	21.1	2.2	16.9	0.57
Maan	295	379	674	24.2	3.4	17.8	2.00
Aqaba	283	385	668	11.8	2.0	8.3	1.30
Total	292	388	680	13.3	100	9.5	0.79

Source: DOS, 2011. Jordan Poverty Report

Poor Jordanian households have some general characteristics. Around 80 percent of poor Jordanians live in urban areas, with most of them living in the east of the country (UNDP, 2013b; Lenner, 2014). In comparison with the rest of the population, poor households tend to have larger families and younger ages on average. Almost half of the poorest group depends on employment as the main source of income. Seventy-five per cent of the employed poor work in the private sector. The average income for the poor is JD 241. Around 44 percent receive some forms of loan. Half of them do not participate in social security. They face low wages and job competition, as a result of the increasing numbers of migrant workers (Ministry of Social Development, 2019). Thus, they have to control their income tightly to be able to cover the basic needs of their household.

Thirty-two poverty pockets were identified in 2008 compared to 22 pockets in the 2006 study. Although Amman has the lowest poverty rate of all governorates, it is home to the largest number of poor individuals due to the concentration of population in Amman. Several sub-districts, including Wadi Araba, Rwashed, Mraighah and Ghawr Almazra'a, Diesah have very high rates of poverty exceeding 40% [23].

[23] The World Bank (2009). Jordan Poverty Update - Volume I: Main Report. Report No. 47951-JO

The most significant causes of poverty for rural Jordanians are high unemployment in rural areas and low wage rates; drought seasons, which in recent years have become an almost permanent feature, an average family size of poor households in rural areas of some 9 persons (compared with a national average of 4.8); desertification and deterioration of pasture land; and uneven economic growth.

Increased drought episodes will erode already impoverished livelihoods, leaving households and communities more vulnerable to future droughts and hazards. For vulnerable rural households, even minor drought episodes can lead to yield losses and can have devastating impacts on precarious, non-diversified livelihoods. Furthermore, population growth coupled with rapid urbanization have resulted in relatively unsafe living conditions and little access to basic amenities/services in urban centers. Jordan's approach to fighting poverty is based upon a comprehensive social protection concept with limited direct interventions to support those most in need, consistent with SDG1 of the 2030 Agenda and its associated targets.

The absolute poverty rate (food and non-food) dropped from approximately 21% in 1990 to 14.4% in 2010. Although the poverty rate remained at approximately the same level, it increased to 15.7 percent in 2018 (UNDP, 2013b; UNICEF, 2020b). The absolute poverty rate (food and non-food) was 14.4% in 2010, and the abject poverty rate (food poverty) was 0.32 % in 2010. The proportion of people living below the abject poverty line (food-poverty line) dropped from 6.6% in 1992 to 0.32% in 2010. The rural poor make up 33.5% of the total poor in Jordan, the disadvantaged among rural populations are often the first victims of natural resource degradation and are impacted by crisis more severely than any other segment of the population. Lack of employment opportunities, poor labor productivity and lack of decent employment in agriculture are, therefore, a serious constraint to food security in Jordan. This situation also contributes to increasing rural-urban migration and the accumulation of food insecure people in the cities.

Despite the high incidence of poverty in rural areas and existing poverty pockets, the number of economically underprivileged people in rural areas does not exceed 33.5% of the total figure in the kingdom. The poverty in Jordan may be dominated by urban poverty, which has different characteristics from rural poverty, but carries a high social price if not addressed.

In 2010, the absolute poverty rate in the Kingdom was 14.4% (**Table 1.6**). This figure represents the percentage of the Jordanian population under the absolute poverty line. The absolute poverty line is equal to an expenditure of 814 JD per individual per year (or 67.8 JD per individual per month). The consumer price index was 125 in the year 2018 compared to the base period of 2010. Using a naïf approach, of multiplying the poverty line expenditure for 2010 with the consumer price index, one can estimate roughly the absolute poverty line for 2018 as 1017 JD per person per year. For a household of 4.8 persons this equates to 4,884 JD per household per year (or 407 JD per household per month).

Although the highest poverty rate was seen in the governorate of Ma'an (26.6%), the highest total numbers of poor were seen in the governorate of Amman (about 37,000 households). The data indicates that -there is a higher incidence of poverty in rural areas (16.8%) compared to urban areas (13.9%). A 'poverty pocket' represents a rural district or sub-district in which more than 25% of the population are below the absolute poverty line. In 2010, 27 rural 'poverty pockets' were identified. The poverty gap index was 3.6 in 2010, which measures how far on average households are from the absolute poverty line. The poverty gap is also more significant in rural areas, which means that on average poor households in rural areas are poorer than poor households in urban areas. The households sitting immediately above the absolute poverty line, approximately 22.5% of households, are vulnerable to falling into poverty.

Table 1.6: Poverty Indicators in Jordan in 2010 and forecast for 2018 using consumer price index

Indicators	**Poverty Rate**	**Absolute Poverty Line**		**Abject Poverty Line**		**Nonfood Poverty Line**		**Poverty Gap Ratio**	**Poverty Severity Ratio**
Unit	Percent, 2010	JD Per capita /Year 2010	JD Per capita /Year 2018	JD Per capita /Year 2010	JD Per capita /Year 2018	JD Per capita /Year 2010	JD Per capita /Year 2018	Percent, 2010	Percent, 2010
Amman	11.4	814	1018	336	386	478	631	2.7	0.86
Balqa	20.9	814	1018	336	386	478	631	5.9	2.1
Zarqa	14.1	814	1018	336	386	478	631	3.4	1.17
Madaba	15.1	814	1018	336	386	478	631	3.7	1.04
Irbid	15	814	1018	336	386	478	631	3.6	1.18
Mafraq	19.2	814	1018	336	386	478	631	5.6	2.24
Jerash	20.3	814	1018	336	386	478	631	1.2	0.27
Ajloun	25.6	814	1018	336	386	478	631	6.3	1.95
Kerak	13.4	814	1018	336	386	478	631	3.7	1.31
Tafileh	17.2	814	1018	336	386	478	631	3.5	0.85
Maan	26.6	814	1018	336	386	478	631	8.3	3.36
Aqaba	19.2	814	1018	336	386	478	631	4.3	1.48
Kingdom	**14.4**	**814**	1018	**336**	386	**478**	631	**3.6**	**1.21**

The poverty rate indicator is heavily used by the government of Jordan for monitoring and evaluating the poverty phenomenon. The poverty rate is defined as the percentage of the population falling below the absolute poverty line. The official estimated poverty rates for the years 2002, 2006, 2008, 2010, and lastly 2017 are 14.2%, 13%, 13.3%, 14.4%, and 15.7%, respectively. Official poverty statistics are produced using the nationally representative

Household Expenditure and Income Survey (HEIS)[24]. Poverty in Jordan increased between 2010-2018. The poverty rate for Jordanian citizens is higher than that of the Syrian refugees. The COVID-19 pandemic is expected to have increased the number of poor. The results show that the Syrian refugees have more challenges in meeting their basic needs and that their poverty, considering all aspects is higher than among the Jordanian poor. While the Jordanian's income poverty is more challenging when compared with the Syrian refugees.

The percentage of the Jordanian households that were just above the poverty line, and are considered as vulnerable households, was 22.5 per cent in 2010 (UNDP, 2013b). The poverty rate among the Syrian population, representing 12 percent of the total population was 78 percent, in 2018[25]. Without a doubt, the consequences of the COVID-19 pandemic are exerting more pressure on people's jobs and income. Besides that, it could affect their access to basic needs, such as education, food, water and sanitation, and healthcare, which are also issues that can affect poverty.

1.3.8 Food Security & Household Expenditures

Household expenditure and income surveys provide data that is used for identifying and measuring the poverty status of Jordanian households (**Table 1.7** and **Table 1.8**). The COVID-19 pandemic affected the household income for both Jordanians and Syrian refugees in Jordan, where the average monthly income had fallen from JD 368 before the pandemic to JD 215 in March 2020. It is worse for the Syrian refugees, who had a higher percentage of permanent job loss as a consequence of the COVID-19 pandemic, than the Jordanians (ILO, 2021).

By June 2020, 40 per cent of the Syrians reported that they had more than 100 JD in debts per capita. In addition, around 90 percent of them had to use negative emergency coping mechanisms, e.g., reducing their food intake, or reducing their expenditure on education or health (World Bank Group et al., 2020).

Jordan has always attached priority to the issue of food security, from both an access and availability standpoint. The most recent estimates show that the prevalence of food insecurity in the country remains excessively high. The Food Insecurity Survey shows that 12.8% of the total population were affected by severe food insecurity. The latest data on stunting shows that 7.7% of children under five years of age suffered from some form of under-nutrition.

Jordan is highly vulnerable to fluctuations in international prices of basic commodities. Satisfying the growing demand for food, of a growing population, will need to be addressed within the

[24] A. Alsharkawi, M. Al-Fetyani, M. Dawas, H. Saadeh, and M. Alyaman, "Poverty Classification Using Machine Learning: The Case of Jordan," *Sustainability,* vol. 13, no. 3, p. 1412, 2021.
[25] UNICEF, "Geographic Multidimensional Vulnerability Analysis–Jordan," UNICEF2020.

context of extreme water scarcity, as the demand for water for domestic use and sanitation services is increasing for Jordanian and non-Jordanian residents alike. This struggle falls among many other economic and social challenges The Department has conducted several surveys of family expenditures and income in the years 1966, 1980, 1986, 1992, 1997, 2002, 2006, 2008, 2010, 2013, and 2017.

Table 1.7: Average Annual Current Income of Household Members by Source, Governorate and Urban/Rural (in JD) in 2014

Governorate and Urban/Rural	No. of Members	No. of Households	Income from Employment	Own Account Incomes	Income from Rents	Property Income	Transfers Income	Total income
Amman	2,403,720	513,503	985.7	301.8	495.5	28.1	478.2	2,289.3
Balqa	424,057	82,113	812.6	112.6	250.8	7.1	362.1	1,545.2
Zarqa	**939,709**	**186,073**	**738.6**	**120.7**	**214.7**	**4.4**	**319.3**	**1,397.6**
Madaba	157,989	30,611	802.8	60.4	252.1	9.0	356.3	1,480.5
Irbid	1,108,082	214,209	785.7	196.2	283.1	3.8	472.8	1,741.6
Mafraq	290,886	51,401	703.7	77.2	254.8	2.2	331.5	1,369.4
Jerash	188,296	37,131	795.1	278.6	196.6	5.5	341.5	1,617.3
Ajlun	144,199	26,929	786.0	163.3	251.4	2.1	526.1	1,728.8
Karak	241,589	46,762	869.0	154.3	246.0	8.4	463.6	1,741.3
Tafiela	88,984	16,918	1,047.1	88.6	182.0	0.6	393.7	1,712.0
Ma'an	121,920	21,081	804.4	176.9	227.2	34.3	330.1	1,573.0
Aqaba	138,377	26,623	1,069.0	138.8	358.2	0.0	251.5	1,817.5
Urban/Rural								
Urban	5,113,528	1,040,881	889.0	220.8	367.6	15.8	429.8	1,923.0
Rural	1,134,280	212,472	772.5	148.7	240.8	6.9	391.7	1,560.6
Kingdom	6247808 1	1,253,352	867.9	207.7	344.6	14.2	422.9	1,857.2

Source: Department of Statistics (2014). Household Expenditure & Income Survey 2013

Table 1.8: Average Annual Household Income by Source of Income and Governorate and Urban/ Rural (JD) in 2017

Source of Income	Incomes from Own Private Work	Income from Employment	Transactions Incomes	Property Incomes	Rentals Incomes	Average Total Income
Amman	1,281	4,804	3,944	175	2,451	12,657
Balqa	1,095	5,016	3,464	112	1,764	11,451
Zarqa	858	3,979	3,324	30	1,371	9,563
Madaba	736	4,403	3,710	6	1,558	10,414
Irbid	727	3,959	4,128	30	1,587	10,432
Mafraq	547	4,000	3,312	40	1,239	9,139
Jerash	822	4,141	3,062	2	1,050	9,078
Ajlun	392	3,846	4,757	10	1,042	10,051
Karak	786	4,828	4,877	10	1,230	11,755
Tafiela	515	4,922	3,415	37	1,245	10,133
Ma'an	515	4,335	3,375	51	1,300	9,576
Aqaba	561	5,775	2,711	1	1,256	10,303
Urban	1,020	4,526	3,818	104	1,937	11,406
Rural	668	4,212	3,780	16	1,269	9,952
Kingdom	**980**	**4,491**	**3,813**	**94**	**1,862**	**11,242**

1.3.9 Food and Nutrition

Access to sufficient food and nutrition is considered one of the basic human needs that is crucial for survival. Food insecurity and poverty are connected; poverty prevents people from access to sufficient food, and many poor people suffer from malnutrition[26]. Access to food, among other dimensions of poverty, is considered more important than monetary measures of poverty (World Bank, 2017). Good and sufficient food can keep people healthy and allows them to participate in education and work, which are also among their minimum basic rights. Imbalances in nutrition can reduce human capital and working capacity, thus affecting poverty.

The 2017–2018 Jordan Population and Family Health Survey (JPFHS) was the seventh of this kind to be conducted in the country, and was implemented by the Department of Statistics (DOS) from early October 2017 to January 2018. The funding for the JPFHS was provided by the Government of Jordan, the U.S. Agency for International Development (USAID), the United Nations Children's Fund (UNICEF) and the United Nations Population Fund (UNFPA). Technical assistance for the survey was provided by ICF International through The Demographic and Health Survey (DHS)

[26] F. AlSaid Herbawi, "Partnership for Poverty Alleviation: A case study of the partnership between government and national civil society organisations in Jordan," Independent thesis Advanced level (degree of Master (Two Years)) Student thesis, Examensarbete vid Institutionen för geovetenskaper, 2021/40, 2021.

Programme, a USAID-funded project that provides support and technical assistance in the implementation of population health surveys in about 90 low-middle income countries. The main objectives of the survey were to collect data on key demographical indicators such as fertility, childhood mortality, maternal and child health status. Data serve the purpose of measuring the progress towards national and international development goals (such as sustainable development goals) and facilitating evidence-based policies. The latest JPFHS survey was nationally representative. It collected data from urban and rural areas separately across all 12 administrative regions.

Jordan is considered a food secure country, with a moderate hunger level. It scored 11.2 in 2018 on the Global Hunger Index. It has a challenging geographic location that makes it more dependent on imported food. Thus, vulnerable people are the ones who are affected the most, as they are not be able to cultivate the arid lands or to afford to buy their vegetables and fruits from the market, due to the high prices. The DOS, 2016 data indicated that 0.5 per cent of the Jordanian households were suffering from food insecurity for the period 2013-2014, while 5.7 percent were considered vulnerable to food insecurity[27]. The level of food insecurity varies between the Governorates. The same report shows that the highest rate of insecurity in the population is in Ma'an, and the lowest was in Aqaba, which has no food insecurity. The highest rate of vulnerability to food insecurity was recorded for households in Umm Al-Rassas District, a sub-district of Amman Governorate, with 25.6 percent vulnerability to food insecurity.

The impacts of COVID-19 put pressure on the vulnerable people in Jordan. First of all, the import costs of agricultural products increased, due to some countries restricting their exports of certain agricultural products, e.g., legumes and rice. Jordan's imports of wheat, corn, and rice are high, and the exporters of these products were among the 50 countries most affected by COVID-19. This made Jordan's food supply volatile during the pandemic (WFP, 2020). A survey by the UNDP (2020f) showed that about half of the Jordanian respondents reported that food prices had been increased significantly, while about a third reported that food prices have slightly increased during the lockdowns. The World Food Programme[28] showed that the percentage of food insecurity in Jordan in December 2020 was 3 percent for Jordanians, amounting to 219,186 individuals, while around 53 percent of Jordanians are vulnerable to food insecurity, corresponding to 3,872,286 individuals (according to the Food Security Index/CARI), with rural areas being the most vulnerable. Among all the governorates, Al-Tafilah is by far the most food insecure region with 20 percent of households being food insecure (Figure 1.8).

[27] DOS and ICF, "Jordan Population and Family and Health Survey 2017-18. ," Department of Statistics (DOS) and ICF. 2019., Amman, Jordan, and Rockville, Maryland, USA: DOS and ICF.2019, Available: http://www.dos.gov.jo/dos_home_e/main/linked-html/DHS2017_en.pdf.

[28] WFP, "WFP Jordan Country Brief, January 2021," 2021

25.7 per cent of the Syrian refugees are food insecure. while 67 percent are vulnerable to food insecurity. The remaining 7.3% are food secure households[29]. With an economy already in crisis, COVID-19 pushed 17 percent of Jordanians to permanently lost their jobs with unemployment skyrocketing to 26 percent in 2020. This led Jordanian households to adopt livelihood-coping strategies to adapt to food insecurity. Up to 42 percent of households were resorting to harmful livelihood coping strategies (crisis or emergency level) to address essential needs, compromising future household coping and productive capacities[30].

While the vast majority of Jordanian households show an acceptable food consumption (96 percent), the economic impact of the COVID-19 pandemic forced households to economize with food, as 55 percent of households used consumption-based coping strategies (as compared to 34 percent in 2014). A quarter of all households (25 percent) reduced the number of meals eaten per day and ten percent relied on help from social nets, such as friends and relatives, to mitigate food shortages. On average, households spend around 41 percent of their available budget on food.

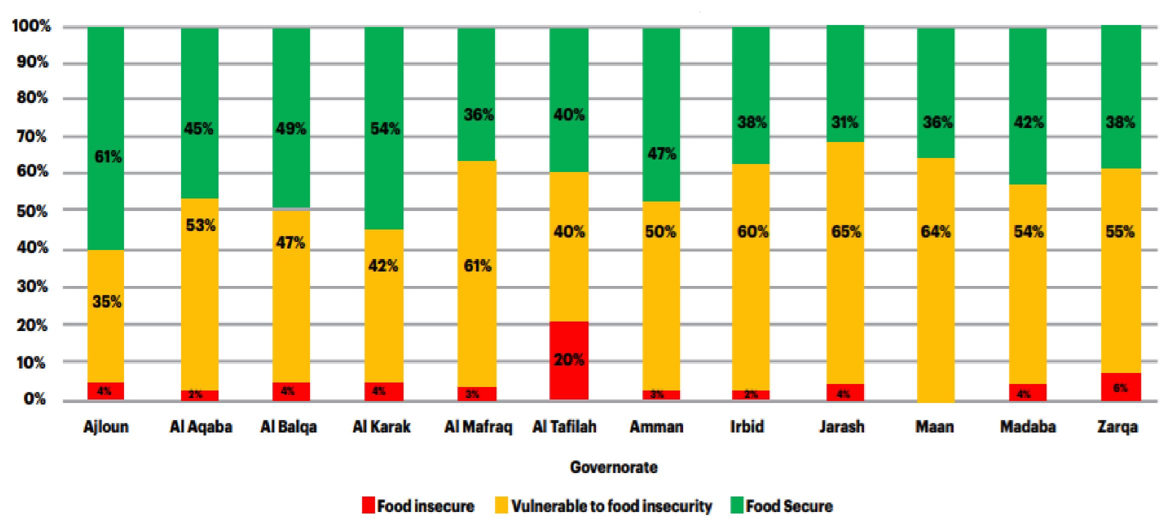

Figure 1.8: Food Security Index (FSI) for Jordanians, by governorate, Aug 2020

[29] WFP, "Jordan Food Security Update: Implications of COVID-19 (July-August 2020)." World Food Programme, Amman2020.
[30] https://reliefweb.int/sites/reliefweb.int/files/resources/WFP-0000122056.pdf

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, the political situation in Egypt has been unstable. As a result, the Natural Gas supply line in Sinai has been exposed to several bombing incidents, therefore the gas supply from Egypt had been reduced to 16% of the 2012contractual terms. 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, since the trade balance was affected as exports had stalled due to the disruption of trade routes, caused by 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 to 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 up to 7.25% in 2012.

The government spent an estimated $53 million on medical care for refugees between January and April of 2012, with only $5 million provided in direct support by UN agencies during this period. In order to cope with this situation, the government 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 was estimated that an additional $180 million would 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 on the Kingdom, resulting from the Syrian crisis. 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 Regional Economical Context

The Jordanian economy is one of the smallest economies in the region. A lack of natural resources, a high population growth rate, the ongoing regional conflicts, the rising cost of health care and the growing expectations of people, have posed challenges to the country's sustainable social and economic development. Due to the COVID19 pandemic and its negative effects on health, the economy and society, it is expected that financial support from donors will be directed to the health sector to mitigate the effects of this pandemic, and this may negatively affect the availability of the required support from international bodies or public budgets at the national level to implement projects to protect the environment in general and climate change projects in particular[31].

Over the past decade, Jordan's economy grew at an average annual rate of 2.4 percent. However, job creation has not been strong enough to meet the needs of the country's fast-growing working-age population, which grew at an average annual rate of 4.5 percent over a decade owing to the large influx of refugees, mainly from Iraq and Syria. Jordan has been affected by the adverse regional and global political and economic crises, starting from the global financial crisis in 2009, then the Iraqi and Syrian conflicts that disrupted the trade routes, accompanied by the disruption of favorably-priced natural gas supplies from Egypt in 2011. The depressed oil prices in 2014 caused a slowdown the Gulf countries' economy that indirectly affected the economy of Jordan, due to the decrease in remittances.

In the light of the most uncommon health and economic crisis in modern era, which was caused by the Coronavirus pandemic (COVID-19), leaving behind an unfolded shadow in the economies of both developed and developing countries, global economic activity receded, creating sudden and unexpected levels of economic stagnation, unemployment, deteriorating public finance and high levels of public debt. The Jordanian economy was not an exception, as it experienced its first economic contraction in more than three decades; contracting by 1.6 percent, the

31 https://unfccc.int/sites/default/files/resource/Jordan%E2%80%99s%20Second%20Biennial%20Update%20Report%20for%20web%2010-5.pdf

unemployment rate rose to unprecedented levels, exceeding 23 percent, whilst the inflation rate reached 0.3 percent. The external sector was the one most affected by the repercussions of the pandemic, as reflected by its main indicators, following the decline of both, travel receipts by 75.7 percent, and total exports by 4.5 percent, which contributed to widening the current account deficit to 8.0 percent of GDP; nearly four times its rate in 2019. In terms of public finances, the overall fiscal deficit of the general budget, including foreign grants, increased by 3.7 percentage points, to reach 7.0 percent of GDP in 2020[32].

Jordan is a small, lower middle-income country with a narrow natural resource base and scarce water resources. The gross domestic product (GDP) per capita was JD 2,829 in 2017. In light of the pandemic, the real GDP per capita decreased by 3.8 percent to reach JD 2,738 in 2020, and the unemployment rate among Jordanians increased to reach 23.2 percent, affected by the repercussions of the Covid19 pandemic, on the one hand, and the structural imbalances that exist in the labor market, especially the crowding out effect of low-paid foreign labor, who took over part of the newly created job opportunities in the economy[33].

The Jordanian economy continues to be under stress from the unfolding implications of COVID-19. Jordan is forecast to register higher unemployment rate, starting in the second quarter of 2020 and well into 2021 (up to around 26 percent). This will be the result of the effects of a strict lockdown on an already fragile economy, mainly based on tourism, informal labor – which together employ more than 52 percent of the Jordanian workforce – and small and medium-sized enterprise (SME) – which accounts for approximately 95 percent of private sector businesses 6. Jordan's travel and tourism sector — constituting around 13.8 percent of GDP in 2019 — saw a 56.5 percent drop in revenues in the month of March, rising up to an estimated 90 percent by August[34].

External debt was about 42 per cent of the total GDP in 2020. The major sources of earnings are services, industry, foreign aid and remittances. Accordingly, the preliminary data of 2020 revealed that the current account deficit, including grants, widened to stand at 8.0 percent of GDP, whilst the deficit, excluding grant, stood at 10.9 percent of GDP in 2020. For example, the growing industrial sector (e.g., potash, phosphorous, fertilizers, clothing, and pharmaceuticals) collectively generated about 24 per cent of GDP in 2020. Both potash and phosphate witnessed a decline by 9.2 percent and 11.9 percent, compared to a growth rate of 9.0 percent and 5.4 percent, respectively, during 2019.

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[32] CBJ, "Monthly Statistical Bulletin. November, Volume 55, No. 6, p 66," Central Bank of Jordan, Amman, Jordan2021, Available: https://www.cbj.gov.jo/Pages/viewpage.aspx?pageID=66.

[3333] CBJ, "Monthly Statistical Bulletin. Volume 54, No. 6, p 66," Central Bank of Jordan, Amman, Jordan2020, Available: https://www.cbj.gov.jo/Pages/viewpage.aspx?pageID=235.

[34] https://reliefweb.int/sites/reliefweb.int/files/resources/WFP-0000122056.pdf

The agricultural sector was one of the least affected sectors by the repercussions of the pandemic, given the different nature of agricultural activities, as well as the result of the mitigating curfew and closure measures imposed on this sector compared to other economic sectors. This also comes in light of the high external demand, which contributed to alleviating the repercussions of the pandemic, reflected by the growth of agricultural exports by 4.2 percent. Despite the pandemic, the agriculture sector grew by 1.6 percent, compared to a growth of 2.6 percent in 2019. This sector maintained its contribution to the overall GDP growth rate, at basic constant prices by 0.1 percentage point, while maintaining its relative importance to GDP at 5.5 percent. The slowdown in the performance of this sector was partially attributed to the decline in investment due to the decline in the volume of capital of new agricultural companies registered with the Ministry of Industry and Trade during 2020 to reach JD 12.1 million, compared to JD 23.1 million in 2019. It is worth mentioning that the Agricultural Credit Corporation decided at the end of November 2020 to postpone loan installments owed to farmers for a period of three months; about 30 thousand farmers benefited from this measure, at a total cost of JD 10 million.

1.6 Land Use Land Cover

Land use in Jordan includes a mixture of rural, agricultural and urban activities that reflect both climate and socioeconomic characteristics of the country. Analysis of land use/cover map of 2017 (**Table 1.9** and **Figure 1.9**) shows that agriculture is practiced in 5% of the country's land; 4% based on rainfed agriculture and 1% (96 thousand ha) based on irrigated agriculture (Table 1). Most of the country is dominated by arid lands and desert surfaces that include sparsely vegetated areas used as open rangelands in the area known as Badia. Forests form only 0.4% of the total area and are mainly concentrated in the high rainfall zone in the north and to a lesser extent in the southern highlands. These important biogeographic zones are under the threat of land fragmentation and urbanization, deforestation and adverse climatic trends of frequent droughts and heat waves. Generally, most land use activities are taking place in the high rainfall zones, while irrigation is practiced in both the Jordan Valley, using surface and groundwater, and in desert areas, where groundwater is pumped to irrigate vegetable and tree crops. The non-vegetated areas of sand, plains of basalt, chert, and bare rocks constitutes about 58% of Jordan's area and are mainly used as open rangelands, with mining activities. These low rainfall areas, treasury lands with tribal fronts, are highly degraded, with a harsh and dry environment.

Table 1.9: Analysis of land use/cover types in Jordan.

Land use/cover category (%)	Area (km^2)	%
Built-up, urban areas	899	1.00
Cropland, rainfed/fallow	2,487	2.78
Cropland, rainfed cereals and trees	1,090	1.22
Cropland, irrigated	958	1.07
Forest, open and closed cover	387	0.43
Mud flat (Qa'a)	2,305	2.57
Rangeland, Steppe	4,215	4.71
Sand plains	6,303	7.04
Soil, bare and sparse veg.	14,868	16.60
Rock and mountains	14,029	15.67
Stone, basalt plain	9,027	10.08
Stone, chert plain	20,243	22.61
Wadis of desert	12,144	13.56
Water bodies, dams	59	0.07
Water, sea	530	0.59
Total	**89,544**	**100**

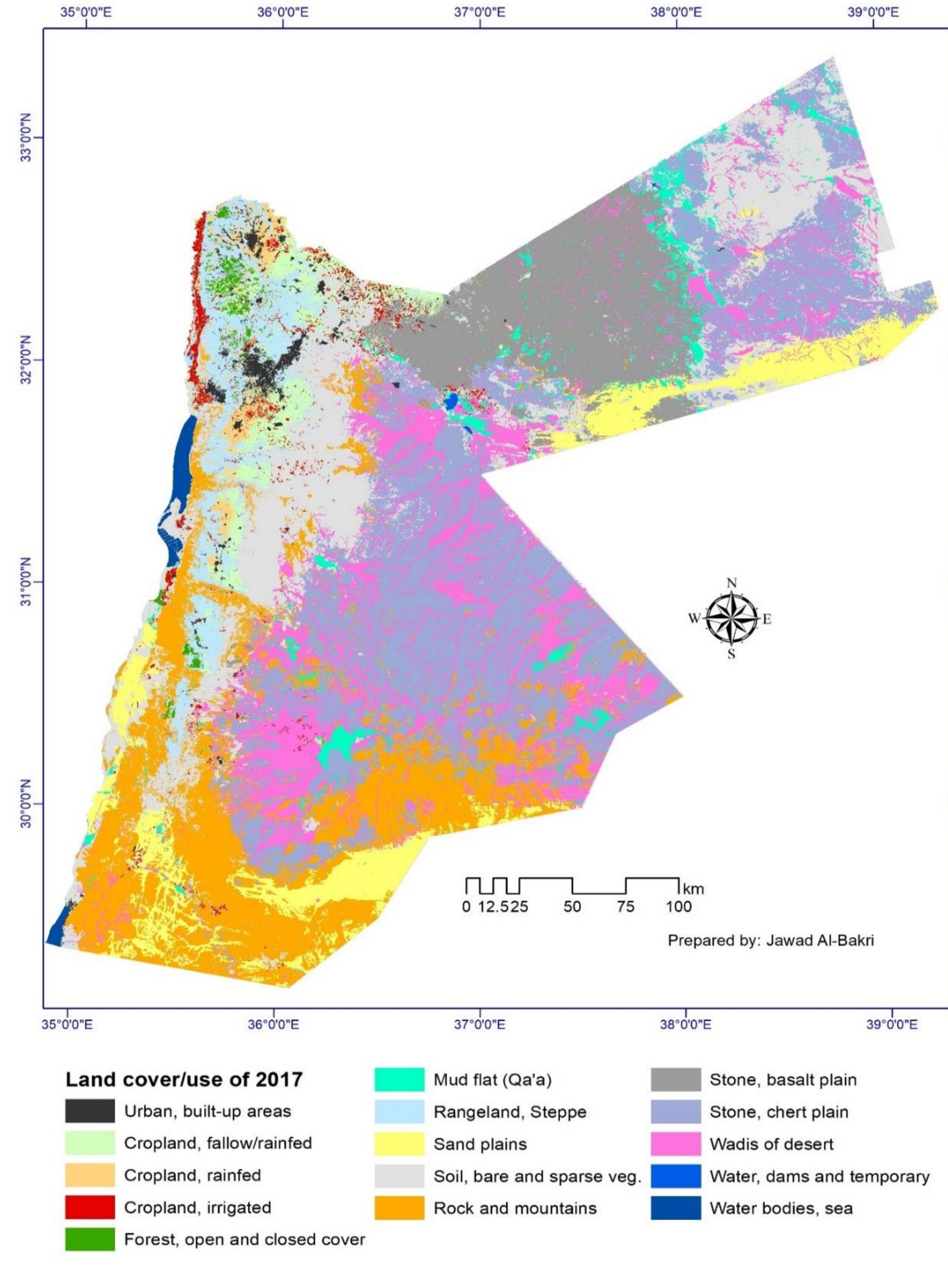

Figure 1.9: Land-use/Cover Map of Jordan in year 2017.

1.7 Agriculture Profile

Summary

Agricultural areas = 400 thousand ha (4.5% of Jordan)

Irrigated areas = 96 thousand ha

Main crops produced: Vegetables, Olives and Fruits.

Livestock: Sheep (3 million), Goats (0.8 million), Cattle and Poultry.

Self-sufficiency: Vegetables, Olives, Fruits, Eggs, Milk and Dairy

Partial self-sufficiency: Citrus, Chicken meat.

Direct Contribution to GDP = 3%

The agricultural sector in Jordan comprises of both plant and animal production subsectors. Although the direct contribution of the agricultural sector to GDP is less than 3%, this sector has an important contribution to the food security of Jordan and economic contributions, related to the industrial sectors of food processing, fertilizers and raw material. The sector also has important political, social and environmental dimensions as it stabilizes rural communities in their lands and reduces the risks of migration from rural to urban areas.

The plant production subsector includes vegetables, trees, and to a minor extent, cereals. The animal production subsector includes livestock products from sheep, goats, poultry and cows. Activities of the agricultural sector are taking place in the Jordan Valley (JV), Mediterranean Highlands and the Badia (desert). In the JV area, irrigation is used for the main agricultural activity. The detailed study of Al-Bakri (2021) showed that the total irrigated area in Jordan reached 96 thousand ha, of which 36% were located in JV. The main irrigated crops in JV during 2017 were citrus, date palm, grapes, vegetables and to a lesser extent cereals and fodder. The agricultural activities in highlands, included rainfed cultivation of olives, fruit trees, vegetables and cereals, in addition to irrigation. The area of Badia shifted towards irrigated agriculture during the last three decades and the irrigated area of fruit trees and vegetable in this region constitutes more than 50% of the total irrigated area in Jordan [35] [36].

Livestock systems that include sheep and goats is practiced all over the biogeographic zones of Jordan, where transhumance movement system is practiced between JV, highlands and the Badia. The livestock sector of poultry and cattle is mainly concentrated in rural areas, where part

[35] Al-Bakri J.T., Shawash S., Ghanim A. and Abdelkhaleq R. 2016. Geospatial Techniques for Improved Water Management in Jordan. Water, 8(4): 132; doi:10.3390/w8040132

[36] Al-Bakri J.T. et al. 2021. Assessment of Climate Changes and Their Impact on Barley Yield in Mediterranean Environment Using NEX-GDDP Downscaled GCMs and DSSAT. Earth Systems and Environment 5(3): 751-766. https://doi.org/10.1007/s41748-021-00238-1

of the fodder is produced, (most fodder and forage are imported). A summary of total agricultural lands, livestock numbers and production is shown in **Table 1.10**. The numbers presented in this table are collected from the open data of the Department of Statistics (http://dosweb.dos.gov.jo), land use/cover mapping and detailed irrigation studies [37] [38].

Table 1.10: Summary of Agricultural Production in Jordan during 2017.

Category (unit)	Area of Production	Sufficiency (%)
I. Agricultural lands (ha)	275,072	--
1- Lands under irrigation management (ha)	123,956	--
2- Lands irrigated in 2017 (ha) Vegetables = 51%, Tree crops =38%, Mixed = 6%, Fodder = 5%	95,792	--
3- Rainfed lands (ha) Vegetables = 7%, Tree crops = 34%, Field crops = 59%	151,116	--
4- Livestock feed (Tonnes DM)	2,666,374	31
II. Plant Production (tonne)		
1- Vegetables	1,737,051	144+
2- Olives	145,332	102
3- Fruit trees, excluding banana	246,111	97+
4- Citrus	107,318	67
5- Field crops	205,850	4
III. Livestock numbers and farms		
1- Sheep (million heads)	3.06	
2- Goats (million heads)	0.77	
3- Cattle (million heads)	0.07	
4- Cattle farms	889	
5- Poultry-meat (Farms)	1,623	
6- Poultry-eggs (Farms)	286	
IV. Livestock production		
1- Milk (tonne)	401,871	100
2- Eggs (million)	801	102
3- Dairy products (tonne)*	226,882	100
4- White meat (tonne)**	209,305	81
5- Beef (tonne)	30,770	13
6- Mutton and lamb meat (ton)	15,558	39
7- Goat meat (ton)	9,505	100

+ Weighted average figure.
* Self-sufficiency for cheese = 29%, powder milk is totally imported.
** For chicken, fish import = 95%.

[37] Al-Bakri J.T., Shawash S., Ghanim A. and Abdelkhaleq R. 2016. Geospatial Techniques for Improved Water Management in Jordan. Water, 8(4): 132; doi:10.3390/w8040132

[38] Bakri J.T. et al. 2021. Assessment of Climate Changes and Their Impact on Barley Yield in Mediterranean Environment Using NEX-GDDP Downscaled GCMs and DSSAT. Earth Systems and Environment 5(3): 751-766. https://doi.org/10.1007/s41748-021-00238-1

Jordan has limited agricultural lands, suitable for rainfed crops of cereals, fruits and vegetables. Therefore, most agricultural production depends on irrigation. In terms of food sufficiency during 2017, Jordan was self-sufficient in olives, fruit trees and vegetables. Also, the country was self-sufficient in production of fresh milk, eggs and dairy products. However, most livestock and poultry products were based on imported forage and concentrates. In terms of cereals, self-sufficiency ranged between 1% for wheat to 5% for barley and corn. Further analysis of self-sufficiency for vegetables showed imbalance among the different crops in terms of importance for food security, levels of production and market prices. For example, self-sufficiency from tomato and watermelon reached 170 and 242%, respectively. Meanwhile, self-sufficiency from carrots and onions were 87 and 55%, respectively.

The challenges for the agricultural sector to achieve self-sufficiency and food security are the low levels of rainfall, the limited and scarce water resources, the steep slopes in the highlands with high rainfall, the adverse climate change and the frequent droughts. In addition to the biophysical factors, the country witnessed rapid population growth resulting from waves of refugees from surrounding countries. As a result, urbanization resulted in land fragmentation and permanent loss of most agricultural lands in the high rainfall zones. Only the crop of olives is suited to the conditions of small landholding size and the rough topography experienced in the highlands' areas. Therefore, increasing agricultural production to meet the food demands of the growing population would be a future challenge under the conditions of both climate change and scarce water resources.

1.8 Water Profile

Summary

Total rainfall volume = 8,165 MCM

Total developed resources = 1,116 MCM (43% GW, 15% TWW, 42% SW)

Total Consumption = 1,167 MCM (56% irrigation, 42% Domestic, 2% Other).

Deficit between supply and demand based on all water resources = 265 MCM

Deficit between supply and demand based on renewable water resources = 422 MCM

Per capita use from renewable freshwater resources = 74 m^3/year

1.8.1 Water Supply

Due to the arid climate and limited water resources, Jordan is ranked as the second country worldwide in terms of water scarcity and has the lowest per capita share of water. The problem of water scarcity has been exacerbated by the political instability in the region and the main transboundary surface water resources have decreased over time. In the long-term (80 years), the country's land is expected to receive about 8.2 billion cubic meters of rainfall per year. About 5% (431.5 MCM) of the rainwater recharges groundwater aquifers, while 2-3% is transformed into direct flood flow. The largest share 92-93% of annual rainfall is lost to evapotranspiration. As such, the developed surface water resources do not meet the demand for water, and therefore the country depends on groundwater resources and on-conventional source of treated wastewater.

The surface water resources are mainly the water stored in the main dams and the water received from the Yarmouk River and the Tiberia Conveyor (Peace Water). The developed surface water resources are mainly located in the basins that receive relatively high rainfall. These include Yarmouk (shared with Syria), and side-branches of the Jordan Valley: Wadis Mujib and Hasa, where the main dams were constructed to provide water for different uses (**Figure 1.10**). Some of these dams receive treated wastewater that is mixed with rainfall water, before being used to irrigate different crops in the Jordan Valley. The total stored capacity of these dams, at the end of 2017, reached 280 MCM, excluding 55 MCM of saline water stored in Al-Karamah dam. The desert dams and ponds stored about 110 MCM of water which was used for livestock watering and as drinking water in some remote areas.

Groundwater sources in Jordan include renewable and non-renewable basins (**Figure 1.11**) that provide water for agricultural, industrial and domestic uses. The safe yield and quality of water differs from one basin to another. The long-term safe yield of renewable sources is 275 MCM/year, while the non-renewable water abstraction was planned at 125 MCM in Disi and 18 MCM in Jafr. The safe yield of renewable groundwater during 2017 was estimated at 335 MCM. A summary of the total developed water supply during year 2017 is shown in **Table 1.11**.

Table 1.11: Summary of available and developed water supply from different sources in 2017.

Water Source	**Amount (MCM)**	**Per capita (m^3)**
1. Surface water	280	28.6
2. Surface water -Transboundary	125	12.8
3. Renewable groundwater	335	34.2
4. Non-renewable groundwater	143	14.6
5. Desalinized groundwater	4	0.4
6. Treated wastewater	164	16.7
Total sources	**1051**	**105**
Total fresh sources	**883**	**88**
Total fresh renewable	**740**	**74**

1.8.2 Water Consumption

Due to the limited freshwater resources, water consumption is rationed. The data in the annual water budget is presented in terms of consumption and only the groundwater balance is reported in the form of the gap between safe yield and demand or consumption for the agricultural sector. For drinking water, demand is not achievable, and consumption is based on scheduled quotas for the different geographic areas in Jordan. **Table 1.12** summarizes the water consumption among the different uses in Jordan during 2017[39]. The figures were obtained from the report of the annual water budget of 2017[40] with corrections made for irrigation water consumption based on the study of Al-Bakri (2021)[41]. The distribution of water consumption among sectors is shown in Figure 1.12. Irrigated agriculture consumed 56% of the total water use during 2017, while domestic uses consumed 40% of the water an obvious gap between safe yield and abstracted water was noticed in 2017, as groundwater abstraction reached 728 MCM, while the safe yield was only 478 MCM.

[39] MWI (Ministry of Water and Irrigation, Jordan), 2017. Jordan's Water Sector: Facts and Figures, MWI, Amman, Jordan.
[40] MWI (Ministry of Water and Irrigation, Jordan), 2018. Annual Water Budget of 2017, MWI, Amman, Jordan
[41] Al-Bakri J.T. 2021. Assessment of Ground Water Abstraction in Jordan during Years 2017, 2018 and 2019. A report for GIZ Water Program project "Management of Water Resources (MWR)", GIZ, Amman, Jordan.

Table 1.12: Total Amounts (MCM) of Developed Water Sources and Their Use in 2017.

Water source	Use				Sum (MCM)
	Domestic	Industry	Irrigation*	Pastoral	
1. Surface water	131.3	2.4	149.4	5.0	288.1
2. Groundwater					
Renewable water	222.3	22.3	320.0	2.1	566.7
Non-renewable water	112.5	4.9	44.0	0.0	161.4
Desalinized water	3.6	0.0	0.0	0.0	3.6
3. Treated wastewater	0.0	2.5	144.2	0.0	146.7
Total	**469.7**	**32.1**	**657.6**	**7.1**	**1,166.5**
% Consumption	40.3	2.8	56.4	0.6	100
Deficit (Without considering GW safe yield)	235	0.0	30*	0.0	**265**
Deficit (Considering GW Safe yield)	348		74	0.0	**422**
Average annual per capita consumption (m^3)	44.6	3.0	62.5	0.7	**111 m^3**
Average annual per capita consumption from fresh water resources (m^3)	44.6	2.8	48.8	0.7	**96.8 m^3**

* Based on the study of Al-Bakri (2021).

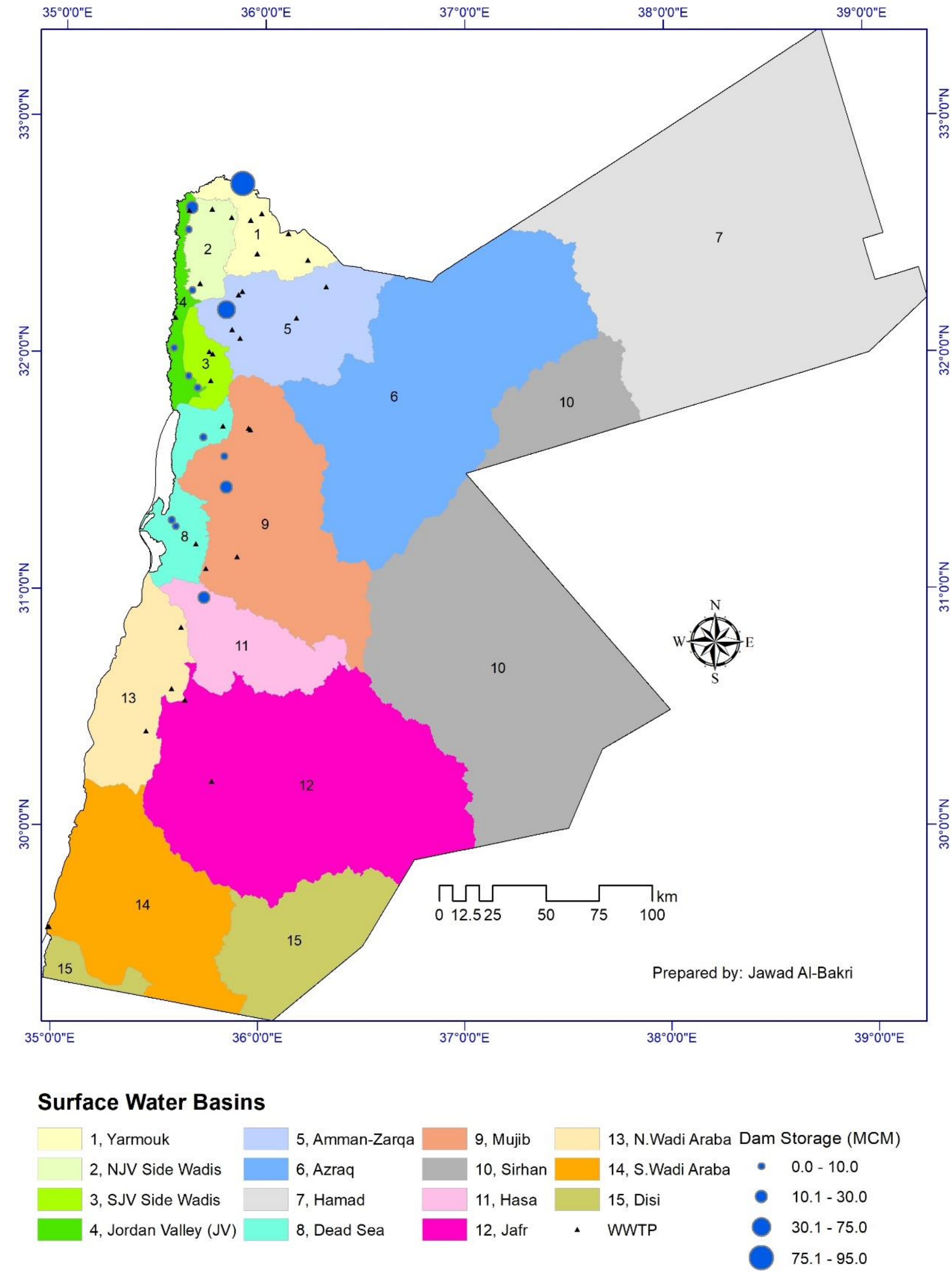

Figure 1.10: Surface water basins, main dams and WWTPs in Jordan.

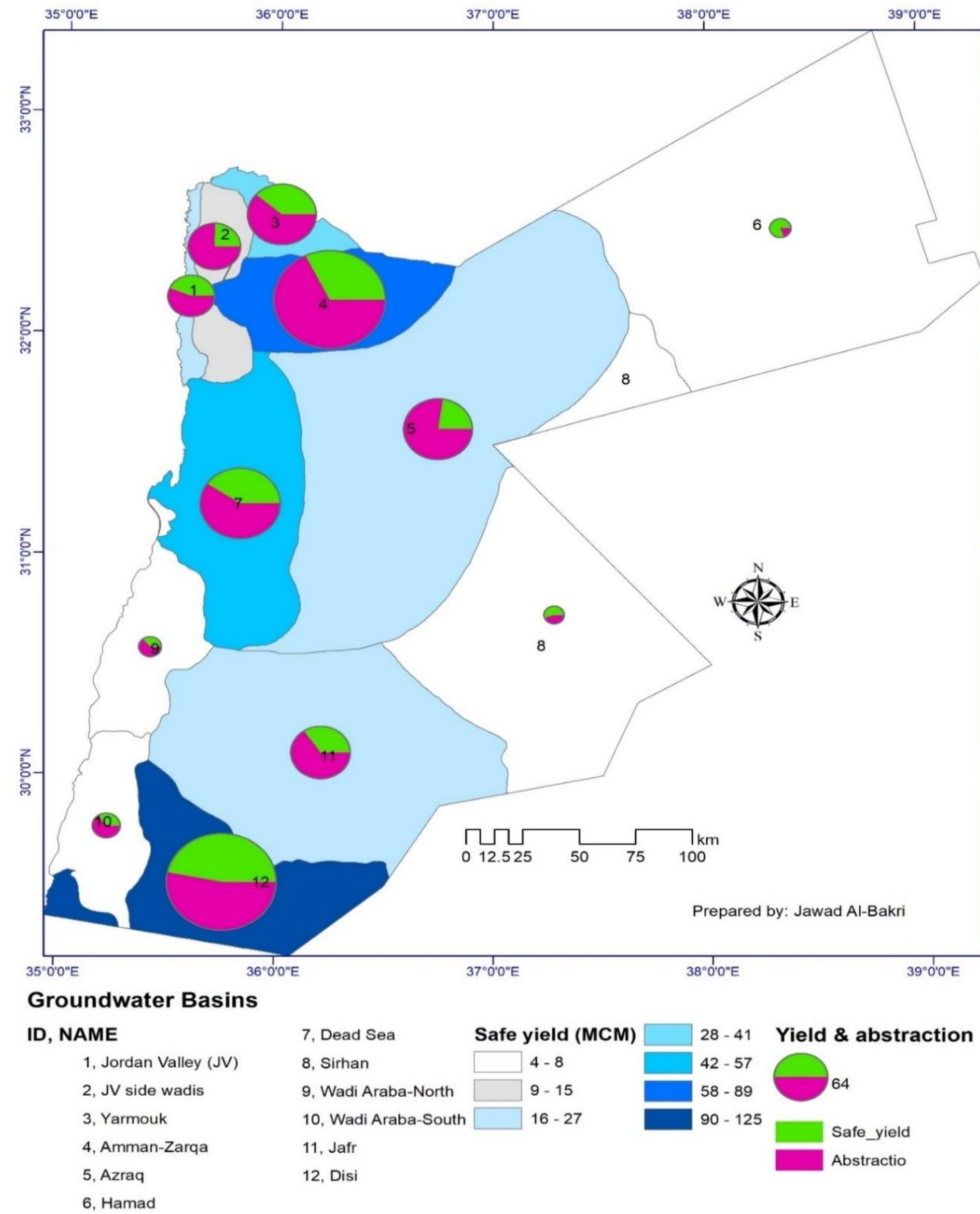

Figure 1.11: Groundwater basins in Jordan and their water balances in 2017 (Sources of data: MWI 2018[42], Al-Bakri 2021[43]).

[42] MWI (Ministry of Water and Irrigation, Jordan), 2018. Annual Water Budget of 2017, MWI, Amman, Jordan

[43] Al-Bakri J.T. 2021. Assessment of Ground Water Abstraction in Jordan during Years 2017, 2018 and 2019. A report for GIZ Water Program project "Management of Water Resources (MWR)", GIZ, Amman, Jordan

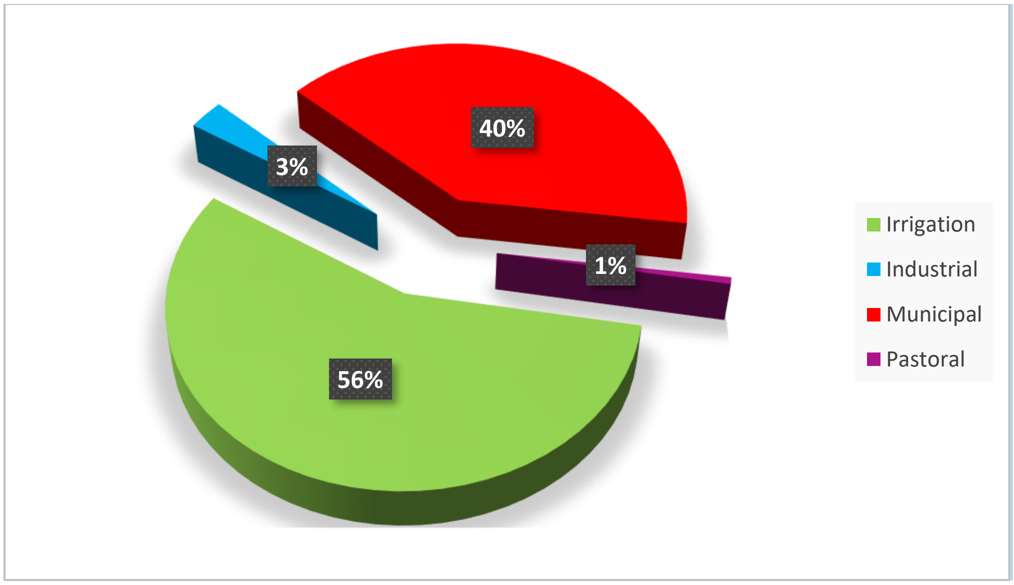

Figure 1.12: Water consumption, by sector, in 2017.

1.8.3 Water Deficit in 2017

Estimation of water deficit for domestic water demand was based on the gap between consumed water and the daily per capita needs that would ensure low levels of health risks (as defined by WHO), i.e., 100 liters per capita per day (lpcd). Since the total population of Jordan was 10.05 million in 2017, then the total annual domestic water needs would be 367 MCM. The average domestic water losses were 48% (MWI 2017), which means that the total domestic demand would actually be 705 MCM. The total domestic water delivered was 470 MCM, therefore, there was a deficit in domestic water estimated as 235 MCM. The deficit in irrigation water was in the Jordan Valley and reached 30 MCM. In total, the water deficit in 2017 reached 265 MCM. Considering that 113 and 44 MCM were coming from non-renewable resources for domestic and irrigation use, respectively, then the overall deficit for 2017 reached 422 MCM.

1.9 Energy Sector Profile

Energy poses great challenges to Jordan due to its lack of indigenous energy resources and its dependence on imports, while it needs relatively large amounts of energy for sustainable development. Jordan currently imports about 90% of its energy mix, including crude oil, oil derivatives, and natural gas. Local sources, including renewable energy, do not contribute more than 10% of these needs. The cost of imported energy, as it was in 2020, is about 15% of GDP.

The total primary energy consumed in Jordan in 2020 amounted to about 8.4 million tons of oil equivalent, of which crude oil and oil derivatives constituted 50%, while natural gas comprised 38%, renewable energy 11%, imported electricity 1%, and coal and lignite coke 2%. The per capita primary energy consumption reached 810 kgoe.

Development of the energy policies and legislation is being made continuously to update and develop the sector-related strategies; the most recent was the Energy Sector. The Energy Strategy for Jordan (2015-2025) was approved in December 2015. In 2020, the Ministry of Energy and Mineral Resources issued a new energy strategy for 2020-2030. It was approved by the Ministerial Council in March 2020, together with a framework for the implementation plan. The new strategy aims to increase the contribution of the local resources in the energy mix and decrease the heavy burden of the energy cost on the national economy and study the impacts of the renewable energy projects on the electricity generation system.

Over the past few years, all the adopted energy strategies aimed to substantially achieve energy security by diversifying energy sources and forms imported, developing and utilizing traditional and renewable local energy sources. Furthermore, it adopted liberalizing energy markets policy, including oil products markets, encouraging private investment in energy infrastructure projects, promoting regional connectivity projects by maximizing their values, and improving energy efficiency in all sectors to ensure integrative policies implemented within specific programs and mechanisms.

1.9.1 Electricity Profile

The Jordanian electrical system has been frequently strengthened and developed to face the electric demands and accommodate the new traditional and renewable power plants. The installed generation capacity in the electricity sector is currently 5425 MW, out of which 1425 MW renewables are connected to the transmission grid, forming what accounts for 16% of the total electric power generated (excluding the 720 MW of renewable energy projects connected to the distribution networks) and what accounts to 20% of the total power generated in the Jordanian electric grid, both transmission and distribution networks. Work is being done to secure the additional generation capacities required, to be added to the electrical system, through the expansion of electric power generation, based on private generation projects owned, financed, and managed by the private sector.

The national electrical network for transmission and distribution has expanded to include all governorates of the Kingdom and has reached most rural communities, including those in remote areas. The percentage of the population with electricity in 2020 was about 99.9%, which is similar to percentages found in developed countries. The electricity consumption per capita accounted for 1905 KWh in 2020. It is noted that during the past five years, the annual growth rate in demand for electricity in Jordan, reached about 5.7%, comprising about 8.3% for the domestic sector, and 2.5% for the industrial sector. The annual rates of demand for Primary energy, amounted to 3% for the same period, including 9% for the transport sector. This indicates that the increase in demand for energy and electricity was not concentrated in the sectors that contribute most to economic growth, such as the industrial sector.

The construction of the Green Corridor Project is one of the most important achievements, which increased the capacity of the electricity transmission from the south to the center of the Kingdom from 500 MW to 1400 MW. Jordan's electrical connection with the neighboring countries has also been under development. The exchange of electricity with Egypt continued, which led to the stability of Jordan's electricity. The agreement to export electricity to the Jericho region in Palestine has been renewed and the agreement to export electricity to Lebanon has been signed. Moreover, the Jordanian–Iraq interconnection will be executed to supply Iraq with 150 MW. In a similar context, a memorandum of understanding has been entered into between the governments of the Hashemite Kingdom of Jordan and the Kingdom of Saudi Arabia to proceed towards the countries' electrical interconnection.

1.9.2 Renewable Energy & Energy Efficiency Profile

The Ministry of Energy and Mineral Resources has succeeded in building a legislative and procedural base in renewable energy, which led to a significant increase in the participation of renewable energy in the energy mix, whether by signing many energy purchase agreements needed by introducing Direct Proposals Schemes or by using solar energy to cover consumption of different sectors, using net metering and wheeling systems. This has led to a significant rise in the contribution of renewable energy (solar and wind) in the electricity generation mix to about 1425 MW by the end of 2020, reaching 20 % of the total electric power generated. This has created good economic mobility in the local investment sector, especially where projects are located, by creating hundreds of direct and indirect jobs and revitalizing support work by other sectors.

Concerning energy efficiency. The energy intensity in 2020 accounted for 245 kgoe/1000 US$ at constant price, which is considered to be a high value compared with other economically developed countries, which means that many actions could be implemented to increase the energy efficiency. One of these was the establishment of the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) under the Renewable Energy & Energy Efficiency Law, Law N. (13) of 2012. Where the Ministry of Energy and the private sector have succeeded in major investment projects, JREEEF has succeeded in covering the other side, i.e., small-scale projects for various sectors, which constituted an overall integrated effort in the sector, including measures to improve energy efficiency, in addition to small-scale interventions implementing renewable energy. The Ministry's project, funded by Rural Files completed the Ministry's efforts to enhance the use of renewable energy and reduce the cost of electricity for impoverished families, by providing solar systems with 2 kW installed capacity per household, under specific conditions set for this purpose.

In April 2018, the government approved The National Energy Efficiency Action Plan (NEEAP) (2018-2020), which the Ministry is implementing together with partners as an important strategic step that includes the implementation of parallel sector plans in line with renewable energy plans, including public and private institutions. The scheme aims to boost energy efficiency to achieve a 20% reduction of energy consumption by 2020 compared to the average energy consumption during 2006-2010, mitigating greenhouse gas emissions in line with the global GHG emissions reduction.

1.9.3 Natural Gas Profile

Since the commercial operation of Sheikh Sabah LNG terminal in Aqaba in July 2015, the LNG import project has contributed to achieving the strategic goal of increasing the contribution of natural gas to the overall energy mix, by securing an additional source of natural gas supply for Jordan. The terminal has secured the power system with its total need for electricity, since reaching about 88% by the end of 2018. The flow of Egyptian natural gas imports to Jordan has been resumed, since September 2018, to provide additional natural gas supply resources under agreements and MOUs by both countries. Noble Energy has signed a gas sales and purchase agreement (GSPA) with the National Electric Power Company (NEPCO) to supply Jordan with 215 MMSCF/d) of natural gas over a 15-year term starting from the commercial supply date, set at the beginning of 2020.

An essential step for expanding the base of natural gas use in national industries was made to identify the regulatory, contractual, and technical requirements to supply industries with natural gas. Exertive efforts were made to encourage industries to switch to natural gas instead of using more-expensive fuels in a step from the government to increase the competitiveness of industries and reduce production costs.

The equipment associated with the extension of natural gas lines to the factory door was granted exemptions through the Investment Law No. (30) of 2014, and the special tax imposed on natural gas for industries was reduced from 16% to 7%, in addition to an exemption from the special tax for the first three years after introducing the use of natural gas.

1.9.4 Oil Sector Profile

As part of the Ministry of Energy's efforts to increase the security of energy supply, the Jordan Oil Terminals Company (JOTC), a government-owned company, was established in 2015 to manage and operate the oil storage and logistics services across Jordan. A project was carried out to build strategic storage capacities of 440,000 cubic meters (250-300 thousand tons of oil products and 8,000 tonnes of LPG) in the center of the Kingdom. Three LPG tanks with a capacity of 11 thousand cubic meters (6000 tonnes) were added, along with six reservoirs of crude oil and oil products storage in Aqaba, with a total capacity of 120,000 cubic meters (100,000 tonnes), and the construction of three spherical LPG storage tanks, with a total capacity of 11,000 cubic meters (6000 tonnes). Since 2013, three companies have been licensed to market oil products, which strengthened energy supply security. They have developed the oil products distribution market and improved services to consumers. Companies started importing part of the Kingdom's diesel needs by mid-2016 and gasoline-95 by the end of 2016. Marketing companies were able to import all their needs for oil products starting May 2018. In terms of oil refining, the Jordan Petroleum Refinery Company is currently working on the Fourth Expansion Project, which aims mainly to increase the refining capacity of the Jordan Petroleum Refinery Company up to (120) thousand barrels per day (bpd), convert heavy products (fuel oil) into viable light products (gasoline and diesel) and improve the specifications of the oil products produced in the refinery to meet Jordanian and international specifications. It is planned to complete the expansion in 2023.

1.9.5 Oil & Gas Exploration Profile

The National Petroleum Company (NPC) has increased natural gas production from the Risha gas field by expanding exploration operations in its concession area. An ambitious action plan adopted in 2019 enabled The National Petroleum Company (NPC) to increase the rates of natural gas production to 16 (MMSCF/d) by mid-2019 compared to about 9 (MMSCF/d) in 2018. The Ministry of Energy and Mineral Resources is focusing on developing Hamza oil field production and technical maintenance of existing wells.

1.9.6 Oil Shale Profile

Globally, the mature technology from an economic point of view to utilize the oil shale is the direct burning of oil shale for electricity generation. The first electric power plant with direct oil shale burning is being implemented with a generating capacity of 470 MW and an investment cost of 2.2 billion US $. The first unit with a capacity of 235 MW will be put in operation in the first quarter of 2022, while the second unit with the same capacity will be put in operation in the second quarter.

Concerning the oil shale mining technologies of surface retorting or thermal injections for Oil production, all the companies working in this field failed to fulfill the agreed obligations in the production schedule due to change in economic feasibility.

1.9.7 Challenges of the Energy Sector

Despite the achievements made by the energy sector over the past few years, the sector has faced and is facing various challenges, the most important of which can be summarized as follows:

1.9.7.1 Electricity Challenges

Jordan's electricity sector has been characterized over the past few decades by the stability of its technical performance. Jordan power system is one of the best electrical systems in the region and operates within the best technical standards, but in the past few years the sector is facing significant financial challenges, most notably the financial challenge faced by the National Electricity Power Company, concerning in excess of (5) billion Jordan dinars of accumulated debts, due to Egyptian gas interruption during (2011-2015) resulting in the necessity of using other types of fuel (at a time of high oil prices, which was not transferred to the consumers. The recent drop in electricity demand due to consumer-owned renewable energy projects, the expansion of energy efficiency devices, and the slowdown in economic growth have decelerated the growth of electricity loads as expected. The rise in fuel prices has led to an increase in electricity tariffs in most consumer categories, especially the productive sectors, resulting in large consumers exiting the grid and a dramatic decline in electricity tariff revenues.

The significant increase in the contribution of renewable energy sources to the electric power mix in a relatively short time has also created several technical and financial challenges. The most important of which is the difficulty of operating the power system in line with the optimal economic and technological model, the exhaustion of the available capacities in transmission and distribution networks, and the rise in electricity loss in distribution networks (non-technical loss constitutes a large ratio).

1.9.7.2 Improve the Use of Energy Efficiency Challenges

The lack of sufficient awareness among consumers of the means available to improve energy efficiency and its financial returns is one of the major challenges. However, the demand is still below the expected rates, despite numerous incentives for various sectors to implement and improve energy efficiency measures. In addition, there is no inclusive vision for integrative planning between all sectors to improve energy efficiency, such as the lack of public transport required to encourage citizens to use sustainable transport instead of individual modes of transportation, alongside the high loss in the transport networks and circulation of water systems, which consumes approximately 15% of the total electricity consumed in Jordan.

1.9.7.3 Oil & Natural Gas Challenges

Jordan is highly dependent on imports to cover its needs of primary energy sources such as oil and gas. Regional events have contributed recently to creating disruptions, causing high prices. The sector faced two tough and terrible experiences in power supply; the first was Jordan ceasing to import Iraqi oil at preferential prices post 2003, the other the fluctuation and interruption of the Egyptian natural gas supply during 2011-2018.

1.9.7.4 Exploration of Oil & Natural Gas Challenges

The exploration for oil and gas in Jordan is not well on track, mainly due to the lack of sufficient allocated money in the government budgets, needed to facilitate exploring promising oil and gas fields. In addition, the preliminary seismic studies and surveys on open oil and gas exploration areas made it challenging to attract investment, due to the scarcity of financial allocations.

1.9.7.5 Utilization of Oil Shale Challenges

The most important challenges facing investment in oil shale retorting can be summarized as: the high cost of shale oil production compared to the conventional oil prices, the difficulty of securing the sizeable financial investment for the retorting projects, and the technical difficulties facing the retorting projects due to the dependence of the retorting technologies on the quality of the oil shale. The main challenge facing the oil shale direct-burning power projects is the high cost of electricity generation from oil shale compared to other generation methods.

1.10 Transport Sector Profile

At the national level, when looking at the transport sector in Jordan from an environmental point of view, the land transport sector for passengers and goods is the most important, and air transport and maritime transport play only a marginal role. There are a limited number of domestic flights between Amman (Queen Alia International Airport) and Aqaba (King Hussein International Airport). There are no internal sea transport services in Jordan. In the land transport sector, the use of private cars, in general, dominates the transport of passengers, and the use of trucks is predominant in transporting goods (vehicles transporting light and heavy goods).

The main reason for this is the state of Jordan's public transportation, which is recognized to be inefficient, and disorderly. This is obvious from the poor quality of public transport services, the insufficient geographical coverage and the insufficient service frequencies on many lines, the lack of clear information about the routes covered, their timetables and the passenger fares, the small number of bus stops, and the poor maintenance and cleanliness of vehicles.

Public transport is a real challenge to empowering women in various fields. One of the main reasons for women's reluctance to participate in the economic process is the problem of public transportation and their access to their workplaces. According to a study conducted by the "Sadaqa" Foundation, 47% of the respondents said that they had refused job opportunities because of the current state of transportation services.

1.10.1 The Mode Choices of Transportation

The transportation sector, on average, contributes some 10% to Jordan's GDP, as indicated in the Jordan Vision 2025. Currently, many authorities are concerned with organizing transport matters according to the geographical area covered by public transport. The Land Transport Authority is responsible for public transport between governorates, including services between Amman and other governorates. However, the responsibility for public transportation and its facilities, within the capital have been under the responsibility of Greater Amman Municipality since 2007. In Aqaba in the south, the Department of Transport is under the responsibility of the Aqaba Special Economic Zone Authority. The first quarterly report of the performance indicators of the public sector transport in Jordan in 2021 stated that there are 32,925 vehicles under the responsibility of the Land Transport Regulatory Committee, including 5,386 yellow taxis.

The transportation modes consist of the two main categories, Private cars and public transport (PT), which comprises large buses, minibuses, taxis, and shared taxis (running on fixed routes).

For the reasons mentioned above, the majority of trips are made by private car. Therefore, Jordan has witnessed a high growth rate in personal vehicles, approximately 5% on average per year, which exceeded the population growth rate. There is a modest growth rate in the numbers of hybrid and electric cars. However, their popularity is strongly dependent on government policies which until now have not been consistent. In 2020 hybrid and electric cars still made up less than 25% of the private vehicles in Jordan as illustrated in the **Table 1.13** below.

Table 1.13: Number of vehicles, according to the source of energy, for 2020 (source: Driving and Vehicles Licensing Department),

	Gasoline	Hybrid	Electric	Total
No. of Vehicles	**996600**	**261200**	**28500**	**1286300**
Percentage %	**77.4**	**20.4**	**2.2**	**100**

The transportation sector (PT) has a low share of trips primarily because it is typically perceived as a last resort for transportation. Additionally, a considerable number of existing public transport routes are deemed unnecessary and streamlining them could improve the sector's efficiency by cutting the current 1,650 to a quarter of this number. Since the sector is composed of numerous individual operators, who own over 85% of the public transport fleet, managing and enhancing the performance of public transport belonging to such a vast number of owners poses a significant challenge.

There is an even lower share of trips carried out using regular taxis, although these are not available outside of main centers. Innovation is the use of ride-hailing apps. Several companies, notably Uber and Careem, have become very popular. Currently, about 15000 vehicles in Jordan are licensed for use with ride-hailing apps, which have the advantage of not taking up space for parking.

Concerning the freight sector, Jordan is strategically located. It is attractive to investors interested in shipping their goods across the Kingdom to different destinations at a lower cost, in light of the remarkable rise in shipping prices globally. Twenty-two thousand trucks are currently working within the Jordanian territories and cross-border with around 30 million tonnes of goods transported in 2018. Besides these, other modes are used for import and export such as planes and ships and pipelines.

In the year 2020, the transport sector consumed around 47% of the total final energy demand. It is worth mentioning that currently, the energy intensity in the transport sector is too high, which is equal to 0.06 Kgoe/Km per person. And 0.03 Kgoe/tonne/ km. Also, the specific load for vehicles, which is 1.3 passenger/vehicle, is low due to the lack of a modern public transport system. The improvement measures which could be taken to treat the challenges affecting public transportation remain institutional. The introduction of modern modes like Bus Rapid Transit operated in 2021 and increasing the penetration of hybrid and electric cars, will surely improve the value of the aforementioned indicators and decrease the energy consumption in the transport sector.

1.11 The Industrial Profile

The industrial sector in Jordan is considered to be the most economically important sector in terms of value-added to the national economy, use of labor, linkages to other sectors, and technical competence. The Jordanian industrial sector consists mainly of the "manufacturing industries" and the "extractive industries" sectors. These activities are linked backward and forward with transportation, insurance, agriculture, and trade sectors. The industrial sector is a high contributor to Jordan's GDP as it constitutes about 25% in 2020, employing more than 240,000 people, most of them Jordanians, in some 18,000 industrial facilities across the Kingdom.

Concerning our concerns in this report, the extraction sector is the most detrimental in terms of the environment and is responsible for emitting the most greenhouse gases, compared to the manufacturing industry. Therefore, attention will be focused on the extraction.

1.11.1 Extraction Sector

The Jordanian Mining Sector is based on the exploitation of many non-metallic mineral resources (minerals and industrial rocks) such as Phosphates, Potash, Basalt, Glass Sand and Limestone, etc., and on mining, manufacturing industries based on these mineral resources such as Fertilizers, Acids and Cement industries. Mining and extraction are considered the key strategic industries in Jordan, constituting 9% of the Gross National Product in 2020. The revenues were distributed between the Extractive Mining Industries (72%) and the mining manufacturing industries (28%) of the mining sector. The mining sector exports, both Extractive and Manufacturing, contributes heavily to employing Jordanians and other nationalities. In addition, extraction is considered one of the country's major exports, forming 19.7% of the total national exports and catering to the local market's raw materials needs. Jordan is considered a significant supplier of bromine, phosphate rock, phosphate-based fertilizers, and potash to the world. It is among the world's top 10 producers of bromine, phosphate rock, and potash. It also produces modest quantities of calcium carbonate, cement, clay, iron and steel, kaolin, limestone, natural gas, pozzolanic materials, refined petroleum products, silica sand, and zeolites, mainly for domestic use. Moreover, Jordan offers an attractive proposition for investors in the extraction and processing of copper, uranium, and oil shale. **Table 1.14** and **Table 1.15** show the total production from the mineral extraction and mining manufacturing industry in terms of thousand tonnes for 2018.

Table 1.14: Total production from the mineral extraction industry in terms of thousand tonnes for 2018.

Mineral Extraction Production (1000 tons)	2018
Phosphate	**7985**
potash	**2336**
Bromine	**89**
Quarries and mines	**9965**
Silica Sand	**137**
Salt	**49**

Table 1.15: Total production from the mining manufacturing industry in terms of thousand tonnes for 2018.

Mining Manufacturing Industry Production (1000 tonnes)	2018
Fertilizers and Chemical Acids	**882**
Ordinary Cement	**3600**
White Cement	**33**

1.11.2 Manufacturing Industries

The manufacturing sector has a wide range of activities. The national classification of industrial sectors has been determined by a decree issued by the Jordan Cabinet on August 13, 2005, to cover all industrial enterprises operating in one activity or more of industry. Thus, the industrial activities are grouped according to the following ten sectors; (1) Leather and Garments Sector; (2) Therapeutics and Medical Sector; (3) Chemical and Cosmetics Sector; (4) Plastic and Rubber Sector; (5) Engineering, Electrical Industries, and Information Technology Sector; (6) Furniture and Wooden Sector; (7) Construction Sector; (8) Food, Supplies, Agricultural and Livestock Sector; (9) Packing, Packaging, Paper, Carton, and Stationeries Sector; and (10) Mining Sector.

It is evident that the industries listed have varying degrees of production output, and there appears to be no connection between them. Our main focus is to evaluate the environmental impact resulting from their production processes. Although some of these industries may be more substantial than others in Jordan, we will still consider and calculate their environmental impact, which we acknowledge is relatively minor.

1.12 Solid Waste and Waste Water Profile

1.12.1 Solid Waste Profile

In 2018, Jordan generated 3.7 million tonnes of solid waste, growing annually by 5%, of which only 7% to 10% is recycled or salvaged mainly by the informal sector. 0.9 kg of waste is produced per capita per day.

According to the National Solid Waste strategy, formalizing the informal waste recycling and materials recovery sector has become an economic opportunity to sustain landfill infrastructure, improve the livelihood of many poor, marginalized Jordanians and offer decent jobs for Syrian refugees and host communities.

The Government of Jordan has launched a National Green Growth Plan to facilitate the transition towards green growth in six priority sectors; from which the solid waste management sector is one of the sectors[44]. Jordan Vision 2025 has set a 33% reduction target in the solid waste amounts disposed of in landfills or dumpsites by 2025.

Currently, there is 18 recorded landfills in the country, most of which are not adequately designed or operated, demonstrated by their lack of proper link, leachate collecting system, and landfill gas management system. The only sanitary landfill is the Al-Ghabawi landfill, which receives 50% of the waste produced in the country—located 40 km to the east of Amman,

Al Ghabawi is sufficient to dispose of waste until 2035, using safe refuse-tipping technology. The landfill is the first of its kind in Jordan as it is designed with gas collection systems with financial assistance from the World Bank. The project is a potential for electricity generated from landfill gas to be delivered to the national grid, displacing electricity produced by grid-connected power plants that traditionally use heavy fuel oil.

In 1989, the Government of Jordan designated the Swaqa landfill, 125 km to the southeast of Amman, to process hazardous waste. The landfill is overseen and operated by the Ministry of Environment, which has also established a center at the landfill to supervise the safe disposal of electric and electronic waste.

The average daily municipal waste in Jordan is about 3700 tonnes/day. Most of this SW ends up in any of Jordan's 24 dump sites. Seven sites (in the northern parts of Jordan) receive a daily average of about 680 tonnes of SW. In the central and southern parts of Jordan, the daily average

[44] jor201802E.pdf (fao.org)

of SW received is 2620 and 400 tonnes, respectively. These quantities are transported to any one of 17 dump sites in the central part of Jordan.

In collaboration with UNDP, GEF, and the Danish Government, the Government of Jordan established a 1MW Biomethanation plant at Rusaifeh landfill near Amman in 1999. Since its commissioning, the plant has been successfully operating, and efforts are underway to increase its capacity to 5MW. The project consists of twelve landfill gas wells and an anaerobic digestion plant based on 60 tonnes per day of organic wastes from hotels, restaurants, and slaughterhouses in Amman.

It is also important to note that Bio-waste (organic waste) dominates MSW; approximately 60% are food waste, 14% paper, and cardboard, 10% plastic. Therefore, MSW contains sufficient putrescible material which emits LFG (methane and CO_2).

1.12.2 Wastewater Profile

Jordan has very limited renewable water resources of only 100 cubic meters per capita per year, which is basically at the survival level and it is considered to be one of the most water-scarce countries in the world. Therefore, reclaimed water has been evaluated at the highest level of Jordan Government, that it has a full value to the overall water resources of the country, as stated in Jordan's water Strategy 2008- 2022, (Wastewater shall not be managed as waste; it shall be collected and treated to standards that allow its use in unrestricted agriculture and other non-domestic purposes, including ground water recharge).

Over 70% of the Jordanian population is connected to the sewerage system and raw wastewater is discharged to 34 wastewater treatment plants (WWTP). The most widely used technologies are the activated sludge process, with a share of 60%, followed by the wastewater stabilization pond process with a share of 20%, while the trickling filter, membrane bioreactor, and oxidation sludge process each have the same percentage of 6%, respectively. As Samra Wastewater Treatment Plant is a super–large scale, it receives more than 70% of the country's total generated wastewater, reaching 180 million cubic meters in 2020. According to the Ministry of Water and Irrigation, the ratio of industrial to total water use in 2018 was small, around 5%. According to the law, all industries treat their wastewater before discharge into receiving water bodies. Several industrial entities divert their wastewater to public sewer systems according to Water Authority regulations.

1.13 Health Profile

Jordan has advanced health care infrastructure, 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. Figure 1.13 shows the health sector structure in Jordan.

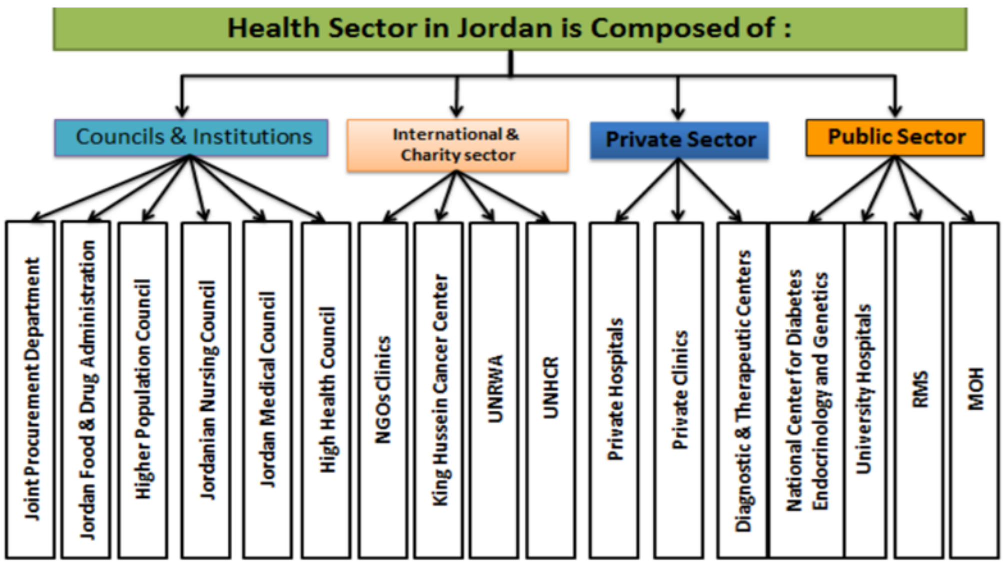

Figure 1.13: The Components of the Health Sector in Jordan

The (MoH) manages the Civil Insurance Program that is the main health insurance program for civil servants. The Royal Medical Services (RMS) manages the Military Insurance Fund that covers health care for military staff and other people including high-ranking officials. Services from the public health sector are complemented by the private sector, which includes both private for-profit and not-for-profit (NGOs) mostly working in peripheral areas. Moreover, the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) also provides health care services throughout Jordan[45].

Jordan's MoH service delivery is established at three levels: primary, secondary, and tertiary. According to the 2020 MoH Annual Statistics Report, there were 117 hospitals with a total of 14,378 beds. About a third of all hospital beds (5415) were in the private sector. There were 14 beds per 10 000 population in Jordan in 2020. However, the distribution of hospital beds is not

[45] The National Strategy for Health Sector in Jordan 2016-2020 by the High Health Council

equitable with a rate of as high as 18 beds per 10 000 population in Amman and as low as 5 beds per 10 000 population in Mafraq governorate.

MoH statistics for 2020 show that there were a total of 1182 (PHCs) distributed as follows: 117 comprehensive health centers, 372 primary health centers, 188 secondary health centers (hospitals), and 505 maternal and child health centers. The PHC centers include comprehensive health centers, regular health centers, peripheral health centers and 505 maternal and child health centers. In addition, there are over 431 dental clinics under the MoH. Primary health care (PHC) is the main vehicle through which health care programs are implemented in Jordan[46]. Table 1.16 summarizes the Jordan demographic and health status for the years from 2016 till 2020 and describes the hospital utilization and the Ministry of Health Centers.

Table 1.16: Health Status in Jordan during the period from 2016 to 2020[47]

Country Demographic and Health Data	2016	2017	2018	2019	2020
Population (100 pop.)	9795	10053	10309	10554	10506
Adult Male Illiteracy Rate (% of 15+Yrs of age)	3	2.9	3.1	3	3
Adult Female Illiteracy Rate (% of 15+Yrs of age)	4	7.5	7.2	7.3	7.3
Crude Birth Rate (per 1000 pop.)	23	23.3	22.3	20.6	20.6
Population Growth Rate (%)	2.4	2.6	2.4	2.3	2.3
Average Persons per Family	4.8	4.8	4.8	4.8	4.8
Total Fertility Rate	3.4	3.4	2.7	2.7	2.7
Life Expectancy at Birth (Yrs) Male	72.5	72.8	72.8	72.3	72.3
Life Expectancy at Birth (Yrs) Female	74.0	74.2	74.2	75.1	75.1
Crude Death Rate (per 1000 pop.)	6.1	6.0	6*	6*	6*
Infant Mortality Rate (per 1000 live births)	17.0	17.0	17*	17*	17*
Maternal Mortality Rate (per 10.000 live births)	19.0	19.0	19.0	29.8**	29.8**
Dependency Ratio (%)	61.4	61.4	61.4*	61.4*	61.4*
Unemployment Rate (%)	13	15.3	18.6	19.1	24.7
Physician / 10000 pop.	26.0	22.6	23.0	27.0	27.8
Dentist / 10000 pop.	7.1	7.1	7.2	7.3	7.7
Nurse (All Categories) / 10000 pop.	26.4	29.2	32.4	29.6	35.8
Pharmacist / 10000 pop.	15.5	15.6	13.1	11.9	13.7
Hospital Number	110	116	116	116	117
Hospital Beds	13731	14779	14741	14081	15003
_Ministry of Health	5177	5170	5208	5231	5251
_Royal Medical Services	2917	3476	3316	3091	3154
_Jordan University Hospital	599	599	599	612	625
_King Abdullah University Hospital	542	542	541	544	558
_Private Sector	4496	4992	5077	5315	5415
Hospital Beds / 10000 pop.	14	15	14	14	14
Admission per 1000 pop.	99	98	97	93	75
Average Occupancy Rate (%)	60.4	56.7	59.5	61.8	52.6
Average Length of stay (days)	3.0	3.0	2.9	2.1	2.2
Average Death Rate (%)	1.7	1.7	1.7	1.1	2.5

[46] https://moh.gov.jo/EN/List/
[47] Ministry of Health Annual Statistical Reports

Comprehensive Health Centers	102	110	111	112	117
Primary Health Centers	380	376	376	377	372
Peripheral Health Centers	194	187	181	187	188
MCH Centers	464	504	506	506	505
Chest Disease Centers	12	12	12	12	12
Dental Clinic	504	26	420	429	431
MOH Budget as (%) of Total Governmental Budget	7.7	6.6	6.6	7.0	6.4
Per Capital of GDP (JD)	2801.0	2829.8	2908.5		

* This indicator needs to be confirmed though verbal autopsy.

** based on 2017

Health needs of the national population are increasing with population growth, changing of population demographics and epidemiological transition of disease. Determinants of poor health such as tobacco use, obesity, and other unhealthy behaviors are becoming increasingly prevalent in Jordan and are contributing to the increased incidence of Non-Communicable Diseases (NCDs). Around one third of the Jordanian population does not have any kind of health insurance. Also, increasing healthcare costs of both services and supplies raises issues on sustainable financing mechanisms for this sustained demand. Furthermore, the continuation of the Syrian crisis for many years and the evolving humanitarian context poses new demands on the health system in Jordan. Syrian refugees' health needs in Jordan continue to place additional pressure on the national health system and its ability to respond. This is aggravated by the increased prevalence of NCDs among refugees. Women and children, disabled, war-wounded, patients suffering from mental health conditions and older refugees needs also present significant challenges. These vulnerable groups require a wide range of costly health services for a long period of time. Additionally, significant vulnerabilities still exist for maternal and child nutrition in Jordan, and low tetanus toxoid vaccination coverage among women of reproductive age group (TT1 65% overall and TT2 coverage 20%) poses serious public health risks and concerns regarding protection of women and their newborn infants from tetanus[48].

Vulnerability and Adaptation to Climate Change constitute 48% of the total healthcare expenditures. Health spending in Jordan is high compared to other countries in the Middle East and North Africa Region (MENA). Overall spending has increased 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 populations; 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

[48] JRP 2020-2022

(EIP) was adopted; life span is 80.18 years. Important progress was achieved in lowering the infant mortality from 30 per 1000 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 rate was 63 deaths/100,000 live births (2010)[49].

Although the Government of Jordan is committed to achieve Universal Health Coverage in line with the Sustainable Development Goals 2030 agenda, Jordan is challenged by a fragmented health system that leads to inequity, duplication of services, inadequate participation of the private sector, limited quality improvement, inefficient use of available resources, poor management of human resources for health, and inappropriately governed health information systems[50].

1.13.1 Health information Systems Assessment

Health information systems (HIS), including civil registration and vital statistics (CRVS) systems, are indispensable sources of health information data for programme monitoring, performance monitoring, and quality of care, planning, and policy making. HIS and CRVS systems are the only information sources that provide continuous information on the coverage of services in the health sector. The availability of HIS data at the subnational level provides countries with an opportunity to assess equity in the provision of health services[51].

While HIS data offers many opportunities to assess various aspects of the health system, the data are often not of high quality; this negatively affects the use of a rich source of health sector data. Quality of data may be influenced by a number of factors such as missing values on vital records (e.g., births, deaths), inconsistency in reported information or undercount of selected populations or groups of people. Any health system reform and intervention will need to rely on reliable information or data and be accompanied by a comprehensive monitoring and evaluation plan that relies on a reliable and integrated HIS (i.e., that draws on and links data from various sources such as census, surveys, or other facility-based records). In order for the HIS to support the health system strengthening objectives, it needs to avoid parallel reporting systems where possible, support single reporting channels, and ensure that feedback from data and analysis is communicated effectively. In Jordan, the Directorate of Information and Studies collects routine health information from the MoH facilities and other public and private hospitals. The Directorate of Information and Studies produces the MoH annual report which is considered the main source

[49] https://unfccc.int/resource/docs/natc/jornc3.pdf
[50] UNITED NATIONS SUSTAINABLE DEVELOPMENT FRAMEWORK UN Country Results Report 2019
[51] Health Metrics Network 2008

of information about health services, including human resources. A National Cancer Registry collects and reports morbidity data using International Classification of Diseases (ICD-10) coding.

The Hakeem Program is the result of the first national initiative in Jordan to computerize the public health care sector. The objective of Hakeem, which was launched in October 2009 under the patronage of His Majesty King Abdullah II, is to facilitate efficient, high quality health care in Jordan through nationwide implementation of an electronic health record solution. Using Hakeem, physicians, pharmacists, medical technologists, and other clinicians are able to access electronic medical records of patients within participating health facilities by entering the patient's national ID number. The electronic medical records that can be accessed include comprehensive medical and surgical history, physical examinations, procedural and surgical reports, current medications, and allergies, as well as in-patient and out-patient clinic visit notes. The system also provides online access to laboratory results, digital radiological exams, electrocardiograms, endoscopic biopsies, eye exams, and videos of echocardiograms and angiograms. Hakeem is built on the VistA system, an enterprise-wide information system used in the United States Department of Veterans Affairs medical system; and is implemented in about 100 facilities. The data server is owned by Prince Hamza Hospital and is different from the MoH server; hence there is no linkage between the two systems. The team observed that the system had no reporting mechanisms and uses ICD-9 coding. The system's equipment and infrastructure related to the program are limited to the needs of implementers and are not allowed to be used for other purposes. The National Health Strategy (2015–2019) provides an agenda that makes strengthening of HIS inevitable[52].

The public health surveillance project complements the Ministry of Health's routine paper-based surveillance system and provides an opportunity to monitor the epidemiology of priority public health diseases, conditions and events that would otherwise not be possible through the online routine platform. Routine paper-based surveillance in Ministry of Health facilities faces many challenges, including:

- Existence of alternate data sources
- Inadequate and fragmented national health information system
- Lack of accurate data on health services
- Limited exchange of information between primary care facilities and hospitals
- Lack of adequate integration of the private sector in surveillance activities
- Absence of unique identifiers to link different datasets
- Shortage of qualified personnel in health information management and medical records
- Limited exchange of information between primary care facilities and hospitals
- No data or report sharing with the Ministry of Health.

[52] Comprehensive Assessment of Jordan's Health information system 2016, WHO, Regional Office for the Eastern Mediterranean

1.13.2 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 vary among sub regions. Despite the variations in diversity of 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.

Climate-related hazards in Jordan include droughts, extreme temperature, storms, landslides and flash floods. Other natural hazards include periodic earthquakes and epidemics. While these hazards are a natural occurrence in Jordan, they nevertheless pose serious constraints on development, and their intensity and frequency are likely to increase under a changing climate. Jordan has witnessed several risks during the last decade. Figure 1.14 and Figure 1.15 provide a summary estimate of number of people affected by the key natural hazards in Jordan and the average occurrence of these hazards.

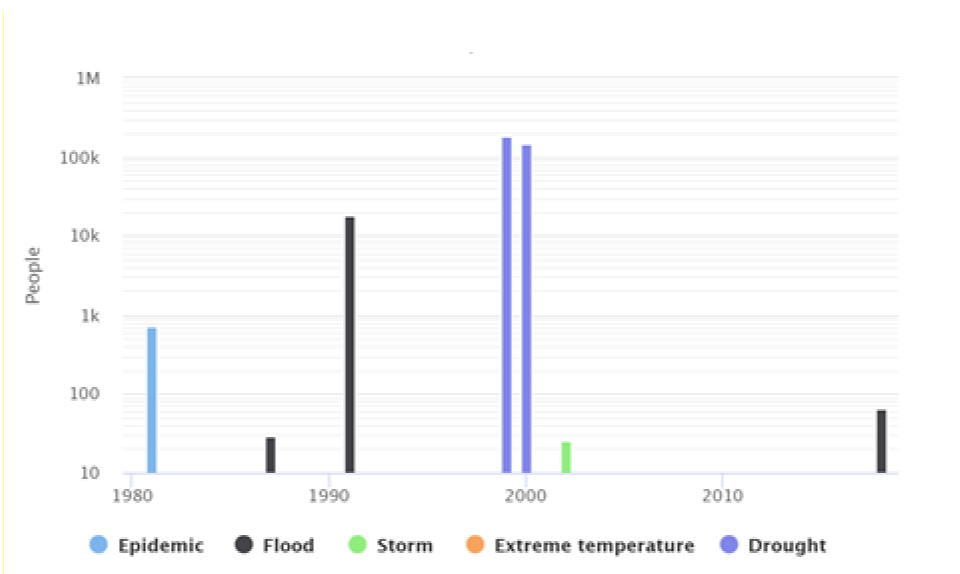

Figure 1.14: Key Natural Hazard Statistics for Jordan from 1980 to 2020[53].

[53] https://climateknowledgeportal.worldbank.org/country/jordan/vulnerability

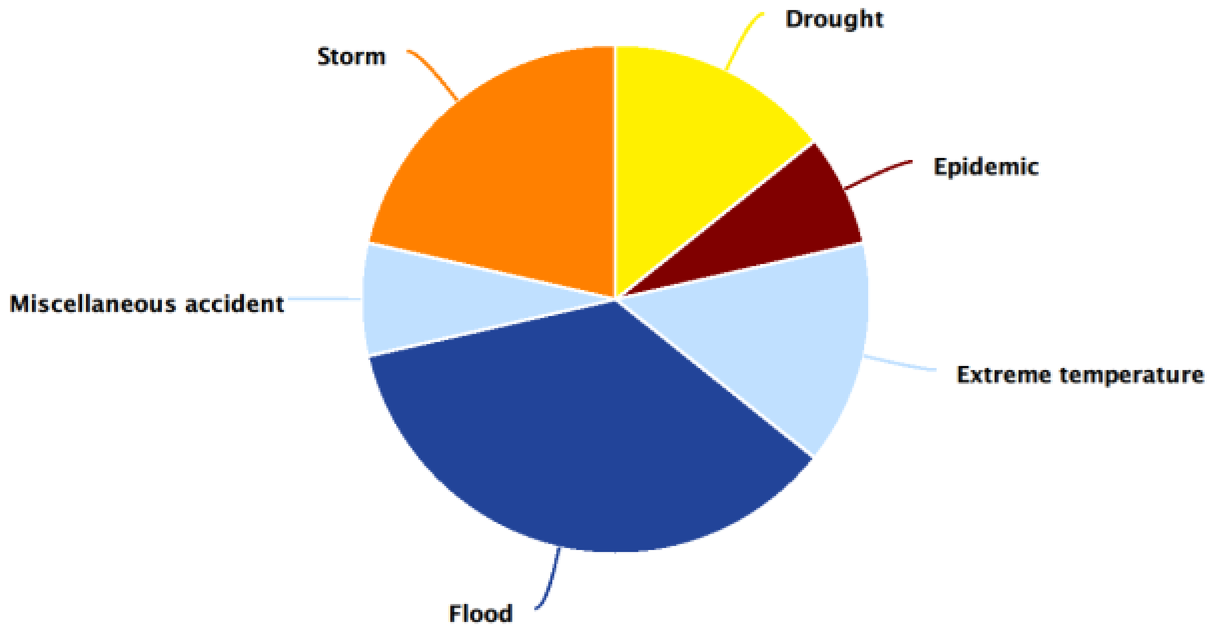

Figure 1.15: Average Annual Natural Hazard Occurrence for Jordan from 1980 to 2020[54].

In the National policy and Jordan's Intended Nationally Determined Contribution, several adaptation options for the health sector were summarized as (1) Strengthen surveillance and establish highly sensitive alert systems by developing a health forecast system for acute respiratory and climate-sensitive diseases; (2) Prevent and control emerging and reemerging vector-borne diseases; (3) Strengthen existing emergency preparedness and disaster management by implementing recognized surveillance monitoring systems; (4) Formulate and implement disaster preparedness policies with adaptive strategies; Enhance capacity building and increase awareness through regular training workshops on hazard preparedness; and (5) Undertake research at the population and individual level to provide a solid basis for formulating adaptation strategies.

In 2012 the Ministry of Health, 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

[54] https://climateknowledgeportal.worldbank.org/country/jordan/vulnerability

that the most visible effect would be on chronic respiratory diseases including bronchial asthma and Chronic Obstructive Pulmonary Disease (COPD).

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 foodborne 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.

Based on TNC report to UNFCCC, Vector Born Diseases (VBD) risk is expected to increase with 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. In addition, access to nutritious food is expected to be reduced; dietary quality and eventually quantity to decline, and micronutrient malnutrition (or hidden hunger) to increase, 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.

1.13.3 Jordan and COVID 19

In addition to the flow of Syrian refugees into Jordan, which continues to place increasing demands on all resources including the health service delivery, the COVID-19 pandemic has caused deep disruptions in the development process in Jordan. The COVID-19 pandemic has had severe negative effects on people, businesses and workers around the world as well as in Jordan. In Jordan, national lockdowns, border closures, and movement restrictions forced enterprises to close or reduce their businesses, i.e., by laying off employees and reducing workers' wages[55]. The import costs of agricultural products increased, causing a restriction of agricultural product exports, and increasing prices of imports especially during the lockdowns (WFP, 2020; UNDP, 2020). Food insecurity increased in Jordan during the COVID-19 pandemic. Food insecurity in December 2020 was 3 percent for Jordanians, while around 53 percent of Jordanians were vulnerable to food insecurity especially in rural areas and among Syrian refugees. With an

[55] wcms_813448.pdf (ilo.org)

economy already in crisis, COVID-19 pushed 17 percent of Jordanians to permanently lose their jobs with unemployment skyrocketing to 26 percent in 2020. This is leading Jordanian households to adopt livelihood-coping strategies to adapt to food insecurity[56].

Jordan has begun its recovery from the shock of COVID-19**,** fully reopening its economy and returning to in-person learning in September 2021 in the wake of an aggressive lockdown at the outset of the pandemic (March 2020–September 2020) and an intensive COVID-19 vaccination campaign. Jordan's economy has weathered the crisis better than many of its peers, contracting by only 1.6% during 2020 and registering modest real GDP growth of 0.3% during Q1-2021. This is in part due to timely fiscal and monetary stimuli by the government, as well as improvement, in terms of trade, caused by the drop in oil prices. Unemployment is on the rise, however, reaching 25% in Q1-2021, with youth unemployment rates reaching an unprecedented 48.1% and women's labor force participation at 14%, one of the lowest in the world. Central government debt rose to almost 106.3% of GDP during November 2020, almost 10 percentage points of GDP higher than at the end of 2019.

The COVID-19 crisis has exacerbated existing structural weaknesses in the country's economy, brought unresolved social challenges to the fore, and put pressure on the country's fragile macroeconomic stance. The immediate and urgent responses by government focused on expanding health services, providing resources for social safety nets, and addressing socio-economic impacts of the pandemic on local businesses. It is essential that any long-term development plan, including National Action Plan (NAP) should take into consideration the short-term impacts of COVID19 on relevant development sectors and introduce measures to enhance long-term resilience for both climate vulnerability and related impacts from COVID19.

Some of the additional factors pose a major challenge for the health system, to meet the growing expectations of the population, including the increased demand for health services due to population growth and epidemiological transition of the diseases in Jordan (which means a lower prevalence of communicable disease, and a high prevalence of non-communicable diseases); and the presence of refugees, in addition to the expected rise in the proportion of young people and the elderly; and rising health care costs, in light of the already constrained economic situation.

Total health expenditure, in both the public and private sector, was estimated at 8.9% of GDP in 2017, with public sector finance having a share of 62.29% of the total healthcare expenditures. The remaining health sectors expenditure distribution is: 33.82% by the private sector, 0.81% by

[56] WFP Jordan Country Brief, January 2021," 2021 WFP, "Jordan Food Security Update: Implications of COVID-19 (July-August 2020)." World Food Program, Amman2020 https://docs.wfp.org/api/documents/WFP-0000122056/download/?_ga=2.5985779.1539456934.1653995455-2121942629.1635334655

UNRWA and 3.09% by non-governmental organizations (NGOs)[57]. Overall spending has increased over the past six years. An extensive network of 1182 PHC facilities has also been formed.

At the level of domestic and international development financing, COVID-19 has caused a diversion of priorities from climate-related development support into more urgent financing for improved health services and supporting social safety nets. The effect is most evident in the national budget, where the public budget for 2021, had a deficit of 1.180 billion JD, accounting for 3.7% of GDP, which is one of the highest in recent years. It is not expected that adequate domestic resources will be available for adaptation related financing, and the gap of financing should be supported through international financing. A key strategy response to these challenges is strengthening the Health Information System (HIS) to enable the generation of timely and reliable evidence for assessing the health situation and trends.

Although the Government of Jordan is committed to achieving Universal Health Coverage, in line with the Sustainable Development Goals 2030 agenda, Jordan is challenged by a fragmented health system that leads to inequity, duplication of services, inadequate participation of the private sector, limited quality improvement, inefficient use of available resources, poor management of human resources for health, and inappropriately governed health information system. The Sustainable Development Report, 2021 contains dashboards and trends progress for Jordan to assess the countries' performance in achieving the goals of the SDGs, and provide a comparison to other countries and regions. Jordan's performance for SDG3 (good health and well-being) is 75%, and it is assessed to be demonstrating moderate improvement to the statistical performance index is rated at 62%. The general ranking for Jordan is 72 out of 165 countries, with a country score of 70.1% compared to the regional score of 67.1%[58].

[57] https://moh.gov.jo/ebv4.0/root_storage/ar/eb_list_page/pdf_%D8%AA%D9%82%D8%B1%D9%8A%D8%B1_2021.pdf
[58] Sustainable Development Report 2021 (sdgindex.org)

1.13.4 Health Response Actions

With WHO support, the Ministry of Health developed many strategic documents including Ministry of Health National Health Strategy (2018–2022), National Action Plan for Combating Antimicrobial Resistance (2018–2022), National Action Plan for Health Security (2018–2022), Comprehensive Multi-Year Plan for Expanded Programme on Immunization (2018–2022), Foodborne Disease Outbreak Manual, National Measles/Rubella Elimination Plan, Emergency Operation Center Operational Draft Plan (2019), Health Information System Strategic Plan (2019–2023), Operational Guidelines for the Implementation of All-Hazards Event-Based Surveillance (December 2019), Contingency Plans for Prioritized Hazards drafted (December 2019), and Emergency Response Plan, Updated Based on Risk Assessment (December 2019)

The GOJ strengthened its capacity, to effectively respond to COVID-19, based on the National Preparedness and Response Plan (NPRP), developed in April 2020[59]. The NPRP aims to prevent, detect, and respond to the COVID-19 outbreak and serves as a practical guide for national authorities and health sector development partners in filling gaps. The GOJ ensures that all COVID-19 interventions are targeted and provided to all Jordanian and non-Jordanian residents, including refugees, registered at the United Nations High Commissioner for Refugees (UNHCR) and the United Nations Relief and Works Agency for Palestinian Refugees in the Near East (UNRWA).

The Jordanian National Committee for Epidemics, a body established in 1984 to research epidemics, spearheaded Jordan's COVID-19 response, assessing the epidemiological situation in the country and recommending policy measures. In addition, the Jordanian government created a Coronavirus Crisis Cell, within the existing structure of the National Center for Security and Crisis Management (NCSCM), an umbrella organization under the Royal Court established in 2015 to coordinate and unify the efforts of national institutions during national crises. The Jordanian military also played an important role in coordinating response measures[60].

The MOH, with support from the WHO, prepared a National Preparedness and Response Plan for COVID-19 (February 2020). The plan aimed to strengthen the GOJ's capacity to prevent, detect and respond to the COVID-19 outbreak, in accordance with IHR technical areas[61]. The COVID-19 Emergency Response Project aims to prevent, detect, and respond to the COVID-19 pandemic and strengthen Jordan's national health system, for public health preparedness. Over the last year, the project renovated four health facilities, fully equipping them with medical equipment and commodities for the management of the COVID-19 pandemic[62].

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[59] MOH (Ministry of Health). 2020.. National COVID-19 Preparedness & Response Plan 2020. Amman, Jordan.
[60] MENA-Covid-19-Survey-Jordan-12-20-.pdf (brookings.edu)
[61] World Bank Document
[62] https://www.worldbank.org/en/country/jordan/overview#3

To address the socioeconomic and health impacts of the pandemic, the government launched two social protection programs in 2020 and 2021, to support vulnerable households and workers, in addition to implementing measures designed to support businesses that were affected by the lockdown, including tax payments, partial payments of salaries, and special loan programs for small- and medium-sized enterprises. The implementation of the public health measures, to limit the spread of the virus, have severely affected the country's economy due to reduced productivity, business closures, trade disruption, decimation of the tourism industry, and disruptions in the transportation, which caused a significant reduction in income and a rise in unemployment.

Jordan's response to containing the spread of the virus was very effective, particularly given the scale and scope of the crisis. The UN issued a framework for the socio-economic response to COVID-19 in Jordan by 2020, which connected urgent health and humanitarian requirements with what needed to be done, to support Jordan in addressing the multiple social and economic challenges including 1) Protecting Health; 2) Protecting People; 3) Economic Recovery; 4) Macro-economics and Multilateral Cooperation; and 5) Social Cohesion and Resilience[63].

A more agile and coordinated response was also facilitated through the planning and close monitoring of the newly formulated Social Protection Response Committee which was set up to manage, organize and monitor the sector's response to COVID-19. The funding of the measures to mitigate the effects of COVID-19 was quickly generated through the establishment of the 'Himmat Watan' Fund. Also, the Jordan's Strategy Forum (JSF), in collaboration with UNICEF, issued the Jordan's National Social Protection Response, during COVID-19, which reviews the government measures taken, as they relate to the three pillars of the National Social Protection Strategy (2019–2025) which are Social Assistance, Social Services and Social Insurance, and also provided lessons learned and recommendations for better shock-responsiveness and an improved response to the COVID-19 pandemic[64].

Jordan still serves as a leading model in responding to the crisis, through its unwavering support and generosity by hosting 1.36 million Syrian refugees and meeting their humanitarian and resilience needs. Jordan Response Plan for the Syria Crisis 2020-2022 was established as a regional and global model in terms of dealing with the Syrian refugee crisis and carrying out a global public good, in the hopes of decreasing the vulnerability of both refugees and host communities and providing longer-term sustainable solutions that will result in tangible effects[65].

[63] JOR_Socioeconomic-Response-Plan_2020.pdf (un.org)
[64] Jordan's National SP Response During COVID- UNICEF JSF.pdf
[65] Jordan Response Plan (jrp.gov.jo)

The Ministry of Health (MoH) has been supported by various international partners in its effort to make the national health system resilient, through the construction and rehabilitation of healthcare facilities and the provision of medical equipment, particularly in host communities in the northern governorates and in Amman. Other ongoing interventions targeting areas with a high concentration of Syrian refugees are: (1) Inclusion of Pneumococcal Conjugate Vaccine (PCV) into national Expanded Program of Immunization (EPI); (2) Strengthening the national screening program for early detection and treatment of Phenylketonuria (PKU); (3) Capacity building of human resources within MoH facilities; (4) Provision of essential drugs, mental health, reproductive health and family planning commodities and critical equipment at public hospitals and health centers; (5) Strengthening of the national NCD control system; and (6) Enhancing absorptive capacities at public facilities, medical warehouses, hospitals and health centers.

The 2018 Vulnerability Assessment Framework (VAF) highlighted that about half of Syrian households have severe or high health vulnerability. Additionally, more than 53% of Syrian spent more than 10% of their expenditure on health items. With regards to the progress towards SDG3 (Good Health Global Index), Jordan scores 76.3%, meaning that the score is moderately increasing but still insufficient to meet the 2030 goal.

The Global Compact on Refugees is a framework for more predictable and equitable responsibility-sharing, recognizing that a sustainable solution to refugee situations cannot be achieved without international cooperation. It provides a blueprint for governments, international organizations, and other stakeholders to ensure that host communities get the support they need and that refugees can lead productive lives. It constitutes a unique opportunity to transform the way the world responds to refugee situations, benefiting both refugees and the communities that host them.

Despite limited financial resources, UN agencies and NGOs have also supported vulnerable Jordanians and Syrian refugees on health-related issues. Interventions are being implemented to ensure that Syrian refugees' health needs are met. Such interventions are oriented at responding to the immediate health needs of Syrians in urban and camp settings and at providing them with access to comprehensive primary and essential secondary and tertiary health services. Specific support is provided to those suffering from war-related injuries as well as acute medical and surgical conditions. Direct and indirect provision of comprehensive emergency obstetric and neonatal services is also provided.

The Government of Jordan has granted access to public health services at subsidized rates for more than 2.2 million Jordanians, without health insurance coverage. Additionally, since March, 2019, Syrian refugees have had access to public health services at the non-insured Jordanian rate (subsidized by 80%). This policy was introduced to improve the level of access to an essential package of health services and, thus, improve refugees' health status while reducing the burden of the crisis on the public health system. The new health policy eliminates substantial access barriers, among vulnerable Syrian Refugees. A recent assessment highlighted that 35% of Syrians are aware of the policy change, while 27% have accessed public health services, since the change of policy. Affording the cost of access to public health, still remains the biggest barrier for among 70% of respondents surveyed[66].

Several projects have been conducted and some have been initiated for supporting the health sector in Jordan. The "Emergency Health Project" is a results-based project that aims to maintain and deliver health care services at the Ministry of Health primary and secondary health care facilities, in addition to improving the efficiency of health services through capacity-building. Uninsured Jordanians and registered Syrian refugees will benefit from the health services provided in health care facilities. The project has supported the Ministry of Health to deliver about 3.5 million (3,447,000) primary health services across Jordan, compared to a lower target of 2,670,000. Additionally, it has supported the delivery of 2,143,000 health services at secondary care facilities (compared to a target of 1,905,000).

In 2019, the Ministry of Health provided Syrian refugees and Jordanians with assistance, amounting to more than 500,000 cases of primary health care assistance, 125,743 cases of maternal and child health assistance, 58,962 cases of specialized mental health services and 36,347 secondary or tertiary referrals. Quality sexual reproductive health services are also provided, including clinical management of rape. Furthermore, support is being provided to community health volunteers and Infant and Young Child Feeding (IYCF) facilities in urban areas, in Zaatari and in Azraq. Mental health services are provided through primary health clinics by community mental health workers.

Findings from the health sector indicate that only 69.6% and 73.7% of Jordanian males and females have health insurance, respectively, with the GOJ aiming to expand the umbrella of Universal Health Coverage (UHC), during 2020, to reach 80% of total Jordan's population with the aim of reaching the entire population by 2025. Additionally, the increased access to public health care facilities, by both refugees and host communities stretched the absorptive capacity of health system, and, in turn, negatively impacted on some health system performance indicators, such as bed ratio and health work force ration per population. Furthermore, current funding trends suggest that only 66% of refugees living in host communities are covered by health services, leaving over 177,000 people with uncertain access. The most updated Vulnerability Assessment Framework (VAF), which is part of the Comprehensive Vulnerability Assessment (CVA), found that 9% of Syrians are part of households with severe health vulnerability and 40% are part of

[66] JRP 2020-2022

households with high health vulnerability. Moreover, the VAF found that 35% of Syrian refugees are severely vulnerable in terms of being able to access health services when needed, 31% of households have the presence of pre-existing medical conditions (e.g., chronic illnesses) that are negatively impacting a family member's day-to-day life, and 63% of Syrian refugee households reported that they face high expenditure on health care[67].

The Household Expenditure and Income Survey 2017-2018 (HEIS) indicate the percentage of people with chronic diseases is 12.6% among Jordanians while for non-Jordanians, including Syrian refugees, the figure is 11.1%. Another study by the Department of Health Services (DHS) shows that prevalence of anemia in children is 31.7% among Jordanian and 34.3% among Syrians, with Ajloun and Zarqa being the most affected governorates.

The Municipalities Law No. 41 of 2015 provides several responsibilities to the Municipality. It addresses several issues and concerns that include city plans and buildings, sanitation and health, fires, flooding, aid to victims, risk prevention, and financial requirements. It requires them to take all necessary precautions and procedures to maintain public health and prevent outbreaks of epidemics among people, in coordination with the competent authorities and has the right to contribute to the implementation of the work and projects of public hospitals and health centers and other health facilities[68].

[67] JRP2020-2022
[68] Jordan National Natural Disaster Risk Strategy 2020-2022

1.14 Biodiversity and Ecosystems

The ecosystems and biodiversity composition are diverse due to Jordan's location at the junction of three biogeographical realms, the Palearctic, the Afrotropical, and the Oriental (Eid and Modry, 2021). This location and the altitude variations (420m b.s.l. up to 1850m a.s.l.) has supported the existence of four bio-geographic regions; the Mediterranean, the Irano-Turanian, the Saharo-Arabian and Sudanian Penetration (Figure 1.16).

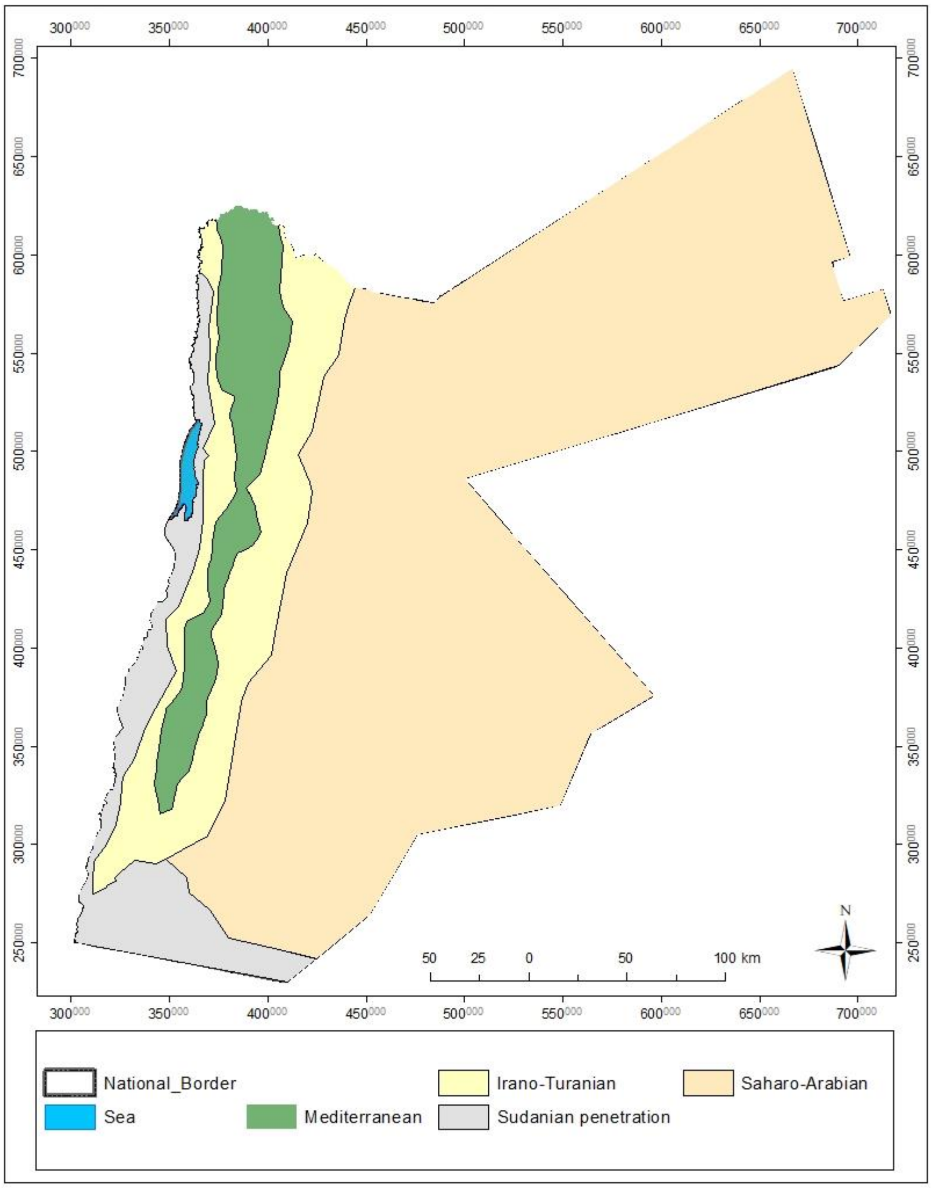

Figure 1.16: Biogeographical regions of Jordan

The Mediterranean is restricted to the highlands (700 to 1850 m a.s.l.) and extends from Irbid in the north, to Ras Al-Naqab in the south, in addition to some isolated representation in the mountains of Wadi Rum. The rainfall ranges from 300 to 600 mm, and the annual temperature varies from 5 to 10° C up to 20 to 30° C. Soil is dominated by the red Mediterranean soil (terra rosa) and the yellow Mediterranean soil (rendzina) which supports the formation of forests and is considered the most fertile region in Jordan. The Irano-Turanian forms a narrow strip of variable width that surrounds all the Mediterranean except in the north. It is characterized by the presence of small shrubs and bushes and altitudes range from 500 to 700 m. Rainfall ranges from 150 to 300 mm per year and the annual temperatures varies from 2 to 5° C up to 15 to 25° C. Soils are mostly calcareous or transported by wind. The Saharo-Arabian comprises the largest part of Jordan encompassing almost 80% of its total area. It is a flat area, with a few hills, or small mountains, which were caused by volcanic eruptions. Altitude ranges between 500 and 700 m, and the annual rainfall ranges from 50 to 200 mm. Annual temperatures range from 2 to 15° C up to 25 to 40° C. Soil is mostly poor, either clay, hamada, saline, sandy or calcareous. Finally, the Sudanian Penetration region starts from the northern part of the Dead Sea and ends at the tip of the Gulf of Aqaba in the south, along the Dead Sea depression and Wadi Araba. The altitude ranges from the lowest point on earth (420m b.s.l.) up to 150m a.s.l. Rainfall ranges from 50 to 100 mm per year and the annual temperature ranges from 10 to 29° C up to 20 to 35° C. Soils are mostly alluvial, saline, sandy and granitic (Eid, 2021; Al Eisawi, 1996).

The diverse regions have enhanced the presence of 19 vegetation types (Albert et al, 2003; Al Eisawi, 1996). For the purposes of the vulnerability analysis, these vegetation types have been adopted as ecosystems (**Table 1.17** and **Figure 1.17**).

The existence of various ecosystem (vegetation) types has enabled the presence of 2,498 vascular plant species belonging to 112 families and around 813 genera, including at least 100 endemic species (Taifour et al, 2016). The red list of Jordan's flora has showed a regionally extinct species (Salvia fruticose), with a further 189 classed as Critically Endangered, 222 as Endangered, and 73 as Vulnerable. In addition, 42 species have been found to be Near Threatened, six are Data Deficient, and 1333 are considered of Least Concern. In fact, most of the threatened species have been recorded in the most vulnerable ecosystems: forests, especially in the north and freshwater ecosystems, especially in the Jordan Rift Valley (Taifour et al, 2017).

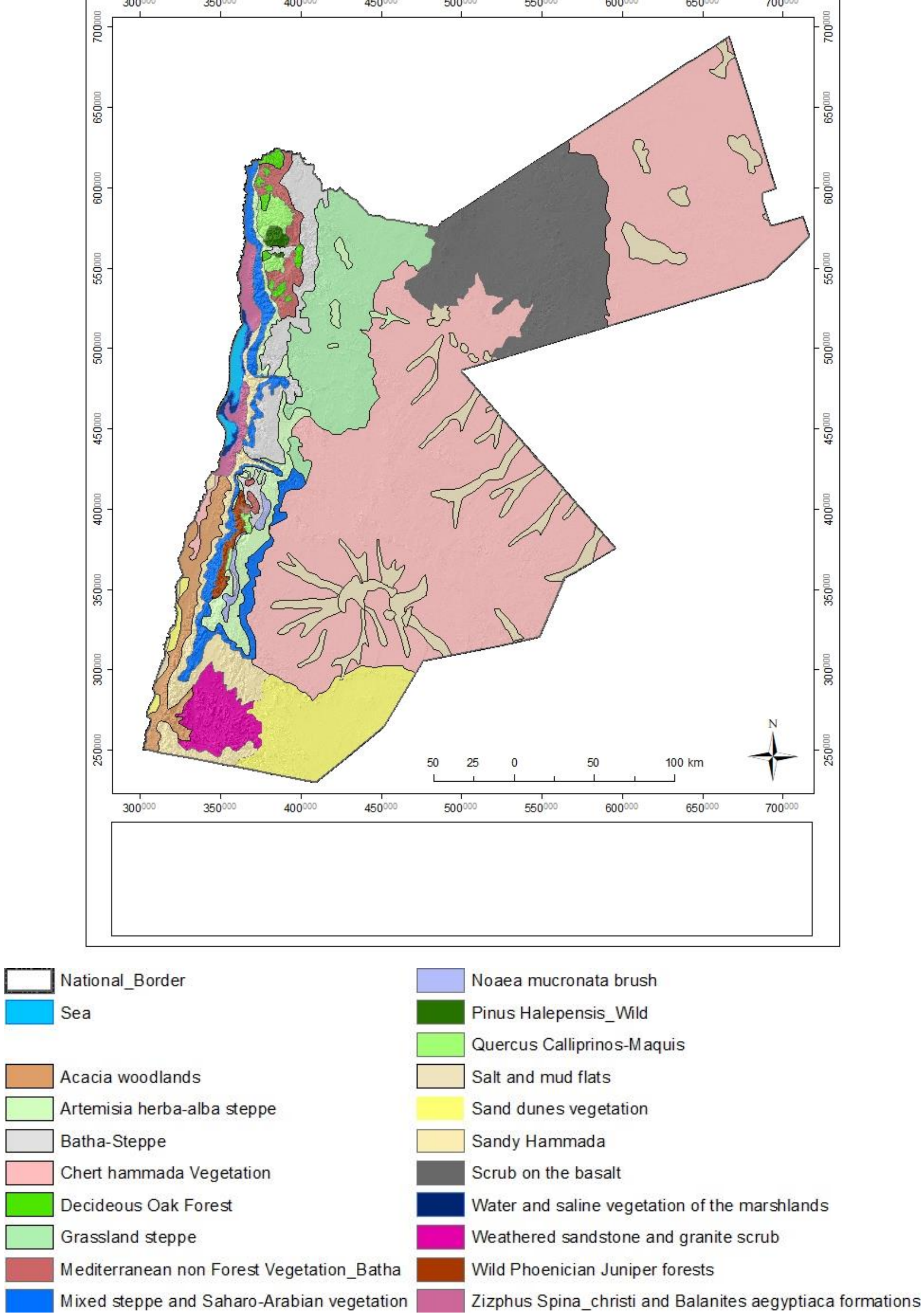

Figure 1.17: Major Ecosystems (vegetation types) in Jordan

Table 1.17: Major Ecosystems (vegetation types) in Jordan

Ecosystem	Description	Area in Jordan and approximate % of area of Jordan[69]	% Of cover in Jordan's network of Protected areas[70]
Forested ecosystems in Jordan			
Pine forest	It is dominated by the Aleppo pine; *Pinus halepensis*. It is located at high altitudes, mostly over 700m, usually on Rendzina and calcareous soil types.	18.3Km^2 (0.02%)	9.6%
Evergreen Oak Forest	It is dominated by the evergreen oak; *Quercus coccifera*. It grows at elevations of more than 700m on red soil (Terra Rossa) on hard limestone bedrock, or as secondary vegetation replacing Aleppo pine forest on calcareous or yellow (Rendzina) soil of soft limestone bedrock.	156.7Km^2 (0.18%)	0.92%
Deciduous Oak Forest	It is dominated by the deciduous oak *Quercus ithaburensis*, which grows at elevations less than 500m. These forests are mostly grown on red or brown soil of hard limestone parental rock. The deciduous oak is called (Mallool in Arabic) and it is the national tree of Jordan	156.3Km^2 (0.17%)	4.62%
Wild Phoenician Juniper Forest	It is dominated by the Phoenician Juniper; *Juniperus phoenicea*, and grows only in the Southern mountains of Jordan at elevations over 1000m in sandy, rocky terrain.	191.7Km^2 (0.21%)	0.78%
Acacia woodland	It is dominated by the Acacia trees; *Acacia raddiana* and *Acacia tortilis,* and confined to the granite mountain bases and to the rocky part of the Sudanian region. Acacia trees are scattered through Wadi Araba, but they get denser toward the hard rocks of the mountain bases until they form a pure stand of Acacia woodland before Aqaba.	1453.7Km^2 (1.63%)	6.94%
Non-forested ecosystems in Jordan			
Mediterranean non-forest	This ecosystem is devoid of forests and consists of shrubs and bushes. Al-Eisawi, 1996 stated that forests could grow in this ecosystem given time, and an absence of anthropogenic pressures.	4,815Km^2 (5.39%)	2.14%
Steppe	This ecosystem is confined to the Irano-Turanian region and may intrude into either the Mediterranean or the Saharo-Arabian region as its composition varies according to the soil and other climatic factors. It can be divided into six sub-categories which are: 1) Batha-Steppe; 2) *Artemisia herba-alba* Steppe, 3) Semi-steppe Batha 4) Grassland Steppe, 5) Mixed Steppe and Saharo-Arabian Vegetation and 6) *Noaea mucronata* Brush.	11293.4Km^2 (12.24%)	2.49%
Hammada (Stoney desert)	This ecosystem can be divided into four subdivisions, which are 1) run-off hamrnada, 2) gravel hammada, 3) pebble hammada, and 4) sandy hammada. The run-off hamrnada is confined to the wadis and watersheds, where stands of *Acacia tortilis, A. raddiana, Tamarix* spp., *Artemisia judaica* and *A. monosperma* dominate. The gravel hammada is the largest, flattest part of	62,867.6Km^2 (70.37%)	0.43%

[69] Source" Taifour et al, 2020
[70] Source: fifth national communication report. CBD

	Jordan, and is made mostly of clayey loam covered by gravels. Low shrubs including *Seidlitzia rosmarinus* and *Filago desertorum* dominate the vegetation. The pebble hammada is covered by black pebbles covered by lichen, which turns the black colour of the pebbles into white-grey growth. Some chenopod plants especially *Salsola vermiculata* and *Halogeton alopecuroides* dominate the Vegetation. Finally, the sandy hammada is the most common along the borders with Iraq and Saudi Arabia where the land is a mixture of either type of hammada, gravel or pebbles, with sandy soil coming from Saudi Arabia. The leading species are *Seidlitzia rosmarinus, Atriplex* spp., *Artemisia herba-alba* and *Anabasis articulata*.		
Salt and Mudflats	This vegetation type is found in the vicinity of the Dead Sea, the desert (Saharo-Arabian) region around Azraq Oasis, and in Wadi Araba. It is composed of exceptionally fine particles, of clay and silt, and occurs in the desert where water accumulates. The dominant plant species present in accordance with their tolerance of salinity, where the arrangement of species starting from the water will be *Suaeda* spp., *Arthrocnemum* spp., *Juncus* spp., *Tamarix* spp., *Nitraria*, *Ziziphus lotus*, *Anabasis setfera, Zygophyllum dumosum, Capparis ovata, Suaeda* spp., *Tamarix* spp. and *Anabasis articulata*. The mudflat holds no vegetation cover but at edges.	1,285.8Km^2 (2.44%)	4.65%
Sand dune	This ecosystem is only found in the Sudanian region, especially in Wadi Araba and Wadi Rum. It is made up of shrubs or bushes, of sand dune fixatives, where the leading species are *Haloxylon persicum*, *Retama raetam, Calligonum comosum*, and *Haminada scopira*.	1760.7Km^2 (1.97%)	35.54%
Wetland (Riparian)	It is represented by the presence of a major Wadi system where *Typha domingensis, Phragmites australis*, and *Inula crithrnoides* are the dominate species.	71.9Km^2 (0.08%)	5.34%
Weathered Sandstone and Granite Scrub	It is represented by tropical varieties such as *Acacia* spp., *Balanites aegyptiaca, Calotropis procera, Maerua crassfolia, Sahadora persica, Haloxylon persicuni, Ochradenus baccatus, Panicum turgidum* and others.	1788 (2%)	0.8%
***Ziziphus spina-christi* and *Balanites aegyptiaca* Formations**	It occurs in the Sudanian region and is confined to the alluvial soils of the Rift Valley. The leading species are *Ziziphus spina-christi, Calotropis procera* and *Balanites aegyptiaca*.	534.3Km^2 (0.6%)	0

The faunal diversity is also enormous with species from Palearctic, Afrotropical, and Oriental origins (Eid and Modry, 2021). Eighty-three mammalian species have been recorded in Jordan (Eid et al, 2020). The red list of mammals in Jordan showed 33 threatened species distributed as 10 Critically Endangered, 20 Endangered, and 3 Vulnerable. In addition, five species are considered as Near Threatened, three Data Deficient and 38 of Least Concern. A single species was reported to be Extinct in the Wild. There are 103 species of reptiles, comprising 36 snakes (Eid, 2021), 3 turtles, 2 tortoise and 61 lizards. As for birds, 436 species have been recorded, of which 341 are migrant, including 15 globally threatened species, and 95 are considered resident. The freshwater fish diversity includes 15 native species including the endemic *Aphanius sirhani* that survives in the Azraq Wetland Reserve. Three species of amphibians have been also been reported in Jordan.

1.15 Marine Environment

The Gulf of Aqaba is located at the most southwestern part of the Hashemite Kingdom 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. Geologically, the Gulf has three small pull apart basins, formed between four left lateral strike-slip fault segments: the Elat Deep, the Aragonese Deep and the Dakar Deep. It was created by the Sinai Peninsula's divergence and forms the southern end of the Dead Sea Transform.

The Gulf of Aqaba is considered to be the only maritime region in Jordan and has a global importance stemming from its geographical location, as it is the bridge, where many floral and faunal species naturally migrated between east and west, north and south. The coastline of the Gulf of Aqaba extends for 27 Km along a narrow and very deep arm of the Red Sea, with an average width of 20 km, reaching a maximum width of 26 km. The average depth is about 800m, but it reaches more than 1850m, in its deepest sections. It consists of a series of embayments, with a wide range of communities present in each, including rocky shore, reef flat, reef face, fore reef, sandy shore, sandy bottom, and sea grass ecosystems. Over a length of 13 km. A discontinuous series of fringing coral reefs and reef flats 150m wide are present.

The coastline of the Gulf of Aqaba is considered a dynamic and complex multi-function system. A wide number of often conflicting human socio-economic activities occur along its shorelines, including urbanization, tourism and recreational activities, industrial production, energy production and delivery, port activities, and shipping. In addition, the coastal system of the Gulf of Aqaba is also characterized by important ecological and natural values; and their high habitat and biological diversity is fundamental to sustain coastal processes and supply ecosystem services which are essential also for human well-being (MEA (Millennium Ecosystem Report), 2005). Human activities often conflict with the need to preserve natural coastal systems and their ecological processes.

1.15.1 Physical Characteristics of the Gulf of Aqaba

The sea level in the northern part of the Gulf of Aqaba fluctuates during the year by up to one meter. The level is high from December through May. but decreases, during July through October. The difference is due to the influence of monsoon winds in the Indian Ocean, which in the winter results in a net flow of water from the Indian Ocean, to the Red Sea and the Gulf of Aqaba and vice versa in the summer months. Other factors that influence the tidal levels include real decrease of water volume due to intensive evaporation from the sea surface, and the variation of a positive component of water exchange through Bab el Mandeb and Suez Canal (SOCER (State of the Cetacean Environment Report), 2015). The maximum sea level (MSL) range, reference to Global MSL, during the year 2013 was 154.3 cm. The highest value was 101.7 cm observed on December 12th, and the lowest value was -52.6 cm recorded on April 23rd. The sea-level anomalies mostly depict a clear yearly cycle, where the lowest monthly mean anomaly (5.0 cm) was in June. The highest monthly mean anomaly was 47.4 cm which occurred in November (National Monitoring Programme 2013).

The Gulf of Aqaba has a low rate of water exchange with the Red Sea, due to the presence of the narrow and shallow passage of the Straits of Tiran (UNDP, 2015). Water residency time of water in the GoA can exceed two years in the upper depths of the Gulf and three years in the lower depths (ISPAN, 1992). In terms of the southern shoreline section of Aqaba, longshore tidal currents are very small and occur in both easterly and westerly directions.

The relative isolation of this desert-enclosed sea, coupled with exposure to an arid, hot climate and high evaporation, causes temperature and salinity to be unusually high, as compared to the average range for oceans. The mean temperature in the Gulf of Aqaba is 27 °C, rising to 31.5 °C (ICRI (International Coral Reef Initiative), 1995). Sea surface temperatures in the Gulf of Aqaba do range from winter lows of 20.5°C (February) to highs in late summer (September) of over 27 °C. During the summer, the Gulf is thermally stratified; a strong thermocline exists, with seawater temperatures below a depth of approximately 200 m remaining at a constant temperature of 21.5 °C. As sea surface temperatures fall in the winter the thermocline collapses and mixing between the upper and lower layers of seawater occurs.

Salinity within the GoA ranges from 40.3 to 41.6 psu (practical salinity units) compared to the standard for an ocean's average salinity of 35 g/l. Vertical salinity differences are very small between 50 and 150 m. In general, the eastern side of the Gulf is less saline, most likely due to the influx of lower salinity waters from the Red Sea (Manasrah et al, 2007). The lack of regular freshwater input and the high evaporation rate contribute heavily to the particularly saline conditions within the GoA (ECO Consult 2006; UNDP, 2015).

At depths greater than 200 m, within the deep basins, the salinity is remarkably homogeneous at 40.6 %, except for the hot brines (Morcos 1970; Degens & Ross 1969), which emerge from the sea floor in areas with an active seafloor rift and are characterized by very high salinity and high temperatures. It occurs at depths of more than 2,000 m where water temperatures can reach up to 60 °C and salinity exceeds 300% (SOCER 2015).

The seawater pH is considered one of the most important parameters for measuring seawater acidity. Records of pH appear to fluctuate around 8.3 with very minor variations, which is typical for all coral reef waters (Manasrah et al, 2019), because these waters are always saturated with calcium carbonate, which acts as a buffer and resists any change to the pH.

1.15.2 Biological Characteristics of the Gulf of Aqaba

The zooplankton community (> 150µm) within the GoA includes the presence of 73 species (45 genera) within 10 taxa namely; Tintinnidea, Foraminifera, Trachymedusea, Thecosomata, Cladocera, Ostracoda, Copepoda, Malacostraca, Chaetognatha and Urochordata. The most abundant zooplankton form is the holoplanktonic which makes up 91.5%, and they are mainly Copepoda and Chaetognatha, which together comprise more than 90% of the total zooplankton. Copepods alone contribute 87% of the total zooplankton abundance (Al-Najjar (2002)). Most copepod species are epipelagic, with seven species found in the GoA; which include *Paracalanus indicus, Calocalanus clausi, Phaenna spinifera, Clausocalanus ferrani, Calanua robstior, Euchirella messinensis, Candacia tenuimana*, and *Corycaeus subullatus* (Al-Najjar (2002)).

The most significant feature of Jordan's marine environment is undoubtedly its coral reef ecosystem, and the associated corals species. The coral reef ecosystem covers a small area, estimated at four km^2, in total (including vertical and horizontal faces), though it occurs along approximately half of the country's short (27 km) coastline (i.e., over 13 km in length) and possesses a remarkably high marine biodiversity. Aqaba reefs also lie within this Red Sea biogeographic zone, which is designated as a Worldwide Fund for Nature (WWF) "Global 200 Eco-Region" because of its unique marine biodiversity (Olson and Dinerstein. 2002).

The Jordanian coastline is fringed by a discontinuous series of coral reefs, in which two morphological units can be distinguished: i) the reef flats and ii) the outer slopes (Bouchon et al. 1981; Al Tawaha et al., 2019). The GoA contains 157 identified hard coral species from which all have been confirmed within the boundaries of the proposed AMR. These species are composed of 153 scleractinian corals (Anthozoa, Scleractinia), one organ pipe coral (Anthozoa, Alcyonacea), and 3 fire corals (Hydrozoa, Milleporidae). Scleractinian coral species found in this study belong to 15 families and 59 genera. Of the scleractinian corals, 147 are zooxanthellate (hosting the photosynthetic dinoflagellates of the family Symbiodinaceae). Fifteen scleractinian corals found and photographed during recent field surveys (Figure 9) are currently known to occur exclusively in the Red Sea and are hence considered Red Sea endemics (Al Tawaha et al., 2019).

In particular, 65% (No=15 species) of the 23 known Red Sea endemic coral species were found in Jordan (Table 5). Based on the collected data, 9.8% of the scleractinian corals recorded between 0 and 30m in Jordan in the present study are Red Sea endemics. It is noteworthy that 5 of the Red Sea endemics, namely *Pachyseris inattesa* Benzoni & Terraneo 2014, *Cyphastrea kausti* Bouwmeester & Benzoni 2015, *Cyphastrea magna* Benzoni & Arrigoni 2017, *Echinophyllia bulbosa* Arrigoni, Benzoni & Berumen 2016, and *Sclerophyllia margariticola* Klunzinger 1879 have been only recently described or resurrected thanks to the integrated systematics approach, including morphological and genetic data coming from a reference collection assembled in Saudi Arabia (Al Tawaha et al., 2019).

The seagrass stands, along the Gulf of Aqaba, are small in comparison with the magnitude of coral reef extent, and the greatest extent of seagrass beds are found at the Al-Mamlah Bay (Tala Bay) area, which is found at the southern edges of the Aqaba Marine Reserve. The species' richness and biodiversity, nevertheless, are very high, with studies indicating the importance of conserving these meadows. The seagrass distributions increased with increasing depth up to 12 m, and decreased thereafter. Three species have been recorded in the region, where the most common and distributed species is the *Halophila stipulacea*. The other two species *Halodule uninervis*, and *Halophila ovalis* are less abundant and only found at shallow depths.

The Gulf of Aqaba includes eighteen genera of benthic macroalgae, including seven chlorophytes, eleven Rhodophytes, and ten Phaeophytes (UNDP, 2015). The highest coverage appears to be evident during spring months. Occasionally, local Aqaba fishermen mix algae with fish pieces and flour, to make a paste, which is used as bait in fish traps.

Endemism in the Red Sea is high, with an estimated 25 species of fish only occurring in the Red Sea. This observation is reflected in the diversity of fish found within the Gulf of Aqaba, where a total of 507 species, belonging to 109 families, have been recorded, so far, which constitutes 40% of the known, 1,280 fish species of the Red Sea. Eight families represent more than 41% of the fish species recorded in the GOA, including Wrasse labridae (51 species), Pomacentridae (29 species), Serranidae (25 species), Apogonidae and Blenniidae (24 species for each), Gobbiidae (21 species), Carangidae (17 species) and Syngnanthidae (16 species). Seven species are recognized as endemic, and several are considered commercially important varieties. More than 50% of the species recorded in Jordan are coral reef dwelling species, which in part is due to the presence of healthy coral reefs (Khalaf, 2004). A first record for an extremely rare species was confirmed from 2 m depth at the seagrass meadow in Al-Mamlah Bay in the Aqaba Marine Reserve. This species belongs to Sea Grass Wrasse *Novaculichthys macrolepidotus*, which was recorded for the first time in 2004 (Khalaf, 2004). Three introduced species, have also been recorded, in the GOA. These include *Sparus auratus, Dicentrarchus labrax*, and *Tilapia,* species from the fish farm project, which was established previously in Eilat (Khalaf, 2004).

Moreover, three flagship species have been identified in the Gulf of Aqaba including the whale shark (*Rhincodon typus*), the Reef stingray (*Taeniura lymma*), and the masked butterfly fish (*Chaetodon semilarvatus*) (Khalaf, 2004). Around 70% of the Jordanian marine fish catch are species belong to the Scombridae family, which is considered of immense importance commercially to Aqaba. The main species fished, include migratory species such as *Katsuwonus pelamis* and *Euthynnus affinis*. Other important commercial fish species are *Decapterus macarellus, Decapterus macrosoma, Caesio lunaris, Caesio suevica* and *Caesio varilineata* (Khalaf, 2004).

Three turtle species have been recorded at the Gulf of Aqaba, and a fourth is expected to be encountered, which is the endangered green turtle *Chelonia mydas* (Disi et al, 2001). The loggerhead turtle *Caretta-caretta* is a vulnerable species, according to the IUCN Red List, which has been recorded at Aqaba, although this record is most likely to be a migrant specimen, arriving through the Suez Canal (Disi et al, 2001). Although uncommon, with few recorded, the vulnerable leatherback turtle *Dermochelys coriacea,* has been confirmed in the GoA waters (Disi et al, 2001; Eid and Al Tawaha. Pers. Observation, 2018). The most abundant and widely distributed species is the hawksbill turtle *Eretmochelys coriacea*. The Black Rock location (towards Tala Bay) has the highest turtle population (UNDP, 2015).

The coastal waters of the Jordanian Gulf of Aqaba and its coral reef ecosystem host a plethora of marine fauna, including hundreds of species of marine invertebrates. Major groups of invertebrates occupying this zone, include gastropod mollusks, rock oysters, barnacles, and chitons. Twenty percent of mollusks and Echinodermata, as well as several species of algae occurring in the Gulf, may be endemic. A study on the distribution of the Giant clams *Tridacna maxima* and *T. squamosa,* within Jordanian waters, suggests that both species are considered keystone species within a coral reef ecosystem and fulfil a niche role within the community. Due to a lack of abundance in Giant Clams' numbers, they are considered endangered in Jordanian waters and hence require protection (UNDP, 2015). Finally, there are 72 species of sponges, and 645 species of gastropods, known from the Jordanian coast of the Gulf of Aqaba.

1.15.3 First Marine Reserve in Jordan

Aqaba reefs also lie within this Red Sea biogeographic zone, which is designated as a Worldwide Fund for Nature (WWF) “Global 200 Eco-Region” because of its unique marine biodiversity. Due to the importance of the Gulf of Aqaba, His Majesty King Abdulla II gave his directive on June 3rd, 2020, to declare the existing area of the Aqaba Marine Park as the Aqaba Marine Reserve. Accordingly, the reserve was declared by the cabinet of Jordan as the first Marine reserve in Jordan, in December 2020, to be part of Jordan’s network of protected areas. It occupies an area of 2.8 Km^2, which represents 3% of the total Jordanian Territorial water area of 96 Km^2, and its shorelines extend over 7 km, which represents 26% of the total coastline length, of 27 km. The reserve is managed by the Aqaba Special Economic Zone Authority (ASEZA) after a Memorandum of Understanding, signed with the Ministry of Environment.

1.16 Urban Context

1.16.1 Population Growth and Urbanization

Jordan has more than 11 million inhabitants, mainly concentrated in the capital Amman, Irbid and Zarqa. [71] During the last decade, population growth rate has fluctuated between 1.37% and 5.00%.[72] The Kingdom's population is anticipated to hit 19 million by 2050, if the growth scenario continues according to the current situation.[73] Most of the population live in urban centers, with a 92% urbanization rate. Jordan is ranked the third most urbanized country in the Arab Region, after Kuwait and Qatar.[74] The capital Amman is heavily inhabited with 97.2% of its population being urban.

For the last two decades, the unprecedented mass migrant influx, aftermath of the political and security catastrophes in neighboring countries - Iraq and Syria - has exacerbated urban challenges in Jordan. In 2021, Jordan hosted more than 3.7 million refugees, from 53 different countries, the majority being Palestinians and Syrians.[75] According to UNHCR records, there were 760 thousand registered refugees, in 2022, mainly Syrians and Iraqis, along with refugees from Yemen, Sudan, Somalia, among others. The number of Syrian refugees reached 1.36 million, of which almost 83% live in cities, with 36% concentrated in Amman and 18.1% in Irbid.[76] The unprecedented surges in population have caused challenges to the urban system, especially concerning water supply and sanitation, groundwater depletion, infrastructure, energy and transport sectors, housing, and services. It has also increased vulnerability to weather events, in tandem with climate change impact.

Arab and south Asian migrant workers have also contributed to population growth in Jordan. Working in manufacturing industries, agriculture, domestic work, construction, and wholesale and retail trade, the number of migrant workers reached 333,283 workers in 2021. Half of the

[71] http://dosweb.dos.gov.jo/
[72] https://worldpopulationreview.com/countries/jordan-population
[73] http://www.dos.gov.jo/dos_home_e/main/Demograghy/2017/POP_PROJECTIONS(2015-2050).pdf
[74] https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?locations=1A
[75] https://www.almamlakatv.com/news/60963-%D8%A7%D9%84%D8%A3%D8%B1%D8%AF%D9%86-%D9%85%D9%82%D8%B5%D8%AF-%D8%A7%D9%84%D9%84%D8%A7%D8%AC%D8%A6%D9%8A%D9%86-%D9%81%D9%8A-100-%D8%B9%D8%A7%D9%85-%D8%B1%D8%BA%D9%85-%D9%85%D9%88%D8%A7%D8%B1%D8%AF%D9%87-%D8%A7%D9%84%D9%85%D8%AD%D8%AF%D9%88%D8%AF%D8%A9
[76] https://reliefweb.int/report/jordan/registered-persons-concern-refugees-and-asylum-seekers-jordan-31-january-2022

expatriate workers reside in the capital, and the rest are distributed between Irbid, Zarqa, Al Balqa, Al Tafileh, Ajloun, and Aqaba.[77]

Rural exodus is a crucial factor in the urbanization phenomenon within Jordanian cities.[78] A wide development gap between governorates, as highlighted in Jordan Vision 2025, exacerbates the disparities in urban-rural development, such as infrastructure and services supply, transport network, employment, and inequalities of livelihood opportunities between governorates that have increased the influx of households and youth moving from other towns to urban centers such as Amman, Irbid, Zarqa, and Aqaba.

Rapid urban growth has pressurized the built environment, causing devastating urban challenges. Land-use changes and unsustainable urban planning, due to uncontrolled urban sprawl, have hindered the process of updating policies and upgrading the planning framework[79], while affecting the ability of cities and municipalities to cope with uncertain challenges, develop, and thrive. Irresponsible consumption and production patterns, lead to increased demand on scarce resources, including a rapid rise in fuel demand, rising land values, housing challenges, solid waste challenges, diminution in green coverage and a paucity of green public places, ineffective water governance, traffic congestion, and air pollution exacerbated by the lack of integrated transport systems, which makes people dependent on private vehicles, are all impacts of urbanization and population growth. They further escalate environmental degradation and lead to an increase in greenhouse gas emissions and leading to increasing climatic crises such as heat waves, drought, water scarcity, and floods.

1.16.2 Urban Settlements and the Built Environment

In an arid country, where more than three-quarters of the land is desert, most of the population have settled across the Jordan Rift Valley, in the north-western part of the Kingdom, in addition to the Mountain Heights Plateau.[80] However, the groundwater dissemination, within the eastern part of Jordan, especially in Mafraq and Azraq, has also contributed to settlements expansion towards the eastern parts.[81]

The swift growth of the construction sector in Jordan, with rising demand for housing and outdated planning laws and building codes, with lack of monitoring, have impacted the quality of

[77] http://www.mol.gov.jo/ebv4.0/root_storage/ar/eb_list_page/%D8%A7%D9%84%D8%AA%D9%82%D8%B1%D9%8A%D8%B1_%D8%B3%D9%86%D9%88%D9%8A_%D9%84%D8%B9%D8%A7%D9%85_2021.pdf
[78] http://www.dos.gov.jo/dos_home_e/main/population/Jordan_International/Jordan-HIMS.pdf
[79] https://www.preventionweb.net/files/68511_nationalnatrualdisasterriskreduciot.pdf

[80] https://books.openedition.org/ifpo/5021
[81] https://books.openedition.org/ifpo/5021

buildings, especially their thermal comfort and exposure to climate vulnerabilities. Vernacular architecture had the ability to adapt to climate conditions for many years, through its natural cooling and heating systems, where passive ventilation is the core of building technics. Building form, building envelope, wall thickness, orientation, and shading devices all contributed to the success of the vernacular buildings. However, the modern contemporary architecture, that has invaded building prototypes in Jordan, causes vulnerability to climate change.

2013 statistics showed that only 21% of households had used thermal insulation in walls, while only 10% of these had used polystyrene foam, as thermal insulation, while roof insulation, has only been implemented in 18% of residential buildings.[82] In 2012, the National Building Council developed the Jordan Green Building Guide, addressing the management of green buildings, site sustainability, and energy and water efficiency. The National Resilience Plan (2014-2016) also recommended adopting housing response criteria, in order to build resilience to environmental issues, for refugees and host communities, related to energy, urban planning, construction, public spaces.[83]

Jordan has witnessed a perceptible rise in real estate prices over the last two decades. The dramatic increase in land prices led to a glitch in the housing system, as the supply of high-end houses, targeted a specific segment of society, without consideration for affordable houses for the general population. Consequently, Jordanian cities, especially Amman, have witnessed peri-urbanization and urban sprawl, causing rapid and inefficient planning responses, and implementation of unsustainable infrastructure expansion, requiring large quantities of construction materials, for: roads and highways, water, sewage, electricity, and telecommunication networks. Thus, an increasing trend from 2013, of 13% of the urban population, living in slums, informal settlements, or inadequate housing had reached 23%, in 2018.[84] In response to housing challenges, the National Housing Programme (2019-2020) aimed at providing affordable housing for low- and medium-income households, through constructing residential communities in different cities such as Amman, Karak, Tafileh, Zarqa, and Mafraq, in addition to developing plots, for residential developments, ready to be sold and built on, for low and medium income families, in nearly all governorates.[85]

Unplanned urban growth has caused underground water pollution, due to the installation of absorbency holes near aquifers. Statistics show that in 2018, only 63% of dwellings were connected to the sewage network, while 36.7% had absorbency holes.[86] Likewise, for the

[82] https://memr.gov.jo/ebv4.0/root_storage/ar/eb_list_page/householdsurveyp.pdf
[83] https://jordankmportal.com/resources/national-resilience-plan-2014-2016
[84] https://data.worldbank.org/indicator/EN.POP.SLUM.UR.ZS?locations=JO
[85] البرنامج الوطني للإسكان - المؤسسة العامة للاسكان و التطوير الحضري (hudc.gov.jo)
[86] (https://jorinfo.dos.gov.jo/Databank/pxweb/en/Environment/Environment__Human_comm__City_Planning__Access%20to%20Services/Ser_02%20.px/table/tableViewLayout2/)

transport system, over 1.7 million vehicles are registered in Jordan[87] [88] and in 2018, the dependency on owning private vehicles, ranged between 45-55% of the population, while the demand is increasing, due to the fact that the public transport system does not provide sufficient coverage for cities and their peripheries.[89]

Households have the largest share of electricity consumption in Jordan, followed by oil, solar energy, and bioenergy[90] Almost all of Jordan's residents have access to electricity.[91] Meanwhile, domestic electrical energy use in Jordan, is three times higher than industrial use. However, some public education and healthcare institutions, and refugees living in informal tented settlements, have insufficient access to energy. Jordan's heating and cooling systems rely on non-renewable energy such as kerosene and gas, accounting for 60% of energy. [92] Solar water-heating systems are emerging devices, accounting for 4% of total energy consumption. Using LED bulbs, installing PV solar panels, and using energy-labelled appliances are some initiatives that have been addressed, to change consumer behavior.

Jordan has weak and insufficient green infrastructure with a low ratio of green spaces per capita. Green spaces are scarce in the 4.5 million populated Amman, owing to urban sprawl that converted green spaces into fragmented greyfield sites, and the urban expansion into greenfield and agricultural lands. In addition to the absence of green spaces, there is a weakness in the regulatory framework, due to the low priority given to the provision of green, public open spaces. The first recognition of the need for green open spaces, in Amman Metropolitan Area was within the 2008 Amman Comprehensive Plan. Neither an implementation scheme, nor law enforcement has been adopted since then. At the same time, ignoring the environmental impact of renewable energy development on green spaces, increasing solid waste, lack of data on biodiversity and industrial ecological standards, and compliance are all green space challenges in the capital.[93] Therefore, only 1% of planned areas in Amman are dedicated to green and open spaces. Currently there is 2.5 m^2 public open space per person, way below the minimum global recommendation of 10 m^2per person.[94] Yet, Amman Green City Action Plan (GCAP) is developed to be an

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87 https://jorinfo.dos.gov.jo/Databank/pxweb/en/Environment/Environment__Human_comm__City_Planning__Env%d9%87l%20concerns/Hum_01.px/table/tableViewLayout2/

88 http://dosweb.dos.gov.jo/DataBank/JordanInFigures/Jorinfo_2020.pdf

89 https://jorinfo.dos.gov.jo/Databank/pxweb/en/Environment/Environment__Human_comm__City_Planning__Access%20to%20Services/Ser_05%20.px/table/tableViewLayout2/

90 https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Feb/IRENA_RRA_Jordan_2021.pdf

91 https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?end=2020&locations=JO&start=2020&view=bar

92 https://jorinfo.dos.gov.jo/Databank/pxweb/en/Environment/Environment__Environmental_Resources__Energy%20Resources__Production%20and%20consumption%20of%20energy/Energy_08.px/table/tableViewLayout2/

93 https://amman.jo/site_doc/AmmanGreen2021.pdf

94 https://jordan.un.org/en/177705-amman-spatial-profile-jordan#:~:text=Enormous%20population%20growth%20patterns%20coupled,economy%2C%20and%20services'%20quality.

overarching strategic plan emphasizing the importance of investing in green infrastructure strategies and projects that will leverage the urban environmental planning process and reduce emissions.

1.16.3 National Urban Planning and Climate Change

- **Regulatory Framework**

The Law of Planning of Cities, Villages, and Buildings, no. 79 for the year 1966, and its amendments, is the bedrock of urban planning in Jordan. This law has a general overview of master planning and land use in Jordan. In 2012, the Ministry of Municipal Affairs – currently known as the Ministry of Local Administration- published model planning and zoning standards, guiding all urban development stakeholders in spatial planning, within all the municipalities, except for Greater Amman. However, these regulations, do not take climate change into consideration.

The City Aesthetic Code for 1990 gives generic recommendations to municipal authorities to support planning policies aimed at making the city more attractive, and improving, the built environment, through land planning; local environment aesthetics; natural and planned sites; public and private parks and gardens; archaeology and archaeological sites; traditional buildings; public services; commercial advertisements and information signs, and maintenance. Yet this code doesn't highlight the environmental perspective, or any climatic considerations.[95] The City Aesthetic Code 2008 also introduces urban design and landscape guidelines.

The National Climate Change Policy 2013-2020 was the first to introduce the correlation between land-use planning and climate change and the importance of mainstreaming climate change impact in urban planning. Consequently, green buildings and renewable energy projects are incorporated in the amended bylaw of Buildings, Cities and Villages Planning by-law No. 13 for the year 2019, and the more recent bylaw for Buildings, Cities, and Villages Planning No. 1 for the year 2022, obliges investors to conduct Environmental Impact Assessments and Traffic Impact Assessments.

Jordan has various strategies and programmes that highlight energy conservation approaches, as in the National Strategy and Action Plan for Sustainable Consumption and Production in Jordan 2016–2025 and the Green Growth National Action Plan 2021-2025. That urged the implementation of energy-saving mechanisms within national building codes and guidelines, including the Thermal Insulation Code and Manual, Solar Energy Code and Manual, and Green Building Guide. Moreover, Jordan has introduced the green growth corridor and smart urban as

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https://pic.hu.edu.jo/Upload/55000000/55090000/%D9%83%D9%88%D8%AF%D8%A9%20%D8%AC%D9%85%D8%A7%D9%84%20%D8%A7%D9%84%D9%85%D8%AF%D9%8A%D9%86%D8%A9.pdf

green growth clusters in its National Green Growth Plan. It intervenes in green energy infrastructure to generate electricity for vehicles in urban centres, while using solar power and biogas to generate power. Other interventions have also been proposed, such as wastewater reuse and biogas from wastewater reuse and landfill, Bus Rapid Transit, public parks, and sanitary landfill.[96]

Jordan's first National Determined Contribution (NDC), published in 2021, has addressed urban systems as a pressing sector for GHG mitigation measures, while indicating a compact city planning approach and climate-sensitive urban design, through adopting green infrastructure systems, expanding green spaces, and enforcing green buildings guidelines. It also fosters rainwater harvesting and enforcing land use laws to avoid agricultural land diminution.[97] Jordan is currently committed to addressing the gap in the national planning system through developing a national urban policy with UN-Habitat.

The city of Amman has been developing strategies and a city vision to connect the dots between urban planning and climate change. Greater Amman Municipality reacted to urban sprawl and urban planning dysfunction in Amman, by developing the Amman Metropolitan Growth Plan in 2008, that focused on planning policies and urban growth scenarios, with an update of the 20-year-old Comprehensive Master Plan, addressing intensification and densification policies, as sustainable scenarios for urban growth, in the Amman Metropolitan Area. These planning strategies and new zoning laws promoted the best urban development setup, against climate change, without affecting infrastructure and agricultural lands. It also proposed transit development, such as the Bus Rapid Transit system and Amman ring road and high-rise development corridors, Al Abdali's new central business district (CBD), and finally tackling climate change through Al Ghabawi Landfill, as a safe and environmentally-friendly waste disposal system, serving Amman, Zarqa, and Russeifa Municipalities.[98]

Amman Resilience Strategy, released in 2017, was adopted in response to challenges, such as the influx of refugees and climate change, with the goals of turning Amman into: an integrated and smart city, which is environmentally proactive, resilient and adaptive. Amman has committed to improving its mobility systems, promoting walkability, institutionalizing planning in the city, and connecting the city digitally, while simultaneously working on its environmental position, by managing and fulfilling climate change commitments and improving energy efficiency and energy security, by different measures, including: diversifying energy sources, applying green building

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96 https://www.greengrowthknowledge.org/sites/default/files/A%20National%20Green%20Growth%20Plan%20for%20Jordan.pdf

97 https://leap.unep.org/countries/jo/national-legislation/updated-submission-jordans-1st-nationally-determined-contribution

98 https://www.amman.jo/site_doc/gen2.pdf

codes and guidelines, improving the waste management system, and managing water resources efficiently.[99]

Greater Amman Municipality fulfilled its aspiration, addressed in its resilience plan, by developing a Climate Change Action Plan, in 2019, allowing it to become a pioneer Arab city, to confront built-environment challenges and climate change in the city. Amman Climate Action Plan is a paradigm shift in Amman's strategies. It strongly aligns with the National Green Growth Plan GG-NAP 2021-2025, while supporting Amman Resilience Strategy. Accordingly, the plan pivots around six pillars contributing to emissions reduction: decarbonizing electricity sources for the city, enhancing waste management and reducing waste, improving energy efficiency in buildings, reducing water use and improving efficiency, improving green infrastructure, enabling sustainable transport mobility, and improving integrated planning for denser, transit-oriented development, to encourage behavior change towards increased public transport use.[100]

Greater Amman Municipality reached another major milestone via Amman Green City Action Plan (GCAP) in 2021. It is turning Amman’s urban environmental challenges into opportunities, and scaling up and accelerating action on urban environmental issues, while introducing systematic and integrated climate change mitigation and adaptation policies and mustering national taskforces as Ministries of Environment, Health, Agriculture, and Transport to implement this plan. It intervenes in Amman through 35 actions laying out land-use planning, energy and buildings, transport system, water, waste management, and climate change adaptation as priority sectors. A comprehensive and reflective land use planning is addressed through three strategic objectives:

- Increase the number of quality green spaces.
- Develop an updated land-use plan.
- Improve the public realm.

However, the roadmap to comprehensive and reflective land-use planning is attained through investment in expanding green infrastructure, developing an integrated green infrastructure strategy, developing a servicing and implementation plan for East Amman, and finalizing and implementing the Amman Strategic Master Plan 2060.

- **Institutional Setup**

Urban planning and design in Jordanian municipalities, go under the broad umbrella of the Ministry of Local Administration. The ministry develops strategic and comprehensive regulatory plans and conducts urban studies of cities and villages around the Kingdom, and paves the way for the municipal council's urban planning mandates, addressed within the Law of Municipalities No.41 for the year 2015 and the Law of Local Administration No.22 for the year 2021, through

[99] https://resilientcitiesnetwork.org/downloadable_resources/Network/Amman-Resilience-Strategy-English.pdf
[100] https://documents1.worldbank.org/curated/en/816961617187012025/pdf/The-Amman-Climate-Plan-A-Vision-for-2050-Amman.pdf

developing land-use and detailed plans to implement comprehensive infrastructure networks, managing transport systems, housing developments, health, educational and religious facilities, and other municipal services such as waste management. Nevertheless, the Jordanian National Building Council (JNBC), the Ministry of Public Works and Housing, Housing and Urban Development Corporation (HUDC), the Royal Scientific Society, in addition to non-governmental organizations such as the Jordan Green Building Council (JGBC), UN agencies, and many others that are all contributing to urban planning and the development context in Jordan.

Meanwhile, Greater Amman Municipality (GAM), Aqaba Special Economic Zone Authority (ASEZA), Petra Development & Tourism Region Authority (PDTRA), and Jordan Valley Authority (JVA) are independent institutions responsible for regional planning and urban development having their laws, by-laws, and regulations within Amman, Aqaba, Petra, and Jordan Valley.

Greater Amman Municipality's mandate is prominent in confronting urban environmental challenges within its regulatory framework. It develops the Masterplan, according to the Regulation of Buildings and Zoning of Towns and Villages No.136/2016. The Planning Directorate and Building Licensing Directorate under the Deputy City Manager for Planning and Economic Development oversee master planning, land-use, zoning, and building permits, referring to the Amman Building and Urban Planning Regulation of 2011. Additionally, the transport department in GAM directs public transport and conducts road maintenance within its boundaries. Furthermore, collecting, transporting, treating, recycling, and disposing of solid waste complying with the regulation "Prevention of Health Nuisance and Waste Collection Fees", within GAM Areas no. 150/ 2016.[101] While 14 different authorities within GAM are mandated for planning, designing, implementing, and maintaining green and open spaces in Amman, no concrete, mandatory legal framework or strict strategy has been implemented, until now for public spaces in Amman.

- **Climate Change and Urban Development**

Urbanization in Jordan have also led to land degradation and a significant decline in groundwater levels. The unsustainable urban planning and land use practices, land fragmentation, urban encroachment on agricultural land, and increasing pressure on natural resources has led to land degradation.[102] It has also impeded groundwater recharge, as the expansion of infrastructure and increase of built-up areas, prevents the penetration of rainfall into aquifers.[103] The traditional and unsustainable land use planning and the outdated and threatened infrastructure have increased the vulnerability to climate change and hampered the adaptation mechanisms.[104]

[101] https://www.ammancity.gov.jo/site_doc/AmmanGreen2021.pdf
[102] https://www.unccd.int/sites/default/files/ldn_targets/2019-05/Jordan%20LDN%20TSP%20Country%20Report.pdf
[103] Abu Jaber, Nizar. Jordan and the climate challenge الاردن والتحدي البيئي, Amman, Dar Al-Shorok,2011.
[104] https://www.undp.org/jordan/publications/national-climate-change-policy-hashemite-kingdom-jordan-2013-2020

Jordan has confronted many environmental challenges, namely droughts incidents and water scarcity. However, population growth has caused air pollution, wastewater, and municipal solid waste as pressing environmental concerns, which increase greenhouse gas emissions. Intensification of urban systems vulnerabilities, attributable to aging infrastructure, unplanned urban expansion, and multilateral resource stresses in tandem with climate change have emerged as climate hazards in Jordan, such as flash floods, droughts, landslides, and heatwaves. Since the 1980s, Jordan experienced three major flood events in 1987, 1991, and the most recent in 2018.[105] Flash floods threaten highly populated urban areas such as Amman, the heritage site of Petra, and Aqaba, risking lives and leaving severe damage to infrastructure and properties.

The construction sector plays a vital role in climate change. It impacts greenhouse gas emissions levels through building materials, construction, and operational emissions throughout the years. Building codes have been developed and updated during the last three decades, contributing to sustainable development in Jordan through building codes and standards aiming at controlling the building industry, preserving natural resources, and protecting the environment, saving energy, and implementing safety guidelines. The recently developed codes are aimed at strongly integrating energy conservation methods in construction settings. For instance: the Thermal Insulation Code and Manual, Natural Lighting Code, Natural Ventilation Code, Energy Efficient Buildings Code, and Manual, Solar Energy Code and Manual, Central Heating Code and Manual, Mechanical Ventilation and Air Conditioning Code and Manual.

Further to building codes, Jordan Green Building Guide is a milestone in building code development, as it intervenes in the sustainability of the built environment and conservation of natural resources, that highly contributes to climate change response. National Determined Contribution (NDC) also promotes building efficiency measures for adaptation to climate change, particularly heat waves.[106]

Transport is responsible for the highest portion of energy consumption in the country. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has conducted national several projects to improve green infrastructure in Jordan and specifically in Amman targeting Jordanian and Syrian workers. In addition, Jordan's transport sector green growth action plan recommended implementing a pedestrian green infrastructure enhancement program in local commercial areas and near public transport.

In the case of Amman, land-use, solid waste, fossil-fuel dominated energy supply and energy consumption of buildings, transport, availability of water and its quality, and industries are main contributors to climate change risks in the capital. The Green City Action Plan highlights

[105] https://climateknowledgeportal.worldbank.org/country/jordan/vulnerability

[106] https://leap.unep.org/countries/jo/national-legislation/updated-submission-jordans-1st-nationally-determined-contribution

environmental challenges in Amman, which pivot around: inadequate air quality, water scarcity, a dearth of green or open spaces, and inefficient waste infrastructure.[107]

In 2015, the Hashemite Kingdom of Jordan established the National Centre for Security and Crisis Management (NCSCM) to ensure a national cohesive preparedness and response to natural and man-induced hazards and crises. Accordingly, the NCSCM developed the National Disaster Risk Reduction (DRR) Strategy 2019-2022, highlighting rapid urbanization as a critical hazard to disaster in Jordan. On the local level, the executive board within the governorates is in charge of preparing and implementing disaster prevention plans and is to be endorsed by the municipal council as per the Law of Local Administration No.22 for the year 2021.

In conclusion, Jordan has made an enormous leap forward in policies and strategies that address multisectoral development attentive to climate change. Yet, integrated planning and building resilience on the national level is imperative in confronting urban climate challenges in Jordan. It is crucial to develop a national urban planning strategy and policies while implementing them effectively in all governorates.

1.16.4 National Cultural Heritage and Climate Change

Jordan has a rich cultural heritage, embracing over 100,000 archaeological sites, with 15,500 sites listed under UNESCO, as official world heritage, formally documented and registered, in addition to a rich and diverse intangible cultural heritage. In 2021, Jordan celebrated the listing of As-Salt – The Place of Tolerance and Urban Hospitality, under the UNESCO World Heritage Sites, in addition to the Baptism Site (2015), Um er-Rasas (2004), Wadi Rum Protected Area (2011), Petra (1985), Qusr Amra (1985). [108] Climate Change has a micro-effect, yet in an accelerated way, on these sites and many others. For instance, through the change in humidity levels, such as experienced by Qusr Amra, Petra, and murals of churches in the north, increase in temperature causing damage to the fragile carved rocks of Petra and an increase in erosion of rock formations in Petra and Wadi Rum, as well as challenges due to the variations in precipitation, drought, and floods.[109] It also affects biodiversity, causing decline and loss of native plants and animal species. Finally, it is worth mentioning that climate change doesn’t only affect sites, but also the bi-faceted connection of people, with each other and with land and heritage sites.

[107] https://www.ammancity.gov.jo/site_doc/AmmanGreen2021.pdf
[108] https://whc.unesco.org/en/statesparties/jo
[109] What We Do - Petra National Trust

2 GHG National Inventory

2.1 Introduction

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 2017, which is prepared by the National Royal Scientific Society (RSS) Team. 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.

Since 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 which states the following:

- Each non-Annex I Party shall, as appropriate and to the extent possible, provide in its national inventory, on a gas-by-gas basis and in units of mass, estimates of anthropogenic emissions of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) by sources and removals by sinks.
- Non-Annex I Parties are encouraged, as appropriate, to provide information on anthropogenic emissions by sources of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).
- Non-Annex I Parties are also encouraged, as appropriate, to report on anthropogenic emission by sources of other greenhouse gases such as carbon monoxide (CO), nitrogen oxides (NOx), and non-methane volatile organic compounds (NMVOC). Other gases not controlled by the Montreal Protocol, such as sulfur oxides (SOx), included in the IPCC Guidelines may be included at the discretion of the Parties.

The GHG national inventory chapter addresses emissions of carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). Those gases are supported by the software and the Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines. Non-methane volatile organic compounds (NMVOCs) emissions resulting from the solvents subsector were estimated using European Monitoring and Evaluation Programme (EMEP/EEA) air pollutant emission inventory guidebook 2019.

2.2 Methodology and Inventory Estimation

The national GHG emissions were estimated for 2017 according to the 2006 IPCC Guidelines and the 2019 Refinement[110] to the 2006 IPCC Guidelines. Estimating the overall national inventory was done using the IPCC Inventory Software for Parties not included in Annex I of the UNFCCC (ver. 2.691, released on 23 January 2020).

The sectors and subsectors that were considered are the following:

1. Energy:
   - Stationary Combustion
   - Mobile Combustion
   - Fugitive Emissions
2. Industrial Processes and Product Use (IPPU):
   - Mineral Industry Emissions
   - Chemical Industry Emissions
   - Metal Industry Emissions
   - Non-Energy Products from Fuels and Solvent Use
   - Emissions of Fluorinated Substitutes for Ozone Depleting Substances and Other Product Manufacture and Use
3. Agriculture, Forestry, and Other Land Use (AFOLU):
   - Cropland and Forest Land
   - Emissions from Livestock and Manure Management
   - N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application
4. Waste Generation, Composition, and Management Data
   - Solid Waste Disposal
   - Biological Treatment of Solid Waste
   - Incineration and Open Burning of Waste
   - Wastewater Treatment and Discharge

In May 2019, at IPCC 49th Session, the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories was adopted by the IPCC in Kyoto, Japan (Decision IPCC-XLIX-9). The IPCC authors have examined a wide range of inventory methodologies and updated them where scientific advances and new knowledge were necessary, following the IPCC decision. The 2019 Refinement does not revise the 2006 Guidelines but updates, supplements, and/or elaborates the 2006 Guidelines where gaps or out-of-date science have been identified. It will not replace

[110] All updates, supplements and/or elaborates on the 2006 Guidelines were identified and adopted in this chapter.

the 2006 Guidelines and should be used in conjunction with the 2006 Guidelines. The structure of the 2019 Refinement is the same structure as that of the 2006 Guidelines to make it easier for inventory compilers to use the 2019 Refinement with the 2006 Guidelines. It includes an Overview Chapter and five volumes (General Guidance and Reporting (GGR), Energy, IPPU, Agriculture, AFOLU, and Waste). The changes are indicated in each volume as Annex "Mapping table" listing the types of refinements that have been done on the volume.

In brief, the main changes that were introduced to the different volumes are as follows:

- In Volume 1, adding new guidance to all chapters.
- Volume 2 introduces methodological issues in the stationary combustion and fugitive emissions chapters, adding a new section for fuel transformation and updating emission factors, and updating the worksheet of the oil and natural gas systems.
- In volume 3, including updates for the emission factors and adding a new section for hydrogen production.
- In Volume 4, developing new guidance, updating carbon stock change factors, and developing new tier 2 method that requires fewer activity data than the current default method.
- Finally, in volume 5, updating the default data, updating the wastewater treatment chapter to reflect additional types of treatment and disposal systems.

The guidance on appropriate estimation methods within the 2006 IPCC Guidelines that includes cross-sectoral good practice guidance for inventory preparation was consulted. It contains procedures for collecting activity data, key category analysis, quality assurance and control, and inventory planning and documentation.

Inventories were prepared on a gas-by-gas basis and in units of mass. Estimates of anthropogenic emissions of the direct GHGs of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) were assessed by sources and removals by sinks. Most sectors and subsectors used Tier 1.

Indirect GHGs were estimated whenever the activity data were available using the EMEP Guidelines and methodology.

For reporting purposes, the notation keys NO (not occurring) or NE (not estimated) and NA (not applicable) were used as necessary in the inventory reporting tables. Emissions were estimated in Gigagrams (Gg) for all direct and indirect gases and Gg of CO_2-equivalent (CO_2eq) for all direct gases. For converting Gg of different GHGs to Gg of CO_2eq, the Global Warming Potential (GWP) values provided in the IPCC Second Assessment Report (SAR) temporal horizon 100 years were used. The following sections report Jordan's GHG inventories by sector and gas by gas basis.

2.3 GHG Inventory by Sector

In 2017, Jordan contributed 32646.79 GgCO_2eq. A breakdown of Jordan's total emissions of GHGs by sector indicated that the energy sector was the major emitter capturing around 76% of total national emissions, followed by the waste sector with a contribution of approximately 12%. The 2017 GHG emissions by sector are shown in **Table 2.1** and **Figure 2.1**.

Table 2.1: GHG aggregate emissions in Gg CO2eq by sector, 2017

Categories	Emissions CO_2 Equivalents (Gg)	Percentage of the overall
Total National Emissions and Removals	**32646.79**	**100%**
Energy	24701.38	75.66%
Industrial Processes and Product Use	3247.38	9.95%
Agriculture, Forestry, and Other Land Use	651.67	2.00%
Waste	4046.37	12.39%

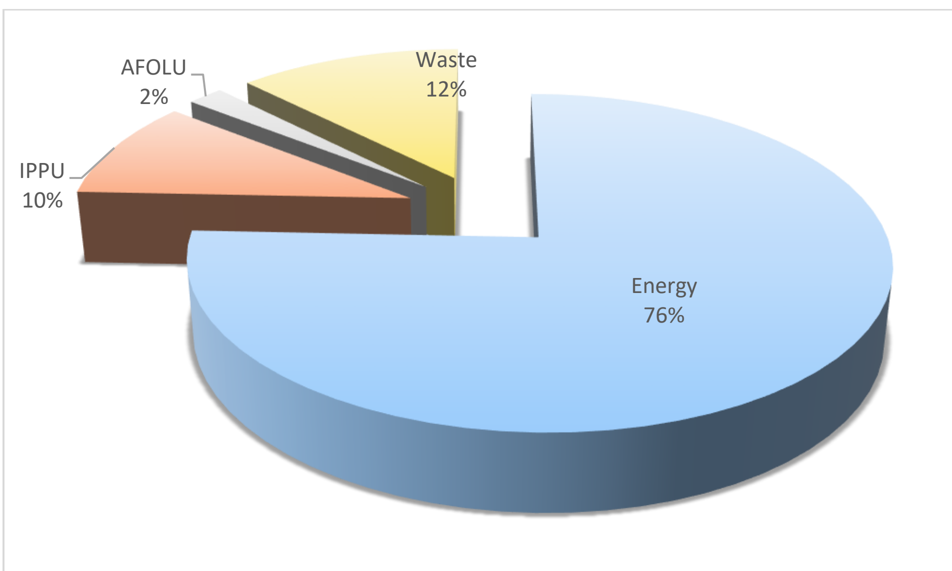


Figure 2.1: GHG aggregate emissions (%) by sector, 2017

In the section below, detailed descriptions are given for the emissions, resulting from the sectors in the year 2017.

2.3.1 Energy Sector

Jordan currently imports around 90% of its total energy comprising almost 12% of Jordan's GDP and straining its economy (MEMR, 2020). The Ministry of Energy and Natural Resources has recently published the National Energy Sector Strategy for 2020-2030, which is considered to be a ten-year plan which aims at setting the roadmap to increasing self-sufficiency through the utilization of domestic natural and renewable resources, as well as the expansion of existing energy developments, thus reducing reliance on costly foreign fuel imports that burden its economy.

The main objectives for the energy sector, as per the strategy:

- Diversification of energy sources by increasing local energy sources' contribution to the total energy mix.
- Increasing energy efficiency in all sectors.
- Reducing energy costs for the national economy.
- Developing the energy sector system in Jordan to make it a regional center for energy exchange in all its forms.

Moreover, the new National Strategy (2020-2030) identified renewable energy usage along with other sources as follows:

- Renewable energy will contribute to 31% of electricity generation by 2030.
- Improving energy efficiency in the water sector by 15% in 2025
- Increasing efficient energy consumption in all sectors by 9%

The forecast growth in renewable energy usage will enable the country to enhance energy security, improve access to affordable energy, create jobs, and meet a significant part of the NDCs target by 2030. The contribution of renewable energy (solar and wind), in the electricity generation mix, at about 1425 MW, connected to the transmission grid, form what accounts for 16% of the total electric power generated (excluding the 720 MW of renewable energy projects connected to the distribution networks) and what accounts in total to 20% of the power generated in the Jordanian electric grid both transmission and distribution networks by the end of 2020. The most significant energy consumer in 2020 was the transport sector with 49% percent share, followed by household, industrial, and other services sectors with 21.5%, 15.5%, and 14% percent share, respectively.

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

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

Total emissions from the energy sector were 24701.38 Gg of CO_2eq in 2017, resulting mainly from fuel combustion activities, as shown in **Table 2.2**. Fugitive emissions (from oil and natural gas) were negligible and accounted for less than 2% of the energy emissions. Significant emissions were recognized within the fuel combustion activities especially at the Energy Industries and the Transport subsectors with shares of 37% and 38%, respectively. Emissions resulting from "Other sectors" (Residential, Commercial, and Agriculture) as well as Manufacturing Industries and Construction accounted for 12% and 8%, respectively, of the total, as indicated in **Table 2.2** and **Figure 2.2**.

Table 2.2: Energy sector aggregated emissions in Gg-CO_2eq emissions, 2017

Categories	**Net CO_2 (Gg)**	**CH_4**	**N_2O**	**Aggregated emissions in Gg - CO_2eq**
		(Gg of CO_2eq)		
ENERGY SECTOR	24061.72	472.84	166.82	24701.38
Fuel Combustion Activities	24041.19	66.08	166.74	24274.01
Energy Industries	9138.76	4.55	9.77	9153.08
Manufacturing Industries and Construction	2043.93	1.22	5.76	2050.91
Transport	9273.83	47.12	143.80	9464.76
Other Sectors (Residential, Commercial and Agriculture)	2890.39	11.27	5.73	2907.39
Non-Specified (Fuels used by the military)	694.28	1.93	1.68	697.88
Fugitive emissions (Oil and Natural Gas)	20.53	406.76	0.09	427.39

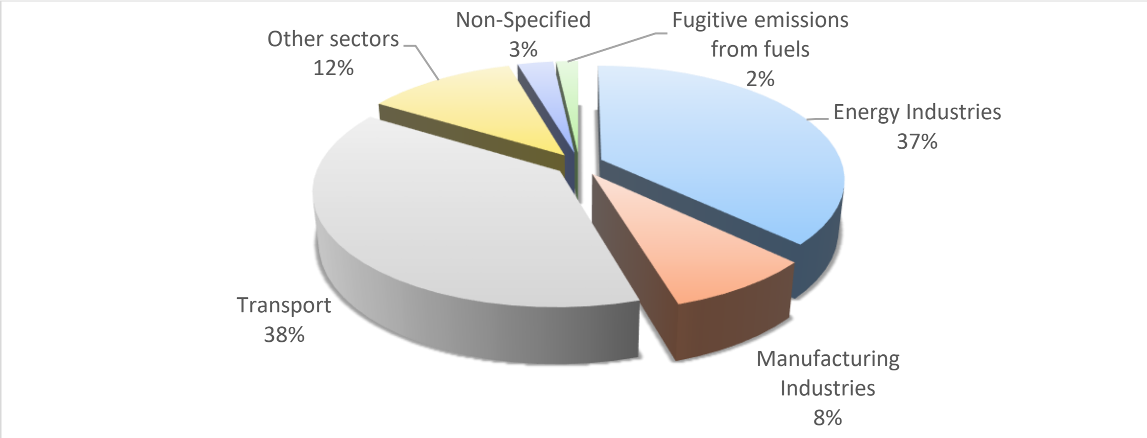


Figure 2.2: Shares of emission (%) per subsector within the energy sector, 2017

2.3.2 International Bunkers

Emissions from international aviation and international water-born navigation were estimated for 2017, as shown in **Table 2.3**.

Table 2.3: Emissions reported as item information under memo 5, 2017

Emissions	Net CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)
International Bunkers	1173.77	0.66	9.57
International Aviation (International Bunkers) *	928.37	0.15	7.69
International water-borne navigation (International bunkers)	245.41	0.51	1.88

*Tier 1 method was used based on the assumption that 10 percent of the fuel is used in the LTO phase of flight. The data was obtained from the environment department in Aviation Authority.

2.3.3 Industrial Processes and Product Use (IPPU) sector

The industrial sector in Jordan is considered one of the main pillars of the Jordanian economy. It has noticeable and multiple contributions to the economic and social development process. The industrial sector contributed directly to about 24% of the national Gross Domestic Product (GDP) during 2017, employing more than 240,000 people, most of them Jordanians, in some 18,000 industrial facilities across the Kingdom.

The industrial sector consists mainly of two types, the manufacturing (converting) sector, which includes the chemical, electrical, engineering and construction, food and beverages, glass and ceramic, tobacco and cigarettes, paper and cartoon, pharmaceutical and medical, printing and packaging, and textile and leather industries. The second type is the mining sector, which includes phosphate, potash, salt, carbonate, lime and limestone, fertilizers, cement and construction materials production, and the minerals extracted from mines and quarries.

The IPPU sector in Jordan generates emissions from a range of mineral and chemical industries such as cement production, lime production, glass production, use of carbonates (such as limestone and dolomite), production, and use of soda ash, ammonia production, and nitric acid production, etc.

In 2017, emissions from the industrial processes and product use sector were 3247.38 Gg CO_2eq, accounting for 12% of Jordan's total GHG emissions. This includes emissions from the minerals industry, product uses as substitutes for ODS (i.e., for Refrigeration, Air Conditioning, and Fire Protection), and the Metal industry subsectors.

The industrial processes sector was also a source of NMVOCs emissions, accounting for 33.21 Gg. In addition to CO_2 and NMVOCs, the industry generated emissions of HFCs with 942.38 Gg of CO_2eq. Estimated emissions are shown in **Table 2.4** and **Figure 2.3**, while **Table 2.5** shows the breakdown of the emissions from the mineral industry, according to its subsectors, the most important of which is the cement industry..

Table 2.4: Emissions of industrial subsectors, 2017

Categories	CO_2eq (Gg)					Gg
	CO_2	N_2O	HFCs	SF_6	Total	NMVOCs
Industrial Processes and Product Use	2045.12	259.86	942.38	0.02	3247.375	33.21
Mineral Industry	1632.20	NO	NA	NO	1632.2	NO
Chemical Industry	NO	228.11	NO	NO	228.11	NO
Metal Industry (Iron and Steel Production)	402.77	NO	NO	NO	402.77	NO, NA
Non-Energy Products from Fuels and Solvent Use	10.15	NA	NA	NO	10.15	29.81
Product Uses as Substitutes for ODS	NA	NA	942.38	NO	942.38	NA

Categories	CO_2eq (Gg)					Gg
	CO_2	N_2O	HFCs	SF_6	Total	NMVOCs
Other Product Manufacture and Use (N_2O from Product Uses)	NO	31.74	NO	0.02	31.76	NA, NO
Other (Food and Beverage Industry)	NA	NA	NA	NO	NA	3.41

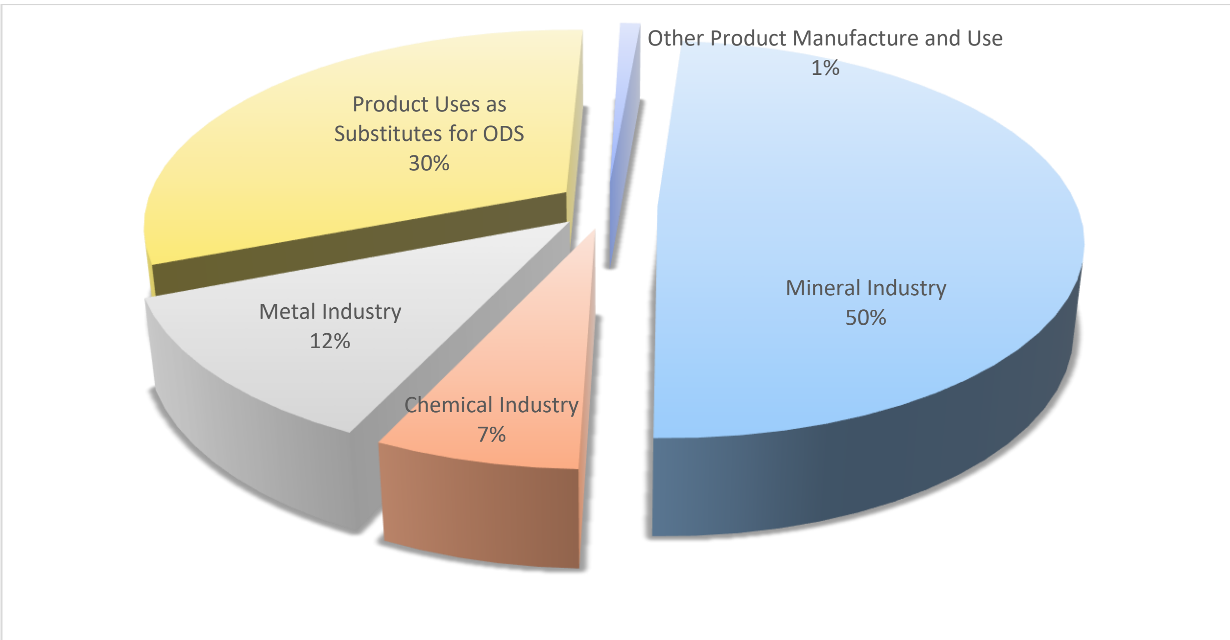


Figure 2.3: Shares of emission (%) per subsector within the IPPU sector, 2017

Table 2.5: Emissions of the mineral industry, 2017

Categories	CO_2eq (Gg)	%
MINERAL INDUSTRY	1632.20	100
Cement production	1543.23	95
Lime production	NO*	NO*
Other Process Uses of Carbonates and other Uses of Soda Ash	88.97	5

* The only factory has been closed since 2012

2.3.4 Agriculture, forestry, and other land-use change sectors

Jordanian agriculture is established along three major climatic regions: the highlands and marginal steppes, where most of the rain-fed farming is practiced, the Badia (mainly livestock systems and some cultivation in a watershed and from deep bore irrigation), and the lowlands (Jordan Valley) that thinly stretches from the North West to the South West.

The highlands have a Mediterranean climate characterized by a hot, dry summer and a cool, wet winter separated by two short transitional periods. The southern and eastern parts of the country are arid, with hot, dry summers and cold, dry winters. Temperature increases towards the south, with exceptions in some southern highlands. Precipitation is highly variable and is confined mainly to the winter and early spring seasons and ranges from over 500mm in the highlands to less than 50mm in the east. The long-term average annual precipitation is 8,317 million cubic meters, of which about 92.5% is lost to evaporation. The Eastern Desert (also known as the Badia) lies east of the mountainous region and covers about 80% of the land area of Jordan, has a low precipitation (the Updated Rangeland Strategy for Jordan, 2014).

According to the Ministry of Agriculture 2018 Statistical Report, cultivated lands account for (2.3-2.8 million dunum). On average, irrigated areas constitute around 1 million dunums (40% of the cultivated areas), while rainfed areas constitute about 1.5 million dunums (60% of the cultivated areas).

The contribution of agriculture to the GDP in relative terms declined sharply from 40% in the 1950s to 4.8% in 2018. Irrespective of how humble the contribution of agriculture is to GDP and economic performance, farming remains essential. The importance of the agricultural sector stems from the fact that it is not only a major source of food, particularly dairy products, fruits, and vegetables, but it is also a source of livelihood for around 25-30% of the total poor population (livestock keepers, smallholder farm households, and landless former agriculturalists) living in rural areas (World Bank- Technical Note, 2018).

The GHG emissions of the AFOLU activities accounted for 2% (651.67Gg of CO_2eq) of Jordan's total GHG emissions in 2017, acting as a net emission source. The emissions were composed of methane and nitrous oxide and were generated by various subcategories. AFOLU emissions and removals are shown in **Table 2.6** and **Figure 2.4**.

CH_4 emissions from livestock are caused mainly by enteric fermentation. The CH_4 emissions increased from 29 Gg CH_4 in 2012 to 33 Gg in 2017 (the difference being 3.8 Gg CH_4 which gives 79.8 Gg CO_2eq), and it is caused by the significant increase of sheep numbers in 2017 (Syrians migrated with their livestock).

Table 2.6: Emissions of the AFOLU sector, 2017

Categories	Net CO_2 (Gg)	CH_4-CO_2eq (Gg)	N_2O-CO_2eq (Gg)	Net CO_2eq (Gg)
Agriculture, Forestry, and Other Land Use	-912.29	696.10	867.85	651.67
Livestock	NA	691.56	21.60	713.16
Land	-923.38	NA	NA	-923.38
Aggregate sources and non-CO_2 emissions sources on land	11.087	4.54	846.25	861.88

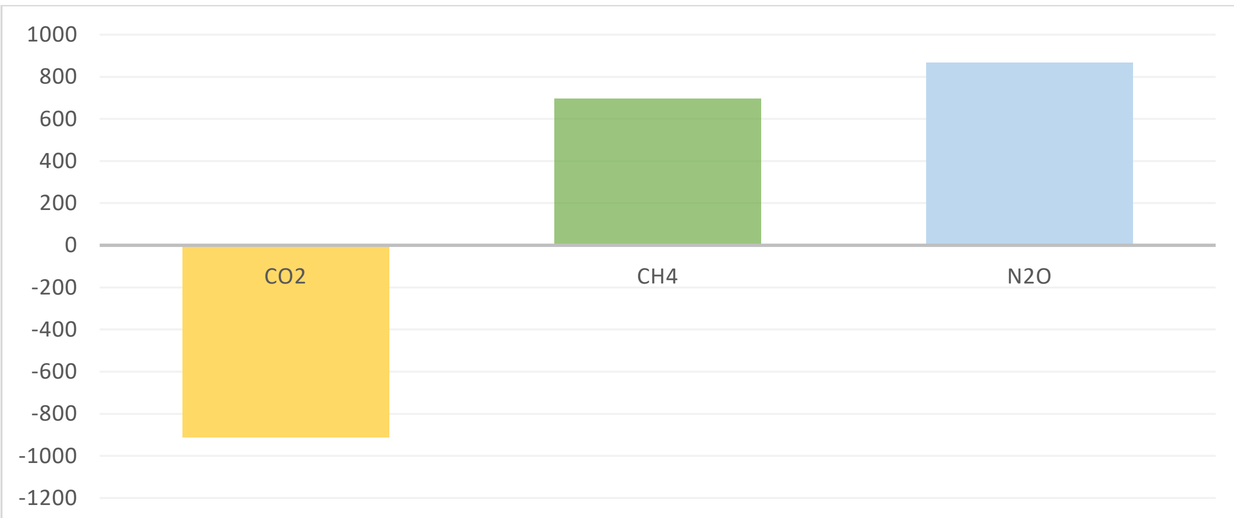


Figure 2.4: Emissions of the AFOLU sector, 2017

2.3.5 Waste Sector

Jordan has experienced a large increase in population over the past decade as a result of a high population growth rate and enforced migration. Economic and cultural development has improved the standard of living and changed consumer habits, resulting in an increase in the volume of MSW over time. However, no official statistics have been disclosed regarding the increase in solid waste generation after the influx of Syrian refugees. Yet, preliminary official estimates refer to a more than 20-35% increase in solid waste generation in Jordan following the Syrian crisis, putting a substantial burden on municipalities as well as on the surrounding ecosystems.

MSW management is one of the most important services provided by municipalities in Jordan. Solid waste is collected from 100 municipalities, which are then transported to transfer stations, sanitary landfills, or open dumpsites. There are 18 recorded landfills in the country, most of which are not adequately designed or operated, demonstrated by their lack of proper lining, leachate collection system, and landfill gas management system. The only sanitary landfill is the Al-Ghabawi landfill, which receives 50% of the waste produced in Amman and Zarqa. Al-Ghabawi landfill is located 23 km to the East of Amman over an area of 2000 Dunums, enough to dispose of waste until 2025, using safe refuse/tipping techniques. The Greater Amman Municipality purchased 1000 Dunums from surrounding lands to rent out to the private sector to encourage investment in waste segregation and recycling.

In 2017, GHG emissions from the waste sector reached 4046.37 Gg of CO_2eq, accounting for 12% of Jordan's total GHG emissions. Most of the emissions were generated from domestic solid waste disposal, which accounted for 94% (3792.30 Gg of CO_2eq) of total waste emissions, while wastewater handling accounted for 5% (193.30 Gg of CO_2eq) of total waste emissions. Table 2.7 and Figure 2.5 show the 2017 emissions breakdown by the waste sector.

Table 2.7: Emissions of the waste sector, 2017

Categories	CO_2	CH_4	N_2O	Total CO_2eq
	(Gg)	(Gg of CO_2 eq)		(Gg)
Waste	32.91	3855.97	157.48	4046.37
Solid Waste Disposal	NA	3792.30	NA	3792.30
Incineration and Open Burning of Waste	32.91	23.26	4.59	60.76
Wastewater Treatment and Discharge	NA	40.40	152.89	193.30

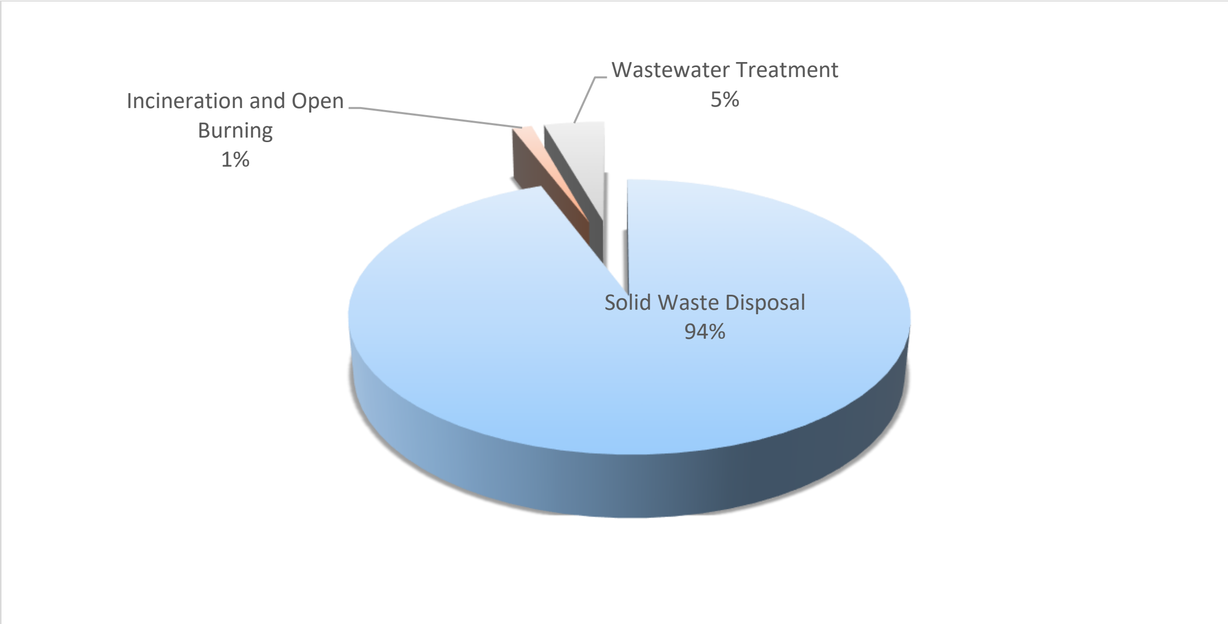


Figure 2.5: Emissions (%) of the waste sector, 2017

2.4 GHG Inventory by Gas

The share of carbon dioxide was the largest with a contribution of 25227.5 Gg accounting for 77% of all GHG emissions, followed by CH_4 and N_2O, accounting for only 15% and 5%, respectively, as indicated in Figure 2.6.

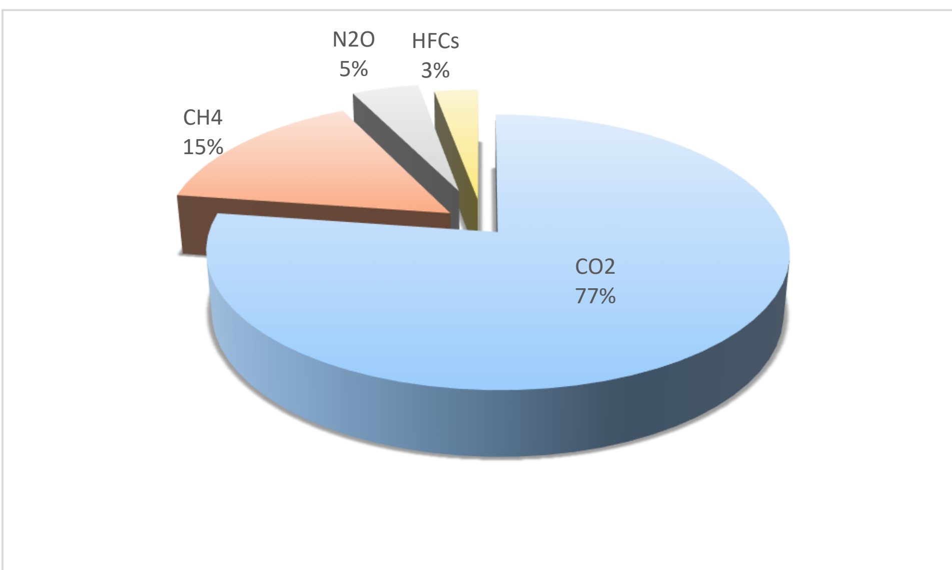


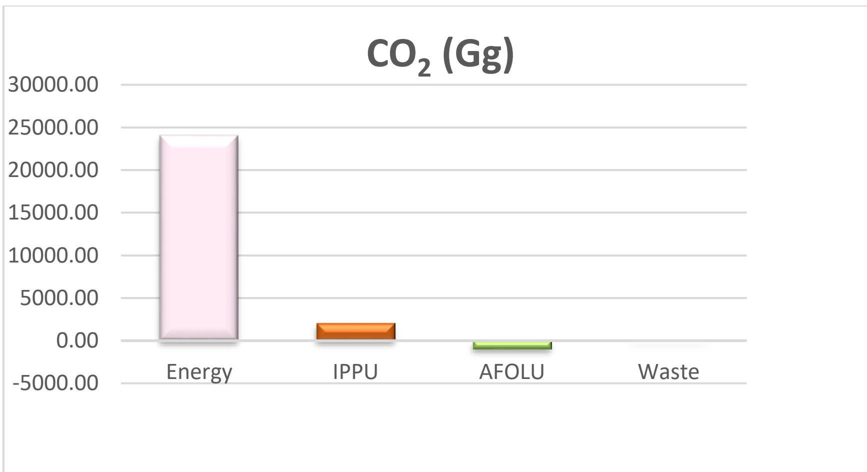
Figure 2.6: National emissions (%) by gas, 2017

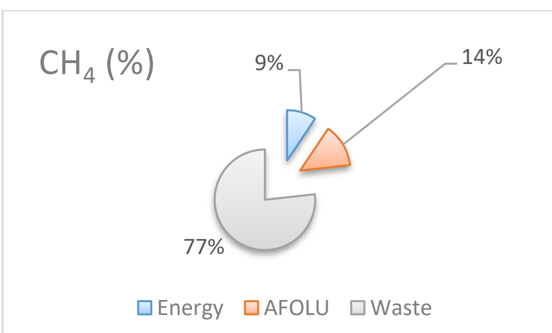
In 2017, most carbon dioxide emissions resulted from the energy sector accounting for 24,062 Gg, followed by 2045 Gg from the IPPU sector. Methane emissions were highest from the waste sector, followed by the AFOLU sector with 77% and 14% contributions, respectively. Nitrous oxide emissions were highest from AFOLU (60%), followed by the IPPU sector (18%) and energy and waste sectors, both of which contribute approximately 11%.

As expected, the IPPU sector contributed 100% of HFCs, and the NMVOCs emissions were mostly from IPPU and Energy. Within the energy sector, the significant emissions were in the form of CO_2 (97%). Within the IPPU sector, the key GHGs were CO_2 followed by HFCs with shares of 63% and 29%, respectively. Within the waste and AFOLU sectors, methane emissions were the highest resulting from solid waste management, livestock, land, and manure management, as shown in **Table 2.8** and **Figure 2.7**.

Table 2.8: GHG emissions (+) and removals (-) in Gg CO2eq by sector and by gas, 2017

Categories	CO_2	CH_4	N_2O	HFCs	SF_6
	(Gg)	(Gg of CO_2eq)			
Total National Emissions and Removals	25227.46	5024.92	1452.01	942.38	0.022
Energy	24061.72	472.84	166.82	NA	NO
IPPU	2045.12	NO	259.86	942.38	0.022
AFOLU	-912.29	696.10	867.85	NA, NO	NO
Waste	32.91	3855.97	157.48	NA	NO





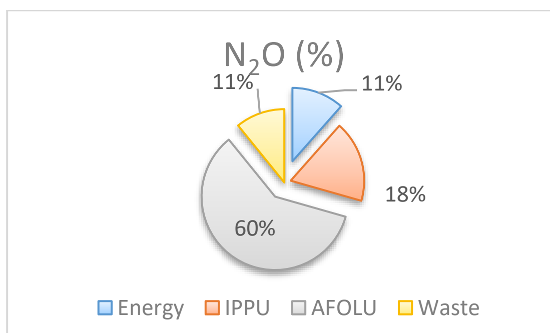


Figure 2.7: GHG emissions by gas for all sectors, 2017

2.4.1 Indirect GHGs and other gases not controlled by the Montreal Protocol

Emissions were calculated for indirect GHGs (CO, NOx, NMVOC) and other gases not controlled by the Montreal Protocol, such as (SOx). The calculations were performed using the EMEP/EEA air pollutant emission inventory guidebook 2019. Results of 2017 are shown in **Table 2.9**.

Table 2.9: Indirect GHGs and other gases not controlled by the Montreal Protocol, 2017

Greenhouse gas source and sink categories	**CO**	**NOx**	**NMVOCs**	**SOx**
	Gg			
Total National Emissions and Removals	122.01	42.94	55.31	0.18
1 - Energy	122.01	42.94	22.7	0.18
1A - Fuel Combustion Activities	122.01	42.94	15.66	0.18
1A1 - Energy Industries	4.65	13.54	0.35	46.82
1A2 - Manufacturing Industries and Construction	7.95	11.42	1.14	16.76
1A3 - Transport	122.01	42.94	15.66	0.18
1A4 - Other Sectors	6.65	6.87	1.75	0.39
1A5 - Other	0.72	2.3	0.2	0.0162
1B - Fugitive Emissions from Fuels	NE	NE	7.04	NE
1B1 - Solid Fuels	NO	NO	NO	NO
1B2 - Oil and Natural Gas	NE	NE	7.04	NE
2 - Industrial Processes (Food & Beverages Industry)	NO	NO	3.33	NO
3 - Solvent and Other Product Use	NO	NO	29.28	NO

2.4.2 Total National Emissions and Removals

Total emissions from all sectors and subsectors in 2017 as generated by the IPCC software (NAI Reporting Tables) are shown in **Table 2.10**.

Table 2.10: Overall 2017 GHG inventory (NAI Reporting Table 1 and 2 from IPCC 2006 software)

Table 1-NAI Reporting: Inventory Year: 2017

Greenhouse gas source and sink categories	Net CO2 (Gg)	CH4 (Gg)	N2O (Gg)	CO Gg	NOx (Gg)	NMVOCs (Gg)	SOx (Gg)
Total National Emissions and Removals	25216.38	206.35	1.88	46.17	131.45	57.01	0.19
1 - Energy	24061.72	22.52	0.5382	46.17	131.45	23.79	0.19
1A - Fuel Combustion Activities	24041.19	3.15	0.5379	46.17	131.45	16.87	0.19
1A1 - Energy Industries	9138.76	0.22	0.03	4.68	14.10	0.36	54.25
1A2 - Manufacturing Industries and Construction (ISIC)	2043.93	0.06	0.02	6.14	9.94	0.92	14.73
1A3 - Transport	9273.83	2.24	0.46	46.17	131.45	16.87	0.19
1A4 - Other Sectors	2890.39	0.54	0.02	2.16	2.35	6.04	0.01
1A5 - Other	694.28	0.09	0.01	0.84	2.77	0.19	0.0189
1B - Fugitive Emissions from Fuels	20.53	19.37	0.0003	NE	NE	6.92	NE
1B1 - Solid Fuels	NO	NO	NO	NO	NO	NO	NO
1B2 - Oil and Natural Gas	20.53	19.37	0.00029	NE	NE	6.92	NE
2 - Industrial Processes	2034.97	NA	0.736	NO	NO	3.41	NO
2A - Mineral Products	1632.20	NA	NA	NO	NO	NA	NO
2B - Chemical Industry	NA	NA	0.736	NO	NO	NA	NO
2C - Metal Production	402.77	NA	NA	NO	NO	NA	NO
2D - Other Production	NA	NA		NO	NO	NA	NO
2E - Production of Halocarbons and Sulphur Hexafluoride				NO	NO	NA	NO
2F - Consumption of Halocarbons and Sulphur Hexafluoride				NO	NO	NA	NO
2G - Other (Food and Beverages Industry)	0	0	0	NO	NO	3.41	NO
3 - Solvent and Other Product Use	10.150	0.000	0.102	NO	NO	29.81	NO
4 - Agriculture		32.931	2.800	NE	NA	NA	NA
4A - Enteric Fermentation		31.402		NA	NA	NA	NO
4B - Manure Management		1.529	0.074	NA	NA	NA	NO
4C - Rice Cultivation		NO		NO	NO	NO	NO
4D - Agricultural Soils			2.726	NA	NA	NA	NO
4E - Prescribed Burning of Savannas		NO	NO	NO	NO	NO	NO
4F - Field Burning of Agricultural Residues		NA	NA	NE	NE	NE	NE
4G - Other (please specify)				NO	NO	NO	NO
5 - Land-Use Change & Forestry	-912.29	0.22	0.00	NA	NA	NA	NO

Table 1-NAI Reporting: Inventory Year: 2017

Greenhouse gas source and sink categories	Net CO2 (Gg)	CH4 (Gg)	N2O (Gg)	CO Gg	NOx (Gg)	NMVOCs (Gg)	SOx (Gg)
5A - Changes in Forest and Other Woody Biomass Stocks	-923.38			NA	NA	NA	NO
5B - Forest and Grassland Conversion	NA	NA	NA	NA	NA	NA	NO
5C - Abandonment of Managed Lands	NA			NA	NA	NA	NO
5D - CO2 Emissions and Removals from Soil	NA		NA	NA	NA	NA	NA
5E - Other (biomass burning)	11.087	0.22	NA	NA	NA	NA	NO
6 - Waste	32.91	183.62	0.51	NO	NO	NO	NO
6A - Solid Waste Disposal on Land		180.59		NA	NA	NA	NO
6B - Wastewater Handling		1.92	0.49	NA	NA	NA	NO
6C - Waste Incineration	1.92	NE	NE	NA	NA	NA	NO
6D - Other (open burning)	30.99	1.11	0.01	NA	NA	NA	NO
7 - Other (please specify)	NA	NA	NA	NA	NA	NA	NA
Memo Items							
International Bunkers	1173.77	0.03	0.03	NE	NE	NE	NE
1A3a1 - International Aviation	928.37	0.01	0.03	NE	NE	NE	NE
1A3d1 - International Marine (Bunkers)	245.41	0.02	0.01	NE	NE	NE	NE
Multilateral operations	NA	NA	NA				
CO2 emissions from biomass	70.412						

Table 1-NAI Reporting: Inventory Year: 2017

	HFC			PFC			SF6
Greenhouse gas source and sink categories	HFC-23 (Gg)	HFC-134 (Gg)	Other (Gg-CO2)	CF4 (Gg)	C2F6 (Gg)	Other (Gg-CO2)	SF6 (Gg)
Total National Emissions and Removals	NA	NA	942.38	NE	NE	NE	0.000001
1 - Energy							
2 - Industrial Processes	NA	NA	942.38	NE	NE	NE	0.000001
2A - Mineral Products							
2B - Chemical Industry							
2C - Metal Production	NA	NA	NA	NE	NE	NE	NA
2D - Other Production							
2E - Production of Halocarbons and Sulphur Hexafluoride	NA	NA	NA	NE	NE	NE	NA
2F - Consumption of Halocarbons and Sulphur Hexafluoride	NA	NA	942.38	NE	NE	NE	0.000001
2G - Other (please specify)							
3 - Solvent and Other Product Use							
4 - Agriculture							
5 - Land-Use Change & Forestry							
6 - Waste							
7 - Other (please specify)							

2.5 Reference Approach

The Reference Approach and the Sectoral Approach often yield different results because the Reference Approach is a top-down approach using the country's energy supply data and has no detailed information on how the individual fuels are used in each sector. This approach provides estimates of CO_2 to compare with estimates derived using a Sectoral Approach. The Reference Approach provides an upper bound to the Sectoral Approach '1A Fuel Combustion' because some of the carbon in the fuel is not combusted but is released as fugitive emissions (as leakage or evaporation in the production and transformation stage). Calculating CO_2 emissions with the two approaches can lead to different results for some countries.

The Reference Approach was used to calculate energy sector emissions in 2017, and the results were compared to those of the Sectoral Approach. The gap between the two approaches is supposed to be relatively small (5% or less). The calculated differences were acceptable; less than 5%, as indicated in **Table 2.11**.

Table 2.11: Reference approach vs. sectoral approach, 2017

Year	Reference Approach	Sectoral	Difference
	CO_2 Emissions (Gg)		%
2017	25222.58	24060.08	4.83

GHG emissions were also estimated using the Reference Approach for the time series (2013-2017) (**Table 2.12** and **Figure 2.8**).

The outcomes indicated a steady increase in energy consumption for 2013-2017. An unexpected decrease in 2015 emissions was noticed due to a change in the energy mix of electricity generation in the form of using natural gas, a less carbon-intense fuel than Fuel Oil and Diesel.

Table 2.12: Emissions trend for time series (2013-2017)

Year	Energy Consumption (TJ)	CO_2 (Gg)
2013	317581.57	22772.64
2014	327784.75	24136.90
2015	345185.21	23936.91
2016	379660.75	24017.75
2017	384415.17	25310.38

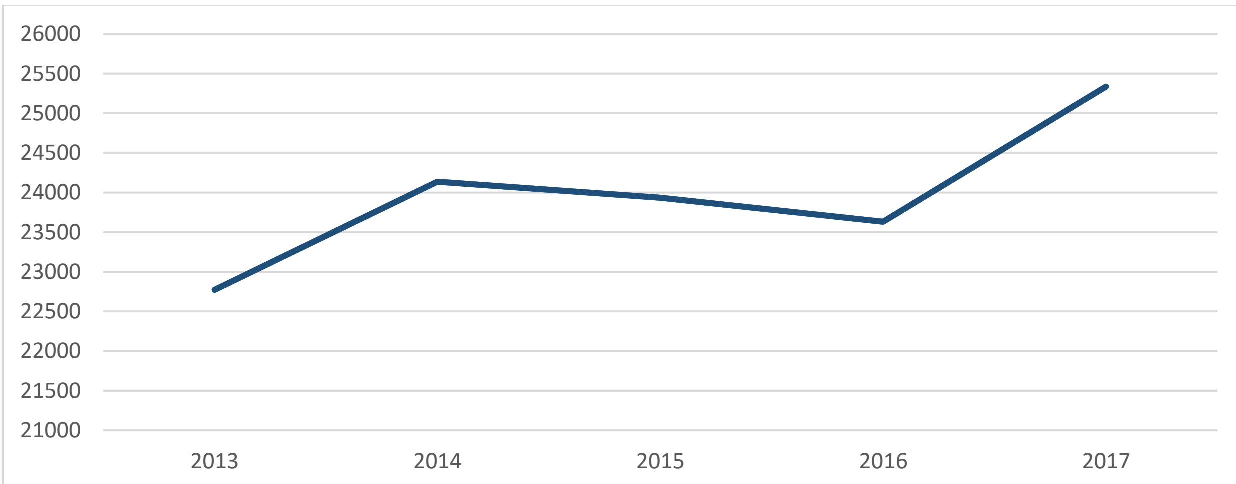


Figure 2.8: Emissions trend for the years 2013-2017

2.6Time Series and Comparison between Current and Previous Inventories

The time series is a central component of the greenhouse gas inventory because it provides information on historical emissions trends and tracks the effects of strategies to reduce emissions at the national level. As is the case with estimates for individual years, emission trends should be neither over nor underestimated as far as can be judged.

All emissions estimates in a time series should be estimated consistently, which means that as far as possible, the time series should be calculated using the same method and data sources for all years. Using different methods and data in a time series could introduce bias, because the estimated emission trend will reflect real changes in emissions or removals and the pattern of methodological refinements. Chapter Five, Volume one of the 2006 IPCC Guidelines, was consulted about good practices ensuring time series consistency.

Recalculations were carried out for the years 2010 and 2012. Also, techniques for combining or "splicing" different methods or data sets to compensate for incomplete or missing data were used for estimating the years 2000 and 2006.

Figure 2.9 and **Table 2.13** provide an overview of Time Series estimation:

- As expected, GHG emissions increases were noticed, between the different years, due to population growth and increased economic activities.
- Category 1.B - Fugitive emissions from fuels, for the years 2010 and 2012, were recalculated using the correct emission factor for onshore - developing countries, and this resulted in new figures (from 1.02 Gg CO_2 eq. to 1.26 Gg CO_2 eq. and from 235.98 Gg CO_2 eq. to 336.75 Gg CO_2 eq respectively)
- Also, Category 2.D - Non-Energy Products from Fuels and Solvent Use was recalculated for 2010 and 2012, due to an error in emission factor unit conversion. Results were modified from 208.80 Gg CO_2 eq. to 226.88 Gg CO_2 eq and from 2.85 Gg CO_2 eq. and 3.09 Gg CO_2 eq respectively.
- All sectors for 1994 will be calculated as part of the third BUR. Collecting data was challenging due to difficulties in getting the activity data for the required year, in due time.
- The IPPU and AFOLU sectors for 2000 and 2006 were not estimated due to difficulties in getting the activity data for the required years, in due time. Recalculation will be carried out as part of the third BUR.

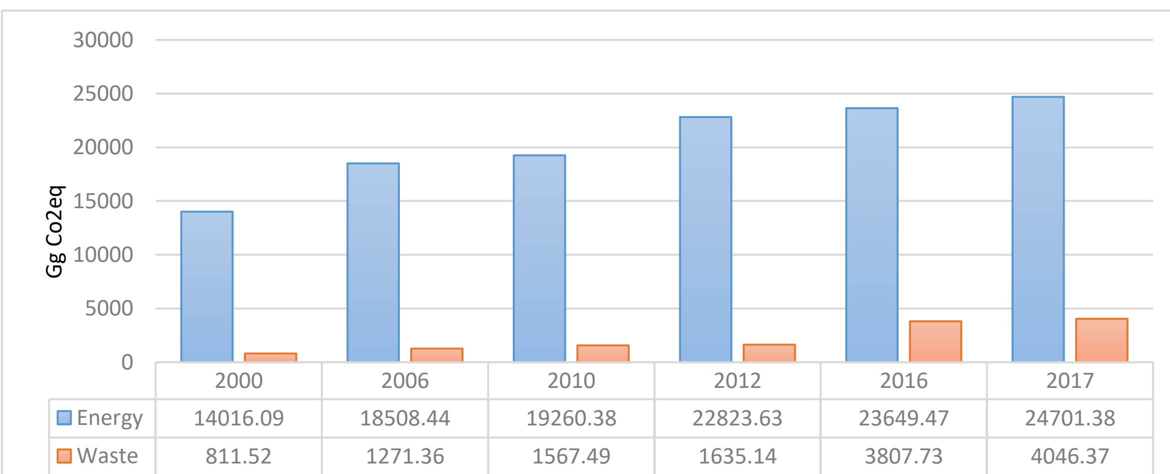


Figure 2.9: Comparison between a time series for the energy and the waste sectors

The above figure illustrates a comparison between the energy and waste sectors for 2000, 2006, 2010, 2012, 2016, and 2017. There is a typical trend of increase along the various years that could be attributed to population increase and economic growth.

Table 2.13: Comparison between a time series of National GHG Inventories

Categories/Years	**2000**	**2006**	**2010**	**2012**	**2016**	**2017**
	Gg CO_2 eq					
Total National Emissions and Removals	14827.61	19779.8	23170.94	28110.71	31063.32	32646.79
1 - Energy	14016.09	18508.44	19260.38*	22823.63*	23649.47	24701.38
2 - Industrial Processes and Product Use	NE**	NE**	1776.09*	3144.71*	3177.42	3247.38
3 - Agriculture, Forestry, and Other Land Use	NE**	NE**	180.5	237.29	428.71	651.67
4 - Waste	811.52	1271.36	1567.49	1635.14	3807.73	4046.37
Memo Items (5)						
International Bunkers	523.53	905.40	1078.11	1110.02	4320.36	4154.33
1.A.3.a.i - International Aviation (International Bunkers)	519.04	734.85	1016.41	1044.24	3394.73	3315.42
1.A.3.d.i - International water-borne navigation (International bunkers)	4.49	162.49	52.2602	56.0552	925.63	838.92
1.A.5.c - Multilateral Operations	NA	NA	NA	NA	NA	NA

* These categories have been recalculated

** These categories were not estimated (they will be estimated as part of the third BUR)

2.7 Key Category Analysis

The key category analysis is an essential element for inventory development and a driving factor to improve its quality. Non-Annex I Parties are encouraged (Decision 17/CP.8), to the extent possible, to undertake any key category analysis to assist in developing inventories that better reflect their national circumstances. The analysis was carried out based on IPCC 2006 Guidelines and Software. Jordan used "level" key category analysis where the contribution of each source or sink category to the total national inventory level was calculated. The Key categories according to the guidelines are those that, when summed together in descending order of magnitude, add up to 95% of the sum of all level assessments.

Parties should try to use a recommended method according to the corresponding decision tree in the 2006 IPCC Guidelines in categories identified as key. It is recommended that Jordan searches for alternatives to gradually apply in future inventory submissions, to the extent possible and based on software readiness and national circumstances, Tier 2 methods in the categories identified as key.

In the total national GHG emissions of 2017, various Fuel Combustion Activities subcategories were among the top four sources accounting for around 65.6% of all emissions, mainly: Energy Industries (Liquid Fuels), Road Transportation, other sectors (Liquid Fuels), and Energy Industries (Gaseous Fuels). Road Transportation, Energy Industries (Gaseous Fuels), and solid waste management kept their rank.

A slight change was detected between Other Sectors - Liquid Fuels and Energy Industries - Liquid Fuels between 2016 and 2017. Where Other Sectors- Liquid Fuels moved up one level compared to Energy Industries - Liquid Fuels, this could be due to the increase of natural gas and renewables in the energy mix for electricity generation. The Manufacturing Industries and Construction (Liquid Fuels and solid fuels), cement production, and AFOLU accounted for the rest of the emissions, as shown in **Table 2.14**.

Table 2.14: Key category analysis (level assessment), 2017

A	B	C	D	F	G
IPCC Category code	IPCC Category	GHG	2017 Emissions CO_2eq (Gg)	2017 Emissions Level from the Given Category	Cumulative Total % of Column F
1.A.3.b	Road Transportation	CO_2	9231.11	0.27	27.1%
1.A.1	Energy Industries - Gaseous Fuels	CO_2	6425.98	0.19	45.9%
4. A	Solid Waste Disposal	CH_4	3792.30	0.11	57.1%
1.A.4	Other Sectors - Liquid Fuels	CO_2	2909.29	0.09	65.6%
1.A.1	Energy Industries - Liquid Fuels	CO_2	2712.78	0.08	73.6%
2.A.1	Cement production	CO_2	1543.23	0.05	78.1%
1.A.2	Manufacturing Industries and Construction - Liquid Fuels	CO_2	1472.03	0.04	82.4%
3.B.1.a	Forest Land Remaining Forest land	CO_2	-923.60	0.03	85.1%
2.F.1	Refrigeration and Air Conditioning	HFCs, PFCs	911.68	0.03	87.8%
3.C.4	Direct N2O emissions from managed soils	N_2O	721.23	0.02	89.9%
1.A.5	Non-Specified - Liquid Fuels	CO_2	694.28	0.02	92.0%
3.A.1	Enteric Fermentation	CH_4	659.45	0.02	93.9%
1.A.2	Manufacturing Industries and Construction - Solid Fuels	CO_2	571.91	0.02	95.6%

2.8 Uncertainty Analysis

The uncertainty analysis is one of the main activities of the inventory process. Uncertainty information is intended to help prioritize efforts to improve the accuracy of inventories and guide decisions on the methodological choice.

The analysis was carried out based on IPCC 2006 Guidelines and Software. "Approach 1: Propagation of Error" was used. Approach 1 is based upon error propagation and estimates uncertainty in individual categories in the inventory as a whole and trends between 2016, 2017, and the base year 2010. The uncertainty analysis was based on the Tier 1 approach and covered all source categories and direct greenhouse gases. The uncertainty estimation for the activity data and emission factors was based on the typical values of the IPCC.

For 2017, the net emissions were 32646.79 Gg of CO_2eq with an uncertainty of ±3.5%, which corresponds to a 95% probability range of 31504.15 to 33789.43 Gg of CO_2eq. Based on the total base year of 2010 and 2017 inventories, the average trend is a 40% increase in emissions from 2010 to 2017. The uncertainty in the trend is ±5% (percentage points), which corresponds to a 95% probability range for the trend concerning base year emissions.

2.9 GHG Inventory Quality Control/Quality Assurance and Review

Jordan acknowledges the need to have a manual for national QA/QC procedures for GHG inventory estimation. This has been listed in Jordan's future improvement plans (section 2.12). Also, during the preparation of the GHG Inventories, the inventory team and the 4NC project management team carried out the following tasks:

- Overall assessment of technical reviews, and accuracy checks performed by the compilers to ensure consistency, accuracy, completeness, and to avoid double counting.
- Checking the accuracy of data input from the original references, confirming that correct references were used, and ensuring no transcription errors exist.
- Checking that parameter and emission units are correctly recorded. Appropriate conversion factors are used and checked for consistency, to ensure that all experts used the same conversions and factors for the various subsectors.
- Checking that the progression of inventory data through the processing steps is correct
- Checking that there is detailed internal documentation to support the estimates and enable full reconstruction of the estimate.
- Checking that inventory data are archived and stored to facilitate detailed review.

In terms of quality assurance, the national GHG inventory chapter was subjected to an international review which was coordinated by the UNDP-UNEP Global Support Program (GSP) and was conducted from 7 to 13 October 2020 by Dr. Carlos López, consultant in national GHG emissions inventories. The review examined mainly the adherence of the inventory chapter to the requirements indicated in the UNFCCC Decision 17/CP.8 Annex, the UNFCCC Decision 2/CP.17 Annex III, and to the advice of the IPCC Guidelines and Guidance. The review outcomes resulted in several direct actions to improve the chapter and an inventory future improvement plan (IIP), described in detail in the following section.

2.10 Future Improvement Plan

The GSP reviewer identified several actions. The improvements are listed below and are rated according to urgency, from immediate to short term and long-term actions:

- The activity data used in the estimate, especially in the subcategories identified as key or significant, to use tier 2, and should be improved as much as possible. In addition, actions to improve data, methods, EF, and other estimation parameters (OEP) should be prioritized in key categories, to use tier 2 (especially in the subcategories 2F1a, 4A Solid Waste Disposal, 3A1c Sheep, and 3B Land). **(Short term and long term**)

- The documentation boxes and worksheet remarks included within the software should be completed. **(Short term**)

- The completeness of the inventory should be improved by: **(short term to long term**)
    - Improving the estimation and reporting of precursor gas emissions in future inventory submissions (activity data and EF are mostly available).
    - Incorporating among the precursor gases, the estimation of NH_3 emissions. This would make it possible to calculate in category 5A the indirect N_2O emissions derived from the atmospheric deposition of Nitrogen from non - agriculture sources.
    - The precursor gas emissions of these subcategories from the second-order subcategories 1.A.3.a.i - International aviation and 1.A.3.d.i - International waterborne navigation (international bunkers) should be estimated and reported using the notation key NE (not - estimated) in the reporting tables, as necessary.

- The key analysis -trend assessment should be used, after improving issues related to the time series of the inventory. Also, qualitative criteria should be applied to the categories located at the threshold of 95-97% of cumulative emissions. **(Short term**)

- Prepare a QA/QC and verification plan and manual for the coming inventory **(short term)**.

2.11 References

- 2006 IPCC Guidelines for National Greenhouse Gas Inventories and its 2019 Refinement.
- Amman Chamber of Industry Website, http://www.aci.org.jo, accessed December 2019.
- Arab Fertilizers and Chemical Industries (Kemapco).
- Amman Chamber of Industry Website, http://www.aci.org.jo, accessed December 2016.
- Amount and Characterization of Dairy Cattle Manure and Poultry Litter in Jordan, AECOM, August 2014.
- Central Bank of Jordan – Statistical Database, http://statisticaldb.cbj.gov.jo/index, accessed December 2019.
- Customs Department, letter No. 18/14/131 dated 8/1/2020
- Department of Statistics website: www.web.dos.gov.jo accessed May 2020
- Department of Statistics, Jordan's country analysis; environmental indicators, 1998, 2000, 2006, 2010, 2012, 2016, and 2017.
- Energy and Minerals Regulatory Commission (EMRC).
- EEA, 2019. EMEP/EEA air pollutant emission inventory guidebook, 2019. Technical guidance to prepare national emission inventories.
- FAO statistic- online (http://www.fao.org/faostat/en/#data/QA), accessed May 2020
- Fact Sheets 3, 4, 8, and 9, prepared by UNEP Ozone secretariat, 2015. (Annex 3)
- HFC Inventory of JORDAN, UNIDO,2015
- Horizon 2020 Mediterranean Report, Annex 2- Jordan, EEA Technical Report, No.6l2014.
- Jordan Investment Commission, sector profile, https://www.jic.gov.jo, accessed December 2019.
- Jordan Chamber of Industry Website, http://www.jci.org.jo, accessed December 2019.
- Jordan Petroleum Refinery Company Annual Reports 1998, 2000, 2006, 2010, 2012, 2016, and 2017.
- Jordan Chamber of Industry Website, http://www.jci.org.jo, accessed May 2020.
- Jordan National Petroleum Company (JPRC) Formal Letter No. 11 /13 /804 dated 10 /6 /2020.
- Jordan Petroleum Refinery Company Annual Reports 2006, 2016, 2017.
- MEMR's Surveys 2012 and 2014 were published on MEMR's website.

- MEMR's annual brochures for 1998, 2000, 2006, 2010, 2012, 2016, 2017, 2018, and 2019.
- Ministry of Energy and Mineral Resources, Annual Energy Balance for 1998, 2000, 2006, 2010, 2012, 2016, and 2017.
- NEPCO Annual Reports for 1998, 2000, 2006, 2010, 2012, 2016 and 2017.
- Ministry of Agriculture (MOA), the Livestock Department, Annual reports of 1998, 2000, 2006, 2010, 2012, 2016, 2017, and 2018.
- Ministry of Water and Irrigation, water strategy of Jordan 2016-2025.
- Ministry of Water and Irrigation Annual Reports 1998, 2000, 2006, 2010, 2012, 2016, and 2017.
- Ministry of Health, Letter No. 2/a/1980 dated 19/10/2016
- M.A. Razzaq, J.U. Ahmed, M.A.M. Hossain, and S. Hossain (2018), A review on Hydrocarbon (HCs) as an Alternative Refrigerant: Based on Thermodynamic and Environmental Approach. Mechanical Engineering Research Journal, Vol. 11, pp. 86-96, 2018.
- NEPCO Annual Reports for 1998, 2000, 2006, 2016, 2017.
- National Petroleum Company PLC. Formal Letter No. 2 /3 /25 /29 / 1/ 3851 dated 25 /6 /2020.
- National Municipal Solid Waste Strategy (2015-2034)
- Project Design Document from (CDM-PDD): Project 3370: Amman Ghabawi Landfill Gas to Energy Project, 28 July 2006.
- Project Design Document from (CDM-PDD): Project 2487: Reduction of Methane Emissions from Ruseifeh Landfill
- Soil type data obtained from Jordan's Atlas: http://ressources.ciheam.org/om/pdf/b34/01002090.pdf accessed on June 2020.
- Solid Waste Value Chain Analysis Irbid and Mafraq- Jordan, UNDP, June 2015.
- Statistical studies for the agriculture sector 2004, 2014 prepared by MEMR for different sectors for selected years.
- Tackling Climate Change through Livestock, Food and Agriculture Organization of the United Nations, 2013.
- Updated Rangeland Strategy for Jordan, 2014.
- Water Authority of Jordan, Directorate of Operation and Monitoring of WWTP.
- Water Authority of Jordan (WAJ) regulation for connection to public sewer No.18/1998.
- World Bank- Technical Note, 2018.
- Eid, E., Abu Baker, M., and Amr, Z. (2020). *National Red data book of mammals in Jordan.* Amman, Jordan: IUCN Regional Office for West Asia Amman.
- Eid, E and Mallon, D. (2021). Wild ungulates in Jordan: past, present, and forthcoming opportunities. Journal of Threatened Taxa.13: 9.

3 GHG Baseline and Mitigation Assessment

3.1 Introduction and Methodology

Based on the requirements of the UNFCCC, this chapter documents the updating and construction of the baseline and mitigation scenarios in detail, based on the approved sectorial strategies, policies, implementation plans, laws, constraints, and trends prevailing in the Jordanian context during the targeted period 2018-2066.

3.1.1 Construction of Baseline Scenario

This simulates the events assumed to occur in the absence of mitigation efforts. In other words, it reflects a future in which there are no policies or programs designed to 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 cost of mitigation options are directly linked to the sound definition of the baseline scenario. The updated baseline scenario in 4NC has been constructed based on the sectorial approved strategies, plans, policies, laws, implementation plans, constraints, and trends prevailing in the Jordanian context during the current time. The construction of this baseline scenario needs huge data and studies, many of these, which were not available in the related institutions, were prepared by the 4NC team, namely, Electricity Generation Expansion Study, Electricity Forecast, and Energy Forecast, up to the year 2066. Also, in many cases, the construction of the baseline scenario required a projection of the current level of each type of activity, for the period 2018-2066. Such projection drew on assumptions made about population growth, GDP, value-added, discount rate, and so on. The macroeconomic variables for the base year and for the short period after were to be obtained from the official institutions.

3.1.2 Construction of the Mitigation Scenario

The mitigation scenario in 4NC was created according to a set of criteria reflecting country-specific conditions such as the potential for significant impact on greenhouse gas emissions, direct and indirect economic impacts, consistency with National Development Goals, the potential effectiveness of implementation policies and programs, sustainability of an option data availability for evaluation, and other sector–specific criteria. All mitigation options considered in TNC and FBUR and currently becoming part of the baseline scenario or became invalid will be removed from the current mitigation scenario. While all other remaining mitigation options will be counted in after adjustment is made in their expected implementation timeline and associated GHG emission reductions. Policies, programs, projects, and other mitigation options will be identified and considered in the current mitigation scenario.

The two baseline and mitigation scenarios were set up for the period 2018-2066. The analytical methodology of the energy sector is based on the LEAP model, the Long-range Energy Alternative Planning System (currently known as Low Emission Analysis Platform). LEAP is an integrated modeling tool developed to track energy consumption, production, and source extraction in all sectors of the economy. In addition to tracking GHGs, LEAP can also be used to analyze local and regional emissions of air pollutants, making it suitable for studies of the climate co-benefits for local air pollution reduction. Also, LEAP model can simulate the effect of selected mitigation options on overall costs and emissions. It is worth mentioning that the first time LEAP was used was in the FBUR project, with a base year of 2015.

In the 4NC, the energy baseline scenario was defined with 2018 as the base year and considers the policies, programs, and projects that have been incorporated in the energy strategy for 2020-2030 as committed and confirmed input for building up the baseline scenario for the period 2018-2066 using the LEAP model. For non-energy sectors such as industrial process and product use, and waste, linkages to macroeconomic, demographic and human behavior datasets from sectorial strategies will be assessed, to use inbuilding up the baseline scenario.

3.2 Baseline Scenario for the Energy Sector

During the last five years (2015-2020) and in the light of the tremendous fluctuating changes in the Jordanian economy and the energy sector during 2015-2020, which has already been mentioned in the energy circumstances section, in addition to COVID-19, with its profound effect on Jordanian society and economy, two strategies for the energy sector were adopted. The first is the Energy Sector Strategy for the period 2015-2025. The second is the Energy Strategy for the period 2020-2030.

The Energy Sector Strategy for the period 2015-2025 was approved by the Ministerial Council in December 2015, which updated the energy planning framework and established the following targets as strategic objectives:

- The achievement of the security of supply - providing the necessary energy for comprehensive development in a sustainable manner.
- The increase in the contribution of local energy sources to the overall energy mix and the reduction of the energy dependency on imports.
- The reduction of the cost of energy on the national economy.

Moreover, specific strategy axes were determined, including:

- The achievement of the security of oil derivatives supply, supplied sustainably and with enhanced competition in the sector.
- The achievement of the security of the electricity supply.
- The achievement of the security of the natural gas supply and the diversification of the sources of imports.
- The exploitation of renewable energy sources for electricity production and the extraction and exploitation of oil shale for generating electricity.
- The introduction of nuclear power for electricity production.

The second strategy, the Energy Strategy for the period 2020-2030, was approved in March 2020. The main objective of this strategy was to undertake a comprehensive review of the energy sector and formulate a long-term strategy to guide the future operation and development of the energy sector, to achieve its policy objectives and meet the energy needs of Jordan economically and environmentally in a sustainable manner.

3.2.1 Significant achievements during 2015-2020, the start of implementation of the Energy Strategy 2015-2020.

- The construction of the Green Corridor Project is one of the most crucial achievements, which increased the capacity of the electricity transmission from the south to the center of the Kingdom from 500 MW to 1400 MW. Jordan's electrical connection with the neighboring countries has been under development.
  The Ministry of Energy and Mineral Resources has succeeded in building a legislative and procedural base for renewable energy, which led to a significant increase in the use of renewable energy in the energy mix, whether by signing the many energy purchase agreements needed, by introducing Direct Proposal Schemes or by using solar energy to cover consumption for different sectors, using net metering and wheeling systems. This has led to a significant rise in the contribution of renewable energy (solar and wind) in the electricity generation mix, to about 1425 Meconate to the transmission grid, forming what accounts for 16% of the total electric power generated (excluding 720 MW of renewable energy projects, connected to the distribution networks) and in total accounts for 20% of the power generated in the Jordanian electric grid, both transmission and distribution networks, by the end of 2020. This has created good economic mobility in the local investment sector, since projects are implemented in different locations, creating hundreds of direct and indirect jobs and revitalizing supporting works in different sectors.
- Concerning energy efficiency, the energy intensity in 2020 accounted for 245 kgoe/1000 US$ at constant price,

- To achieve the strategic goal of increasing the contribution of natural gas to the overall energy mix, by securing an additional source of natural gas supply for Jordan. Jordan Oil Terminals Company (JOTC), a government-owned company, was established in 2015, to manage and operate the oil storage and logistics services across Jordan. The project was carried out to build strategic storage capacities.

3.2.2 Delayed energy infrastructure projects already listed in the Energy Strategy

- **Expansion of Jordan Oil Refinery Project.**

A decision was made to implement an expansion to Jordan Petroleum Refinery Company (JPRC) to improve the specifications of the petroleum products and to convert heavy petroleum derivatives into light products. Having an environmental management system is a requirement from the IFC, for granting the JPRC loan for expansion. In early 2020, the Refinery Company published a call for services, specifically to undertake the planning of an environmental management system that includes an Environmental Impact Assessment, Environmental Audit, Health and Safety, and Risk Assessment. Due to COVID-19, the implementation of this assessment was delayed, and accordingly, the expansion has been postponed. The expected completion date for the project is now 2025 instead of 2022.

- **Construction of the Iraqi Crude Oil Pipeline**

Due to the political situation in the region, a delay occurred in the construction of the Iraqi crude oil pipeline, which was supposed to transport Iraqi oil across Jordanian territory to the export terminal in Aqaba with a capacity of 1 million barrels/day, in addition to a branch to supply Jordan Oil Refinery with 150 thousand barrels/day. The completion date for the construction and operation of the pipeline is expected to be2028 instead of 2022.

- **Oil shale surface retorting projects.**

All the companies working in surface retorting of oil shale are still unable to fulfill the agreed obligations in their production schedules, due to changes in economic feasibility. All the oil shale companies have been asked to postpone their project development period and some of the oil shale companies have closed.

- **Nuclear Power Plant of 1,000 MW.**

In February 2019, the Ministerial Council took a decision to cancel the construction of the nuclear power plant with a proposed capacity of 1,000 MW, which was planned to be operational and contribute to the electricity system in 2023. This is due to the over-committed electricity generation capacity in terms of MW. The council decided to consider the introduction of smaller reactors instead, if this is feasible from the economic and technical point of view.

- **The third round of the renewable energy projects.**

The decision was taken by the Ministry of Energy and Mineral Resources to delay the third round of renewable energy projects, which consists of four 50 MW solar and two 50 MW wind projects, due to the decrease in the growth rate of electricity demand, which was 0-2 % during the period 2017-2020, and due to the over-committed generation capacity in MW.

3.2.3 Energy Infrastructure projects under construction

- **Al-Attarat oil shale project.**

The first electric power plant, with direct burning of oil shale is being implemented with a generating capacity of 470 MW and an investment cost of 2.2 billion US $. the first unit with a capacity of 235 MW will be put in operation in August 2022, while the second unit with the same capacity will be put into operation in December-2022.

- **The Renewable Energy Projects**

All the renewable energy projects listed in the energy baseline scenario of the FBUR, scheduled to be put into operation, during the period 2020 -2025 are being implemented, except for the third round of direct proposal schemes 4×50 MW solar energy projects and 2×50 MW wind energy projects which have been delayed, as previously mentioned. **Table 3.1** illustrates the renewable energy projects currently under construction.

Table 3.1: The renewable energy projects under construction

[

	Project Name		Capacity (MW)	Operation Date
Wind Energy projects	The first round of the direct proposal schemes: -Daihan project (51) MW -El-Abour project (51) MW		102	2010-2021
Solar Energy projects	The second round of the direct proposal schemes: -Mafraq development projects (50) MW -Al Safawi project (50) MW		100	2021
	Baynouna project		200	2021
	Al-Risha PV Project		50	Mid/2021
	East Amman Project		40	Mid/2021
	AL-Qatranna PV Project		30	2024
	AL-Hussiniha (Philadelphia) PV Project		50	2021
	Al-Haq PV Project		50	2021
	Universities' Projects		40	2023
	Welling Projects/ NEPCO's Transmission Grid		370	2022-2023
	Medium Industries		100	2023/2024
	Small Solar Systems (Less than 5 MW)	Net Metering Projects	150	2023
		Welling Projects	130	2023

3.3 Energy Baseline Scenario for the period 2020-2040 with prospective to 2066

Deep discussions with the Ministry of Energy and Mineral Resources officials on all changes in the economy and the energy sector during 2015-2020 affected the sector's strategies, policies, plans, activities, and projects. Therefore, the baseline consistent with the Energy Strategies has been reviewed and rebuilt for 2020-2040, with forecasts to 2066.

To rebuild the energy demand and supply baseline scenario, several matters and issues, which affect and drive the energy scenario were considered. The most important of these are as follows:

- **The over-commitment of electricity generation capacity in the country**

The generation capacity of thermal power plants as of the end of 31 December 2020 reached (4,257 MW) while the generation capacity of renewable energy projects (solar and wind) reached (14,25MW). Comparatively, the maximum peak load for the first half of 2020 was 3,630 MW. This volume of available generating capacity is large compared to the maximum, with an excess of 30%. This contrasts with internationally-recognized practices in the industry, which has limits of 10% -15% excess capacity, especially in electrical systems connected to electricity networks, similar to that used in Jordan. According to the Energy Purchase Agreement, this causes a high cost for the electrical system, since there is a commitment to pay for the cost of capacity for the power stations, even if their operation is suspended, based on the principle of take or pay. Continuous operation of the power stations is not needed as a result of the decline in growth rates in electricity demand, due to many reasons, including these:

- The recent drop in electricity demand due to consumer-owned renewable energy projects, the expansion of energy efficiency devices, and the slowdown in the economy have decelerated the growth of electricity loads below their expected values. The rise in fuel prices has led to an increase in electricity tariffs, for most consumer categories, especially the production sectors, resulting in large consumers exiting the grid and a dramatic decline in electricity tariff revenues.
- The significant increase in the contribution of renewable energy sources to the electric power mix in a relatively short time has also created several technical and financial challenges. The most important of which is the difficulty of operating the power system, in line with the optimal economic and technological model, and the complete use of the available capacities in transmission and distribution networks.

3.3.1 Energy Baseline Scenario for the period 2020-2040.

Based on the two energy strategies mentioned above and the results of the deep discussions with key officials in the Ministry of Energy, the most reliable policies, projects, and activities considered in the baseline scenario up to 2030 and beyond to the year 2066 are summarized in the following sections.

3.3.1.4 The Field of Oil and Oil Products

The main policy is securing the Kingdom's needs for crude oil and oil products. Securing the Kingdom's oil products needs will be achieved by the following:

- Jordan Petroleum Refinery will continue to produce 14 thousand tonnes per day (100 thousand barrels) to meet 60% of the need of the domestic market for oil products, according to 2020 statistics. The remainder of the needs of the domestic market for oil products to be imported. This arrangement is proposed to last up to 2040.
- Implement the expansion of the Jordan Petroleum Refinery to convert heavy petroleum derivatives to light products and improve the specifications of petroleum products. The expansion is planned to be completed by 2028.
- Continue to meet Jordan's needs for crude oil by importing oil from Saudi Arabia by sea, then transporting it in oil tankers to the oil refinery in the center area of the Kingdom. This is planned to continue up to 2029.
- Construction of the Iraqi crude oil pipeline to export Iraqi crude oil across Jordanian territory to the export terminal in Aqaba, with a capacity of 1 million barrels/day, in addition to a branch to supply Jordan Oil Refinery with 150 thousand barrels/day. The pipeline is expected to be completed in 2029. The pipeline project between Jordan and Iraq would remove a large number of trucks from the road network, since trips by oil trucks to the refinery in Zarqa are expected to be mostly replaced by pipeline.
- The continuation of the policy of liberalization of prices of petroleum products. The pricing oil products on a monthly basis in accordance with international oil prices, is considered to be the most successful mechanism and technique to improve the efficiency of consumption and will be continued.

3.3.1.2 The Field of Natural Gas

- The main policy is diversifying the natural gas resources, routes, and suppliers. After the construction and completion of the LNG terminal in Aqaba, which went into commercial operation in September 2015, Jordan can meet all the Country's needs for natural gas for electricity generation and the industrial sector.
- Currently, Jordan imports natural gas by three routes: via the LNG terminal in Aqaba, which went into commercial operation in September 2015, via the Arab Gas Pipeline from Egypt, and via pipeline from the Noble Energy Company, based on a take or pay agreement ended in the year 2035. It is planned to keep natural gas as one of the most significant sources of electricity generation, beyond 2035.
- In 2020, 84 % of the electricity generation of the Kingdom was based on natural gas imported via the LNG terminal and Egyptian natural gas and Nobel Energy Company.
- The natural gas needed for electricity generation during 2018-2022 was estimated to be 350-420 Million Cubic Feet per Day (MMcfd). However, in the period 2023-2025, the quantity will be decreased to 250-350 MMcfd, due to the operation of the oil shale power plants. The demand of the industrial sector for natural gas is estimated to be 150 MMcfd in the same period of 2023-2025.
- In addition, the National Petroleum Company (NPC) plans to develop the Risha gas field, in Jordan, to increase natural gas production from the site to 50 MMcfd as a 1st stage. NPC has announced the Risha field as an investment opportunity and aims to attract a strategic partner for this project.

3.3.1.3 The Field of Renewable Energy

The main policy is utilization of renewable energy resources to generate electricity. As illustrated earlier, in light of the significant progress in utilizing renewable energy resources to generate electricity, the total capacity of the constructed, under construction, and committed projects during 2020-2025 will reach 2,400 MW. Considering the NEPCO situation, the total new capacity of wind and solar energy to be added to the system, during the period 2025-2030, will be 600 MW, of which 400 MW will be wheeling and net metering systems. Beyond 2030, renewable energy resources will be considered as the main candidate for the future expansion of electricity generation, especially if the storage succeeds from an economic and technical point of view. Accordingly, the penetration of the RES in the electricity generation mix will exceed 50% during the period 2030-2040, and this will be considered as a mitigation measure.

3.3.1.4 The Field of Oil Shale

The main policy is utilization of oil shale resources to generate electricity and produce oil.

- Oil shale projects for electricity generation - Due to NEPCO's over-committed electricity generating capacity in MW, the second direct proposal scheme for burning oil shale for electricity generation will be considered in 2030 or beyond, if it has priority from an economic and technical point of view.
- Oil shale projects for the extraction of oil shale: From an economic, technical, environmental, and trade point of view, this kind of project still faces many obstacles and problems, and it is not expected to be realized, during this decade. In Jordan, all the oil shale companies, working in this field, requested an extension of their development period, and some of the oil shale companies closed their businesses. Oil shale companies which have requested a development period extension were: Jordan Oil Shale Company (JOSCO), which had proposed the production of 20,000 barrels of oil shale in 2025, Jordan Oil Shale Energy Company (JOSE), which planned to produce 20,000 barrels/day in 2025, Karak International Oil Company (KIO) which intended to produce 25,000 barrels/day in 2024 and Saudi Arabian Corp for Oil Shale (SACOS), which planned to produce 20,000 barrels/day in 2025.

3.3.1.5 The Field of Nuclear Energy

Considering the over-committed generating capacity in of MW, in the national electricity system, introducing nuclear energy, as an alternative to electricity generation will be considered after 2030. The Atomic Energy Commission is conducting a study to find the best technology to construct small nuclear reactors in several locations inside Jordanian territory, from two to six units with a capacity of 110 MW for each unit.

3.4.1 The Main Macroeconomic and Demographic Data Considered

The main data for macroeconomics, to be used in the baseline scenario was obtained from the official resources as follows.

- Economic Growth Rate

The economic growth rate trends of the GDP (Gross Domestic Product) for use in the baseline scenario, have been sourced from Jordan 2025, a National Vision and Strategy, and from IMF reports on Jordan's economy.

- Value-added, for economic sectors, was also obtained as stated in the Jordan 2025 Vision.
- Population of Jordanians and non-Jordanians in Jordan and the family size were taken from the 2015 census, while the growth rate for both Jordanian and non-Jordanians was obtained from the -Jordan Department of Statistics.
- The official discount rate was considered to be 8%, as announced by the Ministry of Planning and International Cooperation.
- The energy data for the historical period from 2015 to 2018 was obtained from the Jordan Energy Balances for the years 2015, 2016, 2017, and 2018, issued by the Ministry of Energy and Mineral Resources (MEMR), which provides the energy from the supply side, transformation and demand side.
- The detailed data for the energy consumption patterns and trends by each sector and the technologies used for the historical period were obtained from the energy surveys conducted by (MEMR) as follows:
  - Energy consumption survey in transport sector.
  - Energy consumption survey in household sector.
  - Energy consumption survey in service sector.
  - Energy consumption survey in agriculture sector.
  - Energy consumption survey in commercial sector.
  - Energy consumption survey in industrial sector.

Table 3.2 shows the economic growth rate of GDP in real terms, the structural composition of GDP*, and the population growth rate (GR).

Table 3.2: GDP and Population

Item	2018	2020	2025	2030	2035	2040	2050
Population Million*	10.309	10.806	11.994	13.254	14.579	15.956	18.678
Jordanian (GR*) %	2.5	2.3	2.2	2.1	2.0	1.9	1.7
Non-Jordanian (GR) %	2.1	2.1	2.2	1.8	1.5	1.5	1.1
GDP Million JD ** In constant price	29473	29580	32588	38128	45375	54905	77965
GDP Growth Rate % **	1.9	-1.6	2.1	3.4	3.8	4.2	4.2
Structural Composition of GDP (Value Added) %							
Services Sector	67.6	61.4	58	52	50	48	48
Industrial Sector	21.7	27.4	29.5	32	33	34	34
Construction Sector	5.5	5.8	6.6	8	8.8	9.8	9.8
Agriculture Sector	2.9	3.4	4.1	5.9	6.0	6.0	6.0
Non-Profit Organization	2.4	2.0	1.8	2.1	2.2	2.2	2.2

**Department of Statistics*

***Jordan Vision 2025 and IMF. (Constant price)*

The non-Jordanian population is formed of three main groups; the Syrian group entered Jordan during the first Syrian conflict 1984-1986 and stayed in Jordan up to now; the total number of this group was around 700,000 in 2018. This group is considered as Jordanian, in regard to the population growth rate. The second group, around 630,000 Syrian refugees, who entered Jordan during 2011-2016; whose numbers are driven by Syria's political and security situation. The third group is the Egyptian workers; their stay is driven by the Jordan economy and government labor policy.

Details of LEAP input and output are shown in annex 4.

3.5. Primary and Final Energy Demand

3.5.1 Primary Energy Demand

As a result of the baseline scenario analysis, taking into account the sectoral approved strategies, plans, policies, laws, implementation plans, constraints, and trends prevailing in the Jordanian context during the current time and the social and economic variables including the impacts of COVID-19 on the Jordanian economy, which were mentioned earlier, the LEAP output shows that the primary energy required will be 10.3 MToe, 10.9 MToe, 12.4 MToe, and 14.8 MToe in 2022, 2025, 2030 and 2040 respectively with an annual growth rate equal to 2.1% during the period 2020-2030, and equal to 1.8% during the period 2030-2040.

Table 3.3 and **Figure 3.1** show the total primary energy requirements for selected years from 2018-2065. Full detailed data are shown in Annex **Table A.1**. Also Annex **Table A.2** presents the Jordan's Energy Balance for selected years.

Table 3.3: Primary energy requirements (thousand tonnes of oil equivalent)

Baseline	2018	2019	2020	2022	2025	2030	2035
Demand	6,920.	6,813.	7,002.	6,951.	7,871.	9,601.	10,254.
Transformation	3,253.	3,061.	3,063.	3,324.	3,076.	2,799.	3,221.
Total	10,173.	9,874.	10,065.	10,274.	10,947.	12,400.	13,476.
Baseline	2040	2045	2050	2055	2060	2065	
Demand	11,138.	12,216.	13,641.	15,096.	16,693.	18,418.	
Transformation	3,662.	4,074.	4,709.	5,402.	6,165.	7,005.	
Total	14,799.	16,289.	18,349.	20,499.	22,858.	25,423.	

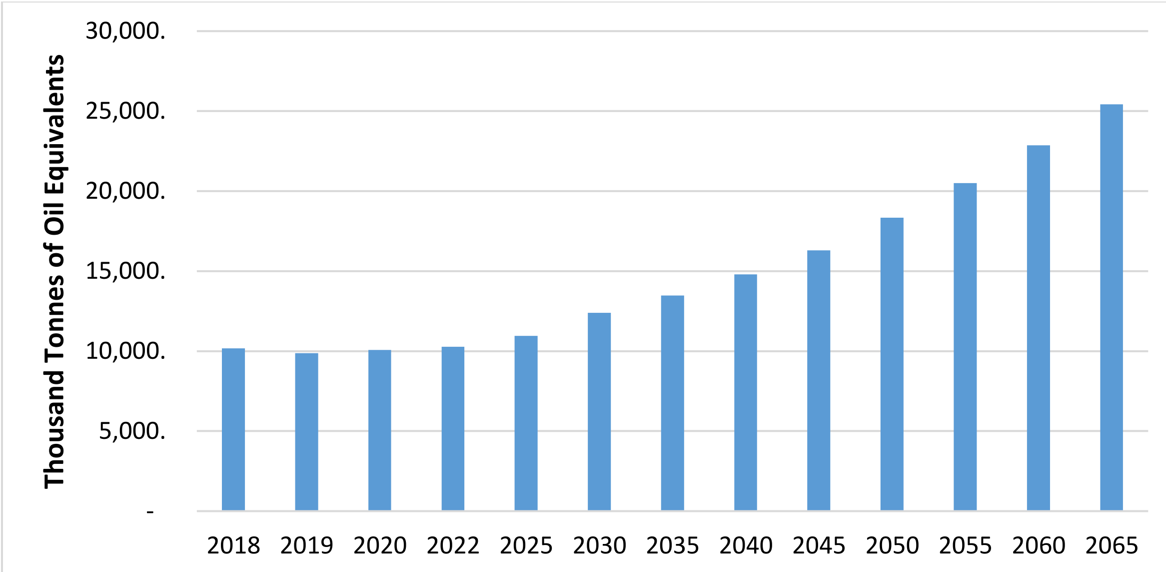


Figure 3.1: Primary Energy Requirements (thousand tonnes of oil equivalent)

3.5.2 Primary Energy Mix

The primary energy mix for some selected years within the study period is shown in **Table 3.4** and **Figure 3.2**, which were illustrated in the yearly energy balances from LEAP output. The primary energy mix in 2030 will be oil products 49 %, natural gas 32%, renewable energy 12%, oil shale 5%, while in 2040, the primary energy mix will consist of oil products 48%, natural gas 31%, renewable energy 12%, and oil shale 4%. It is illustrated that the decline in natural gas contribution in the energy mix is due to introducing more renewable energy for electricity generation.

Table 3.4: Primary energy mix for selected years from the period 2018-2065 (thousand toe)

Fuels	2022	2025	2030	2040	2050
Oil Products	6139	6176	6180	7145	7557
Natural Gas	3014	3047	4045	4598	5488
Renewables	836	964	1245	1761	2115
Oil Shale	120	570	590	645	645
Coal	165	190	360	650	425
Total	10274	10947	12400	14799	16230

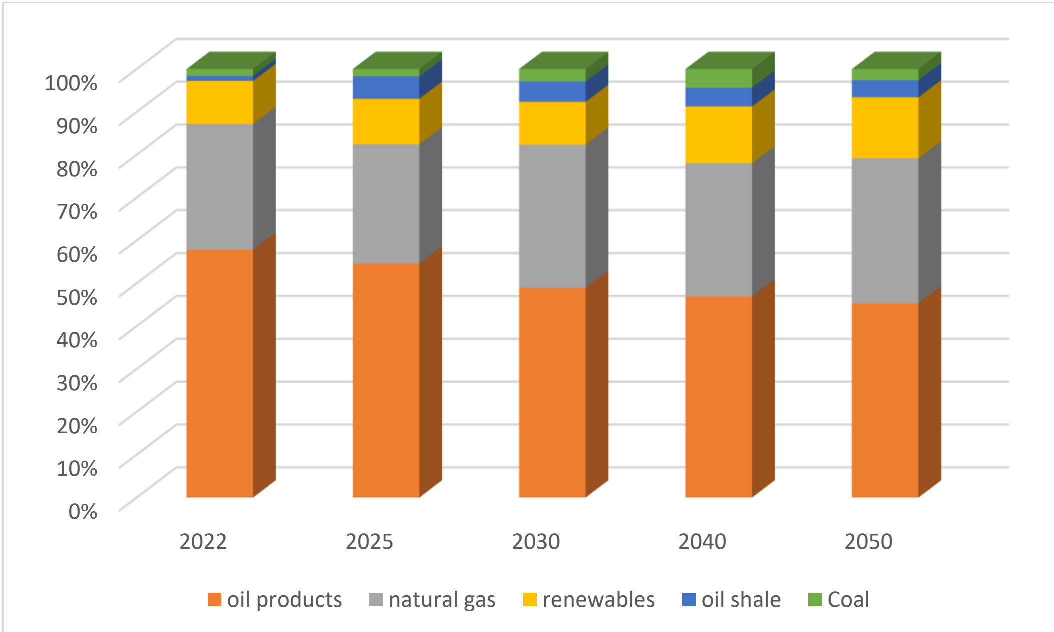


Figure 3.2: The Primary Energy Mix for some selected years.

3.5.3 Final Energy Demand by Sectors.

Final energy demand (consumption) is the total energy consumed by end-users, including transport, household, industry, services, and agriculture. It's the energy that reaches the final consumers' door and excludes energy used by the energy sector itself. In Jordan, it's mainly oil products and electricity. The final energy demand by sectors for the baseline scenario up to 2065 is driven by the GDP and value-added for each sector, the price of the final energy consumed, the population and the growth rate of the population over the same period. Also, the final demand is driven by the behavior of the end-users and their desire to modernize daily life. All of these factors, effecting energy demand, were considered in LEAP analysis.

Table (5) shows the final energy demand by sector for the period 2015-2040. The transport sector consumes around 49% of the total final energy demand in 2020. It is worth mentioning that the energy intensity in the transport sector is currently too high, equal to 0.07 kgoe/km per person and 0.05 kgoe/tonne. The occupancy for vehicles is only 1.3 passengers/vehicle, partly due to the lack of modern public transport systems. This share will decrease to forecast to be reduced to 47% and 45% in 2030 and 2040 respectively, due to the introduction of many improvement measures in the transport sector including Bus Rapid Transit, development of the public transport sector, an increasing penetration of hybrid and electric cars, removing the energy subsidy and pricing oil products, i.e., gasoline and diesel, in line with the international prices.

The percentage of the final energy consumption in the industrial sector is predicted to increase from 14% of the total final energy consumption in 2020 to 16% in 2040, based on the targeted value-added for the industrial sector, stated in Jordan 2025 Vision. The same applies to the service sector, which will witness an average growth rate of around 3% annually and will increase from 6% of the total final energy demand in 2020 to approximately 7.5% in 2040, taking into account the results of the energy efficiency programs in these two sectors.

The residential final energy consumption share will be decreased from 21% of the total final energy demand in 2020 to around 20% in 2040, with a medium growth rate of -2.0% annually. This is mainly due to the pricing mechanism and the transformation to using efficient devices such as LED lighting. **Table 3.5** and **Figure 3.3** show the Final Energy Demand by sector in the baseline scenario for selected years (Thousand toe).

Table 3.5: Final Energy Demand by sector, 2018-2065 (Thousand toe).

Branch	2018	2019	2020	2022	2025	2030	2035	2040	2045	2050	2055	2060	2065
Industrial	954	978	1002	1051	1131	1273	1422	1586	1768	1971	2198	2450	2732
Residential	1436	1470	1502	1568	1671	1854	2037	2216	2411	2653	2919	3212	3534
Services	448	460	471	494	531	598	668	745	830	926	1032	1151	1283
Transport	3351	3412	3472	3596	3789	4197	4604	4999	5428	5960	6544	7184	7885
Other	532	546	559	587	631	711	794	885	987	1101	1227	1368	1525
Non- Energy Sector	127	130	133	139	150	169	189	210	235	261	292	325	362
Total	6847	6996	7139	7435	7903	8802	9714	10642	11659	12872	14212	15690	17323

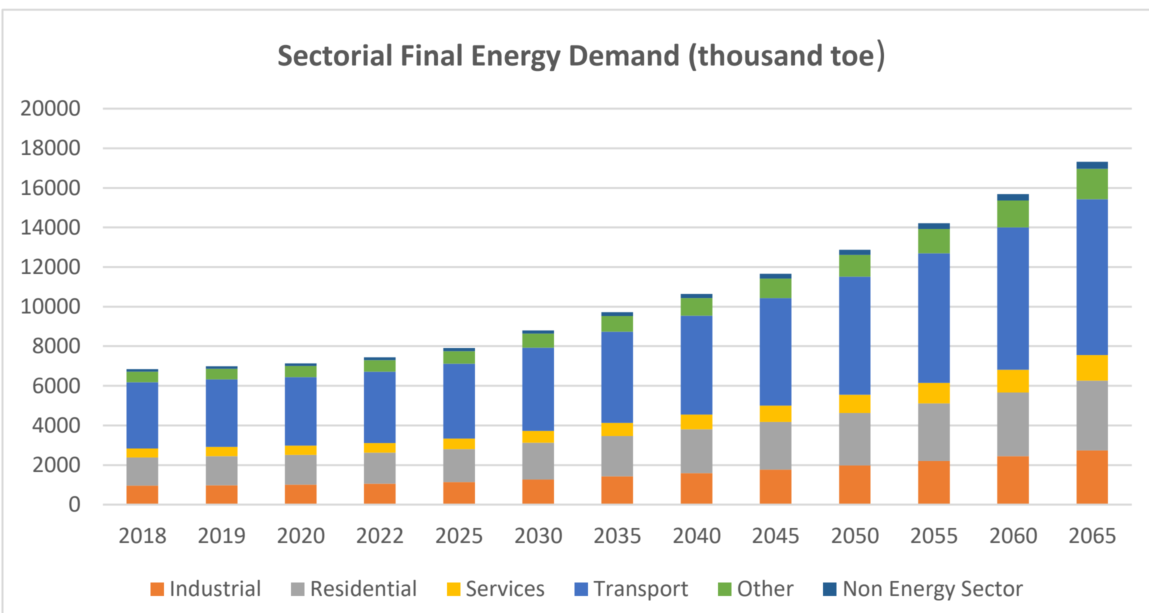


Figure 3.3: The Final Energy Demand by sector (Thousand toe), by sector

For more details, **Annex Table A.2** shows the energy balance for some selected years 2022, 2025, 2030, 2035, 2040, 2045 and 2050. The energy balance shows the relationships between supplies, inputs to the energy transformation processes, their outputs, and the actual energy consumption by different sectors of end-use. The energy balance expresses all forms of energy in a standard accounting unit.

3.5.4 Electricity Requirements over 2018-2065

The baseline scenario, takes into account the agreement signed between Jordan and Lebanon in Jan 2022 to start exporting electricity to Lebanon with a continuous capacity of 250 MW, and the National Conveyer Project which will cover 50% of its electricity needs from the electricity grid and the remaining 50%, which equals 150 MW, by a wheeling renewable energy project. The electricity generation requirements will increase from around 0% annual growth rate in 2018-2021 to 3.5% during 2020-2040.

The electricity demand was 20,950 GWh in 2020, but it is expected to reach 29,833 GWh in 2030 and 40,158 GWh in 2040. Table (6) shows the electricity generation requirements for selected years from 2018-2065. Figure 3.4 shows the electricity requirements in selected years over 2018-2065. For more details see Annex A **Table A.3**.

Table 3.6 also shows the capacity of electricity generation over the baseline period, the capacity is predicted to increase from 5424 MW capacity in 2020 to 7,200 MW in 2030 and 9,210 MW in 2040. The peak load is expected to have an annual growth rate of around 4% from 2020 to 2040. Figure 3.4 shows the electricity requirements in selected years over 2018-2065. For more details see Annex **Table A.3**.

Table 3.6: The electricity requirements in selected years over 2018-2065 (in GWh)

Branch	2018	2019	2020	2022	2025	2030	2035	2040	2045	2050	2055	2060	2065
Electricity Generation (GWH)	**19,882**	**20,589**	**21,275**	**22,723**	**25,210**	**29,833**	**34,792**	**40,158**	**46,159**	**53,121**	**60,912**	**69,616**	**79,327**
Generation Capacity (MW)	**5085**	**5254**	**5424**	**6020**	**6530**	**7200**	**7690**	**9210**	**12870**	**14400**	**14960**	**16100**	**17050**
Peak Load (MW)	**3205**	**3380**	**3630**	**3940**	**4075**	**4750**	**5480**	**6300**	**7250**	**8300**	**9410**	**10500**	**11120**

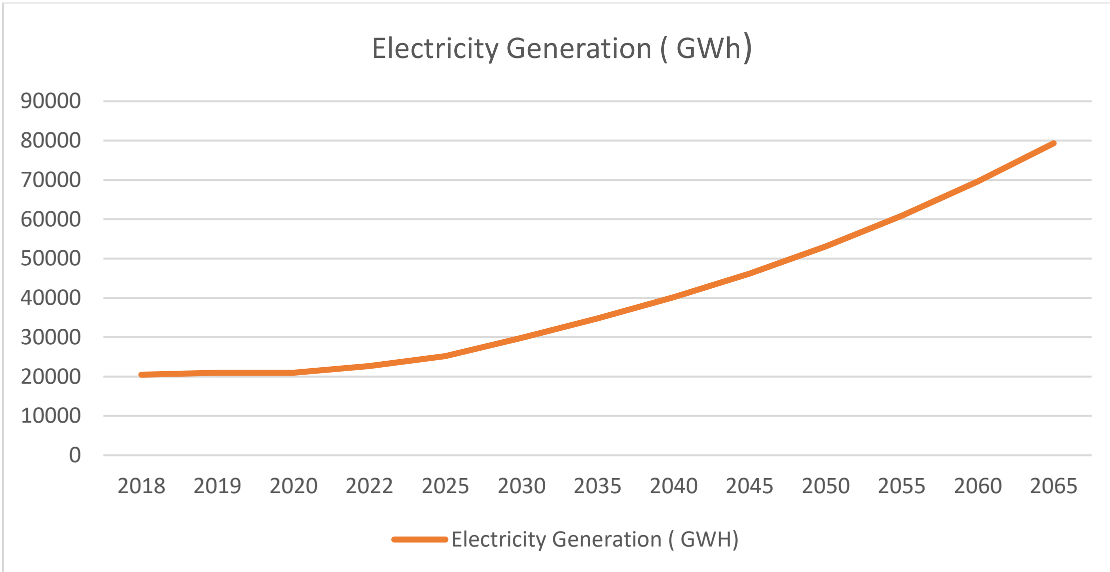


Figure 3.4: The Electricity Requirements over 2018-2065

3.5.5 Electricity Generation by Fuel type.

Table 3.7 and **Figure 3.5** show the share of electricity generation by fuel type in the baseline scenario for selected years. The electricity generation will be mainly from three sources: imported natural gas, renewables (solar and wind), and oil shale; renewables and oil shale are local resources. Renewable energy is expected to contribute 31% in 2030 and 35% in 2040. The share of oil shale will be 6% and 4% in 2030 and 2040, respectively; i.e., no new capacity for electricity generation from oil shale will be added to the system after 2040. The remaining share of the electricity mix is from natural gas.

Table 3.7: The share of electricity generation by fuel type in the baseline scenario for selected years

Fuel Type	2020	2025	2030	2035	2040
Natural Gas	16382	16136	18063	20095	23580
Renewables*	4570	6554	9247	12175	14050
Oil Shale	-	2520	2520	2520	2520
Total	20952	25210	29830	34790	40150

*Including wheeling & net metering

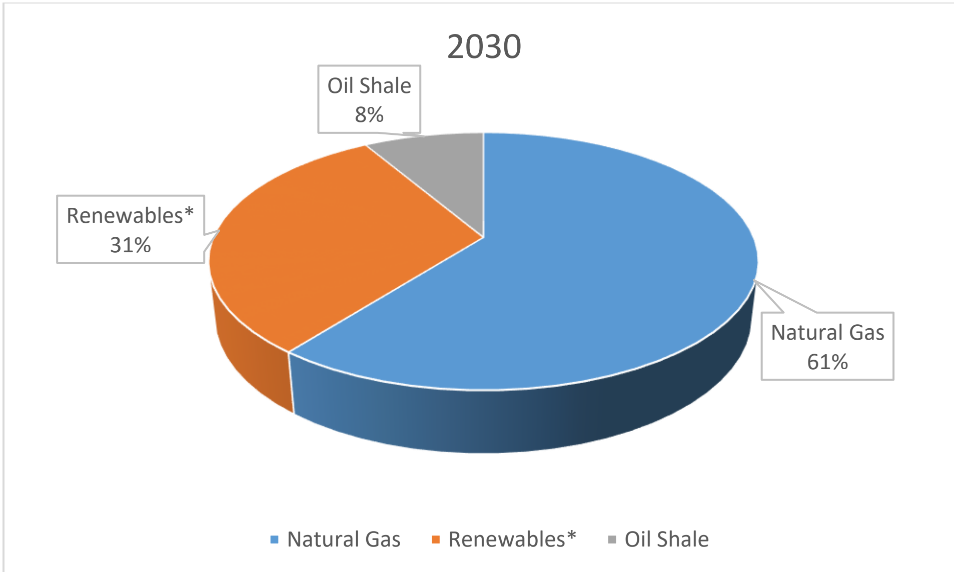


Figure 3.5: The share of electricity generation by fuel type for 2030

3.6. GHGs Emissions from Energy Sector.

3.6.1 GHGs Emissions from Energy Demand and Supply Sector.

Based on the LEAP results, the following paragraphs illustrate the GHG emissions profile of energy demand and supply, in detail. **Table 3.8**, Figure 3.6 and Figure 3.7 show the GHG emissions from the energy sector, both demand and supply, for selected years, in units of Million Metric Tonnes of CO_2 equivalent. These were 25.6, 27.5, 29.1 and 32.9 Mtonnes of CO_2eq in 2020, 2025, 2030 and 2040, respectively, with an annual growth rate of less than 0.9% over the period 2020-2040.

It is worth noting the following:

- The annual growth rate of the primary energy requirements is 2% over the period 2020-2040. The growth rate for GHG emissions does not exceed 0.9%.
- The annual growth rate of GHG emissions for transformation (electricity generation) during the period 2020-2040 will be negative at -2%, while the annual growth of electricity requirements will reach 3.5% in the same period, due to more renewables being introduced to the electricity system.
- In contrast, the GHG emissions from the demand sector, overall, will have a growth rate of 2% over the period 2020-2040. while, the final energy demand will grow by 2.3% annually.
- This analysis indicates that the baseline scenario, which has been approved is an environmentally-friendly.

Table 3.8: The GHGs emissions from the energy sector (Mtonne CO_2eq) in the baseline scenario for selected years

Branch	2018	2019	2020	2022	2025	2030	2035	2040	2045	2050	2055	2060	2065
Demand	15.3	15.6	15.8	16.3	17.1	18.7	20.2	21.7	23.3	25.3	27.4	29.7	32.3
Transformation	11.5	9.7	9.8	10	10.4	10.4	9.7	11.2	12.9	16	19	22.2	27.1
Total GHG	26.8	25.3	25.6	26.4	27.5	29.1	29.9	32.9	36.3	41.3	46.4	52	59.4

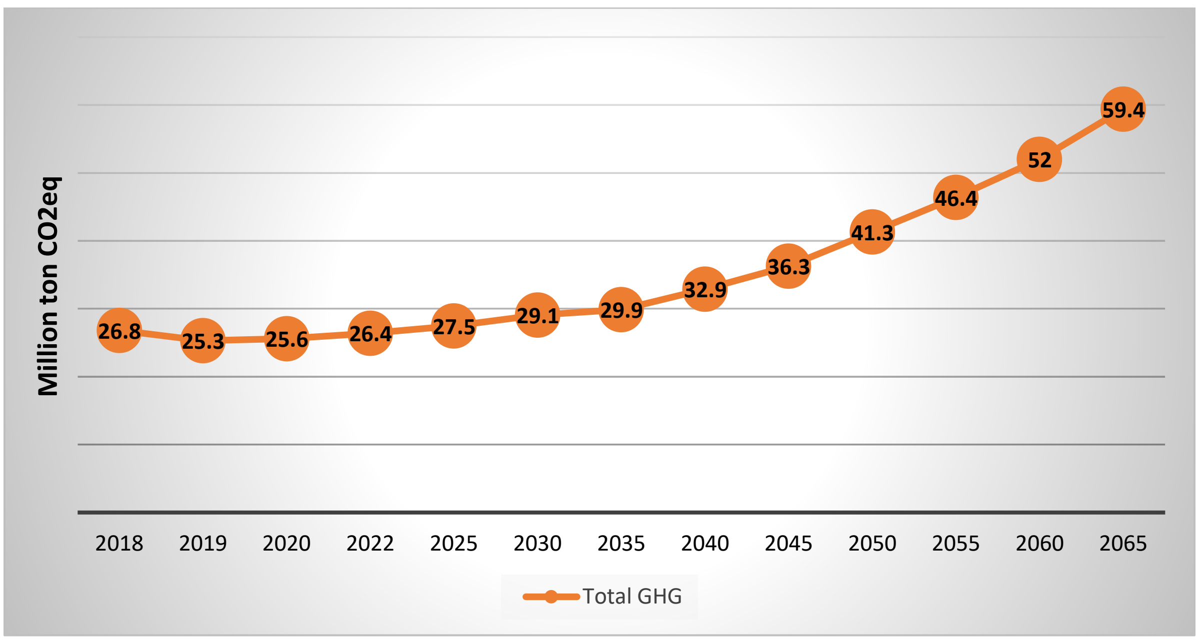


Figure 3.6: The total GHGs emissions from the energy sector (Mtonne CO_2eq) in the baseline scenario, 2018-2065.

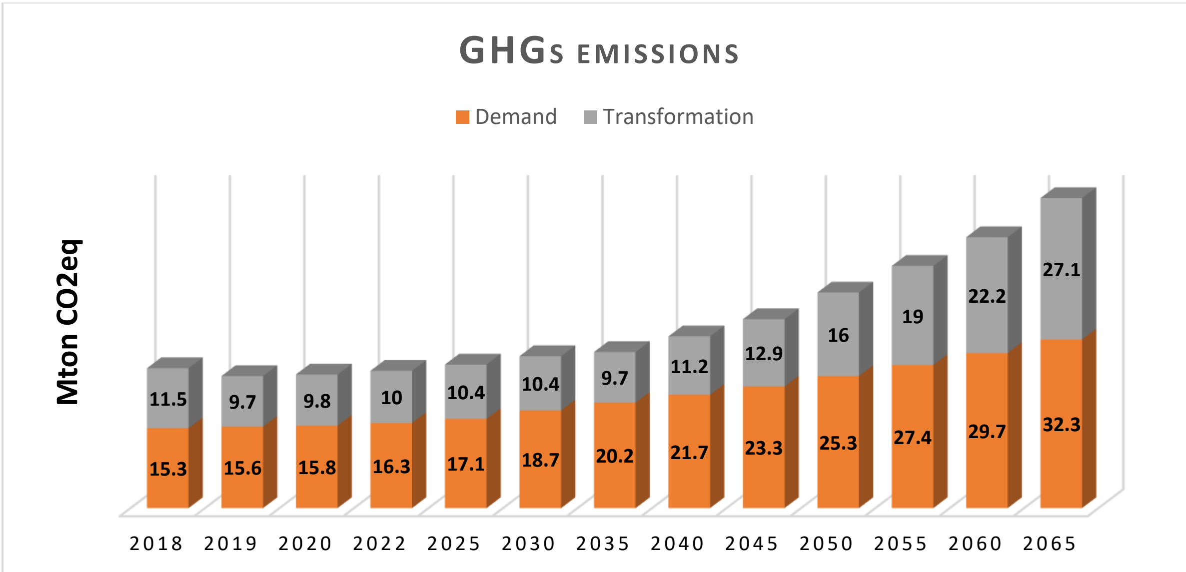


Figure 3.7: The GHGs emissions from the energy sector according to, Demand and Transformation sectors (Mtonne CO_2eq) in the baseline scenario, 2018-2065. For more details see Annex A Table A.4.

3.6.2 GHGs Emissions from Energy Demand and Supply Subsectors

The GHGs emissions from various energy demand and supply sectors are as described below:

- The most noticeable change in the sectorial contribution is in the power sector, where emissions will decline at an average rate of 1.6 % annually during 2020-2040 due to the increasing use of renewable energy to generate electricity and the use of more natural gas for electricity generation to replace the use of oil products, despite the introduction of oil shale to the electricity mix in mid-2022.
- Transport sector GHG emissions will experience a modest annual growth rate at an average of 1.8 % during 2020-2040, and will reach 15.270 Mtonnes CO2eq in 2040 compared to 10.630 Mtonnes CO_2eq in 2020. This is mainly due to the introduction of many improvement measures in the transport sector, including Bus Rapid Transit, development of the public transport sector, and increasing the penetration of hybrid and electric cars.
- Industrial GHGs emissions will grow at the modest rate of 1.3 % annually between 2020-2040, reaching 2.9 Mtonnes CO_2eq in 2040 compared with 2.3 Mtonnes CO2eq in 2020; this is due to the development of the sector and to the government policies that lead to increase the value-added by the industrial sector in the GDP.
- The residential sector share will increase slightly from 1.56 Mtonnes CO_2eq in 2020 to (1.73 Mtonnes CO_2eq in 2040.
- It should be noted that the most significant GHG sources in the energy demand and supply sector are in order: transportation, electricity production, industrial, residential, and commercial. This ranking differs from the TNC, where electricity generation is first followed by the transport sector second, then industrial, residential, and commercial. For more details, **Annex Table A.5** presents the yearly sectorial GHGs emissions from energy demand and supply in the baseline scenario 2018-2066.

Table 3.9 and **Figure 3.8** show the sectorial GHGs emissions from energy demand and supply in the baseline scenario.

Table 3.9: The sectorial GHGs emissions from energy demand and supply in the baseline scenario. ($GgCO_2eq$)

Branch	2018	2019	2020	2022	2025	2030	2035	2040
Industrial	2,237	2,274	2,306	2,374	2,476	2,642	2,786	2,922
Residential	1,545	1,554	1,560	1,571	1,585	1,602	1,598	1,573
Services	474	479	483	493	508	536	563	593
Transport	10,262	10,446	10,629	11,000	11,579	12,828	14,067	15,273
Other	816	837	857	900	967	1,089	1,217	1,35
Transformation	11,470	9,671	9,803	10,019	10,419	10,407	9,691	11,165
Total	26,805	25,262	25,639	26,357	27,535	29,103	29,921	32,883

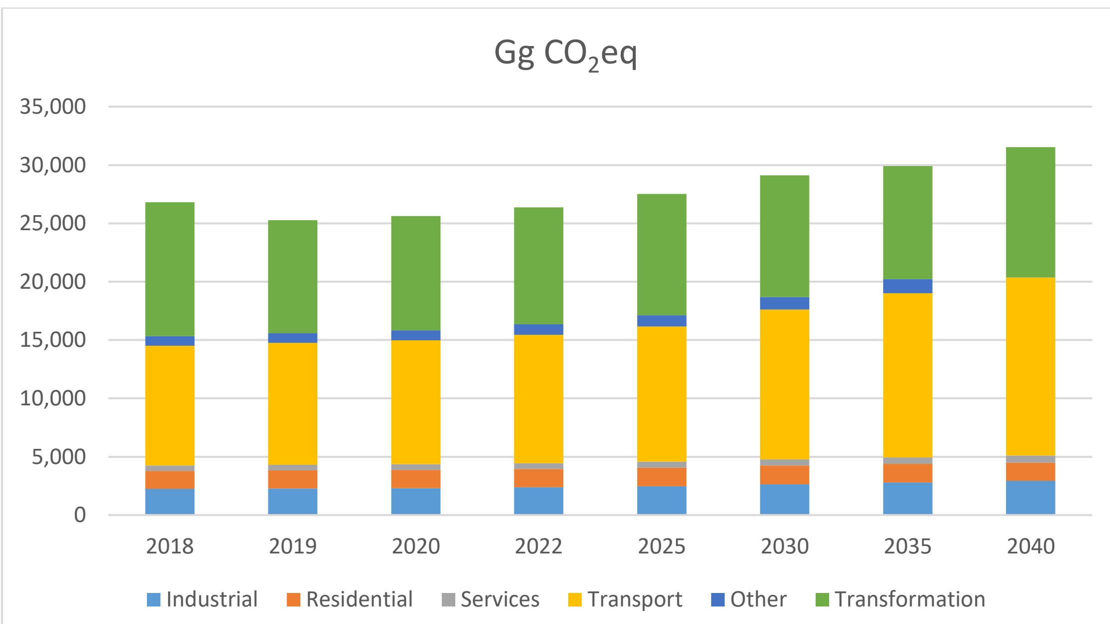


Figure 3.8: The sectorial GHGs emissions from energy demand and supply in the baseline scenario

3.6.3 GHGs Emissions from the Energy Demand and Supply by Gas

Table 3.10 presents the GHGs emissions by gas from the energy demand and supply sector for selected years.

Table 3.10: The GHGs emissions by gas from the energy demand and supply sector (Gg CO_2eq).

GHG	2018	2019	2020	2022	2025	2030	2035	2040
Carbon Dioxide	26,555	25,015	25,389	26,098	27,266	28,812	29,607	32,546
Methane	87	86	87	89	93	100	106	114
Nitrous Oxide	164	161	163	170	177	191	207	224
Total	26,805	25,262	25,639	26,357	27,535	29,103	29,921	32,883

For more details, **Annex Table A.6** presents the yearly sectorial GHGs emissions from energy demand and supply in the baseline scenario by gas 2018-2066.

3.7 Baseline Scenario for the Transport sector

Transport is a vital sector for the Jordanian economy and an essential component of the daily life of Jordanians. Both passenger and freight transport demand are growing rapidly due to economic growth within the country and the region and is concentrated on parts of the transport networks, close to the main urban areas and along key corridors. Consequently, part of the network is under pressure, and performance is below needs. Without interventions, the situation will worsen. At the end of the next decade, part of the system will not perform as needed to support the Jordanian economy and citizens' daily lives. Unreliability and delays will increase, thus causing cost to people and business activities and, in the end, negatively affecting the country's economic performance.

Therefore, in 2014, the Ministerial Council approved the Jordan Long Term National Transport Strategy (2015-2030). Currently, in 2022, the Ministry of Transport intends to issue the New National Transport Strategy for the period (2020-2040).

The main pillars of the two Jordanian Long Term Transport Strategies are the following policies and priorities:

- Complete the existing networks
- Making the best use of existing facilities
- Pursuing a multimodal approach.
- Combining infrastructure investments and policies.
- Making the most of private participation in the transport sector.
- Protecting the environment and reducing negative impacts.
- Emphasizing the regional dimension.
- Having citizens at the core of the transport policy.

Each of these pillars will be implemented by the following policies and actions

- Completing the existing networks.

Assessing missing links and bottlenecks and prioritizing investments is vital to maximizing the benefits in the short run. Investments in transport infrastructure have allowed the Jordanian network to expand, but supply still appears fragmented. Completing the existing networks and solving major bottlenecks will guide the timing and prioritization of the identified interventions.

- Make the best use of the existing facilities.

Improve interconnections, look at the nodes, separate flows, identify small-scale interventions. Inefficiencies may be reduced by matching flows and networks and having networks dedicated to specific flows. Appropriate maintenance (on infrastructure and vehicles) is essential for a safe, reliable, and transport system, which minimizes pollutants.

- Pursue a multimodal approach.

Suitable interconnections between modes, networks, and transport services are critical to an efficient and multimodal transport supply that increases public transport ridership. The railway is a significant player and should rely on an efficient multimodal transport system. Attractive rail service can optimize the functioning of the interchange links within the Jordanian territory. Development of the logistic and rail networks should be consistent in time horizon and design.

- Combine infrastructure investments and policies.

Pricing, regulation, safety, and security policies are essential components of the transport strategy and need to be harmonized with investments. Compared to investments, policies are easier to implement and less financially demanding. Policies may provide benefits already in the short term, but their implementation should be harmonized with the investments. Small scale and better-use policies can offer excellent returns quickly but should be fitted within a long-term strategy.

- Make the best of private participation in the transport sector.

The private sector can positively contribute to the transport sector's future by investing in infrastructure and operating services. Setting up an appropriate regulatory environment and identifying projects potentially attractive in terms of revenue returns are vital to increasing private participation in transport infrastructure.

- Protect the environment and reduce negative impacts.

Transport activities imply (negative) environmental, economic, and social effects. Decarbonizing the transport sector requires combined policies to increase the modal share of low-carbon transport modes and improve energy efficiency. Promoting innovative technologies is one of the major fields where these combined policies may be applied.

- Emphasize the regional dimension.

The regional dimension is critical, given the strategic role of Jordan as a crossroad of major international and regional transport axes. Promoting the Jordanian transport sector's regional size may leverage higher trade volumes and increased economic growth. Better domestic transport infrastructure is key to attracting and promoting a higher share of transit flows.

- Have citizens at the core of the transport policy.

Mobility is a major facilitator of the quality of life and livelihood and directly influences citizens' daily life and activities. Mobility is fully sustainable when it also addresses the impacts of transport activities in terms of social exclusion-related, economic and social cohesion, and demographic changes. Providing greater accessibility to users becomes crucial to secure access to essential services, mainly when public transport services are poor or inadequate.

3.7.1 Strategies and Plans for Amman City

GAM's Green City Action Plan, which approved in 2021 to promote sector reforms and develop priority projects to modernize infrastructure and municipal services in Amman. Including the main strategic objectives of:

- Increasing the share of public transportation,
- Developing a public realm strategy that supports pedestrian travel,
- Incorporating smart systems in transport planning.

3.7.2 Future Trends in Transport Sector

In the short term (around five years), many projects are being implemented, which will significantly affect transport in Jordan.

- The second part of the BRT network for Amman and between Zarqa and Amman should be operational in 2023, with a modern, comfortable bus fleet.
- The restructuring of public transport services in Amman, Zarqa, Irbid, and Madaba, implementing ITS technology on all buses. Additionally, walkability in Amman is being improved, with the rehabilitation of areas along the BRT lines by GAM.

These projects and improvements are expected to encourage a mode shift in trips from private vehicles to public transport, making it more convenient and comfortable. This is expected to reduce congestion and a decrease in fuel use, with a corresponding drop in emissions of greenhouse gases and other pollutants. These projects may additionally be copied by other governorates and within Amman, where there is potential for further lines of BRT and improvements in walking infrastructure.

- The MoPWH is expected to have completed the necessary rehabilitation of the Desert Highway and carried out widening and repair of roads, as identified in Highways Master Plan. This would lead to improved journey times and reduced congestion, which would lead to more efficient operations for road freight transport.
- GAM's TMMP Update Project should have been completed providing necessary guidance concerning the priority for projects in the transport sector within the city.

It is expected to have more electric cars on the roads of Amman, purchased by GAM and by the public, as they are shown to be efficient for the city- use and as fuel stations and destinations in the city provide more charging stations.

In the medium term (around ten years), large infrastructure projects were planned and committed by the government of Jordan to be implemented. These are expected to include.

- The pipeline project between Jordan and Iraq
- The railway project between Aqaba and Ma’an.

These two projects would impact the oil trucks to Zarqa from Amman and Iraq and trips by freight Lorries between Amman and Aqaba are expected to be replaced mainly by trips by pipeline or rail.

- Work on Amman Civil Airport and King Hussein International Airport is expected to have been completed, allowing more extraordinary passenger trips and boosting the Country's tourist numbers and economic growth.
- Ring roads around Amman, Salt, and Irbid will be completed, improving accessibility for areas around these cities and reducing congestion in the city centers.

In the long-term the foreseen key projects include.

The National Rail Network would connect with the railway from Aqaba at Ma’an. This is expected to carry a large proportion of the freight across Jordan would provide savings in reducing Heavy Goods Vehicles (HGVs) on the road network, reducing congestion, fuel use, GHG emissions, and other pollutants. Metro for Amman could also have been implemented.

Additionally, it is expected to have projects for GAM, as prioritized through the TMMP Update project. Potentially these could include a tram for Downtown Amman and light rail from Amman to Queen Alia International Airport.

It is important to note here that the transport sector is one of the main sectors in the final demand for energy from the energy point of view, so the transport calculations will be within the energy sector. In addition to the improvements mentioned above in the transport baseline scenario, the penetration of electric cars was assumed to be 2% annually.

3.8 Baseline Scenario for the Industrial Process and Product Use (IPPU) Sector

As mentioned earlier, the industrial sector in Jordan is considered the most economically important sector in terms of value-added to the national economy, availability of labor, linkages to other sectors, and technical competence. The Jordanian industrial sector consists mainly of the "manufacturing industries" and the "extractive industries" sectors. These activities are linked backward and forward with transportation, insurance, agriculture, and trade sectors. The industrial sector is a high contributor to Jordan's GDP, constituting about 25% in 2020. Therefore, Jordan 2025, a National Vision and Strategy, gives great attention and priority to developing this sector and intends to achieve the real economic growth rate of the value-added of the industrial sector to reach 33% and 35% of GDP in 2035 and 2040 respectively.

3.8.1 The Extractive Industries

In December, 2017, the government of Jordan issued The National Strategy for Mineral Resources 2016-2025, while in 2020, the Ministry of Energy and Mineral Resources issued investment opportunities in the mineral sector in Jordan.

To achieve the strategic objectives of the mineral sector, specific goals have been defined at the sectorial level to be achieved through initiatives, programmers, and projects and work mechanisms within temporary plans and performance indicators to achieve the strategic goal and its target values, as follows:

- Expanding exploration and prospecting work to identify new places for mineral ores and explore new ores.
- Determining and increasing the size of national reserves of mineral wealth.
- Building a new national database on mineral wealth.
- Completing the legal and legislative frameworks for the exploitation of mineral wealth.
- Attracting local and foreign investments to the mining sector.
- Supporting the establishment of transformative mining industries for mineral ores in Jordan.

In addition, the strategy proposes taking several steps to address the main challenges facing the mineral sector, which directly impact the development of the industry, the increase in investments, and the establishment of the competitive national metal industry. These challenges are:

- The high cost and risk of investing in the mining sector
- The spread of nature reserves over large areas where precious ores are located.

- Increasing intensity of competition for mining products in the local, regional and international markets.
- Failure to completely computerize information concerning mineral wealth and the distribution of its locations.

Concerning our concerns in this report, the extractive sector is the most influential in terms of the environment, and the greater emitter of greenhouse gases compared to the manufacturing industry. Therefore, analysis of the industrial sector, should concentrate on the extractive industries.

According to the value-added growth rate of the industrial sector, targeted in the Jordan Vision 2025 and the targets stated in the National Strategy for Mineral Resources 2016-2025, the projections of production extraction of industrial products that generate GHG in Jordan, up to 2065, have been formulated starting from the base year 2018. The list of industrial products consists of cement production, limestone production, nitric acid, lime production and soda ash. **Table 3.10** illustrates the actual and projected production and extraction of selected products (thousand tonnes), for selected years and.

Table 3.11: The actual and projections of production and extraction (ktonnes)

Year	Clinker produced	Lime produced	Limestone extracted	Nitric acid produced	Soda ash imported
2018	3750	133	970	85	7.0
2020	3900	125	955	89	6.7
2025	4250	147	1040	96	7.7
2030	4675	174	1145	106	8.5
2035	5060	206	1315	118	9.6
2040	5455	230	1520	131	10.9
2045	6050	264	1680	157	12.27
2050	6595	304	1865	173	13.3
2065	7590	404	2276	211	15.6

3.8.2 GHG emissions from the industrial process (IPPU) sector

The IPPU sector contributed 8 % in 2020 of the overall emissions in Jordan, ranking in the third place after the energy sector and waste sector. While it is expected to contribute 2.852, 3.138 and 3.661 million tonnes CO_2eq in 2025, 2030 accounting to 8 %, 9 % respectively of the total. The cement industry is the main emitter to the IPPU sector's GHG emissions. Other contributors include the production and use of lime, limestone, soda ash, and nitric acid. Baseline emissions from the IPPU sector during the period 2018-2066 are listed in the **Annex Table A.7**. **Table 3.12** illustrate the GHG emission from the IPPU sector in the baseline scenario by gas in selected years.

Table 3.12: GHG emission in ktonnes CO_2eq (Gg CO_2eq) from IPPU sector in the baseline scenario by gas in selected years.

Year	CO_2 ktonnes	N_2O ktonnes CO_2eq	Total ktonnes CO_2eq
2018	2336	0.585	2517
2020	2429	0.608	2618
2022	2495	0.637	2695
2025	2647	0.663	2852
2030	2912	0.730	3138
2035	3151	0.790	3395
2040	3398	0.850	3661
2045	3768	0.943	4060
2050	4108	1.03	4427
2065	4730	1.18	5095

3.9 Baseline Scenario for Solid Waste and Waste Water Sector

3.9.1 Solid Waste

In 2020, Jordan generated 3.7 million tonnes of solid waste, growing annually by 5%, of which only 7% - 10% is recycled or salvaged mainly by the informal sector. 0.9 kg of waste is produced per capita per day. In September 2020, the government of Jordan put into force the new Solid Waste Management Framework Law, which will organize the solid waste sector in Jordan for the coming years and provide the basis for better solid waste management. In addition, The Ministry of Local Administration also adopted the National Strategy in 2015, which diagnoses most of the problems the waste management system suffers from. Some of the problems and weaknesses identified by the strategy are low operational efficiency of municipalities and Joint Services Councils, lack of information, low sanitation level at landfills (except Ghabawi), low level of recycling, few projects for waste to energy and composting activities.

The per capita solid waste generation rate is currently around 0.9 kg/capita/day for urban areas in Jordan and is expected to continue increasing in the coming years with urbanization, reduction of family size, and increase in income. Waste in rural areas will continue to increase at a higher rate than in urban areas.

Many solid waste composition studies have been performed in Jordan at different levels to analyze waste received at landfills and others based on samples at initial disposal points. It can be concluded from all the studies that organic waste seems to be the main component of municipal solid waste, in addition to packaging waste, which appears to be primarily significant in urban areas. Waste composition is not fixed and could be changed based on limiting factors such as socioeconomic conditions, urbanization, etc. As Jordan accepts waves of refugees from nearby countries, these incoming people may have other social behaviors that affect the country-level waste composition.

In general, the population growth rate in Jordan has been declining since the 1950s except during exceptional circumstances, such as the Gulf War and the Syrian Crisis, where the population increased by 10.3% and 6.7% in 1990 and 2011, respectively. The strategy suggests that the decrease in the population growth rate will continue and may reach around 1.7 % in 2065. In reality, the growth rate will not continue to decrease. Still, it will reach a fixed value of approximately 2.1% as the growth rate of the population is greatly affected by religious beliefs, social circumstances, and economic situations. The solid waste quantities generated will continue to increase depending on population increase and GDP growth rate. According to the strategy, by 2040, solid waste from urban areas will reach 1.64 and 1.12 kg/capita/day in rural regions. Funds from international agencies contributed to upgrading the solid waste infrastructure. The upgrade in solid waste infrastructure, such as introducing more solid waste transfer stations, will improve the system capacity and improve municipalities' financial situation, mainly medium and large ones. On the other hand, the baseline scenario supposed the Private-public partnership (PPP) in solid waste activities in Jordan would be improved, and there are some excellent examples in Aqaba, Zarqa, and Petra. Accordingly, awareness of public and vocational training of solid waste workers will be improved more, focusing on introducing key performance indicators for waste collection systems and workers at the municipality level.

In conclusion, in the short and medium term, waste quantities will continue to increase with time, in Jordan. To reach decoupling between waste generation and economic growth, robust policies need to be applied. The waste composition will continue to change as the urbanization rate increases, family size decreases, GDP increases and based on other related factors.

3.9.2 Wastewater

As stated before, reclaimed water has been evaluated at the highest level of Jordan government, according to its value to the overall water resources of the country as stated in Jordan's Water Strategy 2008- 2022, (Wastewater shall not be managed as waste; it shall be collected and treated to standards that allow its unrestricted use in agriculture and other non-domestic purposes, including groundwater recharge). Over 70% of the Jordanian population is connected to the sewage system, and raw wastewater is discharged to 34 wastewater treatment plants (WWTP). The most widely used technology is the activated sludge process, with a share of 60%. As Samra Wastewater Treatment Plant is a super–large scale, it receives more than 70% of the country's total generated wastewater, reaching 170 million cubic meters in 2020.

The baseline scenario for the waste sector has been updated considering the following assumptions.

- The economic growth rate GDP and the population are the main drivers for waste sector growth.
- In line with Jordan's water strategy, all possible wastewater will be treated, to replace freshwater for agriculture purposes.
- Current waste consumption and generated wastewater per capita are assumed to be fixed due to the shortage of water in the country.
- All future needed WWTPs will be mechanical with an activated sludge method of operation.
- Biogas utilization from sludge digestion is mainly practiced at the Samra plant. However, others plants, such as Shalalah, have started to utilize biogas, and other plants are planning to do so in the future.

- Current wastewater treatment plants will be regularly modified to account for increased generation of domestic wastewater, driven by population growth. However, the expansion will primarily occur at plants serving urban areas.
- Most of the sludge produced by other treatment plants will be dried and disposed of in landfill sites.
- Factories and industrial plants are located within industrial cities or outside of them. All plants situated within industrial cities are connected to central well-managed aerobic wastewater treatment plants. Plants located outside these industrial cities are mostly connected to domestic wastewater plants, in accordance with Water Authority regulations.

Table 3.13 shows actual and projected generated amounts of domestic solid waste (2018 -2065), quantities of wastewater discharged to WWTPs for selected years,

Table 3.13: Generated amounts of domestic solid waste (2018 -2065)

Year	MSW Disposed to SWDS Ktonnes	WW discharged to WWTPs Million cubic meters (MCM)
2018	3400	238
2020	3565	242
2025	4377	268
2030	4837	296
2035	5853	325
2040	6410	356
2045	6984	386
2050	8180	419
2065	9840	557

3.9.3 GHG emissions from the waste sector.

According to the baseline scenario, the total GHG emissions from the waste sector reached to 3643 GgCO_2eq in 2020 and are expected to reach 4438, 4901and 6448 GgCO_2eq in 2025, 2030, and 2040, respectively. This puts the waste sector as the second-largest emitter of GHG emissions in Jordan, accounting for 13 % of the total in 2030. Solid waste is responsible for more GHG emissions than wastewater, as Alsamra, the largest WWTP in Jordan, which receives around 70% of the WW in the Country, converted its operation from natural treatment methods to aerobic mode, for which the emission of methane was considered to be negligible. **Table 3.14** illustrates the GHG emissions from the waste sector for selected years.

Table 3.14: The GHG emissions from the waste sector for selected years

year	Solid waste Gg of CH_4	Wastewater		Total Gg CO_2eq
		Gg of CH_4	Gg of N_2O	
2018	151.3	0.0313	0.989	3484
2020	158.6	0.0318	1.005	3643
2022	167.4	0.0327	1.007	3828
2025	194.7	0.0352	1.114	4438
2030	215.2	0.0398	1.230	4901
2035	260.4	0.0427	1.350	5887
2040	285.2	0.0468	1.479	6448
2045	310.7	0.0507	1.604	7023
2050	364.1	0.0551	1.741	8186
2065	434.8	0.0732	2.315	9134

3.10 Baseline Scenario for Agriculture, Forestry and Other Land Use Change Sector

The agricultural sector in Jordan lacked strategic planning during the periods prior to 2002, where agricultural policies were implemented by following short-term plans of the Ministry of Agriculture and related institutions through their annual budgets. The first National Agricultural Development Strategy 2002-2010 was prepared, followed by the Complementary Agricultural Document 2009-2013, the National Strategy Document for Agricultural Development (2016-2025, the National Strategy for Agricultural Development 2020-2025. and the National plan for Sustainable Agriculture 2022–2025. The strategy and document contributed to unifying government efforts and involving the private sector in agricultural development efforts. The strategy identified a total of 174 interventions and projects that will be financed through a host of channels, including the Treasury, the Agricultural Credit Corporation and from foreign aid and grants.

Strategy Ambitious Objectives	Agricultural Sector Policy Challenges
• Increasing the agricultural GDP as a share of total GDP from 2.6 billion JD currently to 3.66 billion JD by 2025 and boosting the added-value of agriculture to 2.48 billion JD from 1.6 billion JD. • Increasing the forest area by 10% by 2025. • Expanding pasture areas • Creating 65,000 jobs in a five-year period and replacing 21,000 foreign workers with Jordanians, • Increasing the number of farmers using digital government-run agricultural services by 30 per cent. • Reducing export costs to facilitate a 15 per cent increase in agricultural exports. • Increasing the productivity of food and agricultural manufacturers by 18 per cent by 2025. • The utilization of modern technology to enhance production and productivity, focusing on strategic crops	• The lack of comprehensive agricultural databases and poor utilization of modern technologies in agriculture that limit the agricultural producer's access to retailers and consumers. • Marketing of products with the closure of neighboring markets due to regional conditions and the need to facilitate export of agricultural products through the Queen Alia International Airport (QAIA). • Lack of refrigerator trucks to transport fruit and vegetables ready for exporting. • Compensating farmers for the damage to crops because of frost. • The high cost of electricity for the agricultural sector. • The need to better manage the issue of non-Jordanian workers in the sector. • The need to support livestock breeders with feed, medicine and vaccines. • Increase in fodder prices due to delay and decrease of rainfall.

The main strategic priorities are:

- Transition towards sustainable, more efficient and productive local agricultural production by preserving production resources, especially agricultural lands and water, improving their utilization methods, expanding high-value crops, controlling the quality of agricultural production and its inputs, reducing risks and frost risks, expanding the use of modern technology, developing and improving the efficiency of agricultural extension and strengthening agricultural research to increase production and productivity.
- Preserving agricultural lands and reducing the fragmentation of agricultural lands through regulatory measures, control urban expansion on agricultural and forest lands, combating desertification of agricultural lands, and preserving the quality and productive capacity of agricultural soils.
- Expanding support programs for existing farmers, to maximize the productivity and water efficiency of existing farms by improving irrigation water use efficiency and improving irrigation water quality

- Preserving the sustainability of agricultural resources and biodiversity through the protection of forest vegetation cover and the protection of biodiversity in the Jordanian Badia, the safe use of agricultural pesticides, the protection of biodiversity habitats, the preservation and protection of wealth, forest lands and pastures through increasing and preserving forest areas, increasing the number of natural forest reserves and rehabilitating technical expertise Forestry in the Ministry of Agriculture, increasing the number of pastoral reserves, restoring degraded ecosystem of rangelands and forests through community based rangeland rehabilitation, developing pastoral areas based on integrated management methods and the participation of the local community, encouraging the establishment of water harvesting methods and using them to develop pastures in the Badia.

Based on the above priorities, the following assumptions were used to project the mitigation activities in the agricultural sector between the years (2018-2066):

- Increasing the volume of investment (fixed capital formation) by 30% through implementing initiatives to develop plant and animal production systems and increasing the value of agricultural production by 36%
- Developing and increasing the productivity of agricultural lands through smart irrigation programs, to increase the efficiency of irrigation water use and increase the productivity of water per cubic meter, and through promoting water-harvesting techniques.
- Protecting and Developing agricultural lands: Evaluating agricultural stations and establishing a mechanism for partnerships with the private sector in the investment of stations, inventory and identification of arable treasury lands and identification of strategic agricultural crops that can be cultivated, financing the exploitation of treasury lands and cultivation of strategic crops, reclamation of agricultural land and construction of water collection wells, reconstruction and exploitation of rainfed lands, capacity building To adapt to climate change in Jordan by improving water use efficiency in the agricultural sector, and reduce land degradation through restoring degraded lands and their sustainable management in northern Jordan.
- Field crops production: Increase productivity per unit area through implementing hundreds of projects using modern agricultural technology (hydroponics, aquaponics, modern irrigation systems, etc.) and supporting the use of solar energy in the agricultural sector, developing and building capacities in the field of modern agricultural technology, and promoting research on the use of modern agricultural technology. The key indicators are increasing the volume of investment (fixed capital formation) by 30%, implementation of 762 initiatives to develop plant and animal production systems, establishment of 17 training centers on modern agricultural technology in the agricultural sector, training of

3,805 farmers on modern agricultural technology, funding 1878 initiative to use modern agricultural technology in agriculture, and implementation of 21 applied research in the field of using modern agricultural technology.

- Animal production: Promoting highly productive animal species under increase in prices of fodder, and other production inputs, preserving livestock and increasing their productivity though support and protection of livestock, establishing, rehabilitating and equipping veterinary clinics and financing the development of livestock. The key indicator is that livestock productivity should be increased by 12% by 2025.
- Fodder production: Development and sustainability of pastures and water harvesting in the Badia through reclamation of rangelands and control of overgrazing in rangelands, introducing species with high productivity, under drought conditions, promoting wastewater reuse in fodder production, and increasing pastoral reserves from 41 to 45 protected areas in 2025.
- Forestry conservation: Development and sustainability of forests and woodlands and improving ecosystem services systems for neighboring forests through maintaining the forests under predicated continuity of drought cycles, urban and rural expansion, expected fire occurrences and trees cutting for fuel. This includes the national afforestation project and the pioneering water harvesting projects for forests and sustainable afforestation, through the exploitation of treated water, the rehabilitation and sustainability of afforestation projects and the development of forest nurseries. The key target is to increase the lands planted with forests by 10% by 2025 and decrease the area of forest lands affected by fires by 3% annually.

As mentioned at the GHG Inventory chapter, the GHG emissions of the AFOLU activities accounted for less than 3% of Jordan's total GHG emissions. The emissions are mainly derived from methane (that is Enteric Fermentation, Manure Management, and biomass burning) and nitrous oxide (which is generated by manure management, and direct and indirect emissions from managed soils).

In terms of forest lands, the increasing potential of the CO_2 sinks is projected to increase through maintaining afforestation programs, forests protection and higher law enforcement at national level. Taking into account the continuous increase in plant and animal production to satisfy the food demand and the associated by national population growth. The AFOLU share of total emissions is modest. **Table 3.15** summarizes the baseline emissions for the agriculture activities for the years (2018-2066). **Annex Table A.8** shows more details the GHG emissions of the baseline scenario for Agriculture Sector - Animal waste in Jordan between (2018-2065).

Table 3.15: GHG emissions of the baseline scenario for LULUCF sector for selected years (Gg CO2 eq.)

Year	Net CO_2 (Gg)	CH_4 CO_2eq (Gg)	N_2O CO_2eq (Gg)	Net CO_2eq (Gg)
2016	-896.8	614.62	710.85	428.71
2017	-912.3	696.1	867.85	651.66
2018	-928.1	705.33	879.36	656.6
2019	-944.1	714.68	891.01	661.55
2020	-960.5	724.15	902.82	666.49
2022	-993.7	743.35	926.76	676.37
2025	-1045	772.92	963.62	691.19
2030	-1136	824.15	1027.5	715.81
2035	-1234	878.78	1095.6	740.24
2040	-1341	937.03	1168.2	764.29
2045	-1457	999.14	1245.7	787.76
2050	-1583	1065.4	1328.2	810.45
2055	-1720	1136	1416.3	832.08
2060	-1869	1211.3	1510.1	852.36
2065	-2031	1291.6	1610.2	870.98

3.11 Total GHG emissions in the baseline scenario

Table 3.16 shows the overall GHG emissions in the baseline scenario for selected years in Jordan, while **Figure 3 9** illustrates the share of the different sectors in the baseline scenario for the year 2030. The ranking from the most significant emitters point of view is energy sector first, waste sector the second, and IPPU the third. This ranking differs from the TNC, where the energy sector is first, IPPU the second, and the waste sector the third.

Table 3.16: The overall GHG emissions in the baseline scenario for selected years in Jordan (Gg CO_2eq)

Year	Energy sector	Waste sector	IPPU sector	AFOLU	Total
2018	26805	3484	2517	657	33462
2019	25262	3548	2574	662	32045
2020	25639	3643	2618	666	32566
2022	26357	3828	2695	676	33556
2025	27535	4438	2852	691	35516
2030	29103	4901	3138	716	37858
2035	29921	5887	3395	740	39943
2040	32883	6448	3661	764	43756
2045	36258	7023	4060	788	48129
2050	41291	8186	4427	810	54714
2055	46421	8630	4620	832	60503
2060	51958	9025	4845	852	66680
2065	59364	9134	5095	871	74464

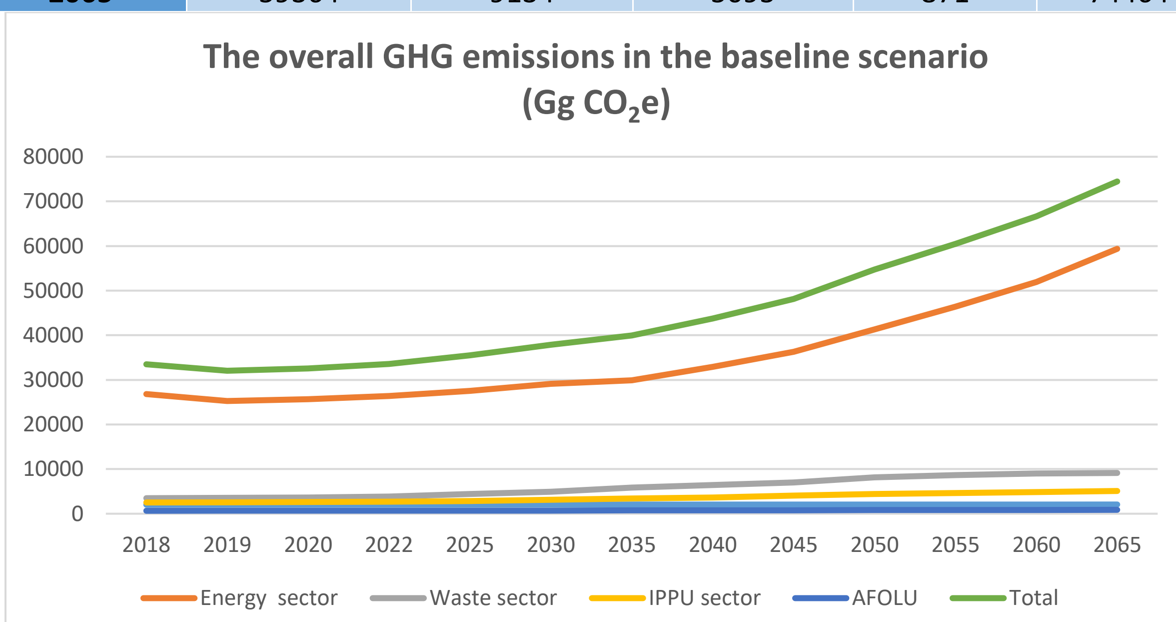


Figure 3 9: The share of the different sectors in the baseline scenario for the year 2030.

3.12 Mitigation Scenario Analysis for Different Sectors

The Hashemite Kingdom of Jordan submitted its Updated Nationally Determined Contribution (NDC) to the UNFCCC Secretariat in October 2021. The updated NDC aims to remove, avoid, and reduce GHG emissions by 31% by 2030 compared to the baseline scenario, which more than doubles the percentage committed compared to the Kingdom's previous INDC submitted in November 2016. The updated NDC shows that Jordan is committed to reducing 5% GHG emissions compared to the BAU scenario unconditionally, and to reduce conditionally an additional 26% if the resources and means of implementation are available such as financial and technological support from partner countries and donors. These NDC are based on the following principles and decisions.

- Decisions 1/CP.19, 1/CP.20, 1/CP.21, and 1/CP.24
- Article 3 of UNFCCC.
- Economic Diversification Initiative (Decision 24/CP.18, Doha, 2012
- Paris Agreement Articles 4.1, 4.7, and 4.15.

The main goal of Jordan's actions is to contribute to the responses taken by countries within the Paris Agreement to keep the average value of global temperature rise well below 2°C for the next 100 years. To motivate the progression in NDC implementation, the Government of Jordan developed and validated the NDC Action Plan in 2019. It is a results-based implementation plan that emphasizes adaptation and mitigation actions prioritized in key sectors which were already covered in the First NDC, namely transport, energy, agriculture, health, water, and waste management. The Action Plan was then circulated through the NDC Partnership's network to seek international support for implementation.

In the year 2020, with the support of the Partnership's Climate Action Enhancement Package (CAEP), the government worked further to prioritize 35 actions out of the whole actions included in the NDC Action Plan and to prepare a cost-benefit analysis for them in addition to developing a Climate Finance Strategy to facilitate reaching out funding sources.

Currently, the government is working to integrate the sectoral actions included in the NDC Action Plan with the government's Executive Development Program (EDP) that will improve their national-priority levels for allocating financial resources and readiness for implementation in the next three years of the government plan.

In the preparation of this chapter of Jordan's 4NC, all mitigation projects included in the NDC (October 2021) and SBUR (December 2020) have been reviewed and assessed to identify those options considered to be still valid and applicable. The cost-benefit analysis and the CO_2

emissions reduction have been updated for each valid mitigation project. Net present value was used in the financial calculations, by converting all present and future revenues and costs over the lifetime of the project to a base of today's cost. A discount rate of 8% was used in all calculations of cost. The discounted unit cost of reduced emissions, which is the quotient of the discounted cost to the total emissions reduction, was also calculated.

The LEAP model was used to perform the energy mitigation analysis. Along with the LEAP model, the standard calculation tool (IPCC 2006) was used to assess the mitigation potential of GHG in other sectors (IPPU, waste, and agriculture and forestry).

The updated mitigation measures include GHG mitigation projects in the following areas:

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

The results of the meetings and discussions with the related ministries and institutions indicated that all mitigation measures listed in the updated NDCs and SBUR were still valid, except the following two projects for renewable energy, as previously mentioned, in addition to some energy efficiency projects as seen below

- 100 MW Concentrated Solar Power (CSP).
- 300 MW Concentrated Solar Power (CSP, which were considered not applicable, due to the reduction of the capital cost of other RE technologies such as Photovoltaic
- Replacing high thermal mass with low thermal mass (LTM) in ceramic factories.
- Returning unreturned condensate to the feed water tanks in food processing.
- Insulating uninsulated pipes, fittings, and tanks in food processing,
- Using Regenerative burners instead of conventional burners in steel reheating.
- Using variable speed drives in the pumps for paper factories.

In the subsequent chapters, all the new or updated mitigation measures and projects are presented as agreed upon with the relevant ministries and institutions, or as already included in the announced strategies of those institutions.

3.12.1 Mitigation Policies and Measures in Primary Energy

The implementation plan of the Energy Strategy 2020-2030 indicated the three infrastructure projects and considered mitigation measures which are described below.

- **Construction of a branch pipeline between the proposed Iraqi crude oil pipelines to export Iraqi crude oil across Jordanian territory to Jordan Oil Refinery,** to supply Jordan Oil Refinery with 100 thousand barrels/day. The pipeline is expected to be completed in 2029. The pipeline project between the refinery and the Iraqi crude oil pipeline would remove a large number of trucks from the network, since trips by oil trucks from Aqaba to the refinery in Zarqa (around 350 km) are expected to be replaced mainly by pipeline. The total length of the branch is 190 kilometers.

- **Natural Gas Distribution Network in Amman, Zarqa, and Aqaba**. According to the energy strategy 2020-2030, Jordan will enhance the usage of natural gas in all sectors such as Industrial, Residential, Commercial, and Transportation. This includes the use of natural gas instead of liquefied petroleum gas for cooking, diesel in central heating and water heating, and gasoline for cars. In 2020, 84% of the electricity generation of the Kingdom was generated from imported natural gas. To deliver natural gas to smaller consumers it will be necessary to construct new low-pressure gas distribution networks to connect customers to the new infrastructure. The project will be executed gradually over 10 years, starting in 2025 and with a capital cost of 110 million USD. Natural gas combustion emits 1.3 times less CO_2 than that of oil, which indicates that using natural gas in the demand side sector as an alternative to diesel, fuel oil, LPG, and gasoline, will mitigate a significant quantity of CO_2 emissions. Using the natural gas distribution networks in the main cities of Amman, Zarqa, and Aqaba will mitigate about 2,708 thousand tonnes of CO_2eq, discounted emissions in the 25 years of the project lifetime (2025-2050).

- **Loss Reduction in Electricity Transmission and Distribution (T&D) Network**, this project seeks to reduce the transmission and distribution losses to 9% in 2027 compared to 13.3% in 2020. The project will be executed gradually over 6 years starting in 2022. The main components of the project will be optimizing the utilization of distributed generation, improving the system power factor, and upgrading or replacing existing conductors and insulators with lower resistance equipment. The cost is estimated to be 48 million USD. This project can lead to a significant reduction in fuel consumption and as a result, a discounted emission reduction of 1,956 thousand tonnes of CO_2, over the 25-year lifetime of the project (2022-2047). **Table 3.17** illustrates a summary description of the main mitigation measures in primary Energy.

Table 3.17: Summary description of the main mitigation measures in primary Energy

Name and a brief description of the mitigation action	Sector and subsector (and GHG reduced)	Implementing institution	Status [Planned, implemented, under implementation, proposed	Main assumptions used in the mitigation analysis	Project Duration	Annual Emissions reductions after completing the project (Gg CO2eq)
1- Construction of a branch of pipeline between the refinery and Iraqi crude oil pipeline across Jordan territory.	CO_2, N_2O	MEMR and Private Sector	Planned To put in operation in 2029.	- The pipeline will be 190 km. diameter 16''. - cost 1.2 MJD/km -the distance from Aqaba to the Refinery is 350 km. The average load for the oil trucks is 40 tonnes/trip.	2029-2065	63.3
2-Natural Gas Distribution Network in Amman, Zarqa, and Aqaba	Supply CO_2, N_2O, CH4	MEMR and Private Sector	Planned. Will be executed gradually over 10 years starting in 2027.	Replace the oil products with natural gas in the demand sector	2027-2065	97.0
3- Loss Reduction in Electricity Transmission and Distribution (T&D) Network	CO2, N2O, CH4	NEPCO	Under implementation	To reduce the transmission and distribution losses to 9% in 2027, compared to 13.3% in 2020. The project will be executed gradually over 6 years, starting in 2022. Grid emission factor=0.537 for 2020, for conventional generation sources.	2022-2060	117
The objective of the mitigation actions						
The objective of these mitigation actions is to reduce emissions by: - Reducing electricity consumption which will result in a reduced quantity of fuels used for electricity generation. - Replacing usage of fuel oil products with natural gas.						

3.12.2 Mitigation Policies and Measures in Renewable Energy

- During the period 2011 to 2017, Jordan has succeeded in building a legislative and procedural base in renewable energy, which led to a significant increase in the participation of renewable energy in the energy mix.
- A translation of what is stated in the Energy Sector Strategy 2020-2030, is that the share of RES in the electricity generation mix will be 31% in the year 2030. The total capacity of the constructed, under construction, and committed projects during 2020-2024 will reach 2400 MW.
- The total new capacity of wind and solar energy to be added to the system during the period 2024-2030 will be 800 MW, of which 400 MW will be wheeling and net metering system. Notice that in 9/5/2022 the Cabinet Decision agreed to establish renewable energy projects with a capacity of more than 1 megawatt to cover the consumption of new investors or expand consumption of the existing project.
- Beyond 2030, renewable energy resources will be considered the main candidate for the future expansion of electricity generation. Especially if the storage succeeds from an economic and technical point of view. Accordingly, the penetration of the RES in the electricity generation mix will exceed 50% during the period 2030-2040. 1600 MW PV (200 MW* 8) is planned to add to the electricity system during the same period as shown in the LEAP run. **Table 3.18** illustrate the summary description of the main mitigation measures in Renewable Energy.

Table 3.18: Summary description of the main mitigation measures in Renewable Energy.

Name and a brief description of the mitigation action	Sector and subsector (and GHG reduced)	Implementing institution	Status [Planned, implemented, under implementation, proposed	Main assumptions used in the mitigation analysis	Project Duration	Annually Emission reductions after completing the project (Gg CO2eq)
1-Construction of 800 MW, PV (100*4) + (400 wheeling and Net –Metering system) by 2030. To achieve the target of 35% of electricity mix from RES, by 2040.	CO_2, N_2O, CH_4	NEPCO, Private Sector	Planned Construction will be gradual from 2025-to 2030	- Grid emission factor=0.537 for 2020 conventional generation sources. - Capacity factor for PV plant 0.25. -Discount rate is 8%.	2025-2055	For one unit of 100 MW annually 112 Gg CO2e
2 Construction of 1600 MW, PV (200*8) during 2030-2040. To achieve the target of 50% of electricity mix from RES by 2040.	CO_2, N_2O, CH_4	NEPCO, Private Sector	Planned Construction will be gradual during 2030-2040	Grid emission factor=0.537 for 2020 conventional generation sources. - Capacity factor for PV plant 0.25. - Discount rate is 8%.	2030-2060	For one unit of 200 MW annually 223 Gg CO2e
3-The Aqaba Amman Water Desalination and Conveyance Project (AAWDCP) - Wheeling Project, 185 MW PV (50% of the overall needed power demand	CO_2, N_2O, CH_4	MOWI	Planned	- Grid emission factor=0.537 for 2020 conventional generation sources. - Capacity factor for PV plant 0.25. - Discount rate 8%	2027-2060	218
OBJECTIVE OF THE MITIGATION ACTION						
The objective of these mitigation actions is to increase the share of RE in the energy mix and to enhance energy security. Using clean RE replaces electricity generated from carbon intense sources.						

3.12.3 Mitigation Policies and Measures in Energy Efficiency

The achievement of the energy efficiency targets from both of the developed to cumulative energy savings of 2781 GWh, fulfilling the 20% target of 2258 GWh until 2020, according to the Arab EE Guideline.

The total investment cost of the 2nd NEEAP is estimated to be 696 million JD delivering annual savings for the users of about 230 million JD until 2020 with an average payback period equal to 2.5 years. The annual CO_2 emission reduction has been calculated at 999 $GgCO_2$ with an imposed cost equal to (-9.4) JD/tCO_2

The Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) was established by the Renewable Energy & Energy Efficiency Law, Law N. (13) of 2012. Has set The National Energy Efficiency Action Plan up to 2030, which will be implemented together with the partners as an important strategic step that includes the implementation of parallel sector plans in line with renewable energy plans, including public and private institutions. The plan aims to boost energy efficiency to achieve a 9% reduction in energy consumption by 2030 compared to the average energy consumption during 2018 with mitigating greenhouse gas emissions in line with the global GHG emissions reduction.

The National Energy Efficiency Action Plan covers all consumption sectors and concludes the following programs.

- Enhance the Energy Efficiency in the well fields and Pumping Stations in the water sector.
- Reduce overall energy consumption in Small & Medium Enterprises in the industry sector through the provision of (RE&EE) Solutions.
- Tourism sector program: Rationalize energy consumption and improve the efficiency of its use for four-star hotels or less in different regions of the Kingdom.
- Domestic Sector Program: providing energy efficiency solutions by distributing and installing energy-saving lighting units and applying methods and solutions for house insulation, and also by providing renewable energy solutions using solar water heaters and photovoltaic cells.
- Public and Governmental Program: Developing the appropriate financial support products for community-based organizations (CBOs) and places of worship and government buildings such as public schools, health centers, municipalities, and other government sector institutions to reduce the overall energy consumption of electricity by installing RE and EE solutions.
- Agricultural Sector Program: Developing the appropriate financial support products for small farmers to reduce the overall energy consumption of electricity through the

installation of renewable energy solutions. During this project, PV solutions for 70 small and medium farms will be installed.

Table 3.19 illustrates the summary description of the main mitigation measures for Energy Efficiency.

Table 3.19: Summary description of the main mitigation measures for Energy Efficiency

Name and a brief description of the mitigation action	Sector and subsector (and GHG reduced)	Implementing institution	Status [Planned, implemented, under implementation, and proposed	Main assumptions used in the mitigation analysis	Duration	Annually Emission reductions after completing the project (Gg CO_2eq)
1•Enhance the Energy Efficiency in the well fields and Pumping Stations in the water sector. The project involves improving energy efficiency and reducing GHG emissions associated with well fields and pumping stations, including measures such as replacing control panels and pumps and pipes and valves.	Water Sector CO_2	MWI, WAJ, MEMR	Under implementation	- **Grid emission factor=0.537 for 2020 conventional generation sources.** The estimated energy saving is 50 GWh. This offers a potential CO_2 saving of 32,000 tonnes/annum	2022-2030	27
2- Rationalize energy consumption and improve the efficiency of its use for four-star hotels or less in different regions of the Kingdom. Improving Energy Efficiency in Small and Medium Hotels, with a target of 120 hotels	Tourism/hotels sub-sector (CO_2)	WOT, MEMR /JREEEF	Under implementation	**Grid emission factor=0.537 for 2020 conventional generation sources.** - Energy saving1820MWh per annum. -the potential CO2 saving of980 tonnes/annum	2018-2030	0.95
3-RE & EE Solutions for Small & Medium Enterprises in the industry sector. LED Lighting and PV, Efficient advice	Energy Efficiency sub-sector (CO_2)	MEMR/JREEEF	Under implementation	**Grid emission factor=0.537 for 2020 conventional generation sources.** Energy saving 2000 MWh per annum. -the potential CO2 saving of 1075 tonnes/annum	2018-2020	1.2
4 Domestic Sector Program: providing energy efficiency solutions by distributing and installing energy-saving lighting units and applying methods and solutions for house insulation, and also by providing renewable energy solutions using solar heaters and a photovoltaic cell. -LED Lighting in commercial buildings (200000) lamps	Energy Efficiency sub-sector (CO_2)	MEMR /JREEEFJREEEF	Under implementation	**Grid emission factor=0.537 for 2020** Energy saving 35000 MWh per annum. -the potential CO2 saving of 18790 tonnes/annum	2018-2025	19.5
5-•Public and Governmental Program: Developing the appropriate financial support products for community-based organizations (CBOs) and places of worship and government buildings such as public schools, health	Public and Government building /Energy Efficiency sub-sector (CO_2)	MEMR/JREEEF	Under implementation	- Energy saving 25000 MWh per annum. -the potential CO2 saving of 13400 tonnes/annum	2022-2030	14.2

centers, municipalities, and other government sector institutions to reduce the overall energy consumption of electricity by installing RE and EE solutions						
6- Agricultural Sector Program: Developing the appropriate financial support products for small farmers to reduce the overall energy consumption of electricity through the installation of renewable energy solutions.	Agriculture Sector.	MOA, MEMR /JREEEF	Under implement ation	: Install PV solution for 70 small and medium farms - Grid emission factor 0.537 kg CO_2/kWh. - Energy saving 1900 MWh per annum. -the potential CO2 saving of 1200 tonnes/annum	2020-2025	0.90
7-Solar Water Heater 90000 system.	Domestic, commercial sectors	MEMR/JREEE F	Under implement ation	- The average domestic SWH system can save up to 400 kg of CO2 per year. - **Grid emission factor=0.537 for 2020**	2020-2030	720
8-Replace all the inefficient street lamps 125W with High-Pressure Sodium Street Lighting 70W. 400,000 lamps	Energy Efficiency sub-sector (CO2	MPWH, GAM MEMR/JREEE F	Planned	**Grid emission factor=0.537 for 2020**	2022-2030	98
OBJECTIVE OF THE MITIGATION ACTION						
The objective of these mitigation actions is to increase EE in different sectors: residential, commercial and industrial. Introducing EE measures will result in substantial reduction of consumption of electricity generated and fossil fuels						

3.12.4 Mitigation Policies and Measures in Transport Sector

- **Bus Rapid Transit Project (BRT).** This project involves the planning, design, and implementation of the second stage of a BRT network in Amman. It will be integrated with the fare collection system for BRT Phase 1 and other public transport in the city. Key activities include the construction of four additional BRT lines (as there are already two lines completed in Amman, which will integrate with Amman Zarqa BRT, due to be completed by the end of 2023), followed by the implementation of fare collection systems. These four lines are:
    - Construction of Phase 2 Line 1 - 23 km from Sweileh to South terminal (Customs Square), via the Airport Road.
    - Construction of Phase 2 Line 2 - 13 km from Sana'a Intersection to South Terminal (Customs Square).
    - Construction of Phase 2 Line 3 - 8km from Princess Basma Street to Prince Hussein Interchange, via the Abdoun Corridor.
    - Construction of Phase 2 Line 4 - 7km from Mahatta to Middle East Square.

- **Urban Bus Reform Public Transport project in Irbid and Zarqa.** The Jordan local bus reform project is planned to provide new bus services for the cities of Irbid and Zarqa, with a public sector-funded model. Each city will have a public sector organization to oversee the operation of the system, be responsible for funding, and plan service changes. The new buses will be of the latest design, which will be reliable, accessible, efficient and safe, and will include some electric vehicles. Furthermore, new ticketing systems will be introduced, through smart cards and ITS, compatible with other existing and planned systems in Jordan. The total number of buses is expected to be approximately 73, depending on the number of electric buses.
- **Intelligent Transport Systems (ITS):** this project involves integrating information and communication technologies into transportation to increase the efficiency of the system. This includes the installation of TV surveillance systems, electronic tracking and electronic payment systems, and electric card charging devices.
- **Increase the Penetration of Electric Cars.** Adopting a policy of increasing the number of electric cars by 3% annually. Jordan has taken measures to support the adoption of electric vehicles, but concurrent efforts will be made to expand its electric vehicle charging infrastructure. The Energy and Minerals Regulatory Commission (EMRC) is currently providing licenses for public and private electric vehicle charging stations and has announced its plans that all new petrol stations must have electric charging facilities.

Table 3.20 illustrates the summary description of the main mitigation measures in the transport sector.

Table 3.20: Summary description of the main mitigation measures for the Transport Sector.

Name and a brief description of the mitigation action	Sector and subsector (and GHG reduced)	Implementing institution	Status [Planned, implemented, under implementation, proposed	Main assumptions used in the mitigation analysis	Project Duration	Annually Emission reductions after completing the project (Gg CO2eq)
1- Bus Rapid Transit Project (BRT). phase 2	**Transport CO_2, N_2O, CH_4**	**GAM**	**Under implementation**	**Phase 1 of the BRT implementation in Amman involved 2 lines of BRT, which has been in operational since 2021 with an estimated saving of 48,000 tonnes of CO_2e per year. It is expected that the implementation of a further 4 lines in addition to this will produce further emissions savings of 96,000 tonnes CO2eq per year, with the caveat that the BRT lines will be of similar length and carrying a similar number of passengers**	**2025-2060**	**96.0**
2- Urban Bus Reform Public Transport project in Irbid and Zarqa	**Transport CO_2, N_2O, CH_4**	**MOT**	**planned**	**Large potential to reduce transport emissions if the new buses displace older, less efficient buses and lead to a mode shift towards public transport from private vehicles. There will be an even larger potential to reduce emissions with the introduction of electric buses due to a shift away from petrol and diesel usage.**	**2024-2060**	**32.0**
3- Intelligent Transport Systems (ITS)	**Transport CO_2, N_2O, CH_4**	**MOT**	**planned**	**Potential to make the public transport system more efficient. If the buses are**	**2023-2060**	**9,6**

				electronically monitored, this will allow for more efficient management through, for example, route choice and fleet dispersal. This will act to reduce congestion, therefore reducing emissions.		
4- Increase the Penetration of Electric Cars by 2% annually.	**Transport CO_2, N_2O, CH_4**	**MOT**	**Planned**	**- A round 28000 electric car in operation in 2022. - replacing gasoline with electricity. - Grid emission factor 0.4702kg CO_2/kWh**	**2023-2060**	**4.5**

3.12.5 Cost Benefit Analysis for the Energy Sector

Total emissions reduction for the mitigation measures and mitigation projects lifetime and the reduction unit cost for the energy sector are summarized in **Table 3.21**.

Table 3.21: The Cumulative reduction for the project life cycle and Reduction unit cost for the mitigation measures in energy Sector

NO.	Mitigation Measures	Cumulative reduction for the project life cycle. (Gg CO_2eq)	Reduction unit cost JD/tonne CO_2eq
1	Construction of a branch of pipeline between the refinery and Iraqi crude oil pipeline across Jordan territory.	1895	-38
2	Natural Gas Distribution Network in Amman, Zarqa, and Aqaba	2035	17
3	Loss Reduction in Electricity Transmission and Distribution (T&D) Network	3528	-40
4	Construction of 800 MW, PV (100*4) + (400 MW wheeling and Net -Metering) by 2030. To achieve the target of 35% of electricity mix from RES, by 2040.	26880	-7.5
5	Construction of 1600 MW, PV (200*8) during 2030-2040. To achieve the target of 50% of electricity mix from RES by 2040.	40140	-7.0
6	The Aqaba Amman Water Desalination and Conveyance Project (AAWDCP) - Wheeling Project, 185 MW PV (50% of the overall needed power demand	6540	-3.9

7	Enhance Energy Efficiency in the well fields and Pumping Stations in the water sector.	810	21.8
8	Rationalize energy consumption and improve the efficiency of its use for four-star hotels or less in different regions of the Kingdom.	28	-29
9	RE & EE Solutions for Small & Medium enterprises in the industry sector.	36	-11.5
10	Domestic Sector Program: providing energy efficiency solutions.	585	-33.9
11	Public and Governmental Program by installing RE and EE solutions	426	-27.6
12	Agricultural Sector Program: PV solution for 70 small and medium farms.	27	-10.3
13	-Solar Water Heater 90000 system	1080	-37.6
14	Replace the inefficient street lamps 125W with High-Pressure Sodium Street Lighting 70W. 400,000 lamps	2940	-9.66
15	Bus Rapid Transit Project (BRT). phase 2	2520	69
16	Urban Bus Reform Public Transport project in Irbid and Zarqa	960	82
17	Intelligent Transport Systems (ITS)	288	20
18	Increase the Penetration of Electric Cars by 2% annually	135	24

Annex Table A.7 illustrates the Cumulative Costs & Benefits 2018-2065 of Mitigation Scenario Relative to the Baseline Scenario for energy measures as shown in LEAB result.

The avoid GHGs emission vs. energy sector Baseline Scenario (included transport.) for selected years are shown in **Table 3.22**, while **Figure 3.10** illustrate the avoided GHGs in mitigation vs. baseline scenario in the energy sector.

Table 3.22: Avoided GHGs emission vs. energy sector Baseline Scenario (included transport) for selected years. (Gg CO_2eq)

Scenarios	2018	2019	2020	2022	2025	2030	2035	2040	2045	2050
Baseline	26805	25262	25639	26357	27535	29103	29921	32883	36258	41291
Mitigation*	24395	22777	22537	23042	21715	21698	21899	23813	26638	32549
The Avoided CO_2eq	2410	2485	2622	3315	5820	7405	8022	9070	9620	9740

*Note that all the mitigation measures and projects constructed after 2014 and now in operation, as wind and solar energy projects, also energy efficiency programs were taken into consideration.

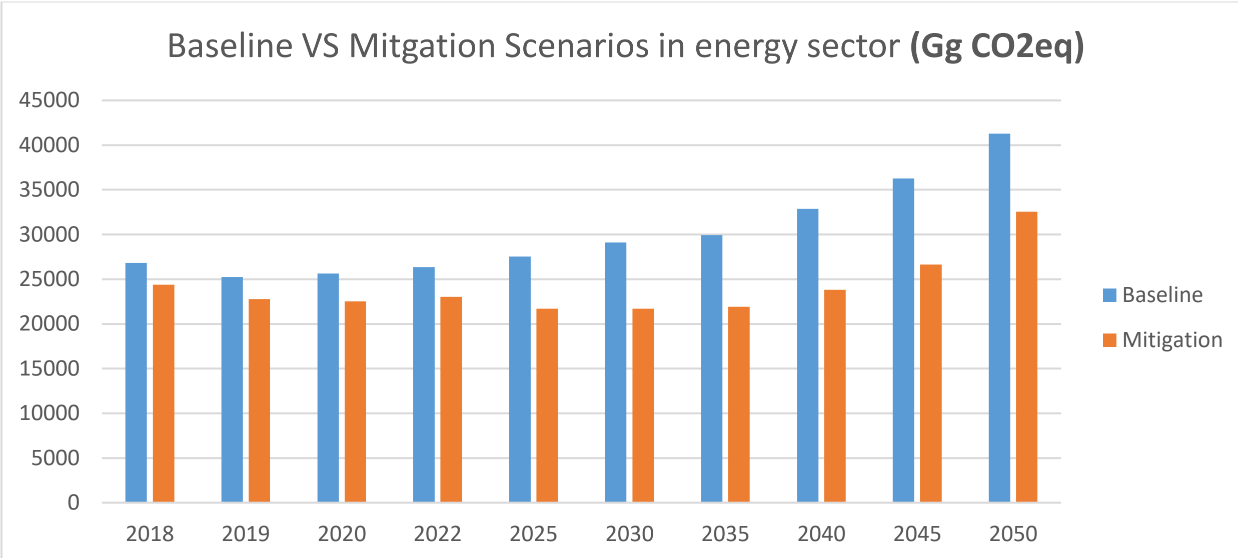


Figure 3.10: The mitigation vs. baseline scenario in the energy sector

3.12.6 Mitigation Policies and Measures in IPPU Sector

- **Use of steel slag and/or fly ash to substitute the raw materials needed to produce clinker at the selected cement plant**

Certain steel slag and fly ash materials (decarbonated kiln feedstock) could be added to the raw material feed to reduce the amount of raw material needed to produce a given amount of clinker. Jordan has more than 5 steel melting and galvanizing factories, therefore there is an available stock of steel slag and fly ash to be used in the cement industry. In this mitigation project, it is suggested to produce a new type of cement CEM V (Composite Cement) at one of the cement industries; mainly the one that has a neighboring steel manufacturing company and can try the production of this type of cement with minor additional costs in comparison to other existing companies. The percentages of blast-furnace slag and natural Pozzolana range between 31-49% each, to produce CEM V/B. A 40% substitution of steel slag/fly ash and a 10% production of new CEM V/B will be assumed at this company. The price of steel slag and/or fly ash is estimated to be 42.3 JD/tonne. The cost of energy and raw materials reaches 61% of the total cost and is based on the assumption of a production cost of 89.7 JD/tonne of cement. This option will reduce the cost by 54.7 JD/tonne of cement. No annual increase in the production costs will be assumed for the project lifetime. The investment cost to grind the steel slag will be estimated as 2,442,928 JD (based on the maximum produced tonnes of CEM II in 2053) based on the estimated cost of 1.37 USD/tonne of cement. It is estimated that implementing this mitigation measure will result in a discounted emission reduction of 250,000 tonnes of CO_2 over the lifetime of the project (2023 - 2053).

- **Increase the percentage of Pozzolana in CEM II**.

Blended cement is a mixture of clinker and additives containing less than 95% clinker. Blended cement types are distinct products with different uses that have different additives and different shares of clinker. More than 90% of cement produced at the local cement companies is CEM II (Portland– Pozzolana Cement) with a percentage of Pozzolana ranging 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 causing the use of Pozzolana of less than 32% (the 3% is substituted by gypsum). A reasonable 2% more substitution could be assumed on average and so a reduction of CO2 emissions by 2% could be assumed as well. Since all local cement companies produce CEM II, there is no need for investment to procure the equipment needed to receive, store, grind, and meter. Pozzolana to the cement product. The operational cost includes the price of extraction of Pozzolana, paid to MEMR previously payment was to the Natural Resources Authority) and transportation. However, this option will reduce the cost of raw materials (mainly limestone) and energy needed to produce the saved clinker that will be substituted by Pozzolana. The price of Pozzolana is estimated to be 36.6 JD/tonne. As mentioned above, this option will reduce the cost by 54.7 JD/tonne of cement to save both energy and raw materials and no extra investment cost is needed.

To have time for the experimental trials is expected to start the implementation of this project in 2023. The project lifetime is assumed to be 30 years. It is estimated that implementing this mitigation measure will result in emission reduction of 367,000 tonnes of CO_2 over the lifetime of the project (2023-2053).

- **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% (at least 13% more (starting from approximately 32%). CO_2 reduction will be calculated by multiplying the annual CO_2 emissions by the reduced percentage of 13%, this percentage will also be 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 as a result of implementing this option. To allow time for the experimental trials, marketing the new product, and setting the legally binding regulations and enforcement measures to control its use, it is expected to start the implementation of this project in 2025. The project lifetime is estimated to be 30 years. The price of Pozzolana is estimated to be 36.6 JD/tonne and also this option will reduce the cost by 54.7 JD/tonne of cement by savings in both energy and raw materials, and with no extra investment. It is estimated that implementing this mitigation measure will result in emission reduction of 238,000 tonnes of CO2 over the lifetime of the project (2025 – 2055).

- **Use of biomass (MSW and/or Sewage Sludge) as alternative fuels**

A potential reduction of CO_2 emissions in the cement industry could be achieved by switching from traditional fossil fuels to biomass fuels. Since most local cement factories are licensed to burn coal, pet coke, oil shale, and alternative fuels such as waste tires 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. A value of 27.5 JD/tonne of alternative fuel is used to estimate the investment cost based on the maximum estimated tonnes needed in 2046. So, the investment cost for this option is estimated at 129 MJD. To allow time for the experimental trials, studies of the maximum percentage of MSW and dried sewage sludge to be used, availability of stocks in the market, testing the emissions, conduct EIA study, and getting the environmental clearance; it is expected to start the implementation of this project in 2023. The project lifetime is estimated to be 30 years. It is estimated that implementing this mitigation measure will result in emission reduction of 814,000 tonnes CO_2 over the lifetime of the project (2023 – 2053).

- **Catalytic reduction of N_2O inside the ammonia burner of the Nitric Acid plant**

This project 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 of reducing approximately 75% to 80% of the N_2O formed at the precious metal gauzes inside the ammonia burner to atmospheric N_2 and O_2 (through communication with KEMAPCO). The selected N_2O abatement technology depends on replacing some of the Al_2O_3 balls that support the platinum-rhodium catalyst with a base metal secondary catalyst, which is capable of reducing N_2O by at least 75%. This project will only be implemented for the sake of GHG emissions reduction; there are no other direct benefits. Therefore, its implementation is strongly dependent on the provision of economic incentives. The project is assumed to start in 2023 and its lifetime is estimated to be the same as the lifetime of the KEMAPCO plant, which is estimated to be 30 years (till the year 2046). It is estimated that implementing this mitigation measure will result in emission reduction of 1,659,000 tonnes of CO_2 over the lifetime of the project (2022 – 2046). **Table 3.23** illustrate the summary description of the main mitigation measures in the IPPU sector.

Table 3.23: Summary description of the main mitigation measures in the IPPU sector.

Name and a brief description of the mitigation action	Sector and subsector (and GHG reduced)	Implementing institution	Status [Planned, implemented, under implementation, proposed	Main assumptions used in the mitigation analysis	Project Duration	Average annual Emission reductions (Gg)
1 Use of steel slag and/ or fly ash to substitute the raw Materials needed to Produce clinker	**Mineral Industry-Cement Production CO_2**	**Cement manufacturing companies**	**Proposed**	**- 40% of limestone is replaced by steel slag/fly ash. - 10% of CEM II/B-P (Portland-Pozzolana Cement) will be converted to a new product CEM V/B. - The annual CO2 emissions from producing CEM II/B-P is multiplied by 4% to calculate the CO_2 emissions reduction. - The price of steel slag and/or fly ash is estimated to be 42.3 JD/tonne. - Investment cost to grind the steel slag is estimated to be $0.1.37/tonne of cement. - The production cost will be reduced by 54.7 JD/tonne of cement**	**2023-2053**	**35**
2- Increase the percentage of Pozzolana in CEM II	**Mineral Industry-Cement Production CO_2**	**Cement manufacturing companies**	**Proposed**	**- a reduction of CO2 emission by 2% is assumed. -the price of pozzolana is estimated to be 36.6 JD /tonne. - the production cost will be reduced by 54.7 JD/tonne of cement.**	**2023-2053**	**55**
3- Produce new cement product CEM IV with 45%of pozzolana	**Mineral Industry-Cement Production CO_2**	**Cement manufacturing companies**	**Proposed**	**-10% of produced CEM II/B-P will be changed to CEM IV. -The annual CO_2 emissions from producing CEM II/B-P are multiplied by 1.3% to calculate CO2emiission reduction.**	**2023-2060**	**31**
4-Use of biomass MSW and/ or sewage sludge as an alternative fuel.	**Mineral Industry-Cement Production CO_2**	**Cement manufacturing companies**	**Proposed**	**- A reduction factor of 0.0231 tonnes CO2 /tonne cement is used for MSW or direct sewage sludge. The price of coal is estimated to be 344 JD /tonne. -The distance between the cement plant and Ghabawi Landfills 100 km. the fuel cost is 0.2 JD /km.**	**2025-2055**	**105**

				- Transport fees are estimated to be 1.5 JD/km -An additional cost of 10 JD /tonne of MSW or /and sewage sludge is assumed to manage any requirements mitigation before use. - 0.175 tonne of dry sludge is required to produce an I tonne of cement. - 0.233 tonne of the dry sledge is required to produce 1 tonne of cement. - 0.098 of coal is required to produce 1 tonne of cement. - 0.20 of coal is replaced. -A value of 27.5 JD /tonne of alternative fuel is to estimate the investment cost.		
5-Catalytic Reduction of N2O inside the ammonia burner of the nitric acid plant.	**Mineral Industry-Nitric Acid Production N2O.**	**Arab Fertilizers and Chemicals Industries LTD (KEMAPCO)**	**Proposed**	**- The capital cost for an integrated secondary abatement project is estimated to be 2.8 Euro/tonne of nitric acid produced. - The operational cost is estimated to be 1Euro/tonne of nitric acid produced. - This abatement technology is capable of reducing the N2O produced inside the ammonia burner by about 75%**	**2023-2053**	**185**
OBJECTIVE OF THE MITIGATION ACTION						
The objective of these measures is to change the raw material inputs, in order to save energy, whilst continuing to produce high quality products. In addition, to introduce new technologies in industrial companies with the aim of reducing GHG emissions from industrial processes						

3.12.7 Cost Benefit Analysis for the IPPU Sector

The costs and the CO_2 emissions reduction for the proposed IPPU mitigation projects have been analyzed. A summary of the results is shown in **Table 3.24**.

Table 3.24: The Cumulative reduction for the project life cycle and Reduction unit cost for the mitigation measures in IPPU Sector

NO.	Mitigation Measures	Cumulative reduction for the project life cycle. (Gg CO_2eq)	Reduction unit cost JD/tonne CO_2eq
19	**Use of steel slag and/or fly ash to substitute the raw materials needed to produce clinker at the selected cement plant**	1050	-8.8
20	**Increase the percentage of Pozzolana in CEM II**	1650	-11.5
21	**Produce new cement product CEM IV with 45% of Pozzolana**	930	-12.8
22	**Use of biomass (MSW and/or Sewage Sludge) as alternative fuels**	3150	-28
23	**Catalytic reduction of N2O inside the ammonia burner of the Nitric Acid plant**	5550	2

3.12.8 Mitigation Policies and Measures in Waste Sector

- **Al Ghabawi landfill to generate electricity from biogas.**

Ghabawi landfill project has been generating electricity since the end of May 2019 by converting waste into bio-gas. The methane gas at Ghabawi landfill, situated some 25 kilometers east of Amman, will be collected and burned to prevent it from being released into the air and harming the environment, while also using the collected biogas to generate electricity. The electricity generated is used to power the landfill, while the remainder is sent back to the national grid.

The landfill serves the capital and the central region, stretching over 3,000 square meters. It receives 1.3 million tonnes of waste annually and is expected to remain in operation beyond the year 2035. The landfill is designed with 9 cells (the cell is a pit of earth 17 meters deep and with an area ranging from 150 to 250 acres). 4 cells have been completed and the work on the fifth cell is under way. \ With an installed capacity of 4.68 MW, an average of 106 MWh per day has been generated. The generators are running at 41.8% of rated load, an availability of 97.9%, after discounting the required maintenance tasks. The project contributes to reducing the emission of 175,000 tonnes of carbon dioxide equivalent by burning about 19 million cubic meters of biogas annually. The capacity of the project will be increased to 7.4 MW after work on the fifth cell is completed.

- **Al-Elkader Domestic Landfill for electricity generation from biogas.**

A Sanitary landfill cell for solid waste in Al-Elkader Domestic Landfill was established with the support of the German Agency for International Development (GIZ) and entered into operation in August 2018. Al-Elkader landfill project will start generating electricity from the first cell in 2024 by converting waste into bio-gas. The **methane gas** from the landfill, situated some 30 kilometers east of Irbid city, will be collected and burned to prevent it from being released into the air and harming the environment, while also using the collected biogas to generate electricity with an installed capacity of 2.2 MW, an average of 48 MWh per day, with an availability of 97%. The project is planned to reduce the emission of 80,000 tonnes of carbon dioxide equivalent by burning about 8.5 million cubic meters of biogas annually. The capacity of the project will be increased gradually by opening other cells during the project cycle.

- **Utilizing Biogas from landfills for electricity generation.**

The proposed projects are for biogas collection and utilization from Al-Dhulil, Al-Salt, and Madaba domestic solid waste landfill. The projects aim at collecting the generated biogas, treating it for impurities, generating electricity by introducing a biogas generator, and connecting the generated electricity to the national electricity grid. The suggested projects will reduce the amount of fuel used for electricity generation.

The starting year for implementing these projects is 2024 and construction activities, commissioning, and testing will take 1 year, so the actual operation for the proposed project will be in 2025. The lifetime of the project is 30 years (2025 – 2060).

- **Biogas generation by utilizing the sludge generated from the Wadi Arab, Baqa'a, and Salt and Madaba domestic wastewater treatment plants**.

The proposed projects aim at generating biogas from the sludge and connecting the generated electricity to the national electricity grid. These projects will reduce the amount of fuel used for electricity generation, considering that a considerable amount of sludge is produced from the wastewater treatment plants without any utilization. In the four projects of Wadi Arab, Baqa'a, and Madaba the construction activities, commissioning, and testing will take 1 year. The starting year for implementing the proposed projects in Madaba and Wadi Al Arab and Baqa'a is 2023 for a lifetime of 25 years (2023 to 2048) while in Salt will be 2025

  - Implementing composting units for pre-segregated bio-waste in 4 Areas with a total capacity of 200 tonnes/day.

The following assumptions were used during the update of waste projects:

- The total amount of organic material generated is assumed to increase annually by 2.2%,
- The density of methane is 0.717 kg/m3,
- The captured methane from all landfills is calculated according to the PRIF study (Environment and use of methane from municipal waste in Amman, 1993), where the average value is used,
- The electricity grid emission factor is considered to be 0.4585 $kgCO_2/kWh$,
- The calculation of generated electricity in MW is based on 8,000 working hours per year,
- The generated electricity from the utilization of sludge produced at wastewater treatment plants is assumed to be sold at a fixed price of 0.094 JD/kWh (each kW produced is assumed to replace 1kW sold from the electricity grid),
- The generated electricity from the utilization of biogas produced from landfills is assumed to be sold at a fixed price of 0.06 JD/kWh,
- The cost of a 1 MW biogas electricity generation landfill system (generator, wells, piping, etc.) is 1.5 million JD, according to the International Renewable Energy Agency (IRENA),
- The cost of 1 MW biogas electricity generation from a biogas system (digester, WWTP generator, piping, etc.) is 4 million JD (Jordan biogas project),

- The fixed annual cost is the sum of maintenance, operation, overheads, and supervision costs (3% of the capital cost) of wastewater treatment plant systems.
- The fixed annual cost is the sum of maintenance, operation, overheads, and supervision costs in biogas projects in landfills (5% of capital investment, according to IRENA).

All mitigation options under the waste sector were considered as energy measures because the biogas will be used for electric power generation. **Table 3.25** illustrates the summary description of the main mitigation measures in the waste sector.

Table 3.25: Summary description of the main mitigation measures in the waste sector.

Name and a brief description of the mitigation action	Sector and subsector (and GHG reduced)	Implementing institution	Status [Planned, implemented, under implementation, proposed	Main assumptions used in the mitigation analysis	Project Duration	Annually Emission reductions (Gg CO2eq)
1 Al Ghabawi landfill to generate electricity from biogas.	Waste-Solid waste. CH_4	GAM MEMR MoEnv	implemented	**Grid emission factor=0.537 for 2020.** **Density of methane = 0.717 kg/m3 (Clean Energy Emission Reduction (CLEER) protocol, ICF, 2019)** **- The captured methane is calculated According to a PRIF study, Amman, 1993 where the average value is used.** **- Assuming every 1 MW produced needs 300 m3 CH4/hr. to be burned** **- The generated electricity will be sold at a fixed price of 0.06 JD/kWh** **- The cost of 1 MW of biogas electricity generation system (generator, wells, Piping, etc.) is 2,940,000 JD (According to International Renewable Energy Agency ARENA)** **- The fixed annual cost is the sum of** maintenance, operation, overhead and supervision costs (5% of capital investment	**2019-2050**	**175 actual figure and will increase to 280 in 2024 and then will increase gradually by open new cells.**
2- Al-Elkader Domestic Landfill for electricity generation from biogas	Waste-Solid waste. CH_4	MOMA	Under implementation	**The same above assumptions**	**2024-2055**	**80 will be increased gradually by open new cells.**
1- Utilization of biogas Produced from Al-Dhulil Landfill in electricity production	Waste-Solid waste. CH_4	Ministry of Local Administration	Planned	Density of methane = 0.717 kg/m3 (Clean Energy Emission Reduction (CLEER) protocol, ICF, 2019) - The captured methane is calculated According to a PRIF study, Amman, 1993 where the average value is used. - Assuming every 1 MW produced needs 300 m3 CH4/hr. to be burned - Electricity grid emission factories 0.537 kgCO2/KWh - The generated electricity will be sold at a fixed price of 0.06 JD/kWh - The cost of 1 MW of biogas electricity generation system (generator, wells, Piping, etc.) is 2,940,000 JD (According to International Renewable Energy Agency IRENA) - The fixed annual cost is the sum of maintenance, operation, overhead and	**2025-2060**	**110**

				supervision costs (5% of capital investment		
2 Biogas collection and Utilization from Al-Salt (Homra) domestic solid waste landfill	Waste-Solid waste. CH_4	Ministry of Local Administration	**planned**	**The main assumption above**	**2027-2060**	**135**
3- Biogas collection and utilization from Madaba domestic solid waste landfill	Waste-Solid waste. CH_4	Ministry of Local Administration	**planned**	**The main assumption above**	**2027-2060**	**103**
4 Utilization of sludge Produced form Wadi Al Arab wastewater Treatment plant**.**	Waste-Wastewater CH_4	Ministry of Water and Irrigation	**Planned**	The captured methane is assumed to be 100% - Assuming every 1 MW produced needs 300 m3 CH4/hr to be burned - Electricity grid emission factor is 0.4585 kgCO_2/kWh - The generated electricity will be sold at a fixed price of 0.094 JD/kWh - The cost of 1 MW of biogas electricity generation system (generator, digester, piping, etc.) is 4 MJD - The fixed annual cost is the sum of maintenance, operation, overhead and supervision costs (3% of capital cost)	**2023-2060**	**31**
5-Utilization of sludge Produced from Baqa'a Wastewater treatment plant	Waste-Wastewater CH_4	Ministry of Water and Irrigation	**Planned**	**The main assumptions as above**	**2025-2050**	**115**
6-Biogas generation by utilizing the sludge generated from Salt domestic wastewater treatment plant	Waste-Wastewater CH_4	Ministry of Water and Irrigation	**Planned**	**The main assumptions as above**	**2025-2060**	**27**
7-Utilization of sludge Produced by Madaba Wastewater treatment plant	Waste-Wastewater CH_4	Ministry of Water and Irrigation	**Planned**	**The main assumptions as above**	**2023-2053**	**10**

OBJECTIVE OF THE MITIGATION ACTION
The objective of the mitigation action is to reduce methane emitted by the anaerobic decomposition of waste at landfills and to use captured methane to produce electricity. This will directly subsidize part of the electricity already produced by the combustion of fuel including natural gas and HFO.

3.12.9 Cost Benefit Analysis for the Waste Sector

Total emissions reduction for the mitigation measures and mitigation projects lifetime and the reduction unit cost for the waste sector are summarized in **Table 3.26**.

Table 3.26: Cumulative reduction for the project life cycle and Reduction unit cost for the mitigation measures in waste Sector

NO.	Mitigation Measures	Cumulative reduction for the project life cycle. (Gg CO_2eq)	Reduction unit cost JD/tonne CO_2eq
24	Al Ghabawi landfill to generate electricity from biogas.	12430	-7.5
25	Al-Elkader Domestic Landfill for electricity generation from biogas	4400	-6.2
26	Utilization of biogas Produced from Al-Dhulil Landfill in electricity production	2760	-1.5
27	Biogas collection and Utilization from Al-Salt (Homra) domestic solid waste landfill	3435	-2.0
28	Biogas collection and utilization from Madaba domestic solid waste landfill	2580	-2.0
29	Utilization of sludge Produced from Wadi Al Arab Wastewater Treatment plant	770	-4.0
30	Utilization of sludge Produced from Baqa'a Wastewater treatment plant	3750	-2.0
31	Biogas generation by utilizing the sludge generated from Salt domestic wastewater treatment plant	675	2.4
32	Utilization of sludge Produced by Madaba Wastewater treatment plant	565	4.0

3.12.10 Mitigation Policies and Measures in AFOLU Sector

All mitigation projects included in the 2nd BUR and Updated Submission of Jordan's 1st Nationally Determined Contribution (NDC) have been reviewed and assessed to identify those options considered to be still valid and applicable. The main mitigation options within AFOLU mainly involve one or more of three strategies:

- Reduction/prevention of emissions to the atmosphere by conserving existing carbon pools in soils or vegetation that would otherwise be lost, or by reducing emissions of CH4 and N2O;
- Sequestration—enhancing the uptake of carbon in terrestrial reservoirs, and thereby removing CO_2 from the atmosphere; and
- Reducing CO_2 emissions by introducing changes within demand-side options (e.g., by lifestyle changes, reducing losses and waste of food, changes in human diet, changes in wood consumption).

There are five mitigation projects for AFOLU are still valid, however there are changes in the description of each project as indicated below:

- **Introduce new trees plantation in Urban Areas**

Losses in urban trees are a continuous concern either due to snowstorms, or from burning, and cutting due to land use change. No official numbers have been published for the losses in urban trees, but it was assumed that average losses are 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.

Based on GAM, Ministry of Agriculture, and Forestry Department, and the Updated Submission of Jordan's 1st NDC, the total suggested number of trees has been changed from 2500 to 32500 trees medium size coniferous trees. In addition, and based on IPCC recommendations and literature, the sequestration factor have been changed from 0.060 tonnes CO_2 per planted medium growth coniferous tree to a series fraction based on plant age (i.e., 10 kg CO_2 sequestered/year per tree till reaching 10 years old, 20 kg CO_2 sequestered/year per tree till reaching 20 years old, 30 kg CO_2 sequestered/year per tree till reaching 30 years old, and 40 kg CO_2 sequestered/year per tree after reaching 30 years old). Thus, planting coniferous trees in an urban setting and allowing them to grow for 44 years, sequesters 0.7-tonnes CO_2 per planted tree. It is estimated that implementing this mitigation measure will result in a discounted emission reduction of 21,990 tonnes CO_2 over the lifetime of the project (2022 – 2066).

- **Forestry- Introduce new plantations in the Northern Area**

There are tremendous losses in forest trees every year due to snowstorms, burning or illegal cutting. Although no official figures have been published regarding the loss, it was assumed that an average loss of around 30,000 trees within the Northern Area, which will be compensated for, mostly by planting pine and coniferous trees. However, based on the recommendations of the Ministry of Agriculture, and Forestry Department, and based on the Updated Submission of Jordan's 1st NDC, the total suggested number of trees has been changed to 2,000,000 pines and coniferous trees. Similar to above, a series fraction based on plant age was used to estimate the sequestration per year. It is estimated that implementing this mitigation measure will result in a discounted emission reduction of 1,250,000 tonnes CO_2 over the lifetime of the project (2022 – 2066).

- **Rangeland restoration and increase in forage production Projects**

The projects suggest that the Ministry of Agriculture establish a public corporation responsible for forage production and sales to livestock owners. The corporation will be responsible for buying the plants and for hiring labor for cultivation. Two areas for production will be considered:

- Project 1: Restoration of Rangeland Areas and Rangelands

100,000 dunums is proposed instead of 50,000 dunums to be planted with perennial fodder shrubs in the Badia (Al Jafr and Al Husseinieh) sub-districts within the Ma'an Governorate. The suggested productivity of this area will be 50 kg/dunum of dry matter (in areas with 100-200 mm rainfall), with a suggested sequestration rate of 5.67 tonnes SOC per hectare (i.e., 20.75 tonnes of CO_2 per hectare). It has been estimated that implementing this mitigation measure will result in a discounted emission reduction of 3,112,830 tonnes CO_2 over the lifetime of the project (2022 – 2036).

- Project 2: New Protected Rangeland Area as Natural Reserve

This previously proposed project is still considered valid. 100,000 dunums in the wide desert valleys of south Badia, will be restored as a natural reserve area. The average annual dry matter production is assumed to increase with good restoration practices from 4 kg/dunum in to 15 kg/dunum.

The project will harness direct benefits for protection of floral biodiversity through controlling the grazing of the indigenous *Atriplex halimus* shrubs. 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 projects 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 by flow from flash floods). It is assumed to have an average of 35 average sized shrubs/dunum and the sequestration rate is of 5.67 tonnes SOC/ha/year rate and a lifetime of 15 years. It is estimated that implementing this mitigation measure will result in a discounted emission reduction of 3,112,830 tonnes CO_2 over the lifetime of the project (2022 – 2036).

- **Promoting Climate-Smart Agricultural Practices in the Jordan Valley**

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 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: 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 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.

Recently, a Climate-Smart Agriculture Action Plan[111] was issued for Investment opportunities in the agriculture sector's transition to a climate resilient growth path. The document highlighted the agricultural context of the country, in addition to the climate change impacts on the available agriculture system, and suggested a prioritized Climate-Smart Agriculture (CSA) interventions in Jordan. Although most of the measures are adaptation options, such as Expand current date palm

[111] Jordan: Climate-smart agriculture action plan – Investment opportunities in the agriculture sector's transition to a climate resilient growth path - Jordan | ReliefWeb

area by 800 ha in small landholdings and increase economic return of current plantations by 50% over 5 years; Expand protected vegetables cultivation by 25% and economic water productivity by 40% over 5 years; (3) adopt advanced olive growing, collecting, processing, and packaging technologies over 5 years of implementing the project, (4) increase barley production through rainwater harvesting combined with the selection and management of suitable lands; (5) Building and running 3 collective Awasi pilot community farms in the north, middle and south Badia adopting latest technologies of feed and milk processing and marketing; (6) Restoring 5,000 hectares with shrubs and grasses using micro catchment water harvesting and improved grazing management in 5 years. The document also assessed the GHGs mitigation of CSA investment packages in which the estimated reduction in GHGs; as presented at **Table 3.27**, is about 823,665 of tCO_2eq over the lifetime of the project (2022 – 2026).

Table 3.27: Estimated Reduction in CO_2eq for the Proposed Climate-Smart Agriculture Action Packages

Climate-Smart Agriculture Action	**CO_2 reduction (tCO_2-eq)**	**Duration**
The investment package on Date Palm aims to convert 800 ha of open field vegetables farmland into new date palm plantations	98,010	5 years
The investment package for vegetables targets in total 370 ha for the conversion of vegetables grown in open field and low tunnels to greenhouses and some to hydroponics	37,608	5 years
The olives investment package aims to integrate climate smart practices on 1000 ha with existing olive production activities.	27,653	5 years
The Barely plantation package intents using better agronomic practices and varieties and water harvesting through micro-catchment structures on 1000 ha	28,212	5 years
The switching livestock package from open grazing to concentrated (collective) farming systems to improve nutritional management and livestock production, as well as by-product processing and marketing	107,387	5 years
The Badia restoration package refers to a large-scale effort to rehabilitate 5,000 ha of degraded land into vibrant shrub- and grasslands	524,795	5 years
Total	**823,665**	

Table 3.28 illustrates the summary description of the main mitigation measures in the AFOLU sector.

Table 3.28: Summary description of the main mitigation measures in the AFOLU sector.

Name and a brief description of the mitigation action	Sector and subsector (and GHG reduced)	Implementing institution	Status [Planned, implemented, under implementation, and proposed	Main assumptions used in the mitigation analysis	Duration	Annually Emission reductions after completing the project (Gg CO_2eq)
1- Introduce new trees plantation in Urban Areas. 32500 trees medium size coniferous trees	AFOLU (CO_2)	MoA, Forestry Department and GAM	Planned	- Sequestration factor from a planted medium growth coniferous tree set as a series fraction based on plant age	2022-2066	0.5
2- Forestry- Introduce new plantations in Northern Area through planting 2,000,000 trees of pines and coniferous trees	AFOLU (CO_2)	MoA, and Forestry Department	Planned	- Sequestration factor from a planted medium growth pines and coniferous trees set as a series fraction based on plant age	2022-2066	28.4
3- Restoration of Rangeland Areas and Rangelands through planting 100,000 dunums with perennial fodder shrubs in the Badia (Al Jafr and Al Husseinieh) sub-districts within the Ma'an Governorate.	AFOLU (CO_2)	MoA	Planned	-The suggested productivity of these area will be 50 kg/dunum of dry matter -It is suggested to sequester in a rate of 5.67 tonnes SOC per hectare (i.e., 20.75 tonnes of CO_2 per hectare	2022-2036	207.52
4 New Protected Rangeland Area as Natural Reserve combined through restoration of 100,000 dunums in the wide desert valleys of south Badia.	AFOLU (CO_2)	MoA and RSCN	Planned	It is assumed to have an average of 35 average sized shrub/dunum and the sequestration rate is of 5.67 tonnes SOC/ha/year rate and a lifetime of 15 years.	2022-2036	207.52
5- Promoting climate-smart agricultural practices in the Jordan Valley through 5 sets of packages	AFOLU (CO_2, N_2O)	MoA	Planned	Climate-Smart Agriculture Action Plan is set with Climate-Smart Agriculture (CSA) interventions	2022-2026	164.73
OBJECTIVE OF THE MITIGATION ACTION						
The objective of these mitigation actions is to (1) reduce/prevent emissions to the atmosphere by conserving existing carbon pools in soils or vegetation that would otherwise be lost, or by reducing emissions of CH4 and N2O; (2) sequester through enhancing the uptake of carbon in terrestrial reservoirs, and thereby removing CO2 from the atmosphere; and (3) reduce CO2 emissions by introducing changes within demand-side options (e.g., by lifestyle changes, reducing losses and waste of food, changes in human diet, changes in wood consumption).						

3.12.11 Cost Benefit Analysis for the AFOLU Sector

Based on experts' judgment, the AFOLU projects is suggested to be repeated till the end of the mitigation scenario study period (2018-2065) to ensure the benefits of these projects are been gained/maximized as much as possible. **Table 3.29** summaries the total emissions reduction for the mitigation measures and the reduction unit cost for the AFOLU sector.

Table 3.29: Cumulative reduction for the project life cycle and Reduction unit cost for the mitigation measures in AFOLU Sector

NO.	Mitigation Measures	Cumulative reduction for the project life cycle. (Gg CO_2eq)	Reduction unit cost JD/tonne CO_2eq	Cumulative reduction till 2066 (Gg CO_2eq)	Reduction unit cost JD/tonne CO_2eq
33	**Introducing new trees plantation in Urban Areas.**	21.99	17.98	21.99	17.98
34	**Forestry- Introduce new plantations in Northern Area.**	1,250.00	8.64	1,250.00	8.64
35	**Restoration of Rangeland Areas and Rangelands.**	3,112.83	7.31	9,130.97	5.66
36	**New Protected Rangeland Area as Natural Reserve.**	3,112.83	19.39	9,130.97	17.95
37	**Promoting Climate-Smart Agricultural Practices in the Jordan Valley.**	823.67	25.25	7,248.25	20.20

3.13.12 Main Result of the Mitigation Analysis

3.13.12.1 Overall GHG Mitigation Scenario

As a result of all mitigation measures and actions which have been considered during the period 2022-2066 in targeted sectors and subsectors including primary energy, electricity, renewable energy, energy efficiency, transport, IPPU, waste, and AFOLU. The total GHG emission in the mitigation scenario will be 27.7, 28.9, and 33.2 million tonnes CO_2eq compare to 35.5, 37.8, and 43.7 million CO_2eq in the baseline scenario for the years 2025, 2030, and 2040 respectively. **Table 3.30** illustrates in detail the total GHG emission in the baseline and mitigation scenarios, also the total GHG emission reduction by sector. Figure 3.11 shows the comparison between the baseline scenario and the mitigation scenario.

Table 3.30: GHG emission reduction from the baseline scenario and the mitigation scenario for selected years.

year	Baseline scenario	GHG avoided in the energy sector	GHG avoided from IPPU	GHG avoided from waste	GHG avoided from AFOLU	Total reduction	Mitigation Scenario
Gg CO_2eq							
2018	33462	2410	-	-	-	2410	31052
2019	32045	2450	44	-	-	2494	29551
2020	32566	2822	175	165	-	3162	29404
2022	33556	3735	175	188	-	4098	29458
2025	35516	6218	674	283	584	7759	27757
2030	37857	7460	695	315	589	9059	28798
2035	39943	8210	990	352	594	10146	29797
2040	43756	9070	1030	397	599	11096	32660
2045	48128	9620	1150	437	620	11827	36301
2050	54714	9742	1430	450	620	12242	42472
2055	60503	10110	1600	470	620	12800	47703

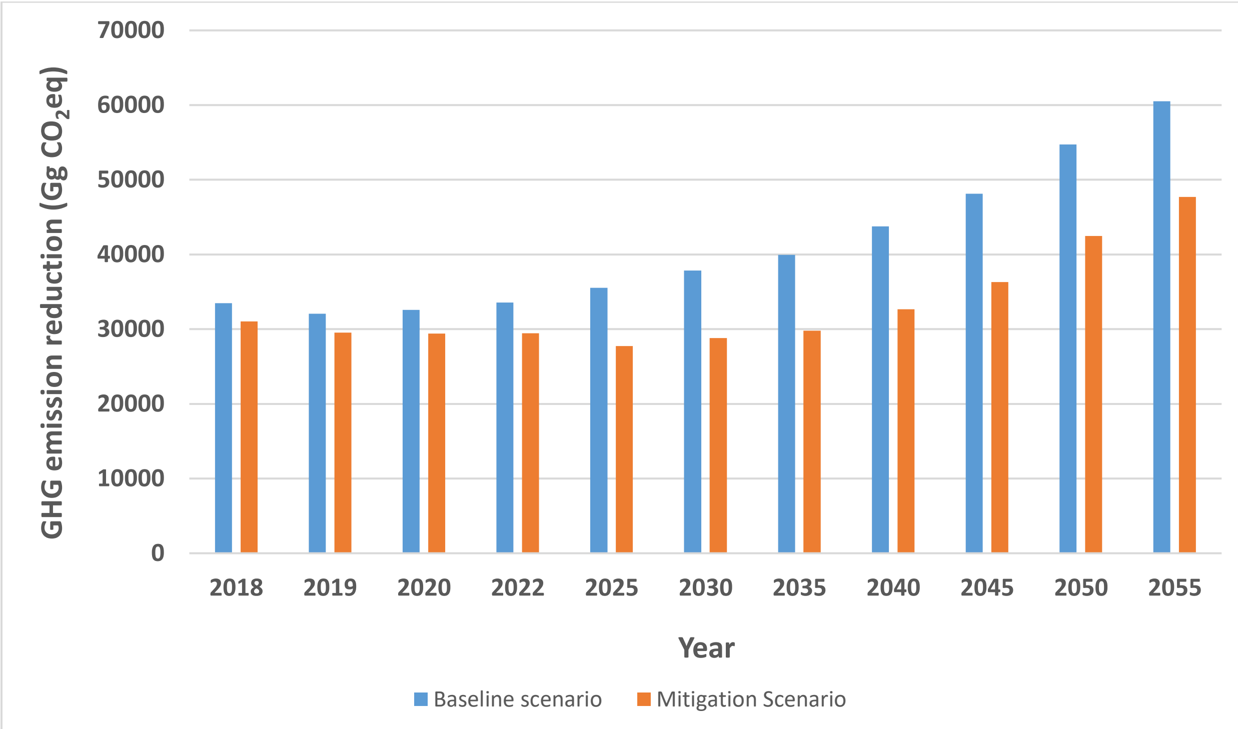


Figure 3.11: Comparison between the baseline scenario and the mitigation scenario.

3.13.12.2 Overall GHG Mitigation Abatement Cost Analysis

According to the analysis of the unit abatement cost and abatement marginal cost curve, the energy mitigation measures and projects are the most feasible options. In specific, from the total reduction of GHG and the unit abatement cost point of view, renewable energy projects should receive the most attention.

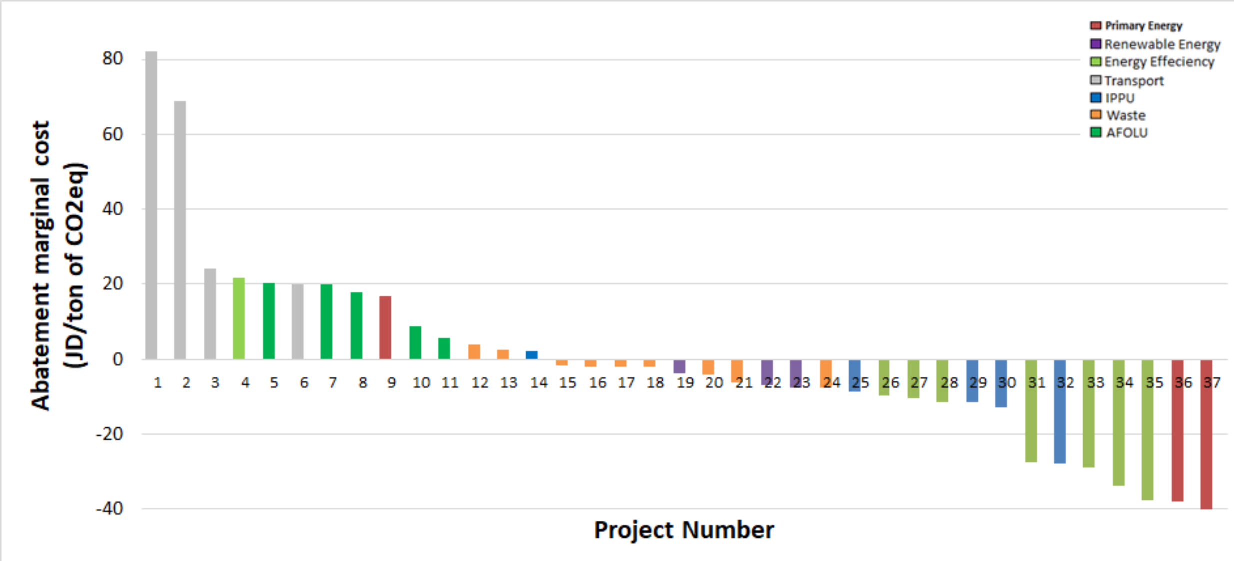


Figure 3.12 shows the abatement marginal cost for all mitigation measures ranked from the highest to the lowest.

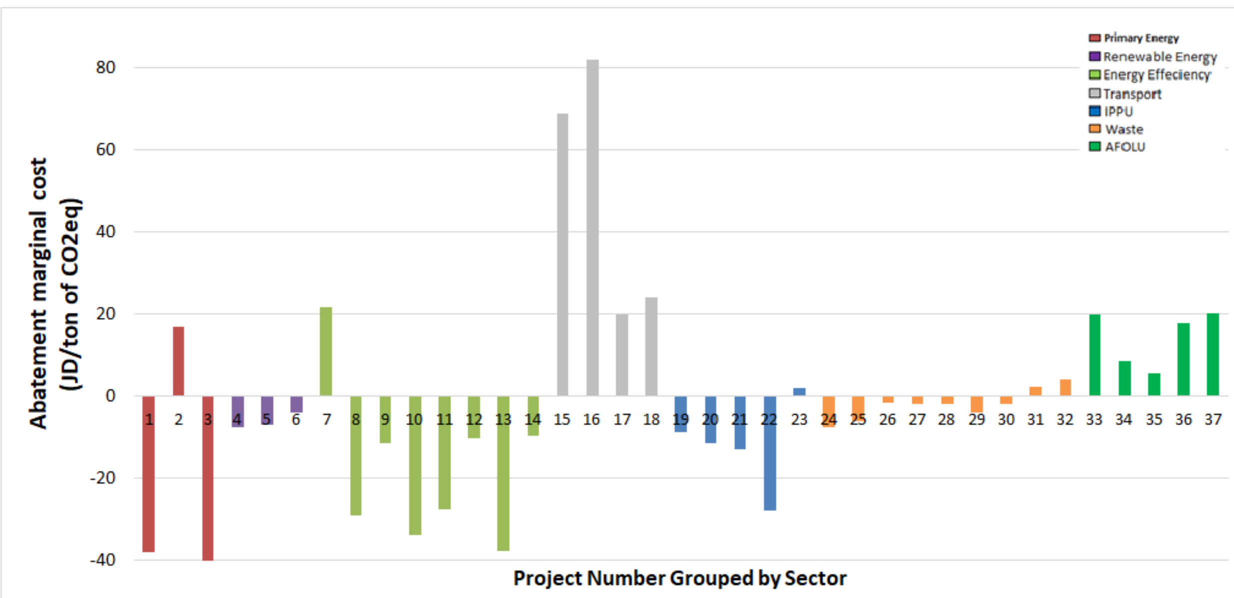


Figure 3.13 show the abatement marginal cost for all mitigation measures with projects grouped according to their sector.

The implementation of these mitigation options will enhance sustainable development by minimizing dependence on imported energy costs to the economy and creating good economic mobility in the local investment sector, especially where projects are located by creating hundreds of direct and indirect jobs and revitalizing supporting works of different sectors. Will contribute to the creation of a green economy and associated socio-economic benefits such as revenue from energy generation, Stable power supply for commercial operators, improved air quality, and health benefits from improved air quality.

Table 3.31: Mitigation Measures and Projects.

NO	Mitigation Measures and Projects	Emissions reduction unit cost (JD/tCO2eq)
	Energy Sector	
	Primary Energy Subsector	
1	Construction of a branch of pipeline between the refinery and Iraqi crude oil pipeline across Jordan territory.	-38
2	Natural Gas Distribution Network in Amman, Zarqa, and Aqaba	17
3	Loss Reduction in Electricity Transmission and Distribution (T&D) Network	-40
	Renewable Energy Subsector	
4	Construction of 800 MW, PV (100*4) + (400 MW wheeling and Net -Metering) by 2030. To achieve the target of 35% of electricity mix from RES, by 2040.	-7.5
5	Construction of 1600 MW, PV (200*8) during 2030-2040. To achieve the target of 50% of electricity mix from RES by 2040.	-7.0
6	The Aqaba Amman Water Desalination and Conveyance Project (AAWDCP) - Wheeling Project, 185 MW PV (50% of the overall needed power demand	-3.9
	Energy Efficiency Subsector	
7	Enhance the Energy Efficiency in the well fields and Pumping Stations in the water sector.	21.8
8	Rationalize energy consumption and improve the efficiency of its use for four-star hotels or less in different regions of the Kingdom.	-29
9	RE & EE Solutions for Small & Medium enterprises in the industry sector.	-11.5
10	Domestic Sector Program: providing energy efficiency solutions.	-33.9
11	Public and Governmental Program by installing RE and EE solutions	-27.6
12	Agricultural Sector Program: PV solution for 70 small and medium farms.	-10.3
13	-Solar Water Heater 90000 system	-37.6
14	Replace the inefficient street lamps 125W with High-Pressure Sodium Street Lighting 70W. 400000 lamps	-9.66
	Transport Subsector	
15	Bus Rapid Transit Project (BRT). phase 2	69
16	Urban Bus Reform Public Transport project in Irbid and Zarqa	82
17	Intelligent Transport Systems (ITS)	20
18	Increase the Penetration of Electric Cars by 2% annually	24
	IPPU Sector	
19	Use of steel slag and/or fly ash to substitute the raw materials needed to produce clinker at the selected cement plant	-8.8
20	Increase the percentage of Pozzolana in CEM II	-11.5
21	Produce new cement product CEM IV with 45% of Pozzolana	-12.8
22	Use of biomass (MSW and/or Sewage Sludge) as alternative fuels	-28
23	Catalytic reduction of N2O inside the ammonia burner of the Nitric Acid plant	2
	Waste Sector	
24	Al Ghabawi landfill to generate electricity from biogas.	-7.5
25	Al-Elkader Domestic Landfill for electricity generation from biogas	-6.2
26	Utilization of biogas Produced from Al-Dhulil Landfill in electricity production	-1.5
27	Biogas collection and Utilization from Al-Salt (Homra) domestic solid waste landfill	-2.0

28	Biogas collection and utilization from Madaba domestic solid waste landfill	-2.0
29	Utilization of sludge Produced from Wadi Al Arab Wastewater Treatment plant	-4.0
30	Utilization of sludge Produced from Baqa'a Wastewater treatment plant	-2.0
31	Biogas generation by utilizing the sludge generated from Salt domestic wastewater treatment plant	2.4
32	Utilization of sludge Produced by Madaba Wastewater treatment plant	4.0
	AFOLU Sector	
33	Introduce new trees plantation in Urban Areas.	19.98
34	Forestry- Introduce new plantations in Northern Area.	8.64
35	Restoration of Rangeland Areas and Rangelands.	5.66
36	New Protected Rangeland Area as Natural Reserve.	17.95
37	Promoting Climate-Smart Agricultural Practices in the Jordan Valley.	20.20

4 Climate Change Impact, Vulnerability & Risk Assessment

4.1 Introduction

Many of the world's countries, including the Hashemite kingdom of Jordan, already struggle under various pressures such as water scarcity, food security, and ecological, economic and social development[112]. These pressures will be significantly exacerbated by climate change impacts, which for many regions will result in intensifying the climatic exposures leading to an increase in the vulnerability of all natural system components. As these competing demands intensify under climate change, effective governance for adaptive planning will become essential[113] [114].

The purpose of this 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 Third National Communication in 2013.

Based on improved information technologies and the experiences gained through the preparation of the FNC, SNC, and TNC, this chapter was developed, through a more advanced comprehensive analysis, using more advanced investigation tools, with groups engagement of sectorial experts. This has aided the understanding of local climate change sequences on sectorial systems, provide better delineation for vulnerable groups and has improved the accuracy of future vulnerability and adaptation assessments. The climate change impacts on agriculture, water, socio-economic, health, biodiversity, coastal zones, and urban sectors were assessed using (1) accurate-non-biased climate exposure predictions developed by MENA CORDEX downscaling technique using two RCPs, (2) updated long historical sectorial data assessment, (3) specialized sectoral modeling vulnerability and risk assessments, and (4) Multi-Decision Support tools for climate change adaptation assessment.

The vulnerability and risk assessments targeted the whole country of Jordan. The impact assessments for the water and agriculture sectors were achieved using specialized modeling programs, including SWAT and AquaCrop, with special emphasis on the four major national groundwater basins of Amman-Zarqa, Yarmouk, Azraq, and Mujib, in addition to Aqaba city at a sub-district level.

[112] MoEnv, 2014. Jordan Third National Communication Report submitted to UNFCCC. Funded by UNDP, Ministry of Environment, Amman, Jordan.

[113] IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, In press, doi:10.1017/9781009157896

[114] UN, 2009. Guidance on Water and Adaptation to Climate Change. Economic Commission for Europe Convention on the Protection and Use of Transboundary Watercourses and International Lakes.

4.2 Methodology for Climate Change Impacts, Vulnerability and Risk Assessment

The assessment applied a robust methodological framework that relies on two main pillars: (1) A quantitative climate change impact, and vulnerability assessment (CCIVA); and (2) Identification and prioritization of adaptation for all sectors.

Impact assessments of climate change were carried out on a sectoral basis for water resources, agriculture, socio-economics, health, biodiversity and the coastal zones at Gulf of Aqaba, and urban sectors. The assessments were in line with the official IPCC's definitions[115]; in addition to UNEP Handbook on Methods for Climate Change Impacts Assessment and Adaptation Strategies, the International Handbook on Vulnerability and Adaptation Assessment, and UNFCCC Handbook on Vulnerability and Adaptation Assessment. The risk and vulnerability assessments considered four main components: (1) the magnitude of exposure to climate change hazards, (2) the degree of sensitivity to the hazard, (3) the resulting amount of impact, and (4) its level of adaptive capacity or resilience (Please see Box 1 for definitions). The following equations identify the relationship between these four dimensions:

$$Vulnerability\ (V) = \frac{Potential\ Impact}{Resilience\ or\ Adaptive\ Capacity} = \frac{Exposure\ (E) \times Sensitivity\ (Is)}{Adaptive\ Capacity\ (Ia)} \qquad \text{Eqn.1}$$

$$Climate\ Change\ Risk = Hazard\ (H) * Vulerability(V) \qquad \text{Eqn.2}$$

[115] IPCC, 2021: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, In press, doi:10.1017/9781009157896

The main steps used for the CCIVA process for each selected sector are articulated as following:

Step 1: Assessment of baseline conditions	• Qualify/Quantify 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: Assessment of possible impacts	• Evaluate and quantify the level of possible impacts resulting from the combination of both exposure and sensitivity to climate change hazards.
Step 5: Assessment of adaptive capacity or resilience	• 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.
Step 7: Assessment of Rsk	• Determine the level of climate change risk as associated drought, heatwaves, and other climate relted hazards.
Step 8: Vulnerability mapping.	• Apply GIS and remote sensing to map the climate vulnerability and risk at the most agreed vulnerable sectors and administrative districts.
Step 9: Porpose and prioritize possible adaptation measures	• Design and apply a multi-crietria system to quantify and prioritize suggested adaptation option using Multi-Criteria Decision Support Tool on a participatory process

BOX 1

Risk is defined as the potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems. Risk can arise from the dynamic interactions among climate-related hazards, the exposure and vulnerability of affected human and ecological systems.

Hazard is defined as the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

Exposure is defined as the presence of people; livelihoods; species or ecosystems; environmental functions, services and resources; infrastructure; or economic, social or cultural assets in places and settings that could be adversely affected.

Vulnerability is defined as the propensity or predisposition to be adversely affected and encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Adaptation is defined, in human systems, as the process of adjustment to actual or expected climate and its effects in order to moderate harm or take advantage of beneficial opportunities. In natural systems, adaptation is the process of adjustment to actual climate and its effects; human intervention may facilitate this.

Resilience is defined as the capacity of social, economic and ecosystems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure as well as biodiversity in case of ecosystems while also maintaining the capacity for adaptation, learning and transformation. Resilience is a positive attribute when it maintains such a capacity for adaptation, learning, and/or transformation.

4.2.1 The baseline assessment

The baseline assessment involved reviewing available scientific, socio-economic and development policies and publications, existing databases, consultation with sectoral groups of experts, to develop a solid historic analysis in terms of climatic hazards and observed vulnerabilities of the selected sectors. It also involved setting the Impact Chain Framework Vulnerability Assessment (ICFVA) to define the factors governing the vulnerability at a sectoral basis. The ICFVA list of the NAP document[116] and the Climate Change Updated Policy (2020-2050) were updated and implemented to estimate the actual vulnerability at each region based on meetings with multiple sectoral groups of experts.

[116] http://www.moenv.gov.jo/ebv4.0/root_storage/ar/eb_list_page/final_draft_nap-2021.pdf

4.2.2 Climate Trends and Climate Change Assessments

Two long historical local climate data sets were used; Jordan Meteorological Department (JMD), and Ministry of Water and Irrigation. The former data set (28 meteorological stations, Figure 4.1) was used to build the trends and climate change projections, while the later data set (147 meteorological stations) was used for validation. The data sets represent temporal station daily climate data of precipitation, minimum daily temperature, maximum daily temperature, mean wind speed, and relative humidity from weather station establishments up to 2020.

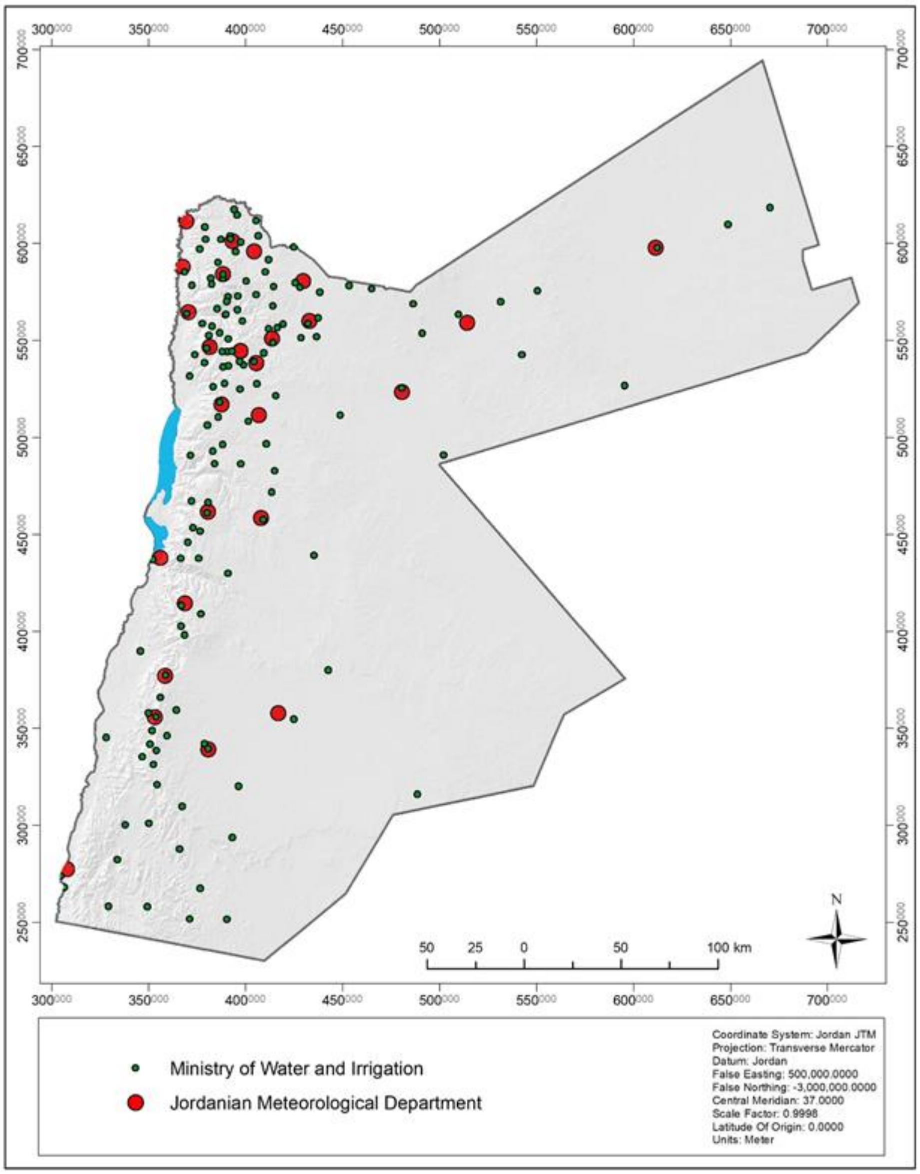


Figure 4.1: Local Meteorological Stations across the country as obtained from JMD.

Another climate dataset was obtained from the (MWI), to validate the historical station values, taking into consideration the spatial extent and location of each station. Data Quality Control (DQC) was managed using JMP statistical software from SAS[117]. The DQC included measures of central tendency (mean, mode, median), dispersion (e.g., range, variance, standard deviation, standard error, coefficient of variation), and distribution (e.g., normality, skewness, kurtosis). Outliers and missing points were managed using three indices; Mahalanobis Distance, Jackknife Distances, and T^2 Statistic. Data gaps were filled using three procedures depending on the data status; (1) filling by mean, (2) linear filling, (3) interpolation from nearest points.

Historical climatic trends of monotonic increase or decrease in the average value between the beginning and the end of an available time series achieved using two methods: (1) the linear regression trends, and (2) nonparametric "Mann-Kendall rank trend test". In this chapter, the JMD data for 28 station points within periods of (1961-2020) on daily, monthly, and annual time series basis were analyzed using JMP statistical program.

In order to ensure effective, accurate, precise climate projections, ensembles are being implemented to forecast future scenarios, that represent Jordan climate. Regional Climate Downscaling Experiments of the Coordinated Regional Climate Downscaling Experiment (CORDEX)[118], was accessed from Earth System Grid Federation (ESGF)[119] global system of federated data centers that allow access to the largest archive of climate data world-wide. CORDEX is being coordinated by the World Climate Research Program (WCRP) under the auspices of WMO/IPCC for the multi-model ensembles dynamic downscaling analysis. In contrary to the TNC, the MENA CORDIX domain[120] was used, instead of the AFRICA CORDIX Domain, since it is preferred for being calibrated/simulated using regional climate stations for the MENA region of which Jordan is a part.

Data from six CORDEX Regional Climate Models was extracted for the Middle East and North Africa (MENA) "Region 13", from the Earth System Grid Federation (ESGF)[121]. The description of the RCMs is presented in **Table 4.1**. The impact portal, [122] was used as a user-friendly interface to access ESGF content. The RCM data represents the historical and future climate parameters for both RCP scenarios, within a grid system of either 50 km resolution and/or 25 km resolution (**Figure 4.2**).

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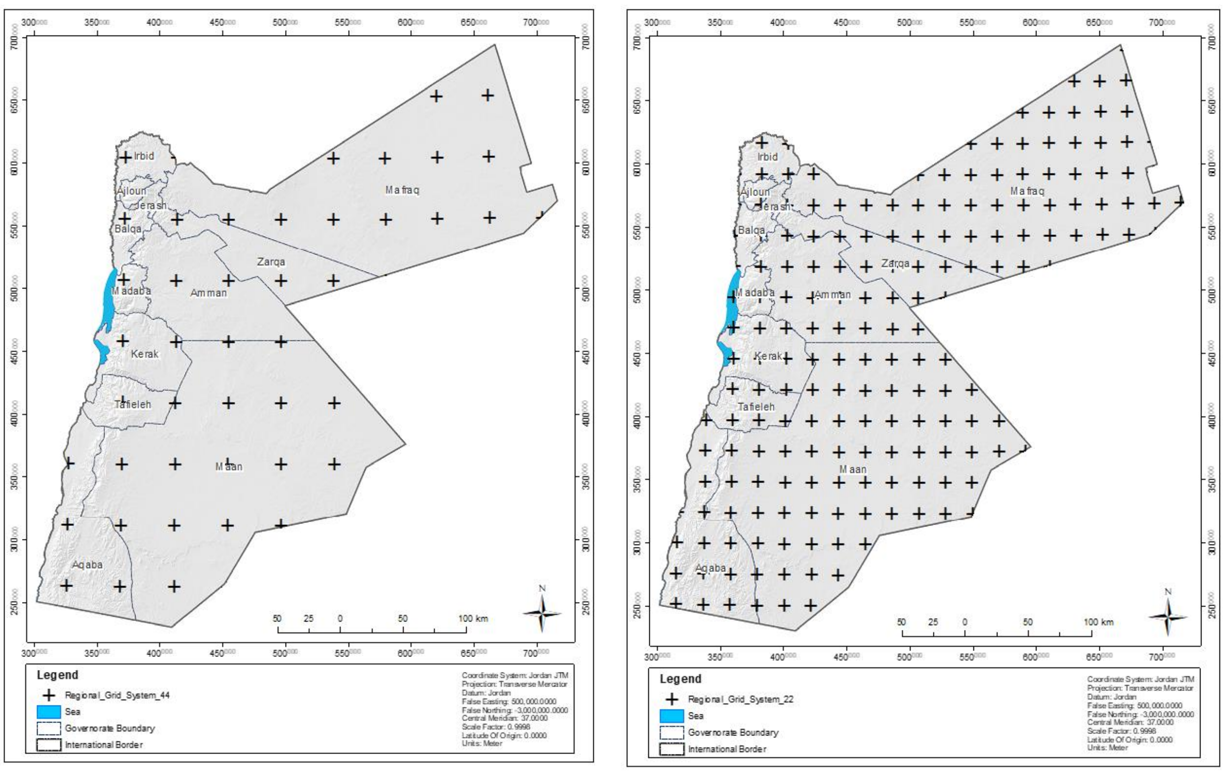
[117] Statistical Software | JMP Software from SAS
[118] Cordex – Coordinated Regional Climate Downscaling Experiment
[119] ESGF-LIU - Home | ESGF-CoG
[120] Contributors - MENA-CORDEX hosted by CyI
[121] https://esgf-node.llnl.gov
[122] www.climate4impact.eu

Table 4.1: Contributors and data availability at CORDIX MENA

Acronym	Contributor	Country	Model ID	Driving Model ID	RCP	Degree	version
BOUN	Bogazici University, Istanbul	Turkey	RegCM4-4	MPI-ESM-MR	4.5	0.44	v2019116
			RegCM4-4	MPI-ESM-MR	8.5	0.44	
			RegCM4-4	HadGEM2-ES	4.5	0.44	v2019116
			RegCM4-4	HadGEM2-ES	8.5	0.44	
CYI	Energy Environment & Water Research Center (EEWRC), The Cyprus Institute, Nicosia	Cyprus	WRF351	CESM1	4.5	0.44	v20210518
			WRF351	CESM1	8.5	0.44	
SMHI	Rossby Centre, Swedish Meteorological and Hydrological Institute (SMHI), Norrkoping	Sweden	RCA4	CNRM-CM5	4.5	0.44	v20131030
			RCA4	CNRM-CM5	8.5	0.44	
			RCA4	EC-EARTH	4.5	0.44	v20131030
			RCA4	EC-EARTH	8.5	0.44	
			RCA4	GFDL-ESM2M	4.5	0.44	v20131030
			RCA4	GFDL-ESM2M	8.5	0.44	
			RCA4	EC-EARTH	8.5	0.22	v20131101
			RCA4	GFDL-ESM2M	8.5	0.22	v20131101



a) 0.44-degree regional grid system **b) 0.22-degree regional grid system**

Figure 4.2: The regional CORDEX MENA grid system

The data was downloaded in the form of NetCDF (Network Common Data Form), that represents file formats, for storing multidimensional scientific data (variables such as temperature, humidity, pressure, wind speed, and direction). The size of the extracted NetCDF files is about one TB (terabyte) and thus requires advanced computers with high resolution and memories (therefore, work stations are preferred).

The NetCDF Extractor V2.0 and Open NC file (v 1.1) (agrimetsoft)[123] was used to view, convert, and extract RCM data based on the local weather station point locations. The extracted files were thus used for both calibration and validation processes.

The uncertainty analysis and the comparison between RCM and local weather station data was performed for three time scales: daily, monthly, and annually. Several indicators were used to investigate the capability and/or power of each of the RCM models, to represent the temporal variations in the local station data. Instead of the delta-temperature / delta precipitation method used at the Third National Communication Report of Jordan to UNFCCC that was implemented for only one closet local station to the RCM grid system, a more professional criteria were implemented. The selection criteria were based on four main criterions that represent statistical tests of (1) Root Mean Square Error (RMSE), (2) Pearson coefficient of determination (r^2), (3) the Spearman p test, (4) Kendall τ, and (5) Nash-Sutcliffe (NSE).

The above-mentioned indicators were tested for all models, for the 28 local weather station points, for the historical period from (1950 to 2005). The model that provides the best representation was selected as a “reference model”, based on minimum temperature, maximum temperature, and precipitation with daily, monthly, and annual data. Therefore, the best projections' ensembles represent coupling the most recent and most observation-fitted Global Climate Models (GCM), with all the Regional Climate Models (RCM) available at 0.44 degrees (50 km) and 0.22 degrees (25 km) resolution that fits Jordan climate.

The calibration and de-biasing process for the “Reference RCM model” was performed using the Statistical Downscaling of General Circulation Models (SD GCM v.2.0) from Agrimet software[124]. The software provides several statistical tools for downscaling CMIP5 models under RCP Scenarios, including the Delta, the Quantile Mapping (QM) (Panofsky and Briar, 1968)[125], the Empirical Quantile Mapping (EQM) (Boe et al., 2007)[126]. There are six efficiency criteria for the

[123] https://agrimetsoft.com/
[124] Statistical Downscaling General Circulation Models (agrimetsoft.com)
[125] Panofsky, H.A. and Brier, G.W. (1968) Some Applications of Statistics to Meteorology. Earth and Mineral Sciences Continuing Education, College of Earth and Mineral Sciences.
[126] Boé, J., Terray, L., Habets, F. and Martin, E. (2007), Statistical and dynamical downscaling of the Seine basin climate for hydro-meteorological studies. Int. J. Climatol., 27: 1643-1655. https://doi.org/10.1002/joc.1602

evaluation phase: Pearson Correlation, Nash-Sutcliffe efficiency, Spearman Correlation, RMSE (Root Mean Squared Error), d (index of agreement), and MAE (Mean Absolute Error). The validation process was performed using the above two methods for the time period (2005 to 2020). The calibrated, de-biased, and validated future climate data is thus obtained up to the end of the 2100, for each local weather station and for the two RCP scenarios (i.e., 4.5 and 8.5).

The confidence of the historical trends and future forecasts were expressed using five qualifiers: *very low, low, medium, high and very high*. The following terms have been used to indicate the assessed likelihood of an outcome or a result: *virtually certain* 99–100% probability, *very likely* 90–100%, *likely* 66–100%, ***about as likely as not*** 33–66%, *unlikely* 10–33%, *very unlikely* 1–10%, *exceptionally unlikely* 0–1%. Additional terms (*extremely likely* 95–100%, *more likely than not* >50–100%, and *extremely unlikely* 0–5%) may also be used when appropriate.

Spatial interpolation maps for each climate parameter were developed for the whole country using co-kriging geostatistical technique based on the Digital Elevation Model (DEM) of 30m resolution using ArcMap (ESRI, v. 10.6.1., 2020)[127]. The presentation of data included three steps; (1) investigation of the spatial variability using semi-variogram analysis, (2) selection of the best representation of the spatial behavior, and (3) interpolation of unknown locations using a simple linear weighted-interpolation scheme between the surrounding points derived from variogram analyses. The generated interpolation maps represent final maps for three long-term time horizons of 2020-2050, 2050-2070, and 2070-2100.

4.2.3 Sensitivity and Adaptive Capacity Assessments

Sensitivity and adaptive assessments were estimated quantitatively for each sector separately based on the updated ICFVA and the judgment of sectoral groups of experts. The bio-physical as well as socio-economic determinants of sensitivity (e.g., proportion of rainfed areas, percent of population living in poverty, percent with access to safe water, etc.) were identified and analyzed based on actual data availability (i.e., legislation and capacity of relevant institution and society) at the sub-district level. For the terrestrial biodiversity vulnerability assessment, the sensitivity and adaptive capacity were identified and estimated based on vegetation cover and not district level.

The individual weights of the selected sectoral sensitivity and adaptive capacity indicators were assigned based on importance derived from scientific research literature and the decisions of sectoral groups of experts. The overall sensitivity and adaptive capacity are thus the sum of

[127] ArcMap Resources for ArcGIS Desktop | Download & Documentation (esri.com)

individual weights multiplied by the selected sectoral sensitivity and adaptive capacity indicators using the following formulae:

$$\mathrm{I_s} = \sum \mathrm{a_i}\,\mathrm{S_i} \qquad \text{Eqn. 3}$$

$$I_a = \sum b_i\, C_i \qquad \text{Eqn. 4}$$

where a_i is the weighting factor of the sensitivity indicator S_i or data point of the target's sensitivity, and C_i is the indicator, and b_i is the weighting factor of the sensitivity indicator C_i or data point of the target's adaptive capacity.

4.2.4 Advance Modeling of Climate Change Impacts and Flood Risk

The projected climate change impacts for the agriculture and water sectors were quantitatively estimated using specialized modeling software. For the agriculture sector, the AquaCrop model (version 6.1, FAO)[128] was used to assess the impacts on yield and water consumption for both irrigated and rainfed crops within the four water basins.

For the water sector, a combination of SWAT (ArcSWAT version 10.24)[129] and AquaCrop models were used to assess the climate change impacts on water supply, including surface runoff and groundwater recharge, and to assess future water demand based on calculated irrigation depth under the climate change projections, respectively. In addition, flood risk at Aqaba coastal zone was assessed through incorporating SWAT and HEC-RAS[130] hydrological models. **Table 4.2** shows the description and the additional baseline setup information used for assessing the impacts on agriculture and water sectors.

[128] Software | AquaCrop | Food and Agriculture Organization of the United Nations (fao.org)
[129] SWAT | Soil & Water Assessment Tool (tamu.edu)
[130] HEC-RAS (army.mil)

Table 4.2: Description of the baseline setup information used for assessing the impacts on agriculture and water sectors

Sector	Name of Model	Objective	Additional baseline setup information
Agriculture	Aquacrop	Assess the impacts on yield and water consumption for both irrigated and rainfed crops within the four water basins.	• Historic crop data including crop calendar and management was obtained from previous studies and field surveys. • Crop yield and area from DOS were used to set a baseline scenario. • LULC map was used to define the percentage share of agriculture types per sub-district level.
Water	SWAT	Assess the climate change impacts on water supply including surface runoff and groundwater recharge.	• Land use and soil maps were used to obtain different outputs that included volumes of runoff and groundwater recharge. • Average changes outputs under climate projections were calibrated using the MWI data. • Amounts of treated wastewater were calculated based on population growth scenarios and MWI data. • Domestic water demand was calculated based on the projected population, assumption of constant per capita share (100 lpcd) and the increase of domestic network efficiency from 52% (present) to 75 (Future). • Water budget was then calculated based on the outputs from SWAT, AquaCrop and population data
	AquaCrop	Assess future water demand based on calculated irrigation depth under the climate change projections.	
Flood Risk	Incorporating SWAT and	Assess the surface runoff under future climate	• soil map from Ministry of Agriculture to define soil hydrological properties, • LULC maps generated for this purpose, • Climate projections data defined in this study
	HEC-RAS hydrological models	To determine the values of water depth, velocity and water surface elevation.	• A 30-m ground resolution of Digital Elevation Model (DEM) to delineate the watersheds using the RAS mapper and to build a two flow dimension watershed geometry and its boundary conditions

4.2.5 Climate Change Impacts and Overall Vulnerability and Risk Ranking

ArcMap (version 10.6.1)[131] Geographical Information System (GIS) tool was used to combine the quantitative results of the exposure, sensitivity and adaptive capacity and leading to a real estimation (i.e., not a comparative scoring or qualification). Numerical scoring system and ranking tools (matrices) were developed using 5 quantitative classes from very low to very high based on normalized scaling of vulnerability/risk from zero to one, using the general formula for each indicator (data point) as follows:

$$X_{i,0\ to\ 1} = \frac{(Xi - X_{min})}{(X_{max} - X_{min})} \qquad \text{Eqn. 5}$$

where, X_i represents the individual data point to be transformed, X_{max} the highest value for that indicator, X_{min} the lowest value for that indicator, and $X_{i,0\ to1}$ the new value to calculate, i.e., the normalized data point within the range of 0 to 1.

4.2.6 Identification and Prioritization of Adaptation Measures

The selection and planning of adaptation measures that respond to the identified climate vulnerabilities and climate change impacts through the following qualitative and quantitative assessment approach:

1. Identification of all possible adaptation measures: The national adaptation measures listed within the updated climate change policy 2020-2050 and within NAP were selected as a “Long list of possible adaptation options/measures” that respond to the identified hazards and vulnerabilities;
2. Setting a qualitative selection criterion: A Multi-Criteria Selection approach was designed to represents a weight scoring technique for six different themes; Relevance, Implementation & Feasibility, Sustainability, Social Aspect, Effectiveness, and Opportunity (**Figure 4.3**). Each theme holds more than one criterion (**Table 4.3**);
3. Screening and prioritization of the preferred adaptation options: implement the suggested qualitative selection criteria on the long list of possible adaptation options and measures through the decision support tool “Multi-Criteria Decision Support Tool (MCDST)” to rank, screen and prioritize the adaptation measures that are environmentally, socially, technically, and legally feasible.
4. Organized national consultation workshop with selected stakeholders and sectorial technical experts in each sector to carry out in-depth analysis of the pros and cons of the

[131] ArcGIS Desktop | Desktop GIS Software Suite (esri.com)

identified adaptation options conduct in a participatory process aimed at approving / prioritizing the adaptation options/measures;

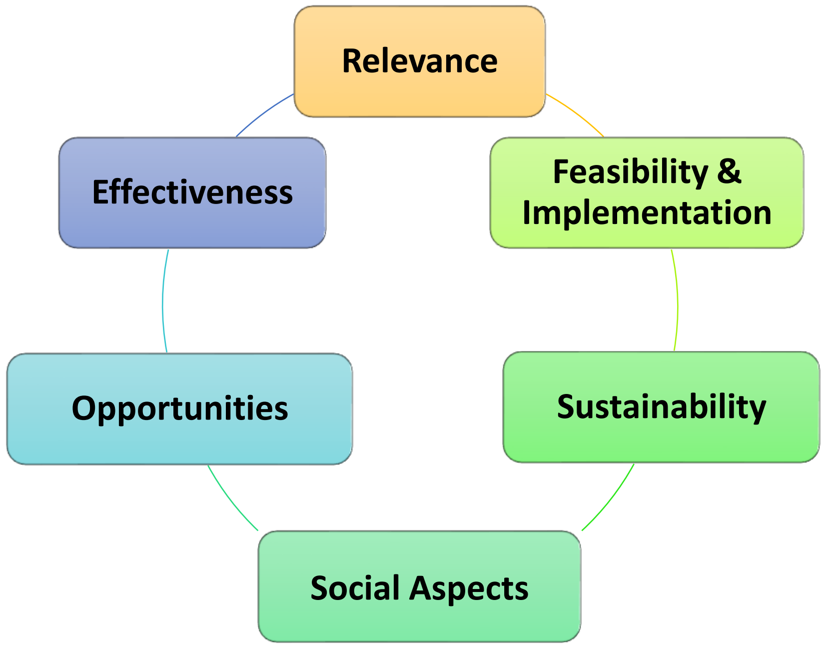


Figure 4.3: Prioritization Criteria Main Themes for Multi-Criteria Decision Analysis.

Table 4.3: Description of the Criterions used in the Multi-Criteria Decision Analysis

Criteria	Sub-criteria	Description
Relevance	National Priorities	The relative priority of activities, including their alignment with wider national priorities (e.g., employment, economic growth, poverty reduction, food security).
	SDGs Priorities	The relative priority of activities, including their alignment with SDGs.
Implementation & Feasibility	Availability of economic and natural resources	Identifying which activities are feasible with the resources available and when these should be undertaken.
	Scope and timing	Identifying activities scope and timing required for accomplishment as (short, mid, or long scale), taking into account all kind of barriers and obstacles.
	Cost Effectiveness (Low-regret)	Identify if this measure will bring high relative benefits compared to costs.
	Human and Institutional Capacity	Estimate if current capacity is sufficient and, if not, what is lacking in capacity gaps.
Sustainability Social Aspect	Adaptive Capacity & Resilience	The degree of benefits in terms of reducing impacts, reducing exposure, enhancing resilience or enhancing opportunities.
	Ecosystem Services	The degree of environmental impacts on ecological systems and services.
	Synergies	If there exist synergies between other measures (mitigation and adaptation).
	Stakeholders and Targeted Groups	Number of females, youth, and marginal population benefiting from the adaptation, including the involvement and benefits of local ownership.
	Public Acceptability	Elaborate on public support or opposition to this measure.
Effectiveness	Robustness	Elaborate how effective this measure could be for a diverse range of plausible future scenarios.
	Reliability	Identify if this measure is untested or the effectiveness of this measure is proven.
	Uncertainty	Estimate how well the risks are understood.
Opportunity	Ancillary benefits	Identify how this measure will contribute to other sustainability and developmental goals
	Technology Development, Innovation, and Transfer Potential	Identify if there is currently a window of opportunity to implement this measure.

The listed measures in the updated Climate Change Policy (2020-2050) were already divided into three implementation periods of short (5 years), medium (5-10 years) and long term (> 10 years). The description and requirements of each adaptation measure was also assessed according to the following criteria:

- Immediate Opportunity (IO): the conditions are in place for the implementation of the activity.
- Urgent Problem (UP): the activity should be implemented promptly in order to address a worrying situation.
- Research and Development (R&D): the activity requires research on innovation (e.g., technologies), which might delay implementation.
- Infrastructure Development (ID): the activity involves the construction/expansion of infrastructure, thereby requiring longer time for completion.
- Institutional Capacity (IC): the building of institutional capacity is required prior to (or during) the implementation of the activity.
- High Cost (HC): significant investments are needed to implement the action, leading to potential delays.
- Social acceptance (SA): awareness raising and sensitization campaigns should be conducted prior to (or during) the activity in order to strengthen social acceptance.
- Stakeholder Engagement (SE): the stakeholder consultation phase might require a significant time period.
- Policy Process (PP): the implementation might be delayed by policy/legislative procedures.
- Co-benefits (CB): actions that result in adaptation and mitigation co-benefits.

These factors were implemented in the above Multi-Criteria Decision Analysis, in addition to being used for assessment at stakeholder and expert group engagements.

4.3 Climate Change Trends and Climate Change Projections

4.3.1 Historical Climate Trends and long-term baseline mapping

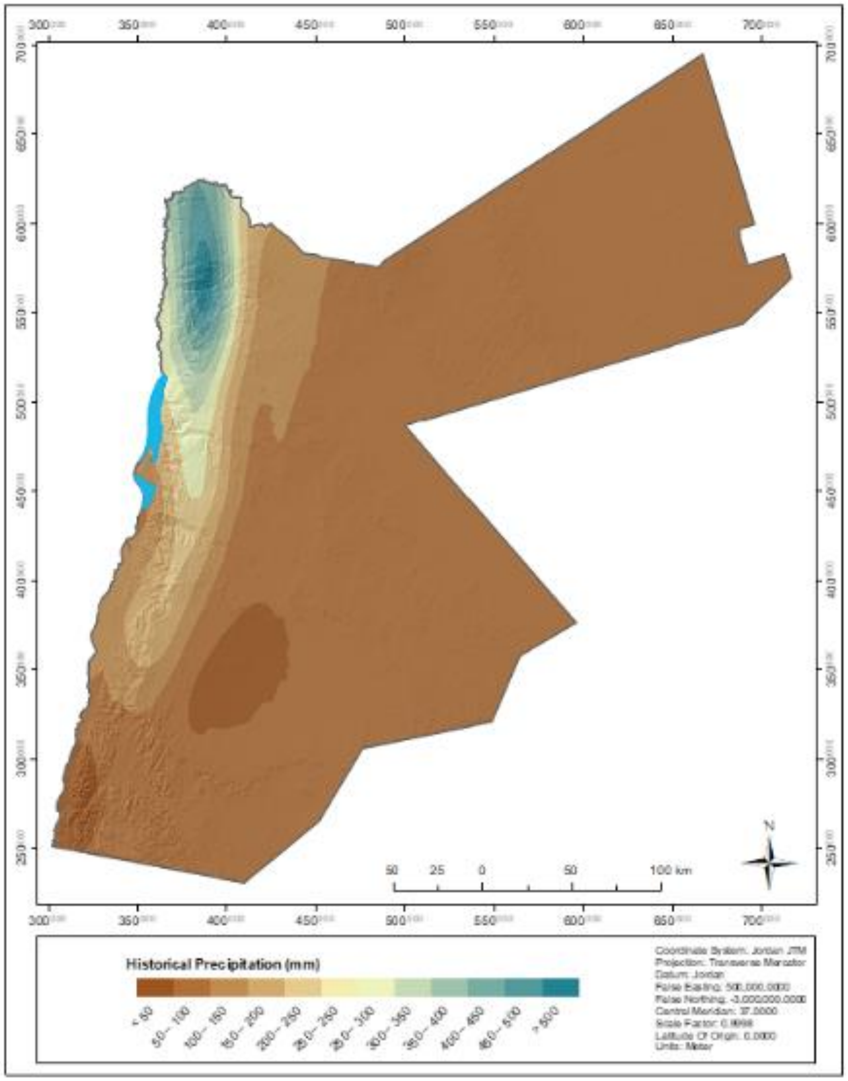
Historical Climate Trends for precipitation, temperature, relative humidity, wind speed, potential evapotranspiration, and dust storm indicate high temporal and spatial variabilities as indicated by significant dispersity regarding time and meteorological station location (Table B.1, Table B.2, Table B.3, Table B.4, Table B.5 **Annex B**). It is ***very likely*** that seasonal precipitation is decreasing by a rate of 0.6 mm per year, regardless of the meteorological station (**Table 4.4**). On the other hand, the temperature variables (maximum, average, and minimum), in addition to relative humidity, evaporation, and dust storms are ***virtually certain*** to increase over time. The rate of change in daily minimum temperatures (0.026 C/y), is four times more significant in magnitude, than that for maximum daily temperature (0.007 C/y), proving the existence and severity of climate change impacts and its sequences on the bio-physical and socio-economical systems that have already been witnessed up to date. The relative humidity and potential evapotranspiration showed significant trends of increase of 0.080 %/year and 17.1 mm/year, respectively.

Table 4.4: Statistical analysis of the temporal climate change variability on yearly basis regardless the station

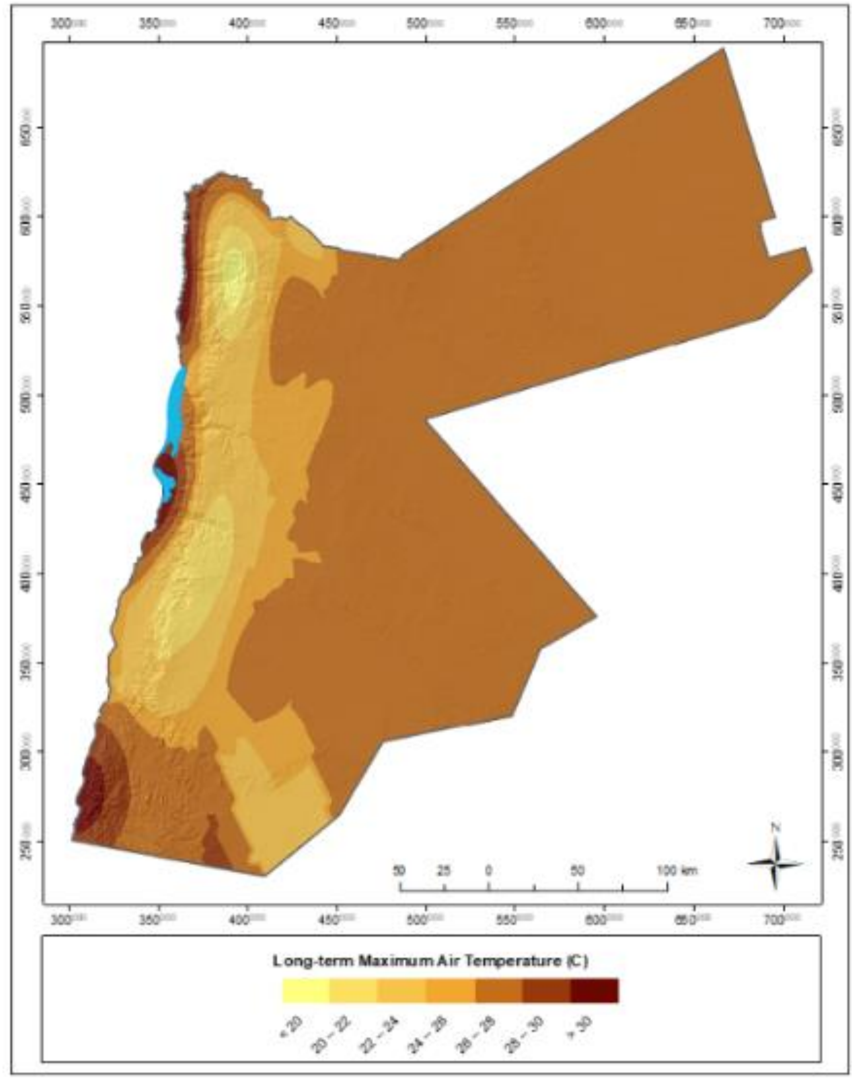
	Mann-Kendall τ	Prob>|τ|	Yearly Rate of change	R^2	RMSE	Prob > F
Daily Maximum Temperature °C	0.0126	<.0001*	+0.007	0.0003	8.88	<.0001*
Daily Minimum Temperature °C	0.0420	<.0001*	+0.026	0.0041	7.09	<.0001*
Daily Average Temperature °C	0.0269	<.0001*	+0.017	0.0016	7.75	<.0001*
Seasonal Precipitation, mm	-0.611	0.7419	-0.607	0.0001	177.02	0.0710
Relative Humidity	0.0663	0.0056*	+0.080	0.0127	7.68	0.0015*
Evapotranspiration	-0.1501	<.0001**	+17.052	0.0556	189.58	<.0001**
Days with Dust storm or Sandstorm (Vis. <= 1 km)	-0.1891	<.0001**	+0.088	0.0713	1.441	<.0001**
Days with Dust storm or Sandstorm (Vis. <= 5 km)	-0.098	<.0001**	+0.060	0.0001	3.325	0.0575

* Significantly different at 95% confidence level.

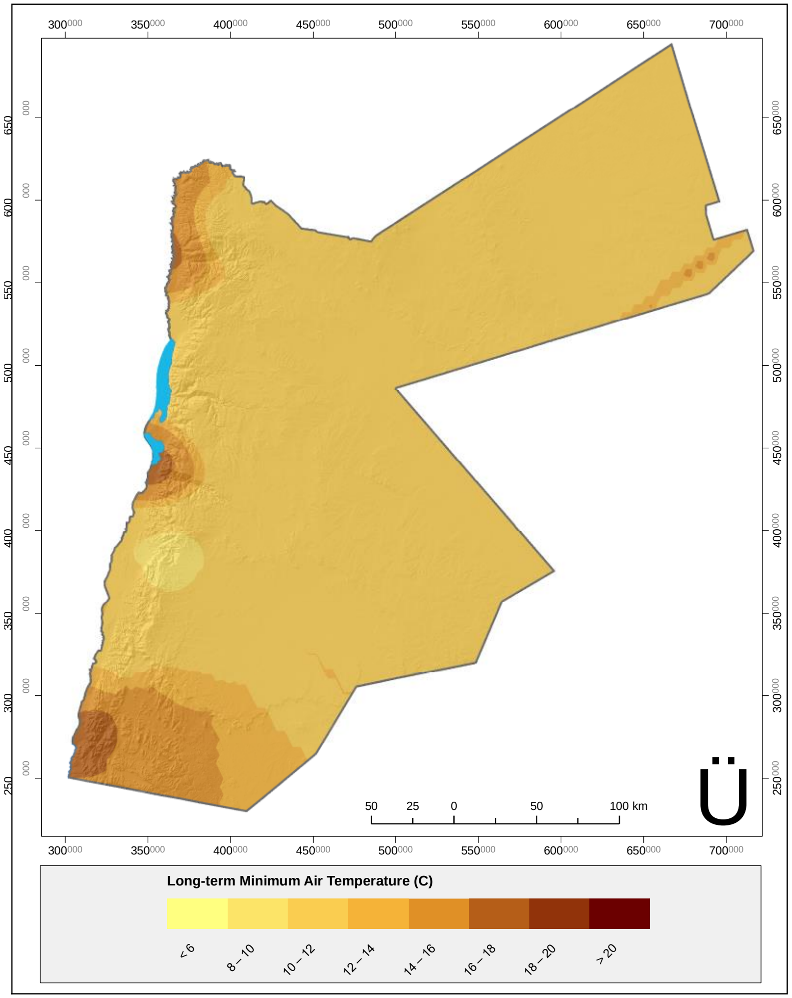
Based on the long-term data from 1950 to 2020, new co-kriging spatial interpolation maps were generated for all climate variables that serves as a baseline scenario for any further investigations



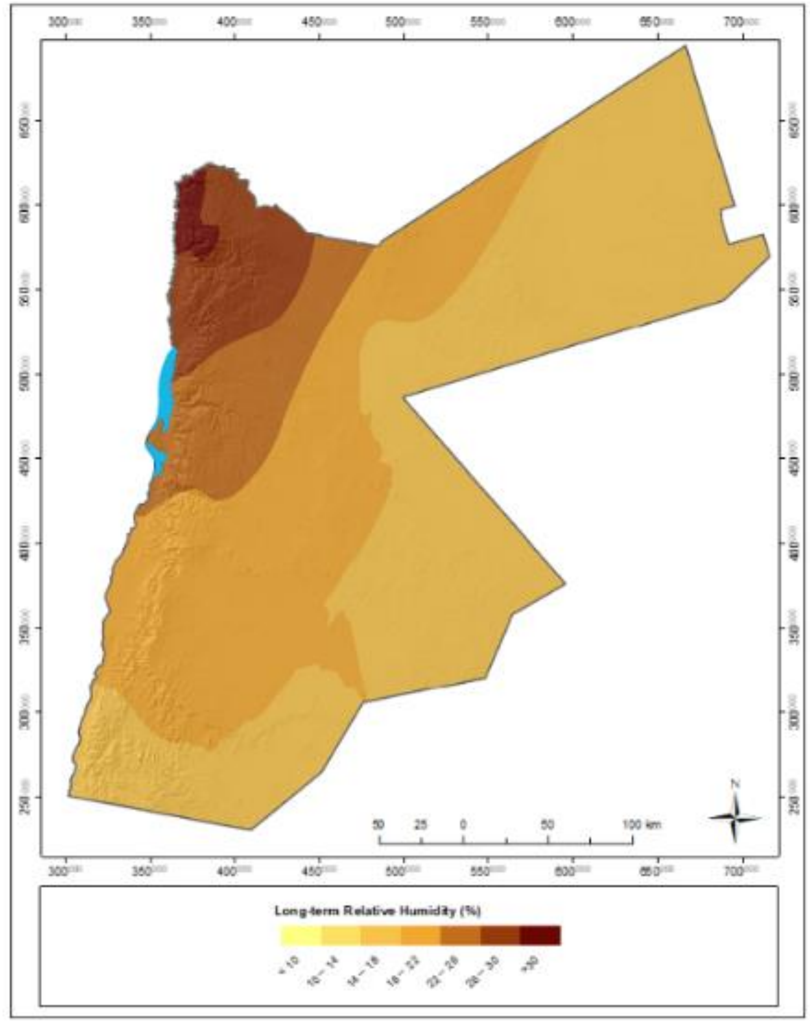
a. Average Annual Precipitation



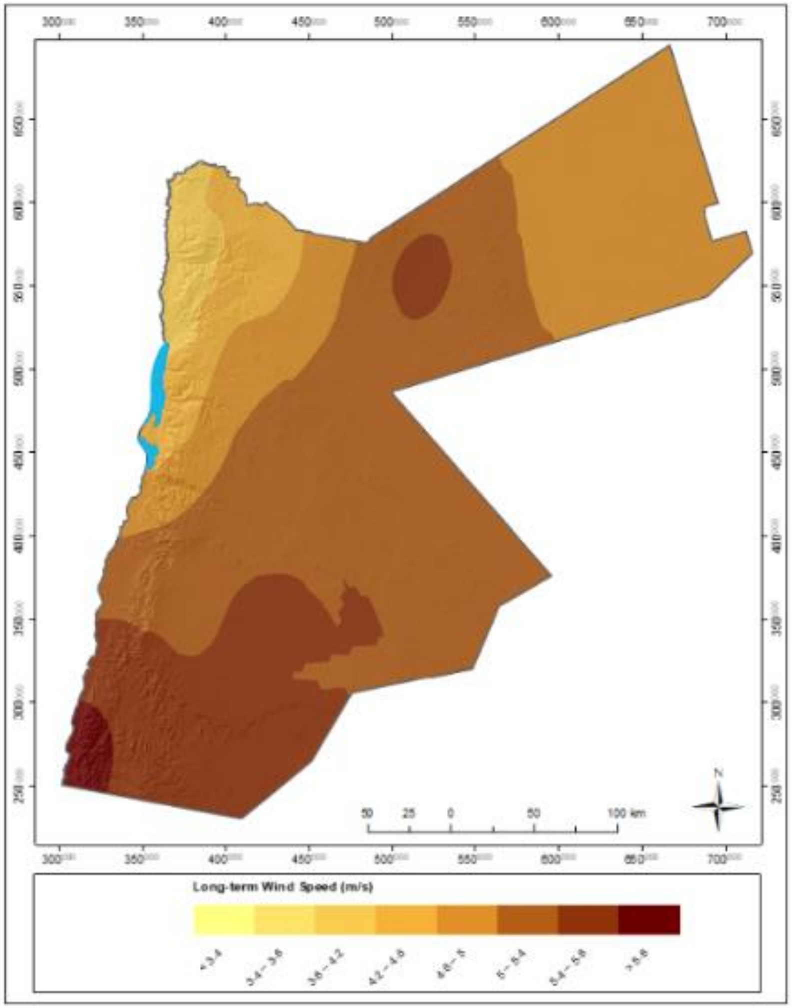
b. Maximum Air Temperature



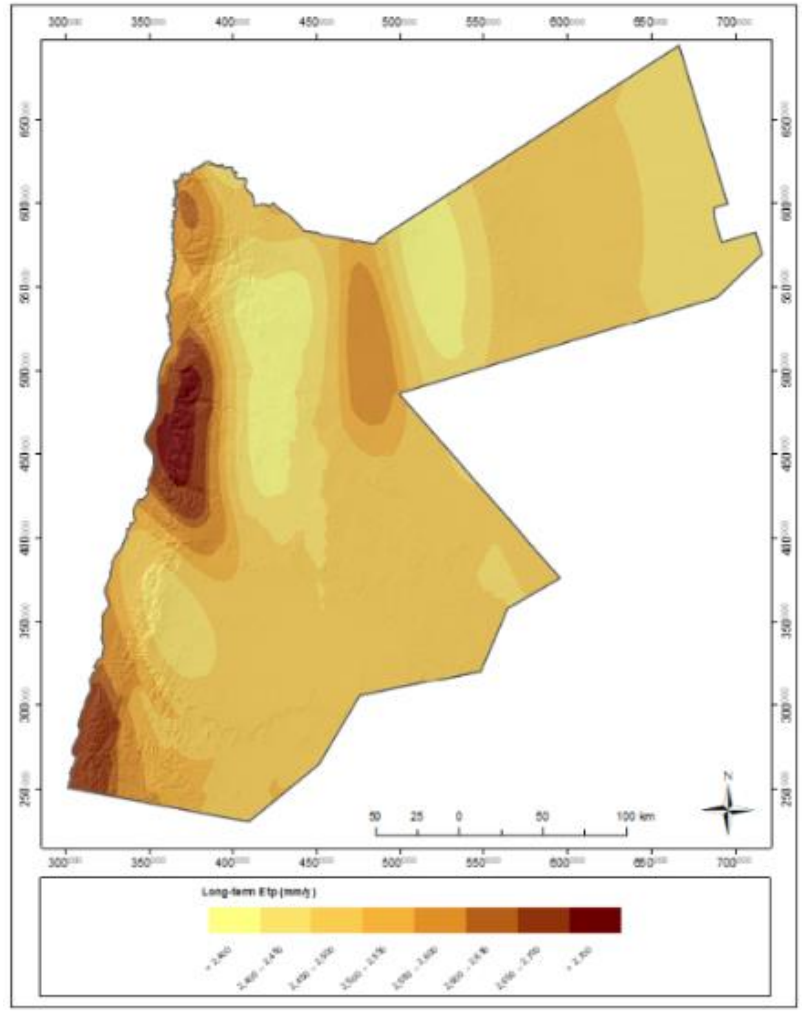
c. Minimum Air Temperature



d. Average Relative Humidity



e. Average Wind Speed



f. Annual ETp

Figure 4.4: Long-term average climate variables in Jordan based on JMD data from 1950 to 2020

4.3.2 Selection of Best RCM

Based on the adopted criteria for selecting the best RCM to represent the local data from 1950 till 2005, **Table 4.5** summarizes the indicator results for seasonal precipitation, maximum air temperature and minimum air temperature, respectively. As presented in the table, the RCM models show various capabilities in representing the local Jordan environment, where the best RCM model identified for both precipitation and temperature climate variables, is the CYI.NCAR-CCSM4. Therefore, the CYI.NCAR-CCSM4 was set as a "***reference model***" for future forecasting taking into account the other RCMs as boundaries for estimating the accuracy of the future forecasts.

Table 4.5: Comparison between RCMs regarding their capabilities to represent local Precipitation.

	SMHI.NOAA-GFDL-GFDL-ESM2M	SMHI.ICHEC-EC-EARTH	SMHI.CNRM-CERFACS-CNRM-CM5	CYI.NCAR-CCSM4	BOUN.MPI-M-MPI-ESM-MR	BOUN.MOHC-HadGEM2-ES
	Seasonal Precipitation					
RMSE	199.3482	204.4536	194.0865	176.9251	202.0494	206.6529
r	0.1895	0.1431	0.1672	0.4177	0.2334	0.1458
Spearman ρ	0.2882	0.2381	0.2422	0.517	0.3703	0.2722
ρ Goodness	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Kendall τ	0.1913	0.1566	0.1606	0.3528	0.2468	0.2225
τ Goodness	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
NSE*	-0.2500	-0.3148	-0.1849	0.0154	-0.1000	-0.0085
	Maximum Daily Air Temperature					
RMSE	6.5160	6.4193	6.5937	6.3210	6.8440	7.1424
r	0.7474	0.7503	0.7571	0.7433	0.7337	0.7025
Spearman ρ	0.7535	0.7582	0.7652	0.7523	0.7389	0.7121
ρ Goodness	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Kendall τ	0.5428	0.5472	0.5529	0.5392	0.5264	0.5117
τ Goodness	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
NSE*	0.4633	0.4788	0.450058	0.4950	0.4910	0.4157
	Minimum Daily Air Temperature					
RMSE	5.7425	5.7864	5.5084	5.4192	5.6251	5.8826
r	0.7277	0.722	0.7405	0.7847	0.7295	0.7012
Spearman ρ	0.7413	0.739	0.756	0.7024	0.7436	0.70214
ρ Goodness	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
Kendall τ	0.5349	0.5331	0.548	0.4985	0.5158	0.5356
τ Goodness	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
NSE*	0.3346	0.3239	0.3873	0.4074	0.3668	0.3423

* NSE represents Nash–Sutcliffe model efficiency coefficient

4.3.3 De-biasing and Validation

For bias correction, the historical data for all stations was implemented taking into account more than 30 years of records used for comparison till 2005, and 15 years of records for validation from 2005 to 2020. Correction factor of multiplicative technique was used for precipitation data, while additive correction factor technique was used for temperature variables.

The de-biasing process was achieved for all climate variables per station. **Table 4.6** shows an example of the de-biasing efficiency for Amman-Airport meteorological station.

Table 4.6: De-biasing efficiency for Amman-Airport meteorological station as an example.

	Climate Variable								
	Precipitation			**Maximum Air Temperature**			**Minimum Air Temperature**		
Method	Delta	QM	EQM	Delta	QM	EQM	Delta	QM	EQM
RMSE	1.098	1.622	1.706	2.462	2.369	2.259	2.303	2.223	2.174
NRMSE	1.515	2.238	2.354	0.106	0.102	0.097	0.198	0.191	0.187
Pearson	0.501	0.501	0.488	0.95	0.95	0.954	0.925	0.925	0.928
Spearman	0.790	0.789	0.787	0.944	0.944	0.944	0.913	0.913	0.917
MAE	0.59	0.88	1	1.99	1.9	1.78	1.87	1.78	1.73
MBE	0	0.53	0.69	0	0	0	0.01	0	0
Index Of Agreement	0.683	0.632	0.605	0.974	0.974	0.977	0.952	0.959	0.962
Nash Sutcliffe model Efficiency	0.122	-0.915	-1.121	0.891	0.899	0.908	0.845	0.855	0.862

4.3.4 Future Climate Projections

The following sections describe briefly the main results, generated from the future projections, for all climate variables developed using the two scenarios (RCP 4.5 and RCP 8.5) based on the de-biased and validated reference RCM model. The future prediction maps for all climate indices were generated using the co-kriging technique with respect to local DEM. To simplify the presentation of the maps, long-term climate variables were developed based on three time horizons; 2020-2050, 2040-2070, and 2070-2100. The temporal changes in future forecast climate variables in the short, medium, and long terms are presented in **Table 4.7**.

Table 4.7: Summary of the future climate forecasts regarding short, medium, and long terms.

		Pcp	Tmax	Tmin	RH	WS	ETp	HW
Historical Period 1990-2020		219.85	25.34	12.49	44.34	4.68	2529.62	143.38
PCP 4.5	Short Term (20-50)	184.47	25.87	13.07	42.81	4.68	2600.03	209.08
	Medium Term (40-70)	185.15	26.24	13.48	42.54	4.68	2643.15	240.15
	Long Term (70-100)	178.36	26.50	13.72	42.23	4.67	2646.89	290.35
PCP 8.5	Short Term (20-50)	201.56	26.13	13.42	42.93	4.63	2612.92	221.85
	Medium Term (40-70)	158.13	26.97	14.07	40.65	4.63	2687.88	304.69
	Long Term (70-100)	111.88	28.43	15.26	38.02	4.58	2782.01	480.27

Where Pcp is precipitation, Tmax is the maximum temperature, Tmin is the minimum temperature, RH is the relative humidity, WS is the wind speed, ETp is the potential evapotranspiration, and HW is the heatwave.

4.3.4.1 Future Projected Air Temperature

By 2100, the country will witness a warmer climate. The minimum air temperature is ***extremely likely*** to increase by +1.2 °C [+0.6 °C to +2.9 °C] according to RCP 4.5 and by 2.7 °C [+2.1 °C to +4.5°C] according to RCP 8.5 (Figure 4.6). Similarly, the maximum air temperature is ***extremely likely*** to increase by 1.1 °C [+0.7 °C to +1.7 °C] according to RCP 4.5 and up to 3.1 °C [+2.6 °C to +3.7°C] according to RCP 8.5 (**Figure 4.7**). For estimating the exposure risk spatially and temporally, the projected differences in average maximum and minimum air temperature for the three time horizons using RCP 4.5 and 8.5 were generated and mapped and presented in **Figure 4.9**

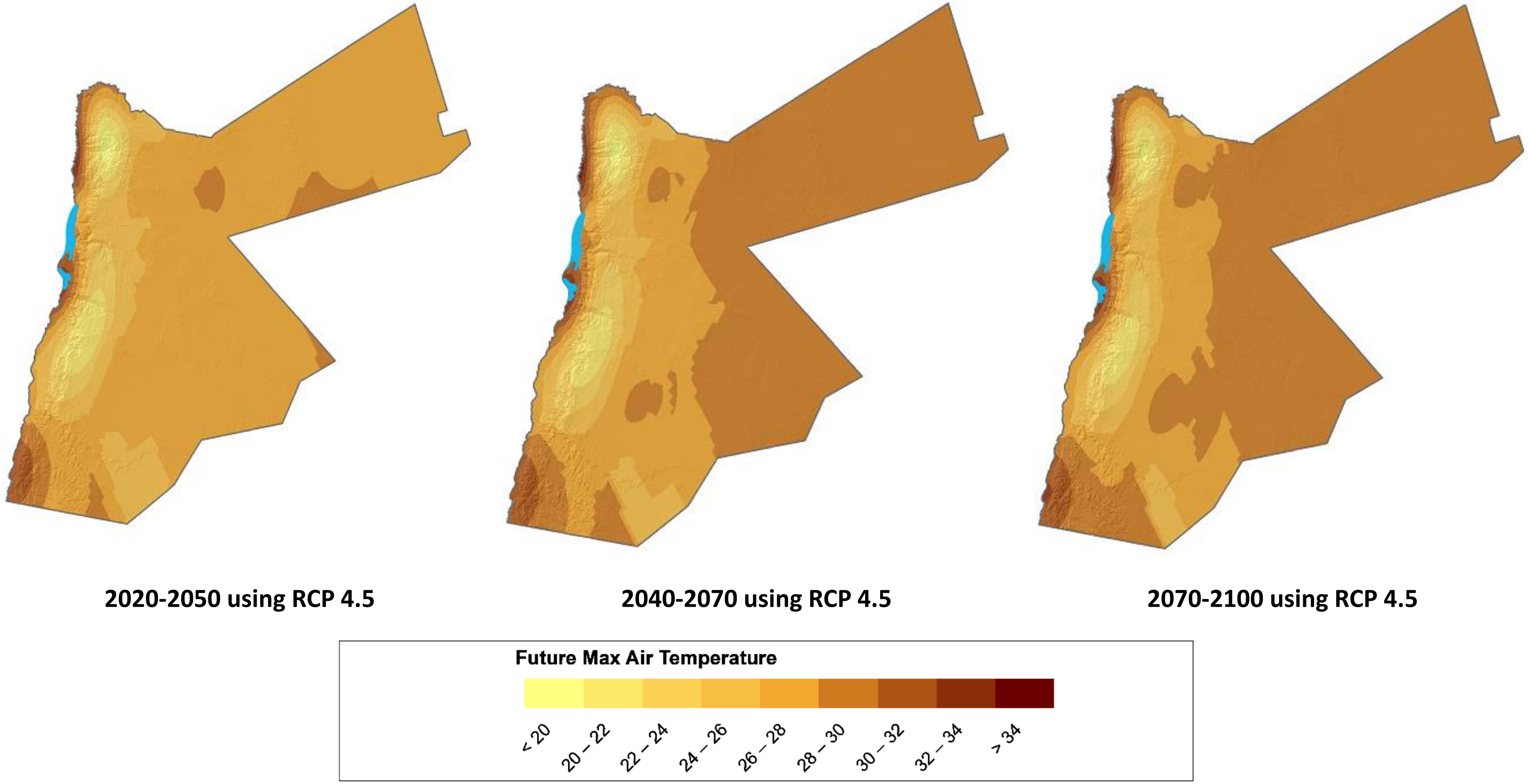


Figure 4.5: Projected average maximum air temperature for the three time horizons using RCP 4.5

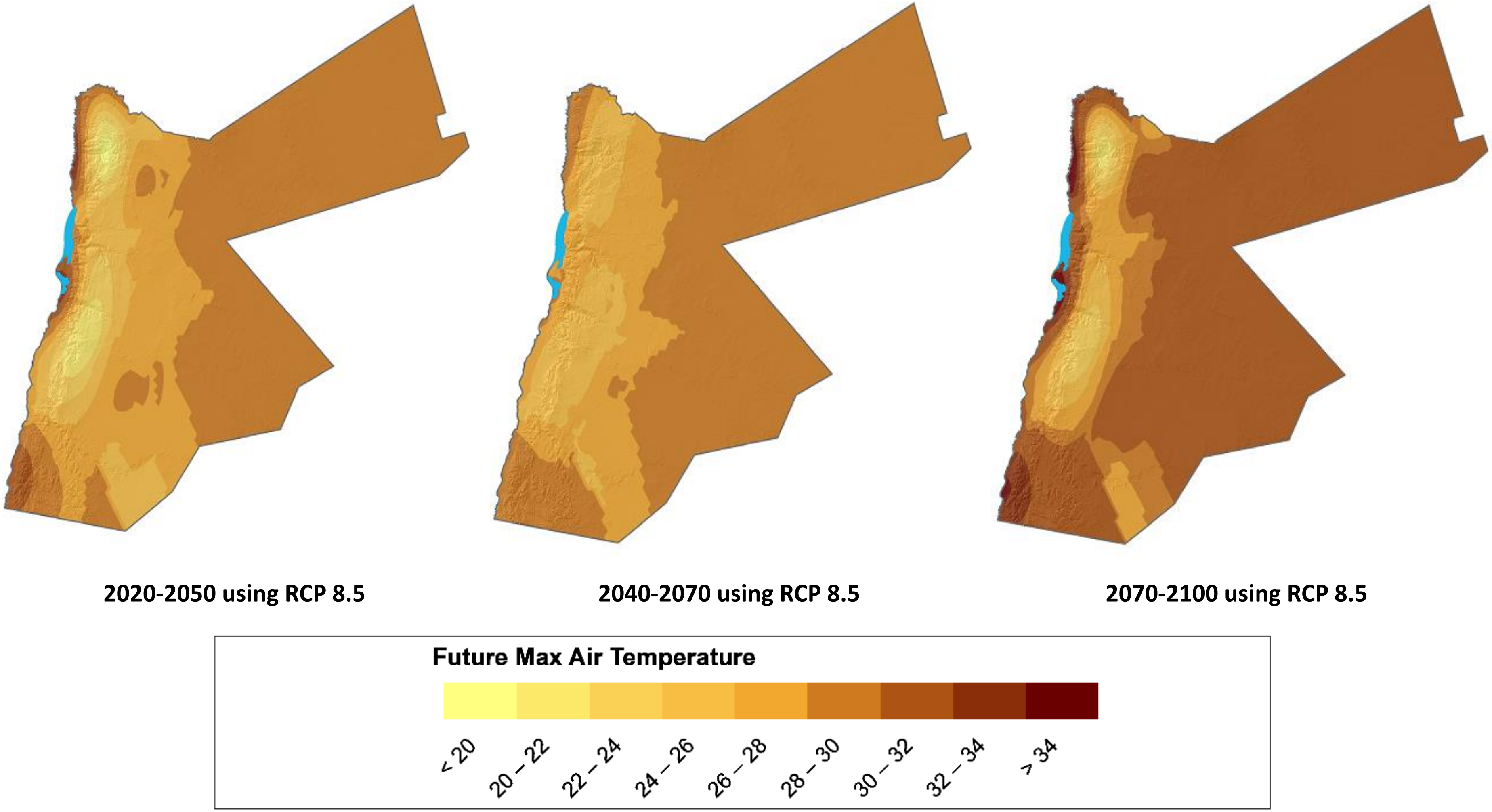


Figure 4.6: Projected average maximum air temperature for the three time horizons using RCP 8.5

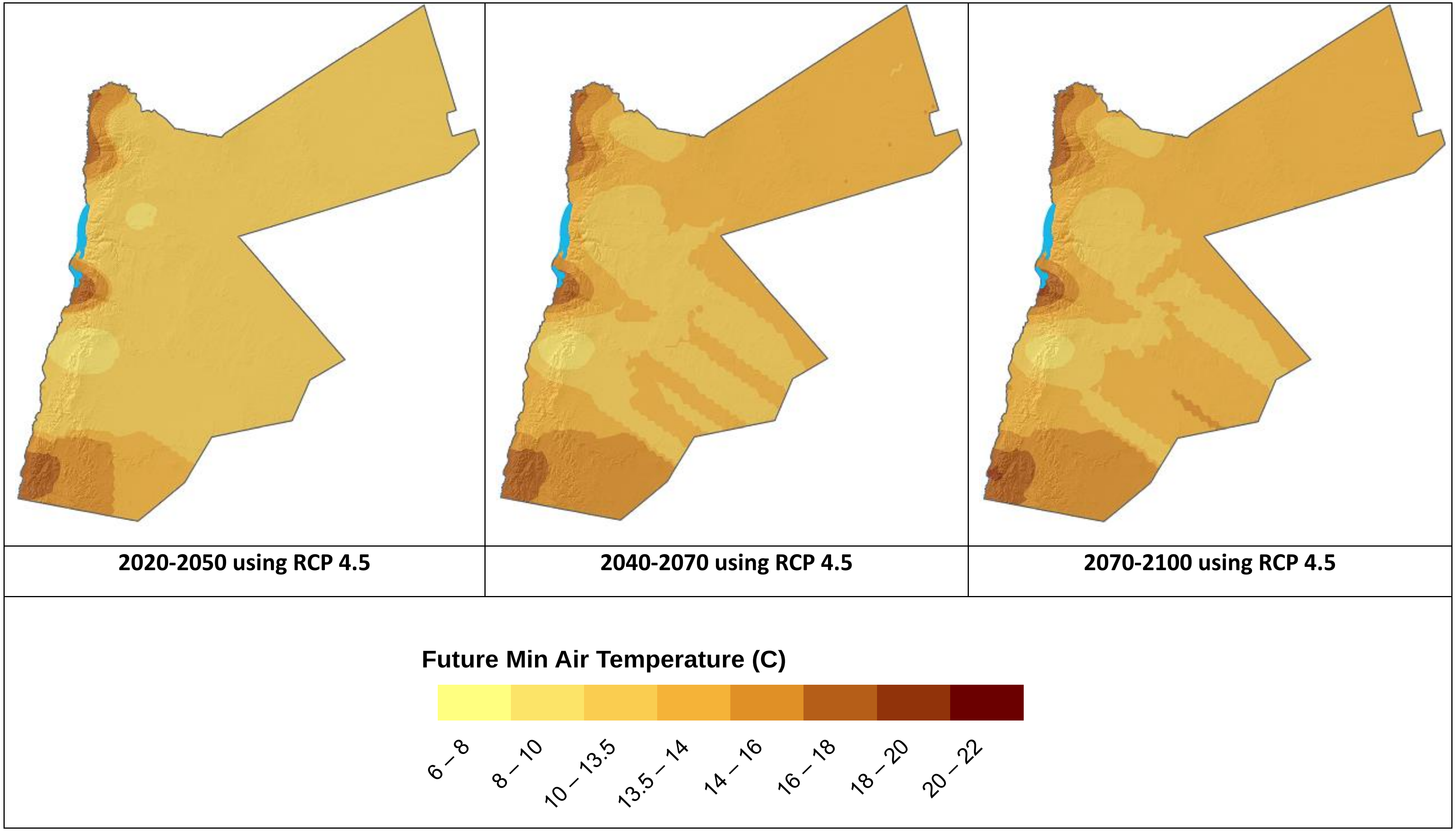


Figure 4.7: Projected average minimum air temperature for the three time horizons using RCP 4.5

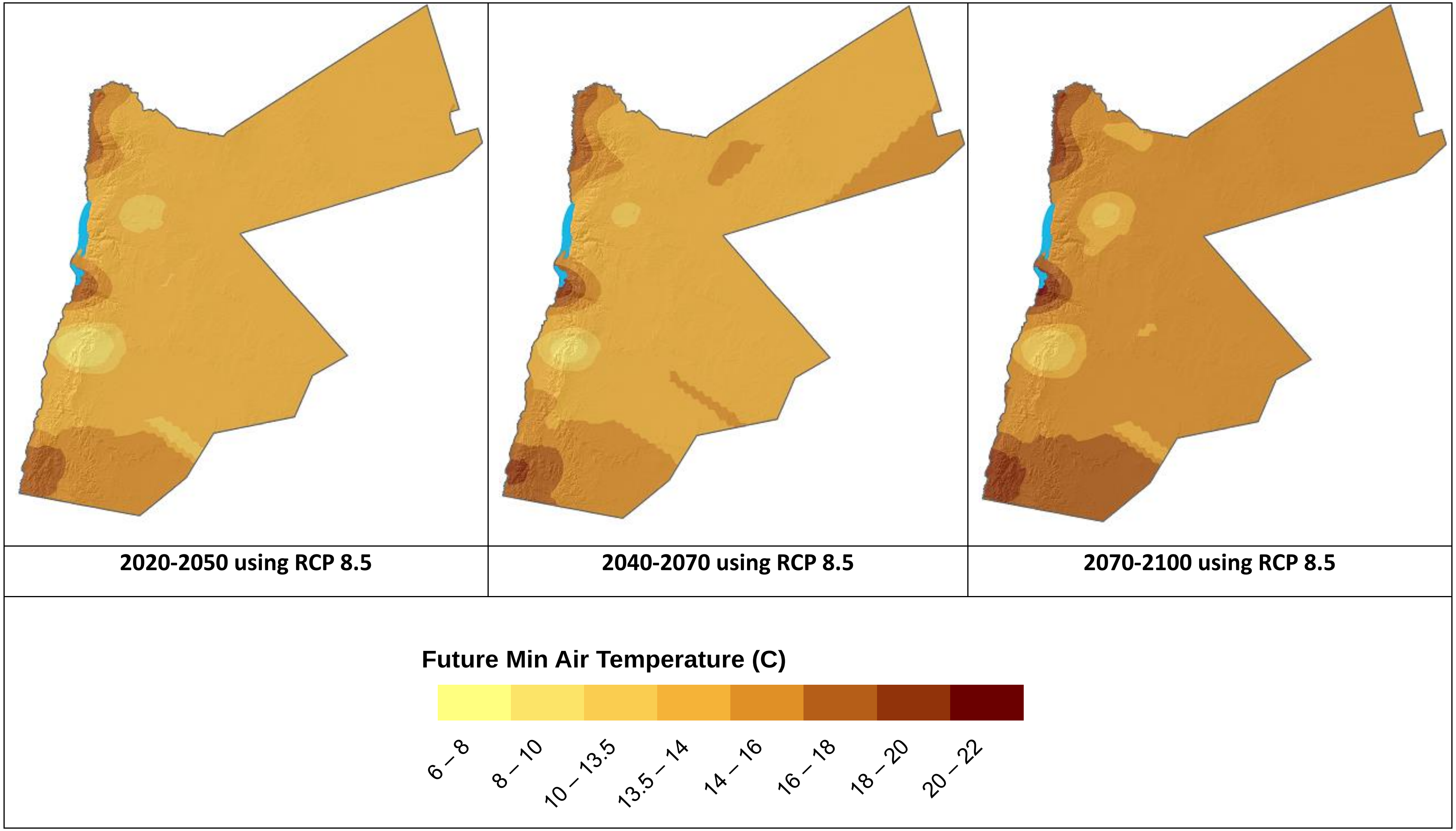


Figure 4.8: Projected average minimum air temperature for the three time horizons using RCP 8.5

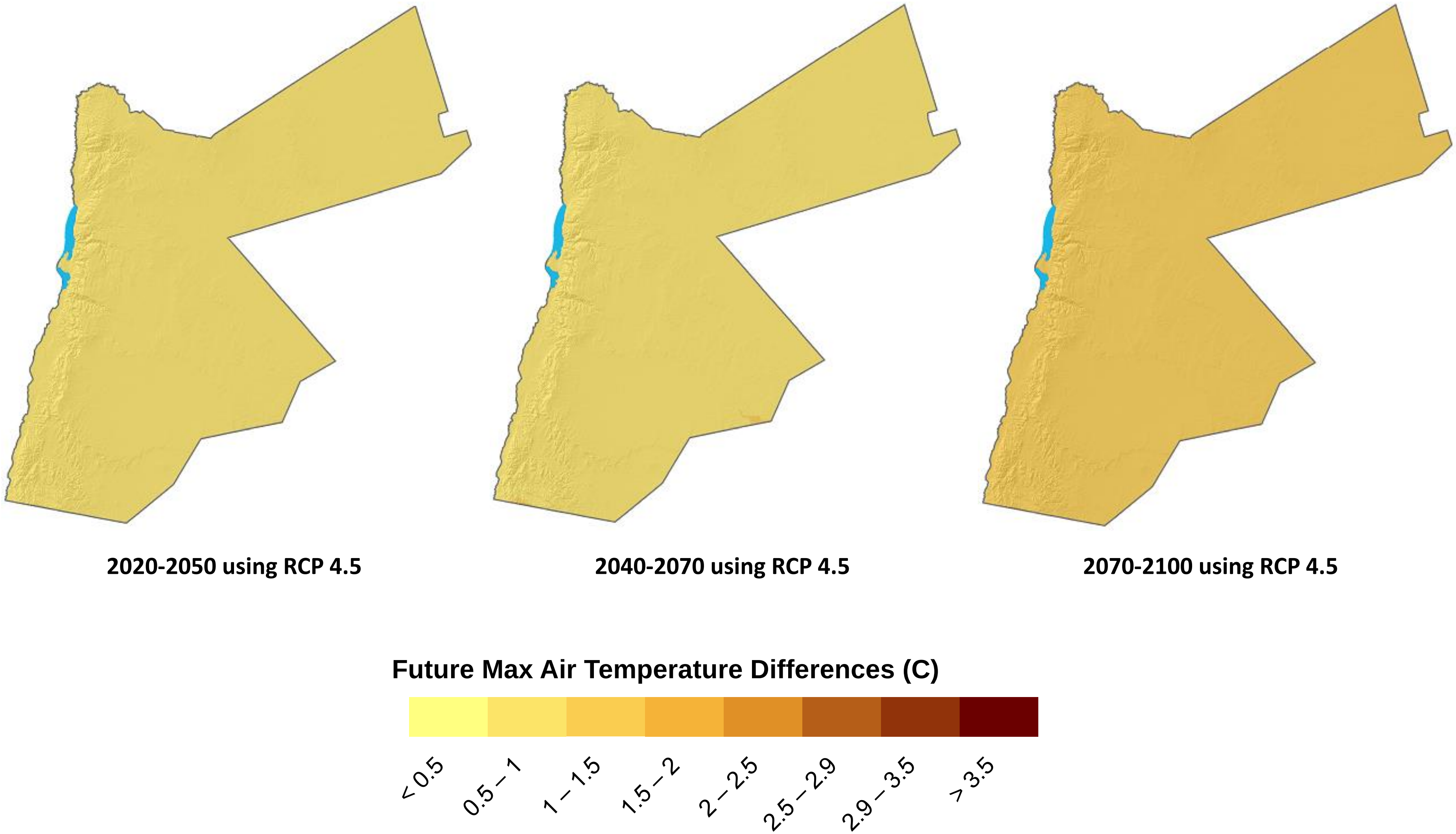


Figure 4.9: Projected Differences in Average Maximum Air Temperature for the three time horizons using RCP 4.5

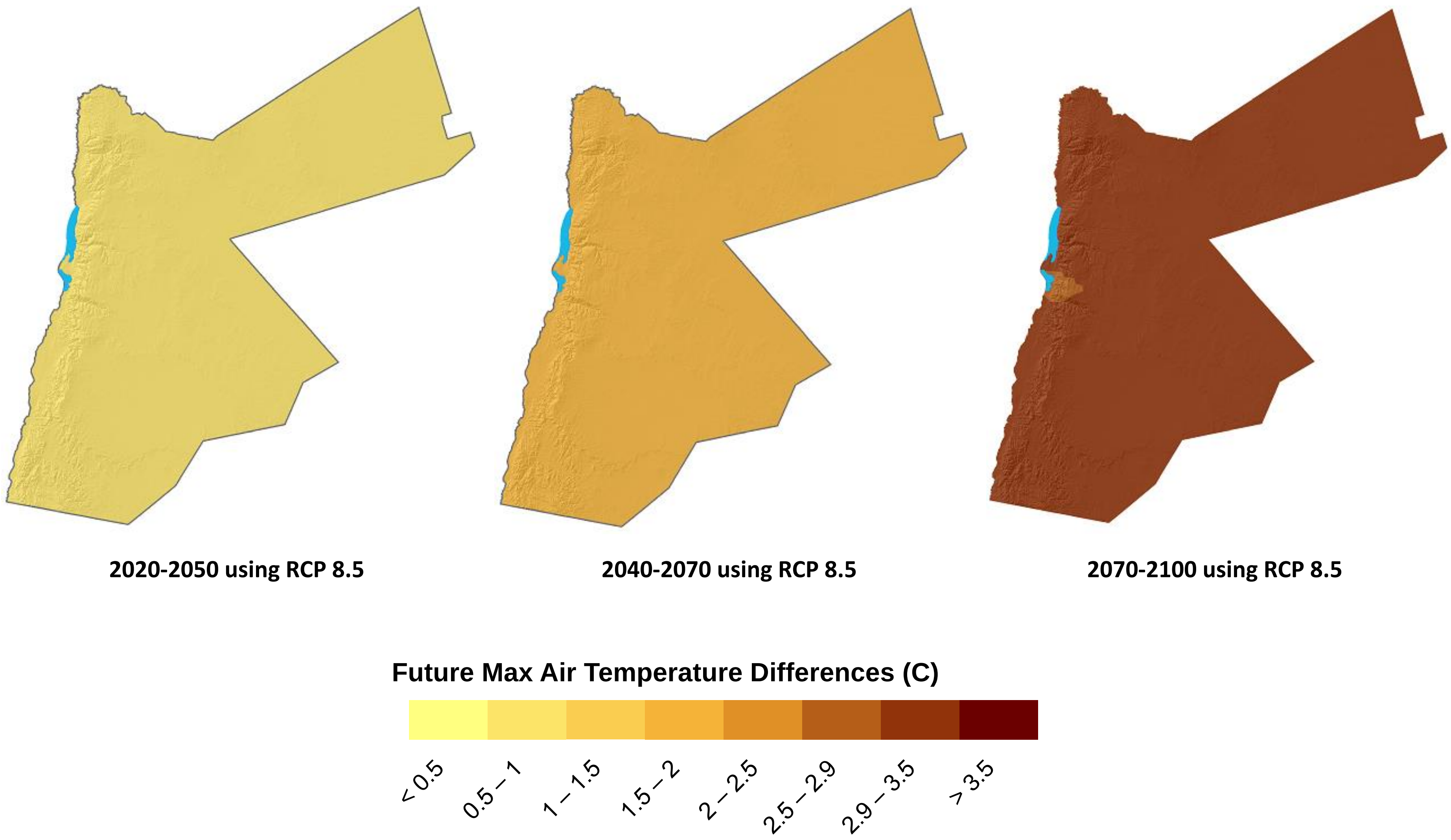


Figure 4.10: Projected Differences in Average Maximum Air Temperature for the three time horizons using RCP 8.5

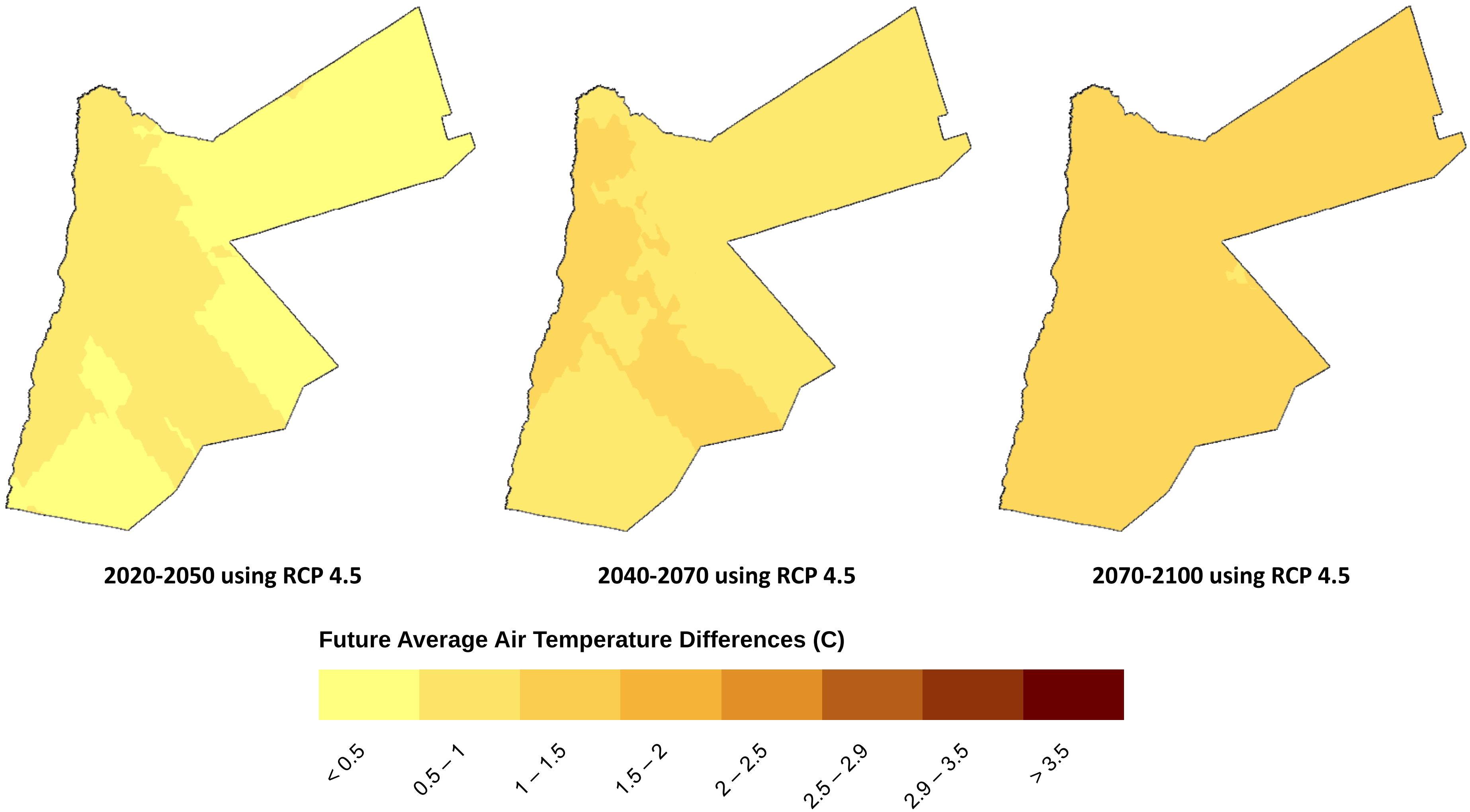


Figure 4.11: Projected Differences in Average Air Temperature for the three time horizons using RCP 4.5

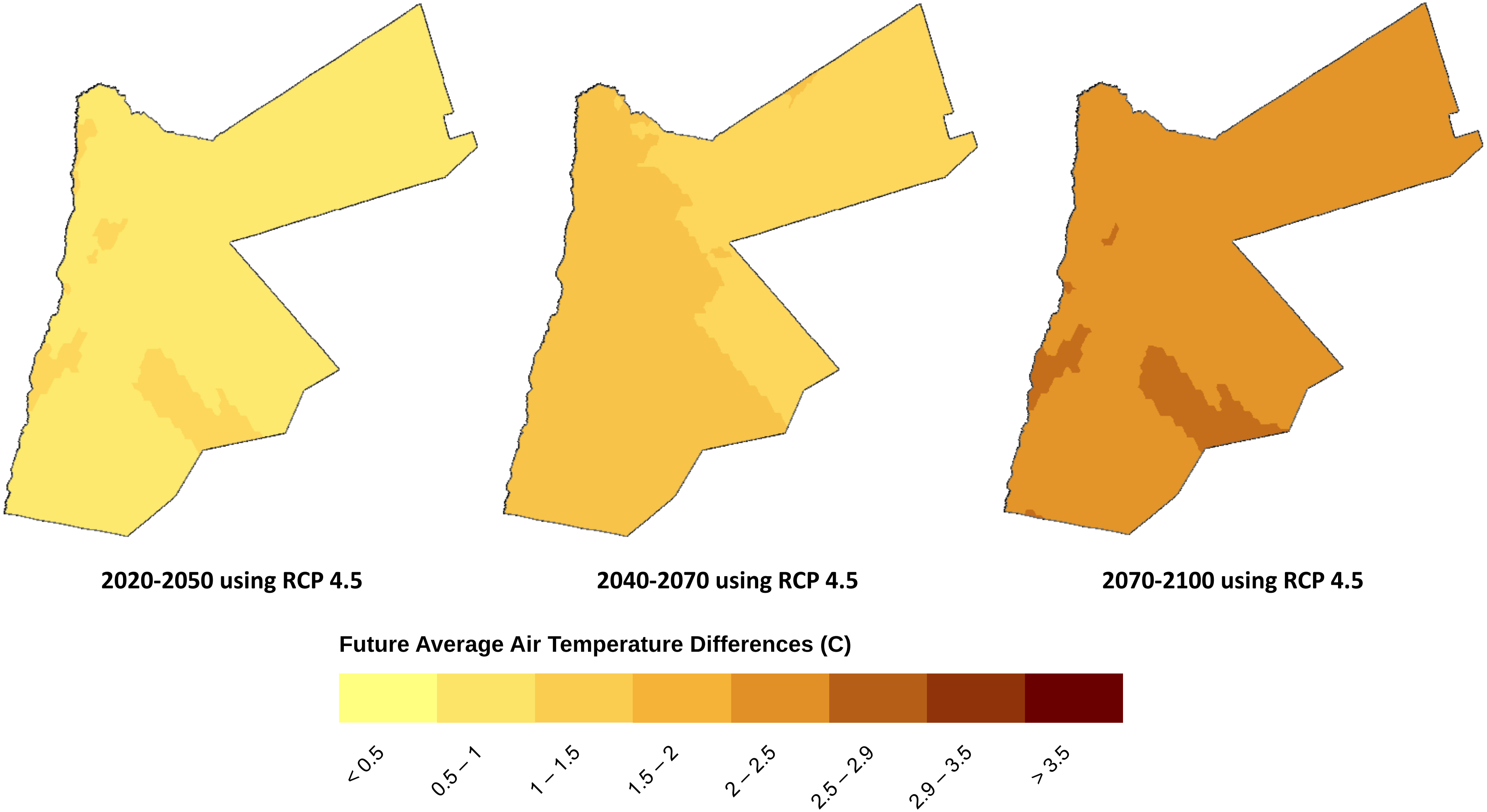
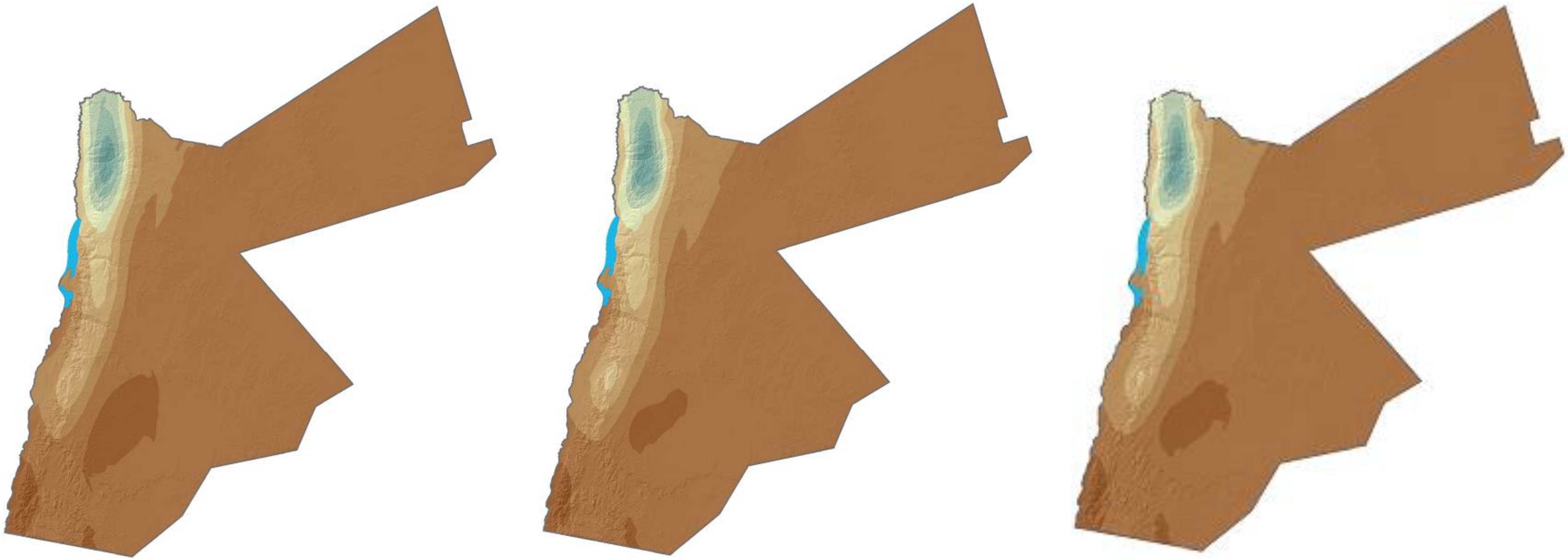


Figure 4.12: Projected Differences in Average Air Temperature for the three time horizons using RCP 8.5

4.3.4.2 Future Projected Precipitations

According to the projected future daily, monthly and seasonal precipitation, the country will witness a significantly drier climate. By the end of the 21st century, the country is ***likely*** to become drier as the precipitation tends to decrease by 15.8% [-7.1% to -31.3%] according to RCP 4.5 and by 47.0% [-23.3% to -57.5%] according to RCP 8.5, taking into account that some zones are predicted to receive more precipitation, with a maximum increase of 19%, according to RCP 4.5, while the whole country is projected to become drier according to RCP 8.5. The significant precipitation decrease is projected to be ***very likely*** in the western part of the country, while the potential increase, are predicted to be ***likely*** to be allocated at toe southern arid zones (Figure 4.13).

For estimating the exposure risk spatially and temporally, the projected differences, in average precipitation, for the three time horizons using RCP 4.5 and 8.5 were generated and mapped and presented in Figure 4.15. It is projected that maximum exposure risk will be allocated at the Northern part (i.e., Yarmouk Basin). This will definitely impact most relevant sectors within the region especially the water and agriculture sectors. On the other hand, the precipitation in the Eastern and Southern Badia regions is ***likely*** to increase up to the year 2050, that could reach a maximum of 40%, as compared to historical baseline scenario then reduces to reach a reduction by 10% by the end of the century.



2020-2050 using RCP 4.5

2040-2070 using RCP 4.5

2070-2100 using RCP 4.5

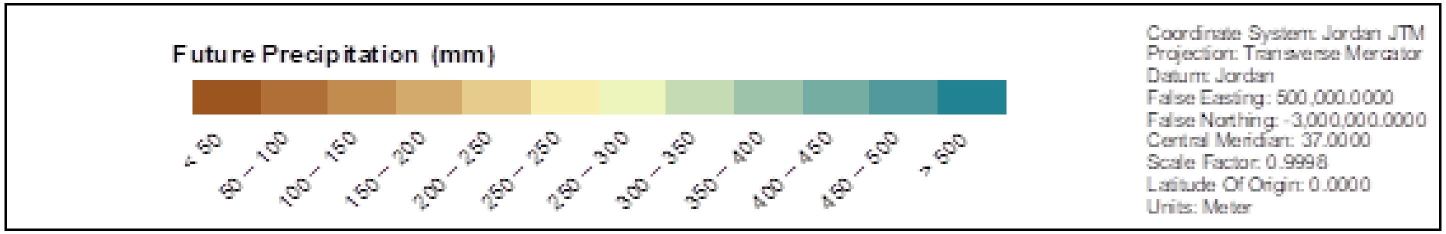


Figure 4.13: Projected Annual Precipitation for the three time horizons using RCP 4.5

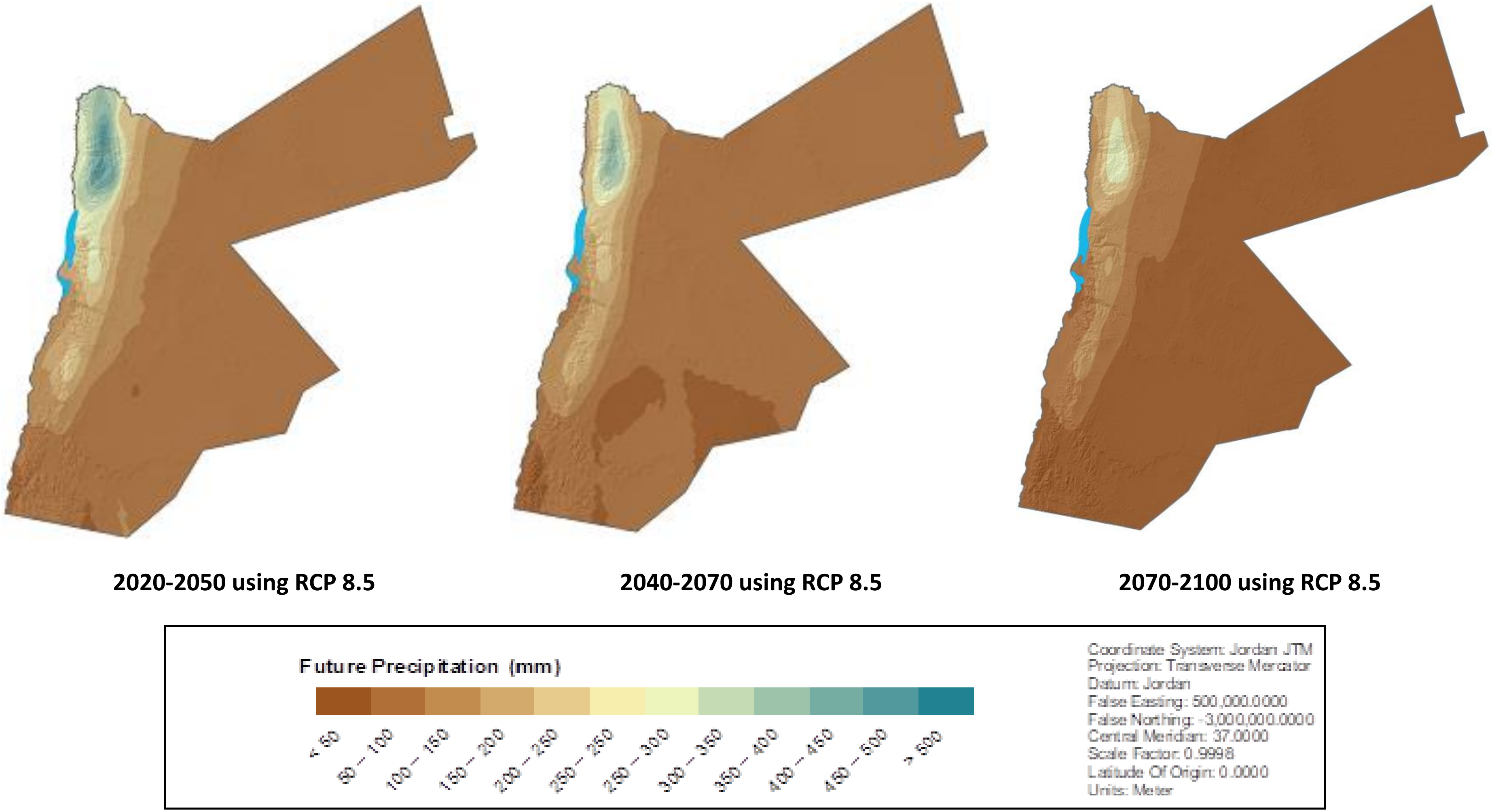


Figure 4.14: Projected Annual Precipitation for the three time horizons using RCP 8.5

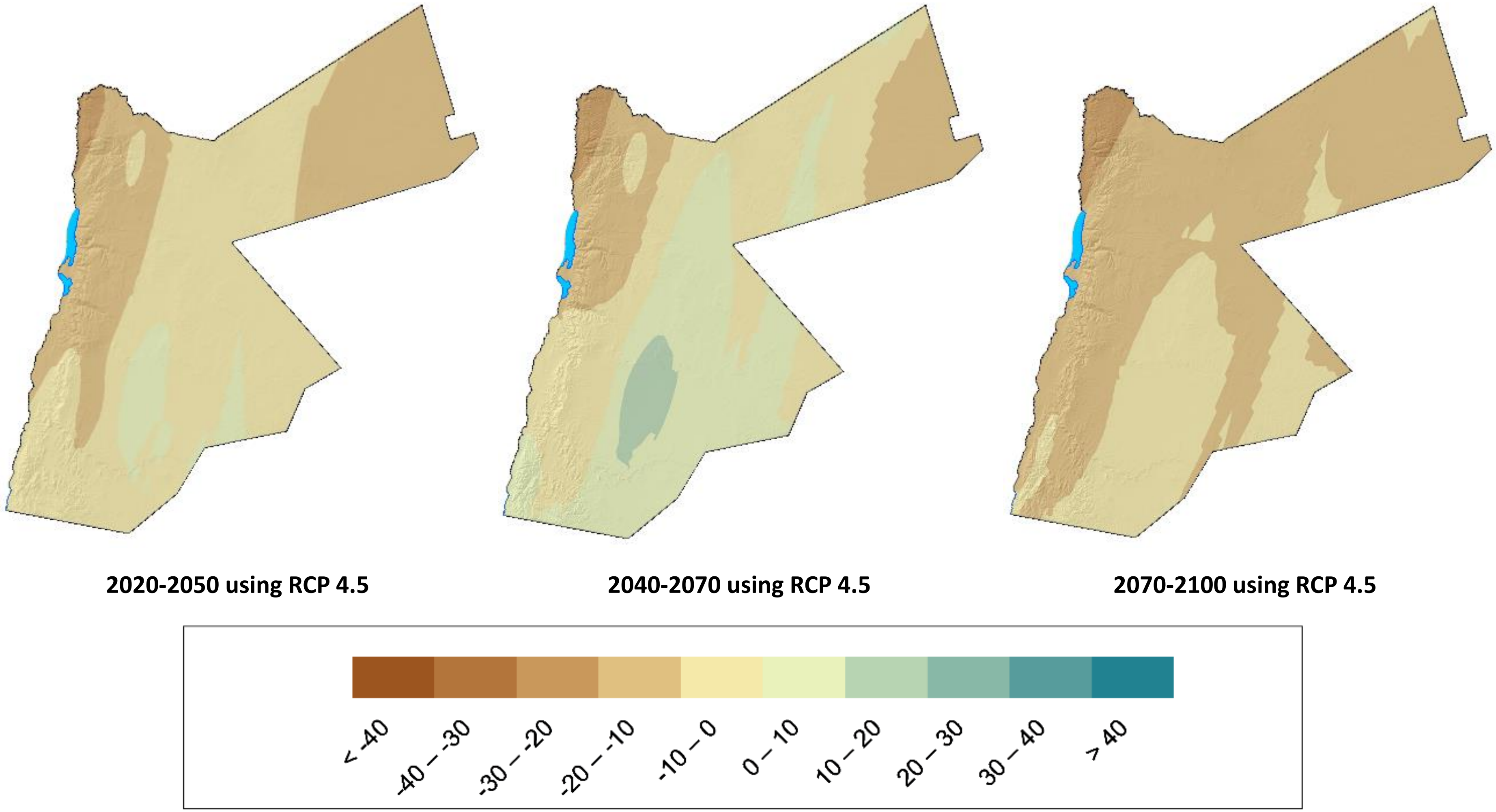


Figure 4.15: Projected Differences in Annual Precipitation for the three time horizons using RCP 4.5

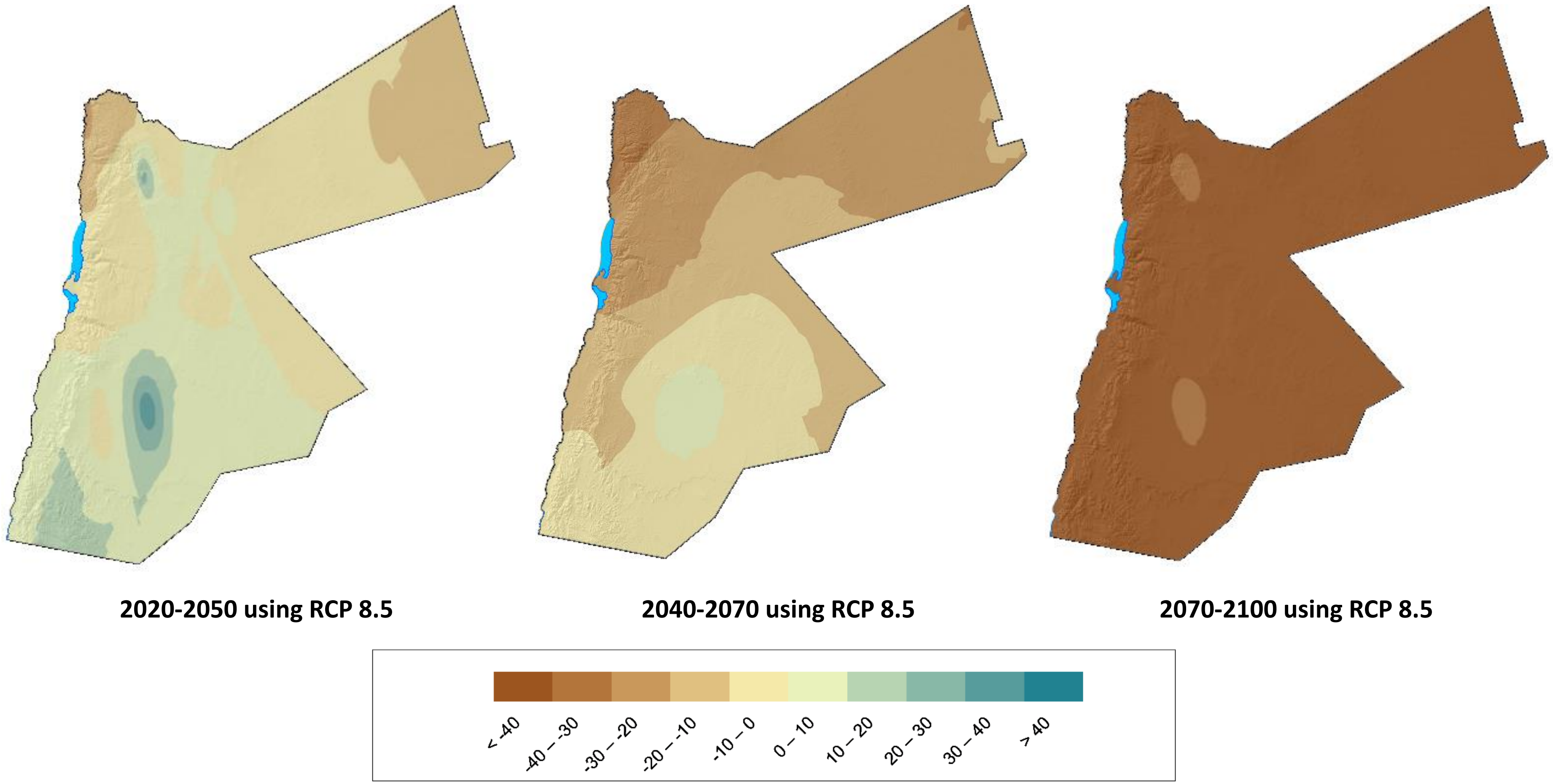


Figure 4.16: Projected Differences in Annual Precipitation for the three time horizons using RCP 8.5

4.3.4.3 Future Projected Potential Evapotranspiration

Due to reduction in precipitation and increase in temperature, the potential evapotranspiration is ***very likely*** to increase by 5.8 % [+4.7 % to +6.9 %] according to RCP 4.5 and by 11.1 % [+8.1 % to +15.3%] according to RCP 8.5. Most of the impacts in the short term are predicted to occur at the southern part of the country, but are expected to expand over time, to cover the western and northern Badia, by the end of the 21st century (Figure 4.17). The projected differences in potential evapotranspiration for the three time horizons using RCP 4.5 and 8.5 are presented in Figure 4.19. In the worst-case scenario, the evapotranspiration for the whole country is ***very likely*** to increase by 15% above the baseline scenario, thus setting the systems under pressure of greater water demand.

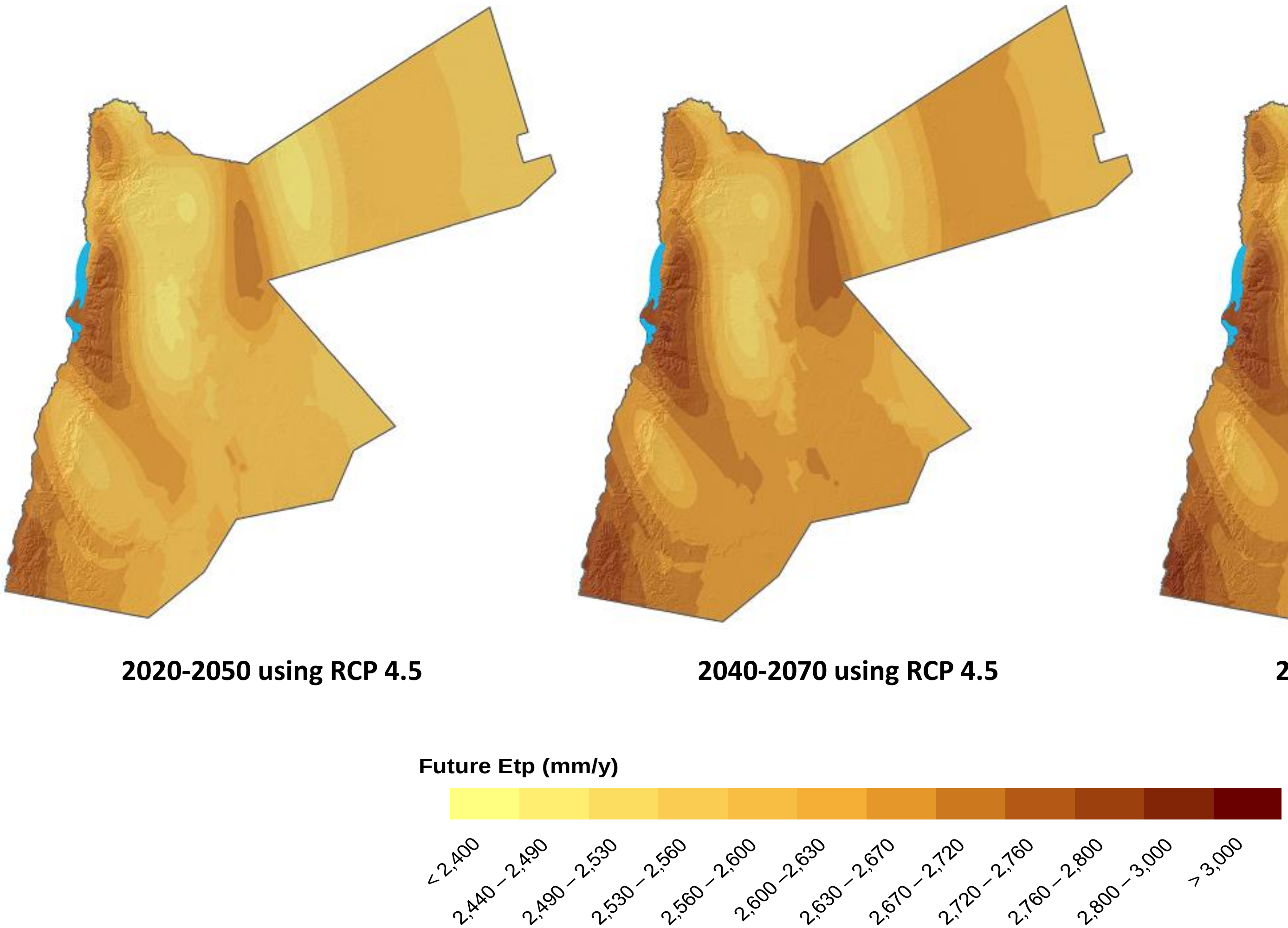


Figure 4.17: Projected annual ETp for the three time horizons using RCP 4.5

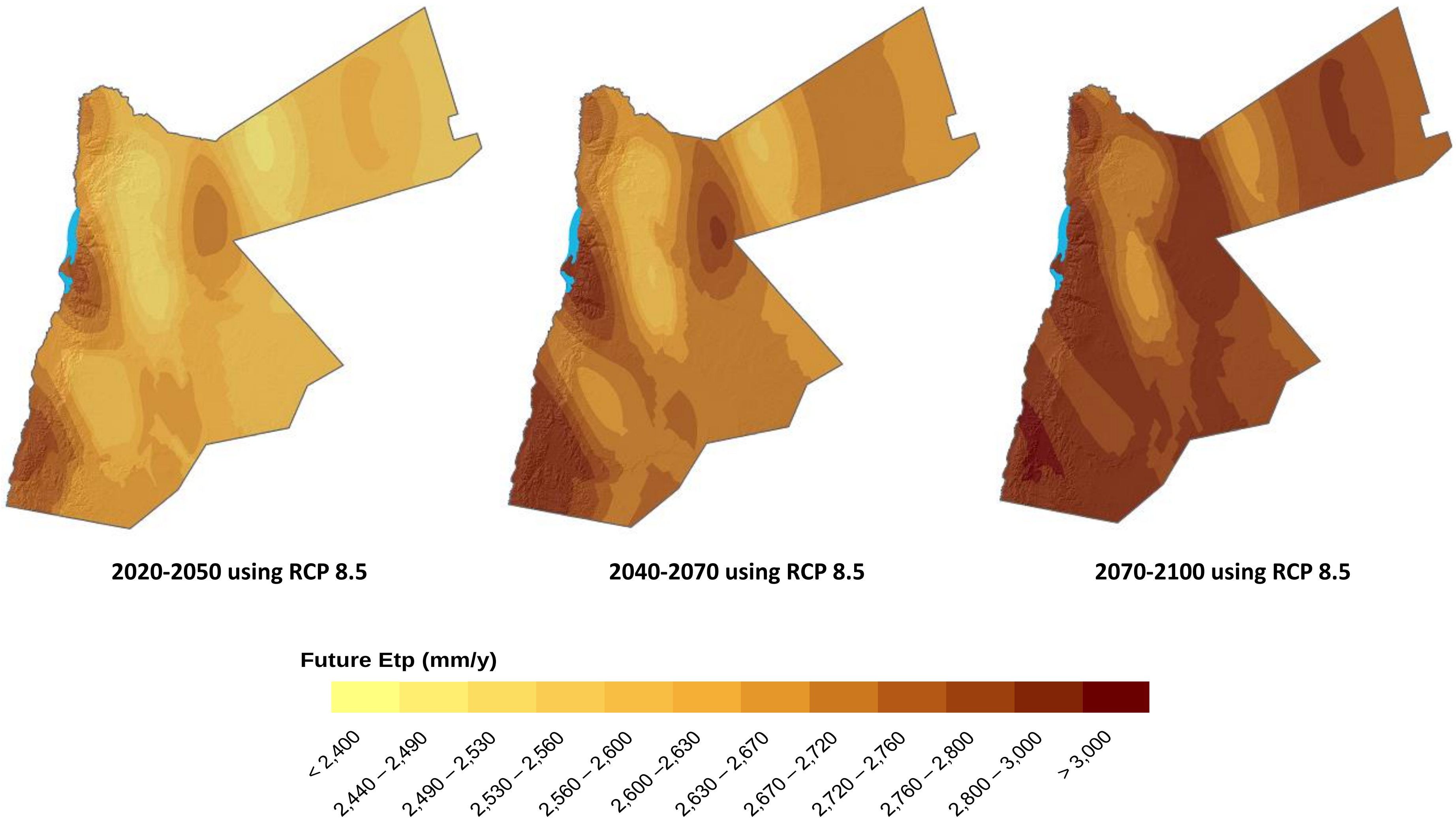


Figure 4.18: Projected annual ETp for the three time horizons using RCP 8.5

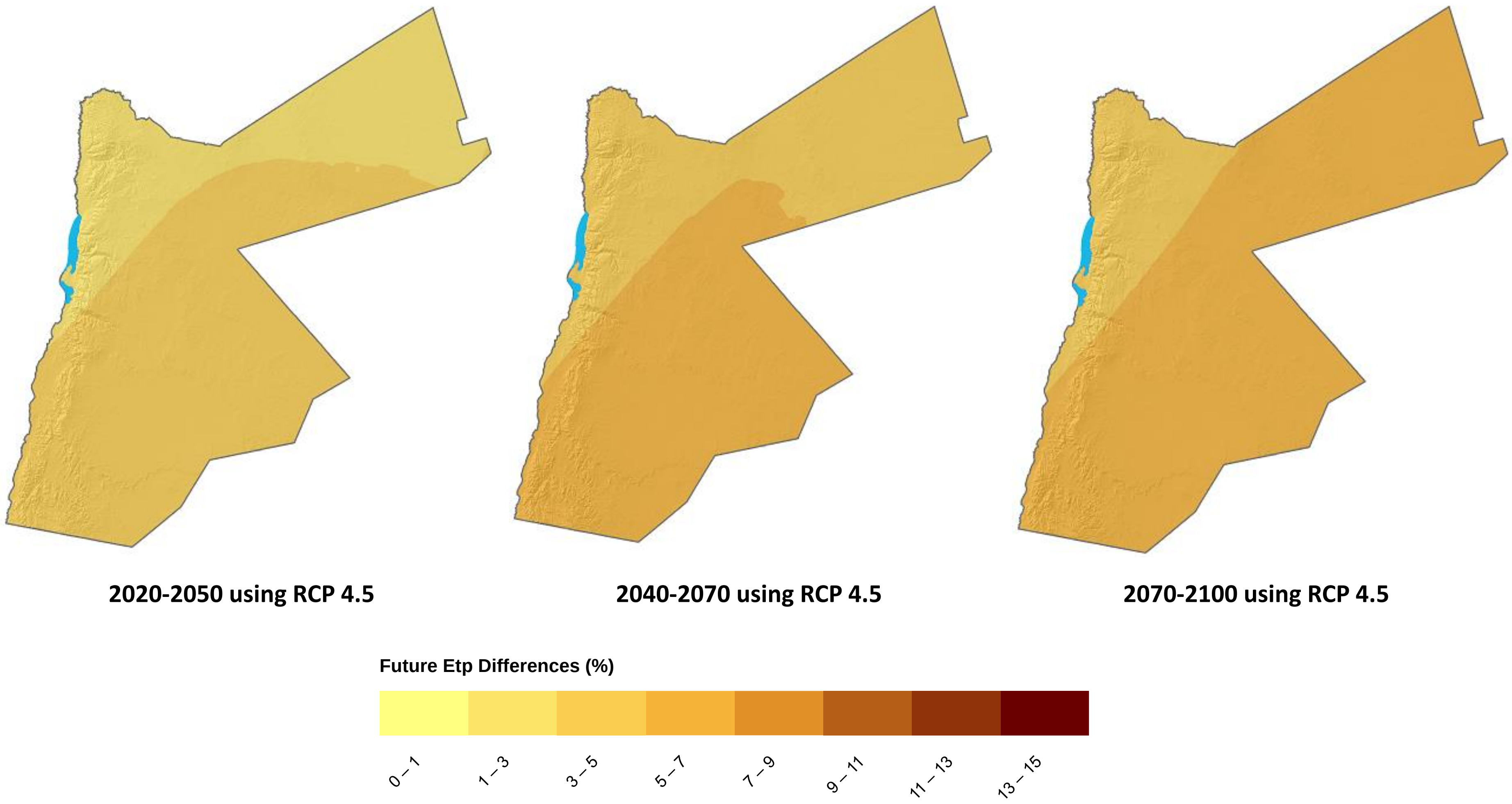


Figure 4.19: Projected Differences in annual ETp for the three time horizons using RCP 4.5

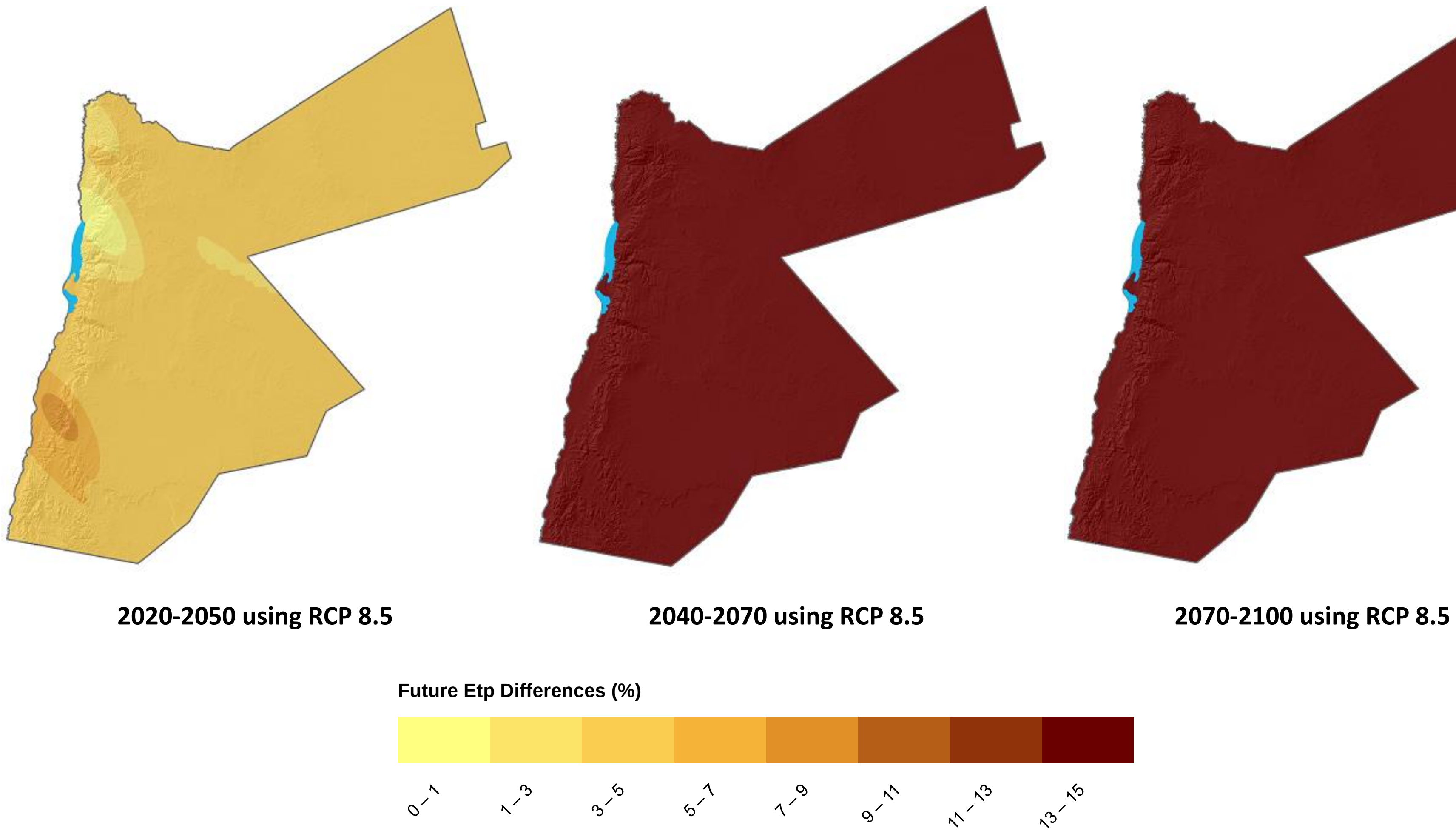


Figure 4.20: Projected Differences in annual ETp for the three time horizons using RCP 8.5

4.3.4.4 Future Projected Relative Humidity

The forecast air relative humidity is ***likely*** to decrease by 3% [-2.5 % to -3.3 %] according to RCP 4.5 and by 7.2% [-6.0 % to -7.8 %] according to RCP 8.5 by the end of the 21st century. The projected differences in relative humidity, for the three time horizons using RCP 4.5 and 8.5 as presented in figures 4.23 4.24, which indicate that the relative decrease in humidity is mild, until reaching the end of the century, using RCP 4.5, while in the worst-case scenario, it starts to increase by more than 6%, by the end of the century. In all scenario cases, the Northern Badia is ***likely*** to be subjected to a decrease in relative humidity at a higher rate than other parts or regions.

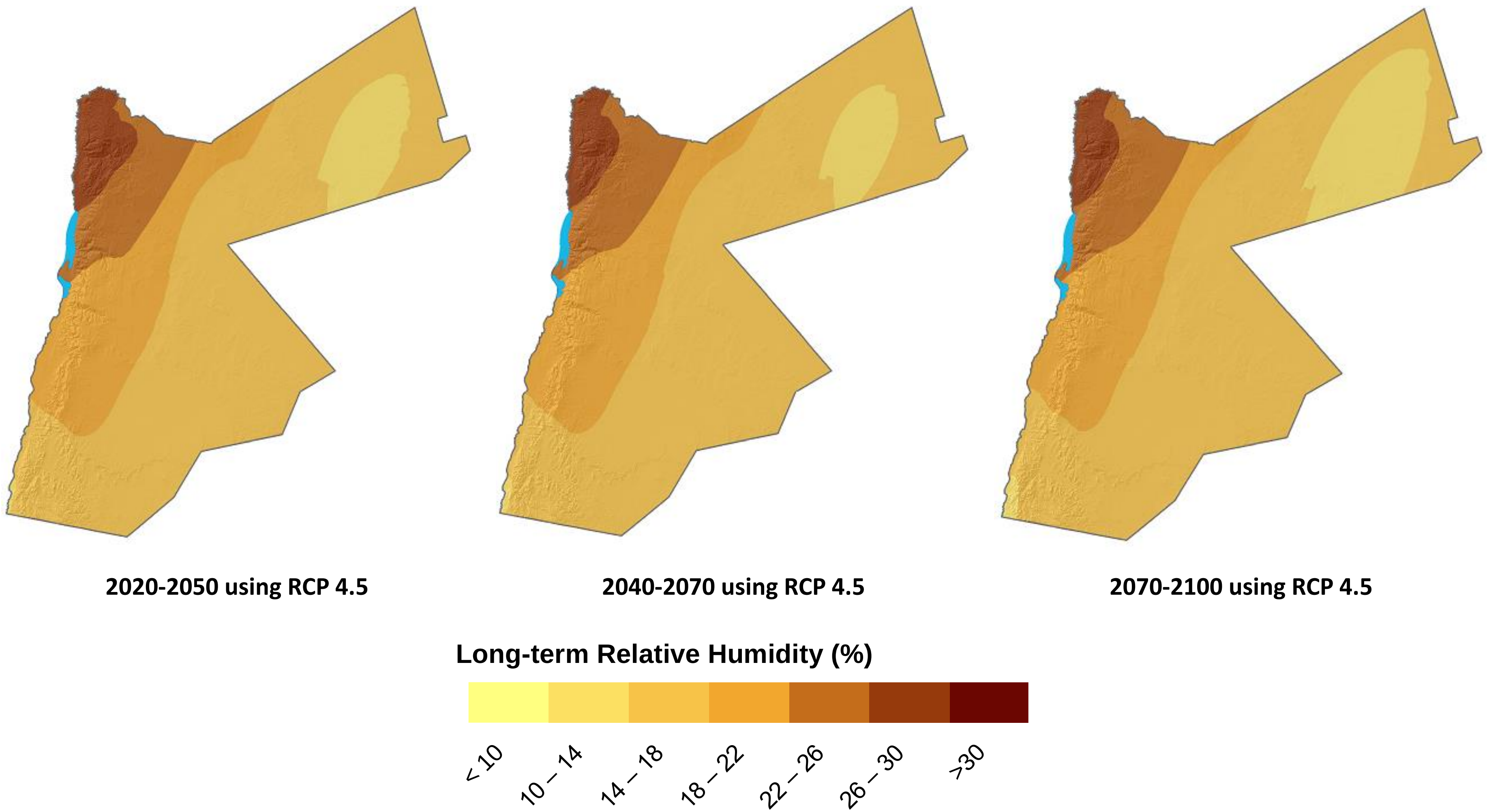


Figure 4.21: Projected average relative humidity, for the three time horizons using RCP 4.5

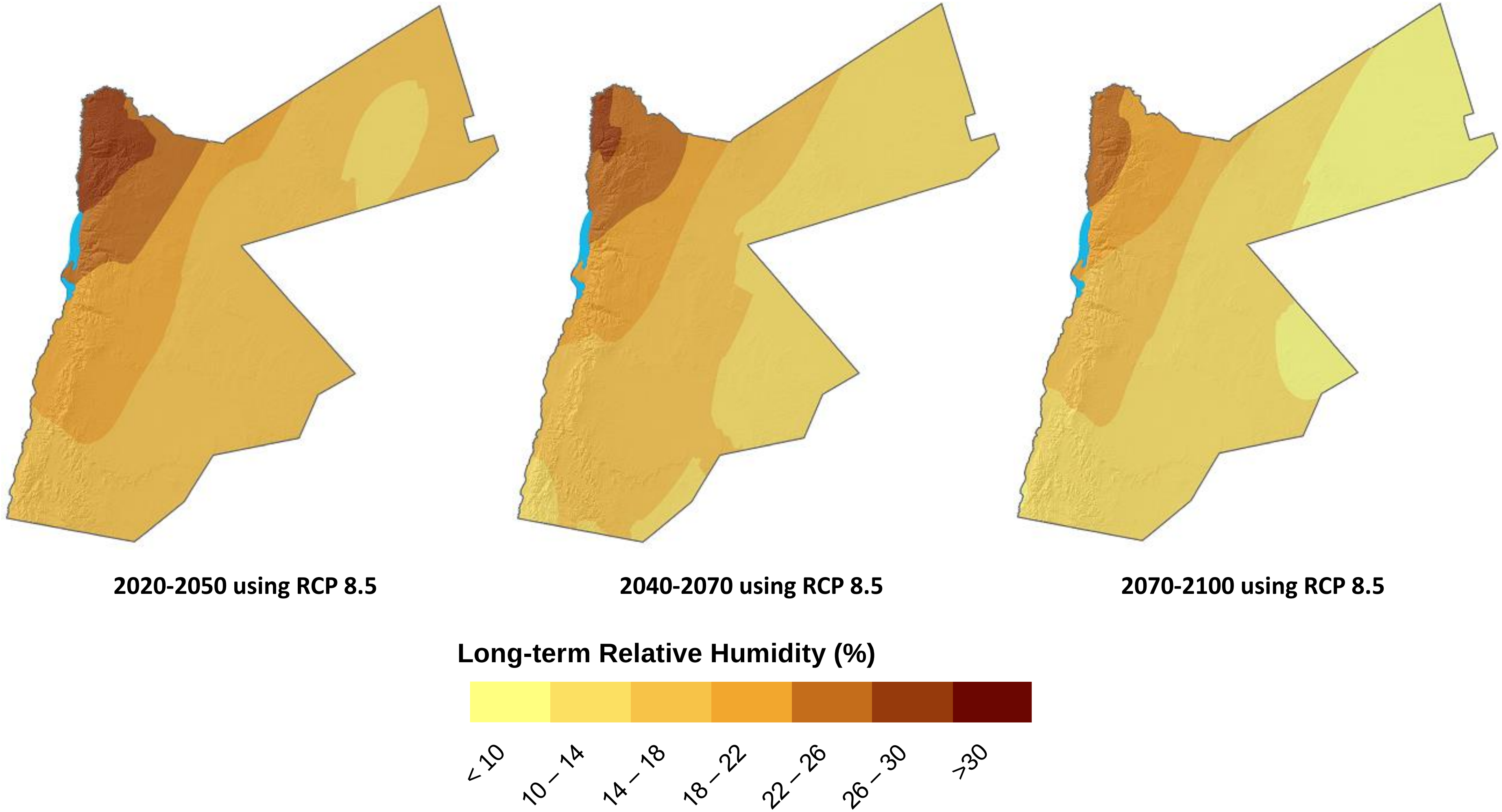


Figure 4.22: Projected average relative humidity, for the three time horizons using RCP 8.5

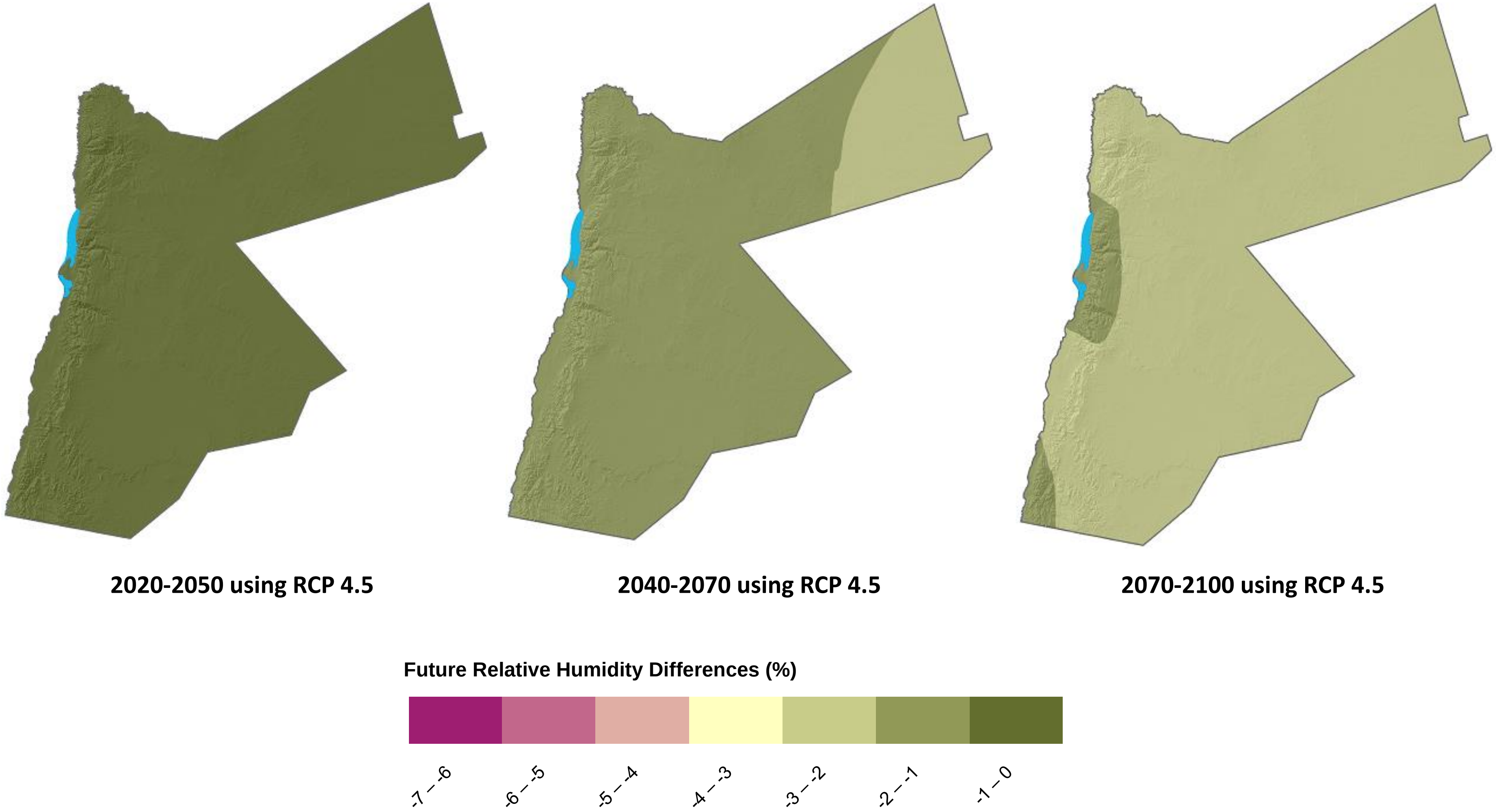
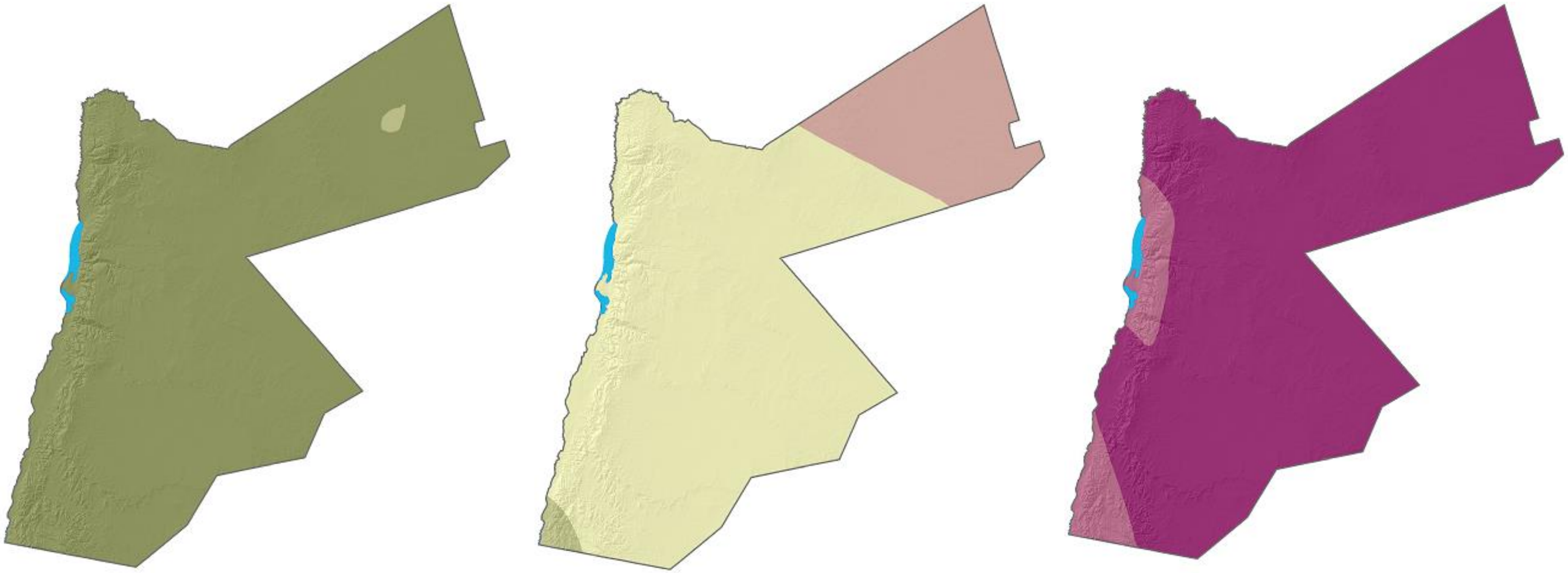


Figure 4.23: Projected Differences in Average Relative Humidity, for the three time horizons using RCP 4.5



2020-2050 using RCP 8.5 **2040-2070 using RCP 8.5** **2070-2100 using RCP 8.5**

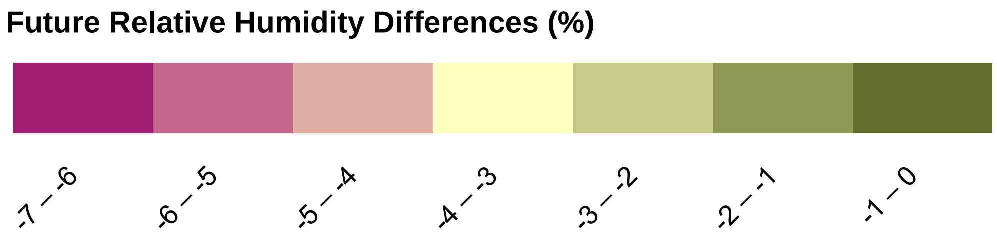


Figure 4.24: Projected Differences in Average Relative Humidity, for the three time horizons using RCP 8.5

4.3.4.5 Future Projected Wind Speed

Wind speed forecasts didn’t indicate significant temporal and spatial changes, especially at RCP 4.5 (Figure 4.25). The RCP 8.5 suggests a slight increase in wind speed of 1% to 2%, by 2035, especially in the northern regions of the country, and reaching a 3% to 4% increase, by the end of the century, along the highlands above the Jordan Rift Valley. Based on the projected differences in wind speed, for the three time horizons, using RCP 4.5 and 8.5 as presented at Figure 4.27, the country is about ***as likely as not*** to be subjected to wind bloom events exceeding 12 m/s.

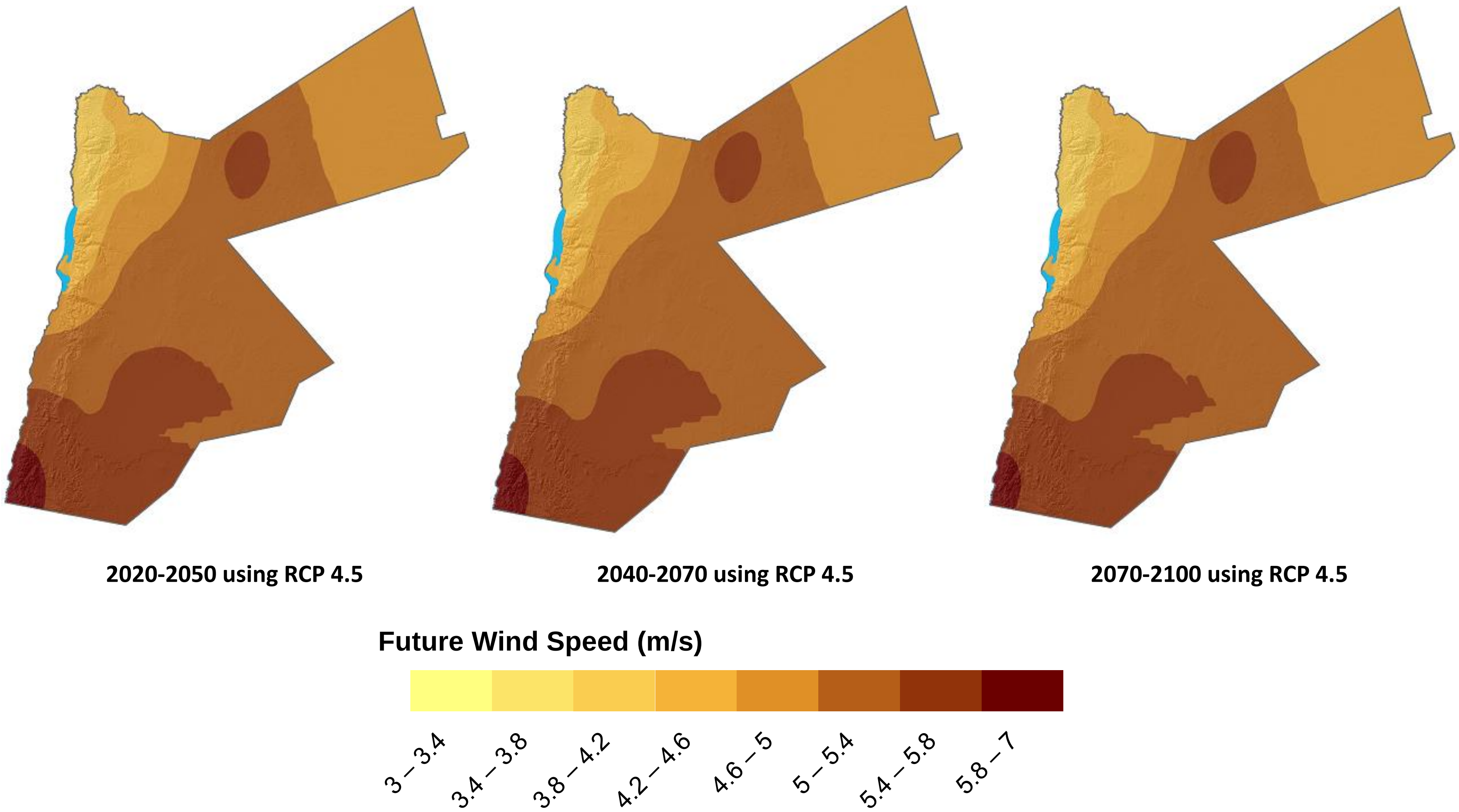


Figure 4.25: Projected average wind speed, for the three time horizons using RCP 4.5

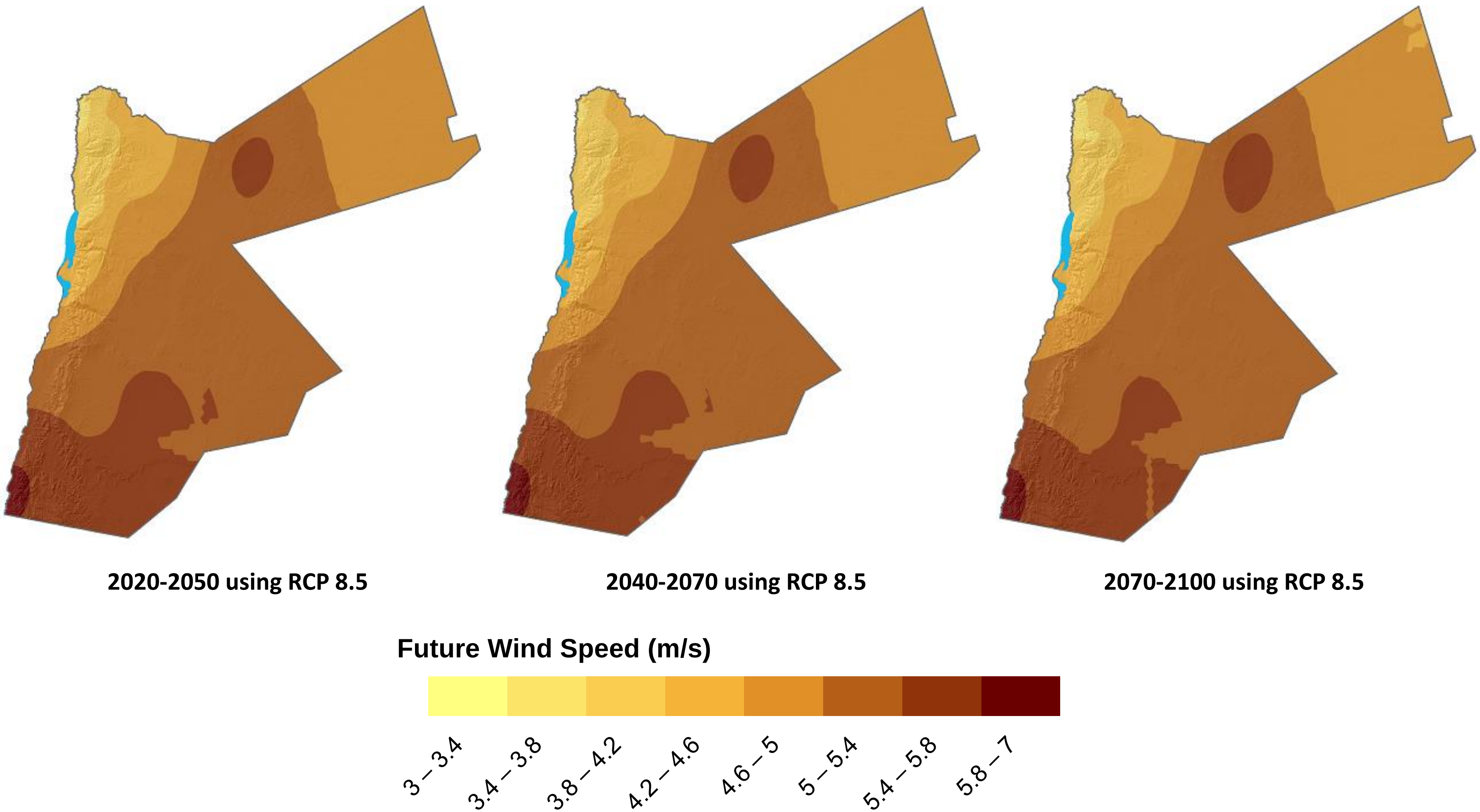


Figure 4.26: Projected average wind speed, for the three time horizons using RCP 8.5

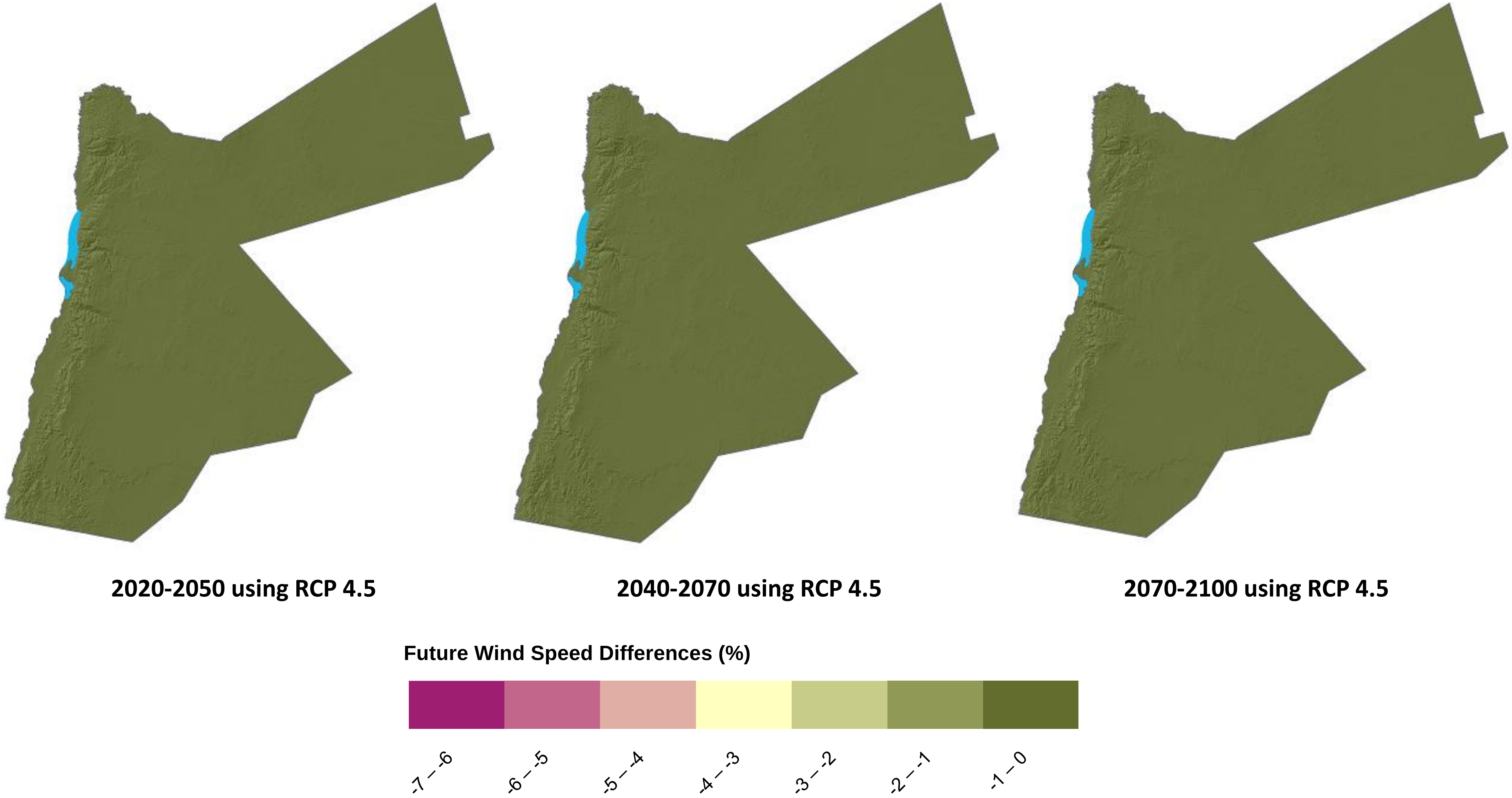


Figure 4.27: Projected Differences in Average Wind Speed, for the three time horizons using RCP 4.5

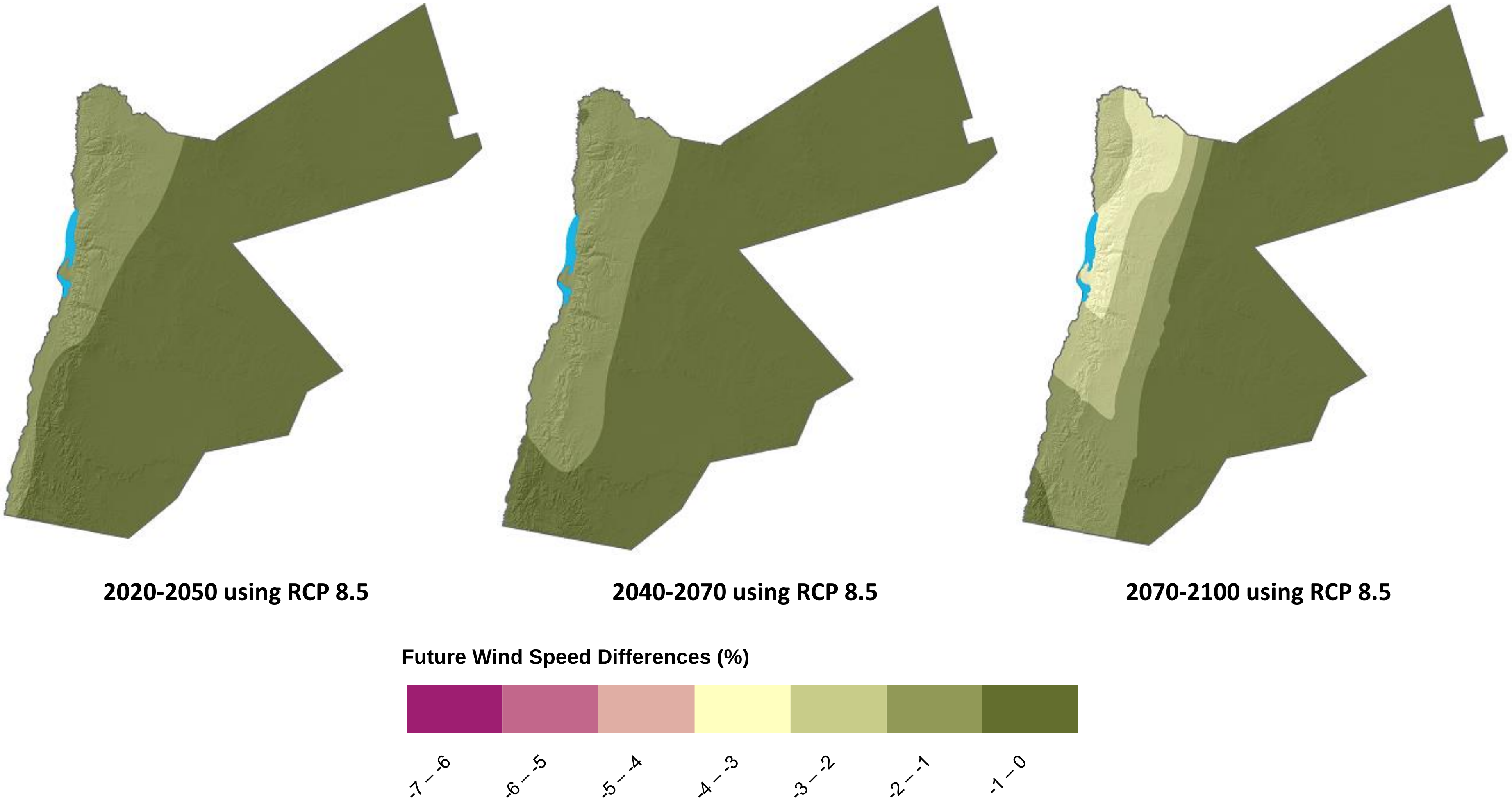


Figure 4.28: Projected Differences in Average Wind Speed, for the three time horizons using RCP 8.5

4.3.4.6 Future Projected Heavy Rain Days

The forecast precipitation intensities show that future heavy rain days (i.e., more than 20 mm, in the case of Jordan) are rare (Figure 4.29). The RCM projections did not show clear significant signs for heavy rain days, however future trends indicate the probability of potential intense precipitation, seems to decrease with time, especially in RCP 8.5, as compared to RCP 4.5. The severity is variable according to the location and tends to become more intense during the mid-21st century and reduces by the end of the 21st century.

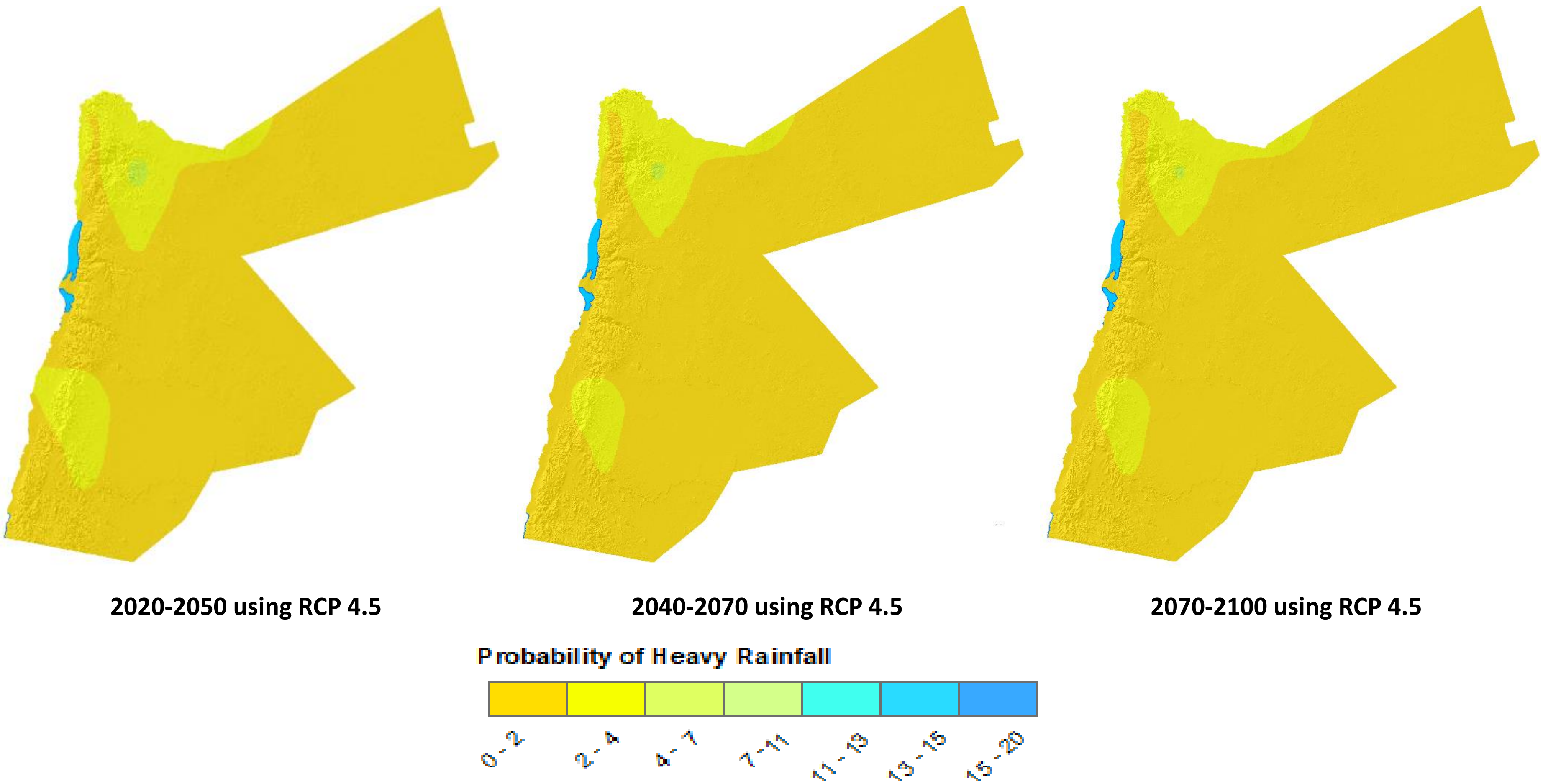


Figure 4.29: Projected heavy rain days, for the three time horizons using RCP 4.5

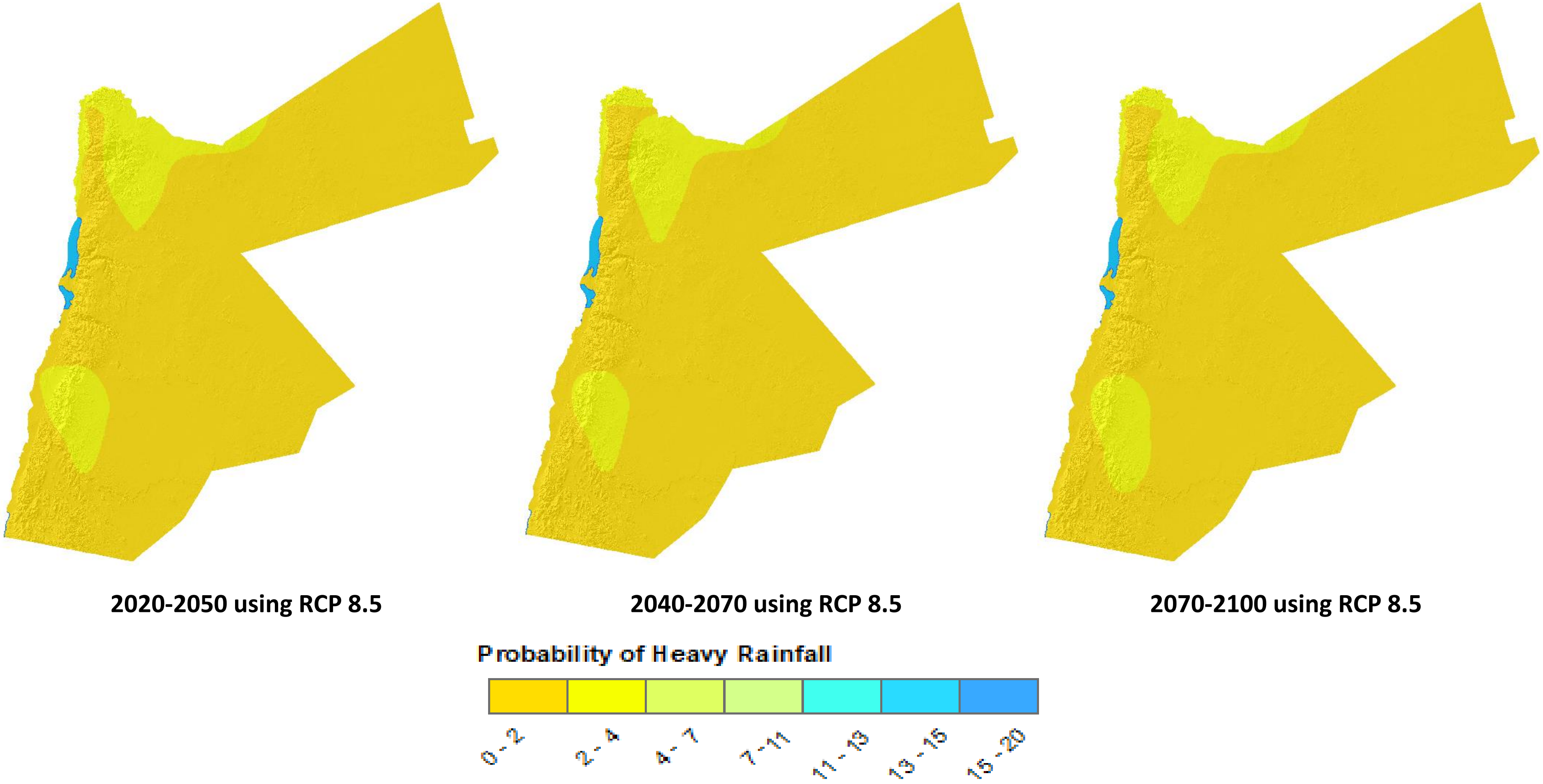


Figure 4.30: Projected heavy rain days, for the three time horizons using RCP 8.5

4.3.4.7 Future Projected Droughts

Drought was assessed using Standardized Precipitation Index (SPI), based on McKee et al. (1993). Standardized precipitation was derived by dividing the difference between the normalized seasonal precipitation and the long-term mean seasonal precipitation, by the standard deviation:

$$\mathrm{SPI} = \frac{x_{ij} - x_{im}}{\sigma} \qquad \text{Eqn. 6}$$

where x_{ij} is the seasonal precipitation at the “”th rain gauge station and “j”th observation, where x_{im} is the long-term seasonal mean, and σ is its standard deviation.

According to McKee et al. (1993[132], 1995[133]), a drought event occurs any time the SPI is continuously negative and reaches an intensity of −1.0 or less, and the event ends when the SPI becomes positive. Drought severity is divided into seven classes in this study; these are; extremely wet (SPI >2), very wet (1.5 to 1.99), moderately wet (1.0 to 1.49), near normal (−0.99 to 0.99), moderate drought (−1.49 to −1), severe drought (−1.99 to −1.5), and extreme drought (SPI <−2).

The SPIs were calculated for the historic time period (1950 to 2020) for all stations, and for the three future time horizons, using the two RCPs. The calculated SPI per station using the historical data and future projections up to 2100, using the two RCPs are presented in

Figure B.1 and **Figure B.2 Annex B**. Based on the number of drought events (i.e. SPI less than -1), Figure 4.31 shows that during the historic period, the probability of droughts was extremely low, reaching a maximum of 19% at the western border, with higher probability along the semi-arid strip extending from the north to the south of the country.

Figure 4.32 show the future projection of drought probabilities based on RCP 4.5 and RCP 8.5, respectively. The drought probability is increasing significantly until the end of the 21st century, especially in the northern region of the country. The drought probability is ***likely*** to increase in magnitude by the end of the 21st century, reaching a maximum probability of 93% using RCP 8.5 as compared to 50% using RCP 4.5. Drought duration is ***likely*** to become longer, with more than 3 consecutive years using RCP 4.5 and more than 5 years using RCP 8.5.

[132] McKee TB, Doesken NJ, Kleist J (1993) The relation of drought frequency and duration to time scales. In: Proceedings of the eighth conference on applied climatology. Am Meteorol Soc., Boston, pp 179–184
[133] McKee TB, Doesken NJ, Kleist J (1995) Drought monitoring with multiple time scales. In: Proceedings of the ninth conference on applied climatology. Am Meteorol Soc., Boston, pp 233– 236

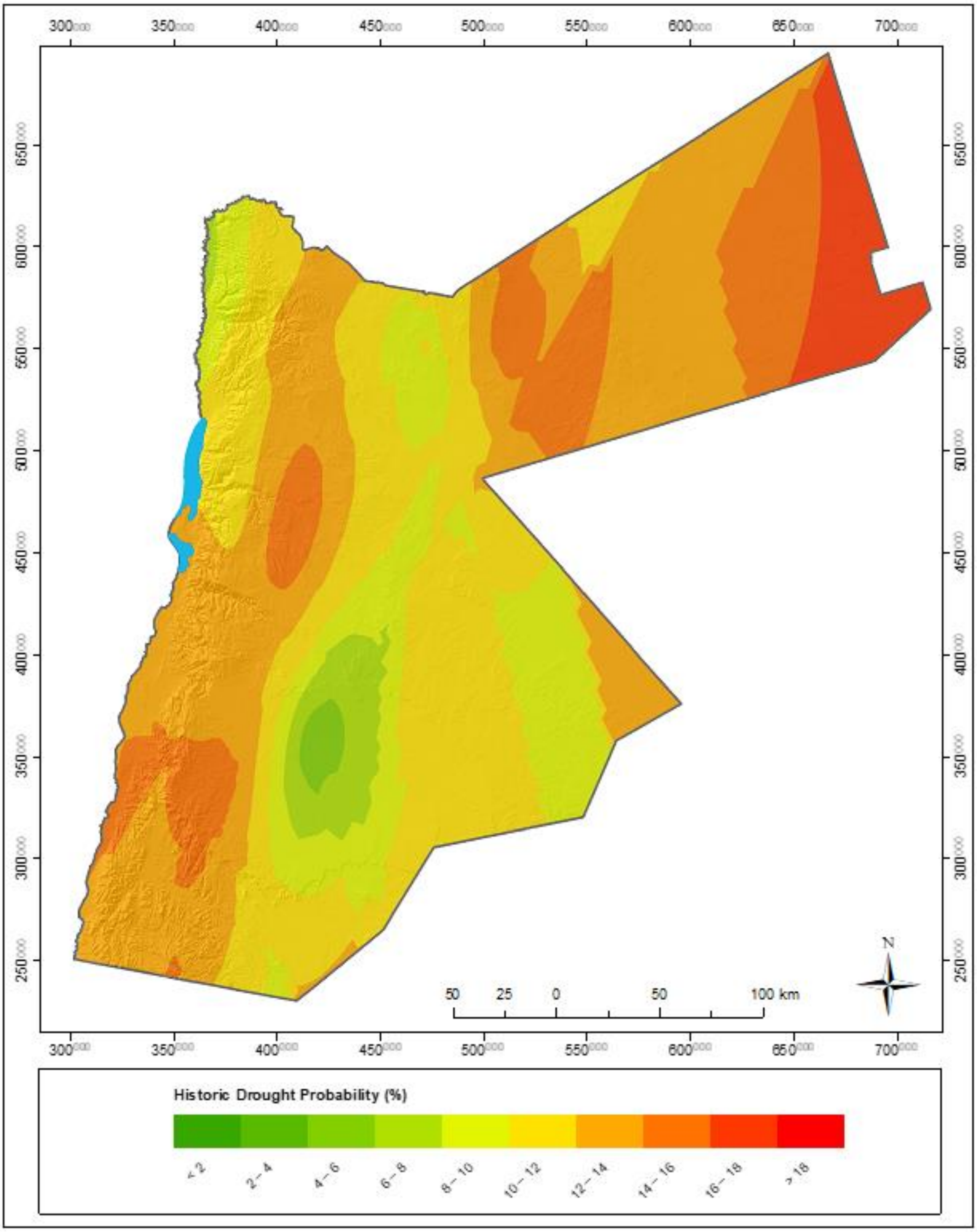


Figure 4.31: Historical SPI estimated by the number of drought events

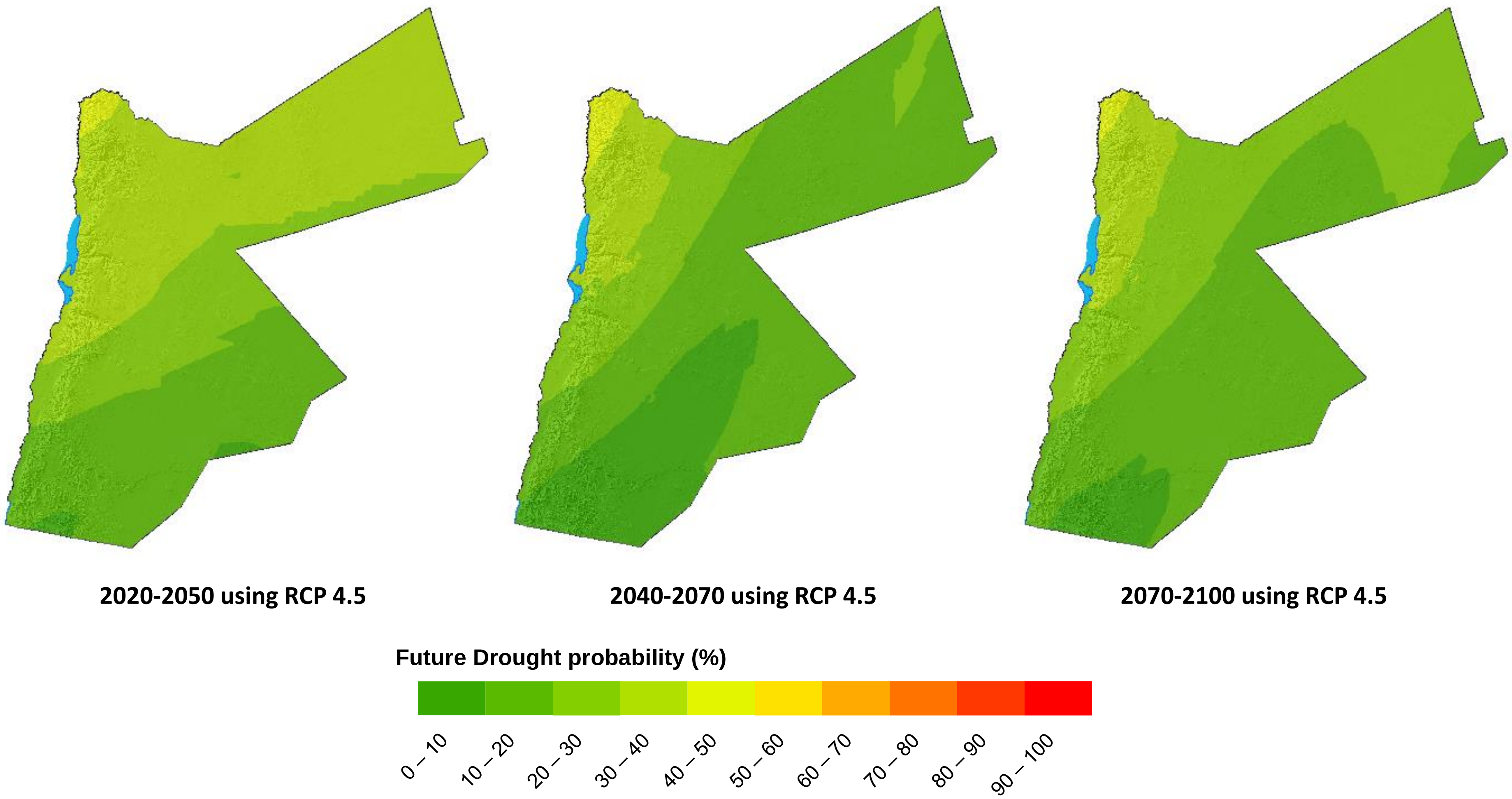


Figure 4.32: Projected Differences in drought probability, for the three time horizons using RCP 4.5

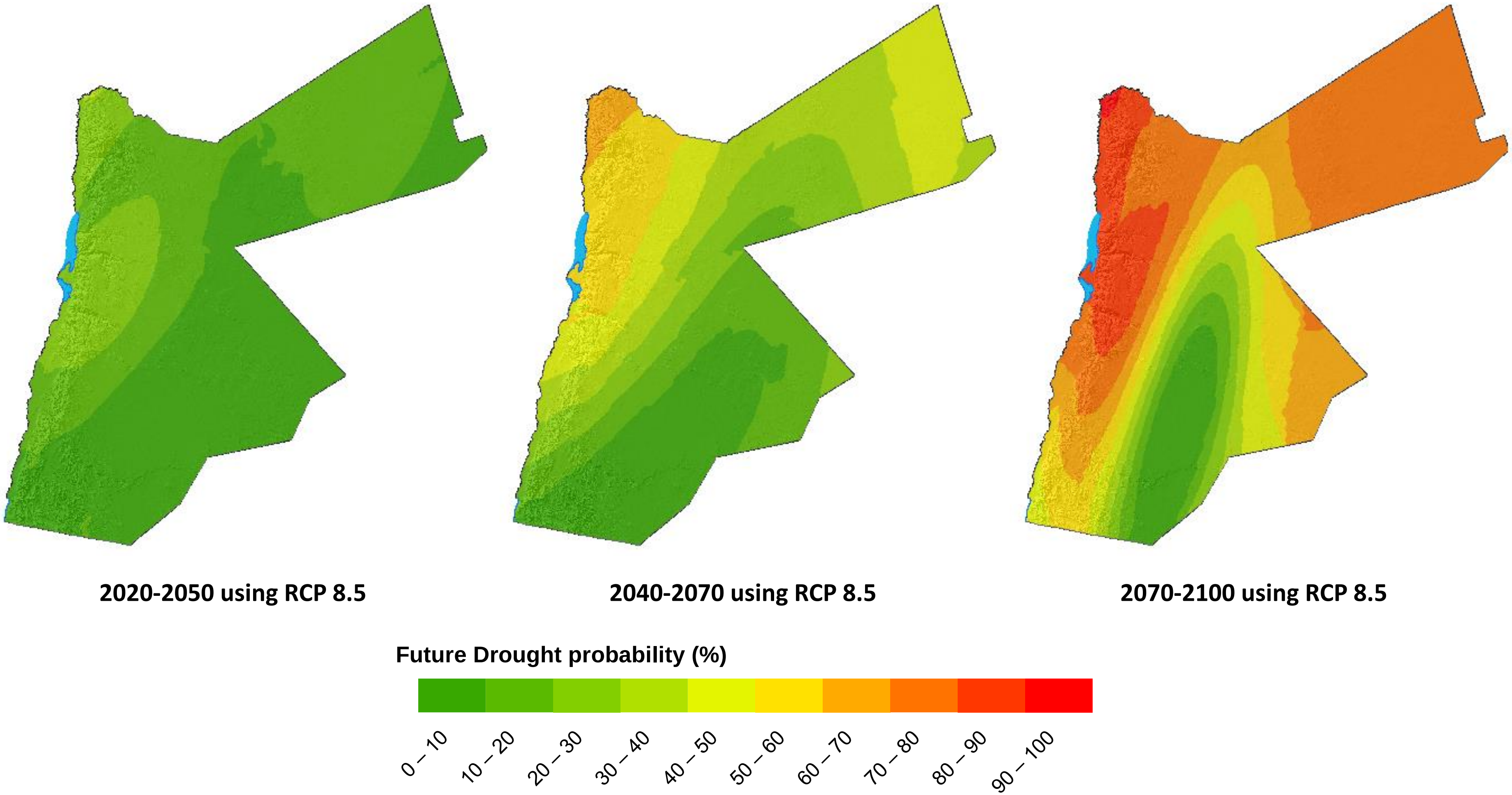


Figure 4.33: Projected Differences in drought probability, for the three time horizons using RCP 8.5

4.3.4.8 Future Projected Heatwaves

Heatwave, from a meteorological perspective, is defined as the period of three consecutive days, when maximum temperature exceeds its normal "long-term average" by 5°C or more. In this section, heatwaves were delineated, by weather station, per month and per year. The total number of heatwave events per year was calculated. In addition, the potential forecast heatwaves for future projections, using the reference model for the two RCPS were also calculated.

Regardless of the weather station, the linear trend analysis of the historical time period from 1990 up to 2020, shows that the number of heatwave events are significantly increasing ($P<0.0001$) with time, at a rate of 0.15 events per year. The occurrence of heatwave events varies from once a year to 15 events per year, depending on the temporal and spatial scale. The highest heatwave intensity existed in the highland regions of Madaba, Shoubak and QAI Airport as compared to the Jordan Rift Valley and the desert areas (Figure 4.34). The temporal trends of historical heatwaves, from 1990 till 2020, regarding each meteorological station, is presented in **Table B.6 Annex B.** Most of the heatwave events occur during March, April and May (Figure 4.35).

The future projections, using the reference model, predict more heatwaves, especially during the late period of 2070 up to 2100. The future predicted heatwave events are more severe in terms of duration and magnitude. As compared to the historical period, the future period (2070-2100) is predicted to have an120% increase in potential heatwave events (ranging from 54% to 398%, based on spatial location), using the RCP 4.5, and about a threefold increase (ranging from 1.5 to 9.0 times as large, based on spatial location) using RCP 8.5 (Figure 4.36). Thus, it is ***very likely*** that more severe threats are expected in terms of heatwave exposure intensity and duration. The projected heatwaves counts, up to the end of the 21st century, using RCP 4.5 and 8.5, according to weather station, are presented at **Figure B.3** and **Figure B.4 Annex B.**

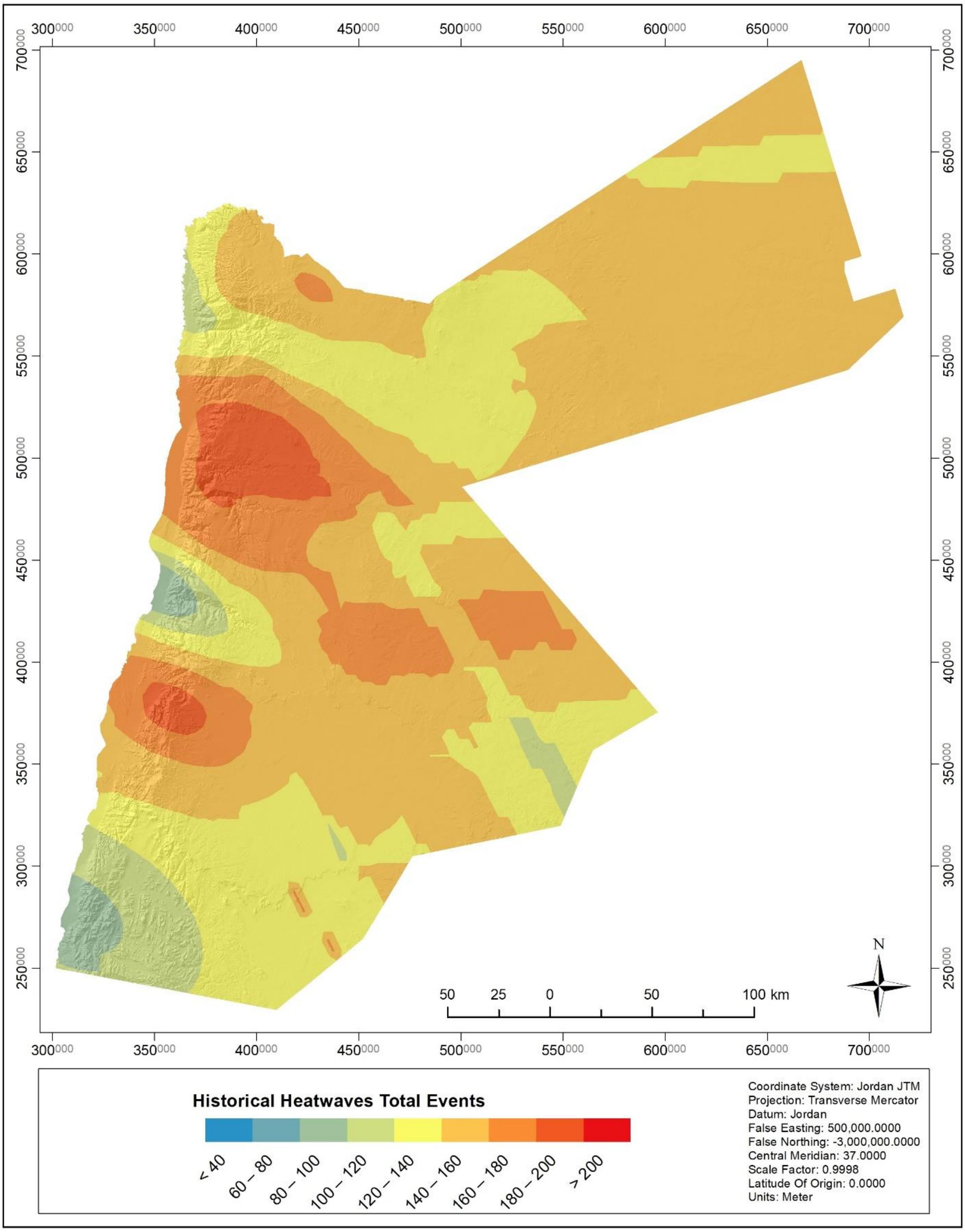


Figure 4.34: Historical heatwaves spatial distribution in Jordan

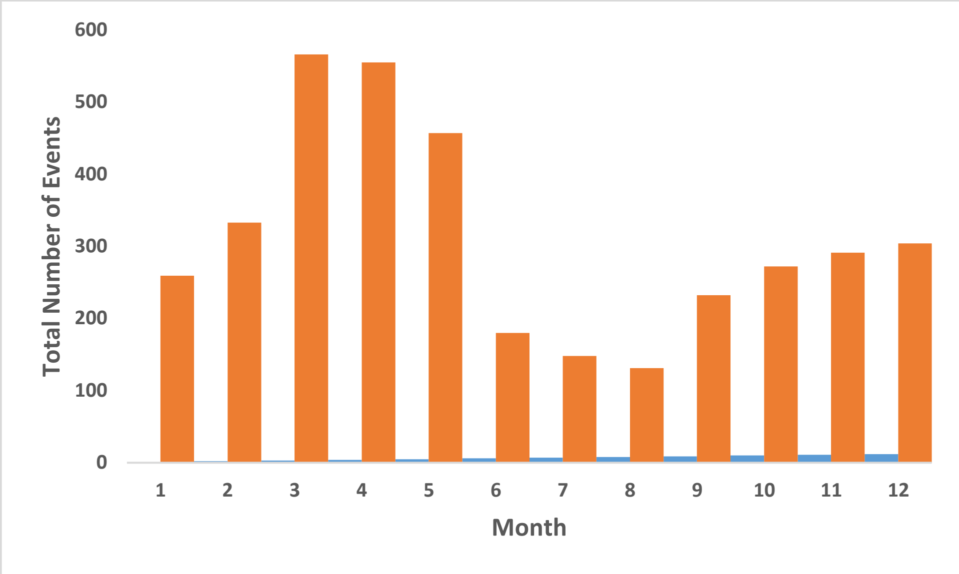


Figure 4.35: Historical heatwave events distribution by month

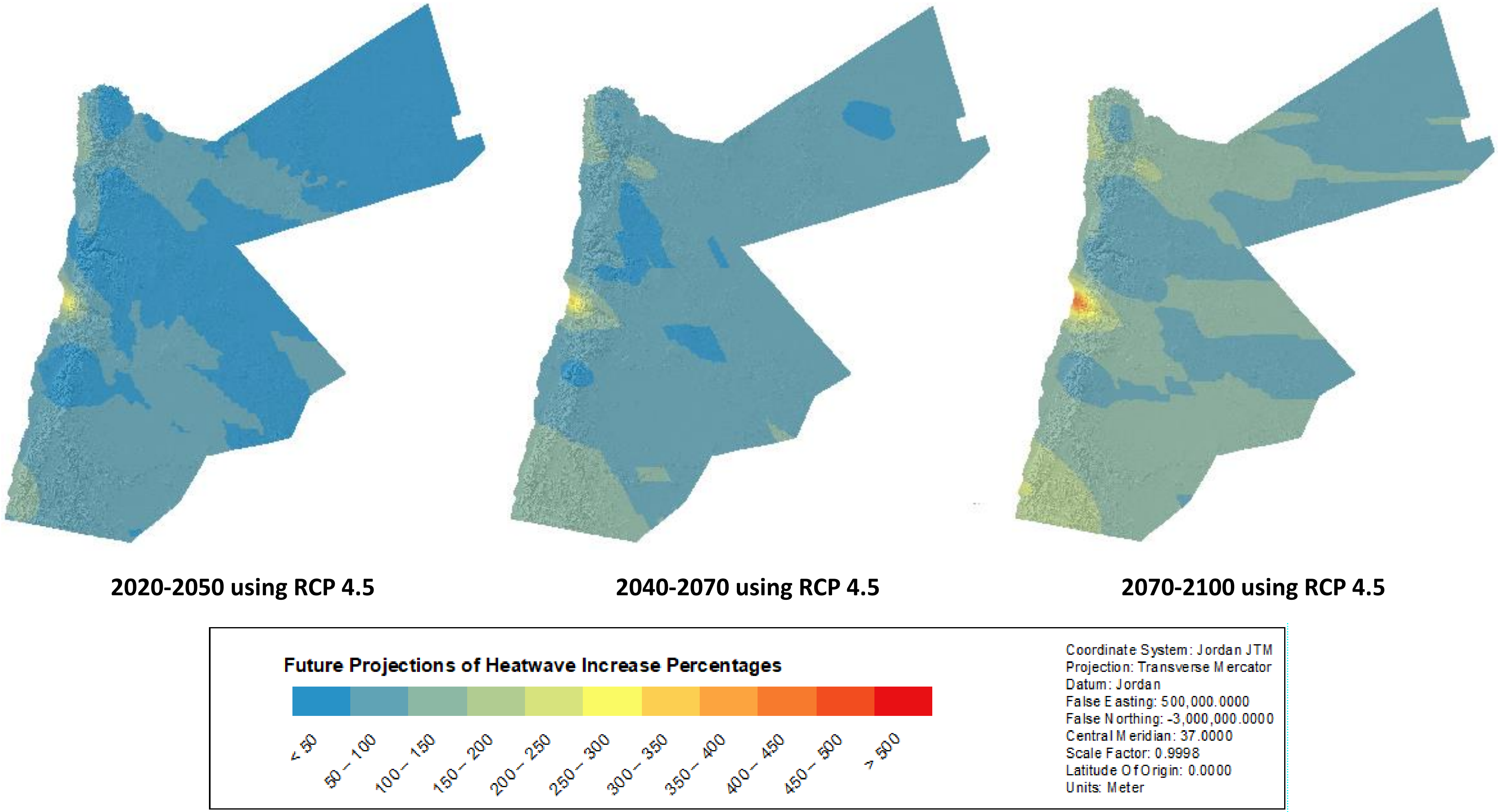


Figure 4.36: Spatial distribution of the potential future heatwaves projection using RCP 4.5

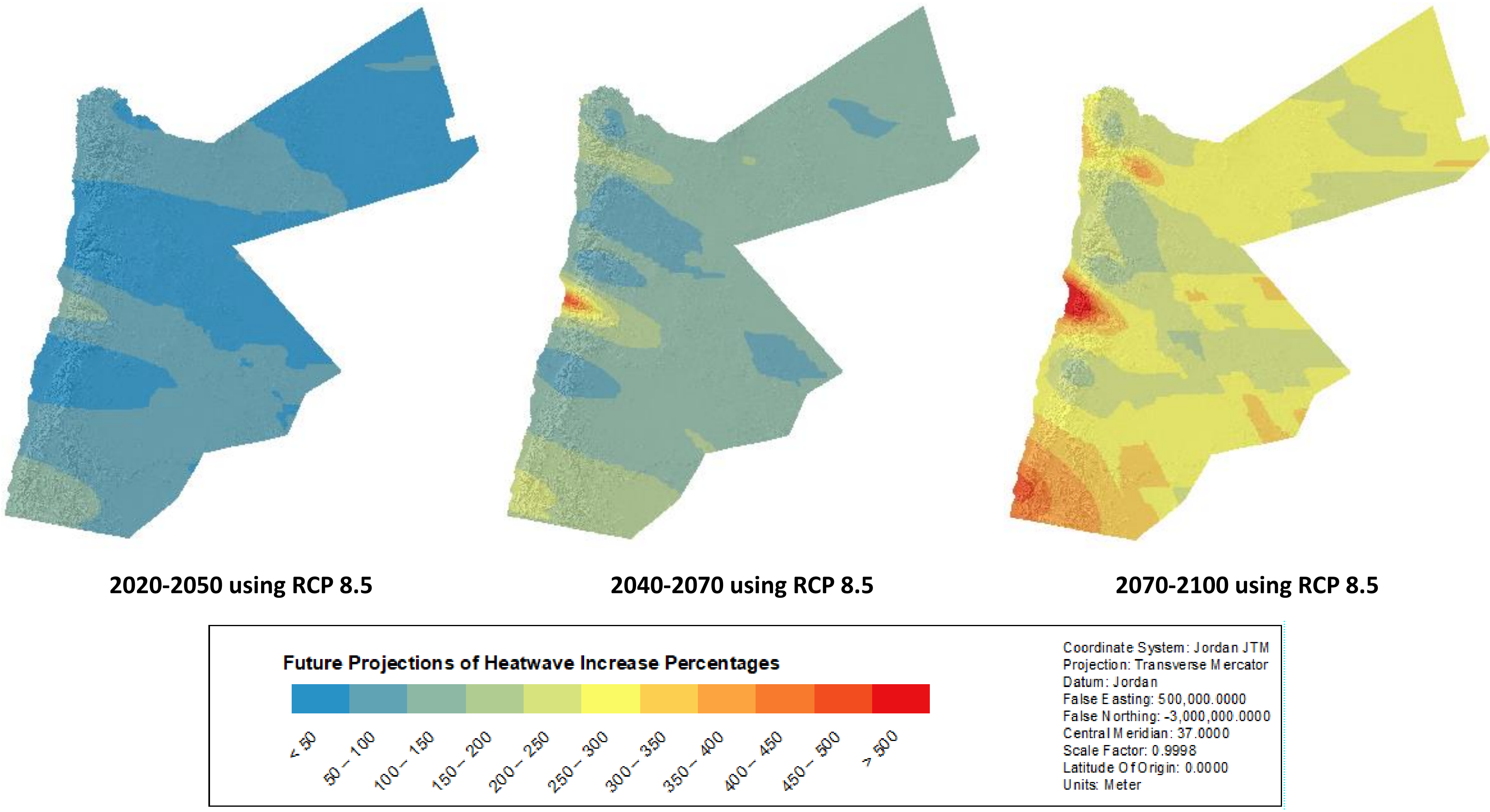


Figure 4.37: Spatial distribution of the potential future heatwaves projection using the RCP 8.5

4.3.4.9 Key messages from the dynamic downscaling study:

Based on future projections and climate forecasts, Jordan is going to witness clear climate change exposures, based on various greenhouse gas concentration pathways. **Table 4.8** below, shows the main messages, that can be interpolated from the comprehensive climate change projections exercise conducted in the 4NC. The trends described below indicate the expected future of the climate in Jordan until 2100.

Table 4.8: Key messages from the dynamic downscaling study

Trend	Details
A warmer climate	For the 2070-2100 period the minimum air temperature is ***extremely likely*** to increase by 1.2 °C [+0.6 °C to +2.9 °C] according to RCP 4.5 and by 2.7°C [+2.1 °C to +4.5°C] according to RCP 8.5. Similarly, the maximum air temperature is very likely to increase by 1.1 °C [+0.7 °C to +1.7 °C] according to RCP 4.5 and by 3.1 °C [+2.6 °C to +3.7°C] according to RCP 8.5.
A drier Climate	For the 2070-2100 period the country is ***likely*** to become drier, as the precipitation tends to decrease by 15.8% [-7.1% to -31.3%] according to RCP 4.5 and by 47.0% [-23.3% to -57.5%] according to RCP 8.5, taking into account that some zones are predicted to receive more precipitation, with a maximum increase of 19%, according to RCP 4.5, while the whole country is projected to become drier according to RCP 8.5. The significant precipitation decrease is projected to be most ***likely*** at the western part of the country, while predicted potential increases are ***likely*** to occur in the southern arid zones.
Insignificant wind changes	Wind speed forecasts didn't indicate significant changes; however, the country is ***about as likely as not*** to be subjected to wind bloom events exceeding 12 m/s.
Mild decrease in relative humidity	For the 2070-2100 period the relative humidity is ***likely*** to decrease by 3% [-2.5 % to -3.3 %] according to RCP 4.5 and by 7.2% [-6.0 % to -7.8 %] according to RCP 8.5. In all scenario cases, the Northern Badia is ***likely*** to be subjected to a decrease in relative humidity at a higher rate than other parts or regions
More drought, a contrasted water balance	Drought SPI indictors reveal an increasing trend of drought in the northern part of the country reaching a maximum of 50% using RCP 4.5 and 93% using RCP 8.5. The magnitude of drought events is increasing with time, from normal to severe, while the duration of the droughts is ***likely*** to become longer, over 3 consecutive years, using RCP 4.5 and more than 5 years using RCP 8.5.

High crop water demands	For the 2070-2100 period, the potential evapotranspiration is ***very likely*** to increase by 5.8 % [+4.7 % to +6.9 %] according to RCP 4.5 and by 11.1 % [+8.1 % to +15.3%] according to RCP 8.5. In the worst-case scenario, the evapotranspiration for the whole country is ***very likely*** to increase by 15% above the baseline scenario, thus setting the systems under pressure of greater water demands.
Intense precipitation and potential floods	The is no significant sign of heavy rain days (more than 20 mm), however future trends indicate the probability of occurrence of potential intense precipitation, that seems to decrease with time, especially at RCP 8.5 as compared to RCP 4.5. On other hand, the severity is variable by location and tends to become ***more likely than not*** intense during the mid-21st century and reduces by the end of the 21st century.
More intense heatwaves	Future predicted heatwave events are more severe in terms of duration and magnitude, where the probability of occurrence increases to an average of 120% by 2100 (ranging from 54% to 398% based on spatial location) using RCP 4.5, and about a threefold increase (ranging from 1.5 to 9.0 times, based on spatial location) using RCP 8.5. Thus, it is ***very likely*** that more severe threats are expected in terms of heatwave exposure intensity and duration, especially in the highlands regions of Madaba, Shoubak and QAI Airport during the months of March, April and May.

4.4 CCIVA for Agricultural Sector

Assessment of climate change impacts on agriculture was based on the analysis of data from the agricultural sector, obtained from DOS, GIS layers and previous studies on irrigated agriculture in Jordan[134] [135]. The data from climate projections, was used to assess the impacts on yield and water consumption for the main irrigated crops in the four basins. This was based on the use of AquaCrop and statistical models to project climate change impacts on both irrigated and rainfed crops (**Figure 4.38**). The data for crop management was obtained from previous studies and field surveys. These included crop calendar and management. Outputs were used to assess the impact of climate change on the agricultural sector in Jordan and to identify changes in agricultural indicators used in vulnerability assessment.

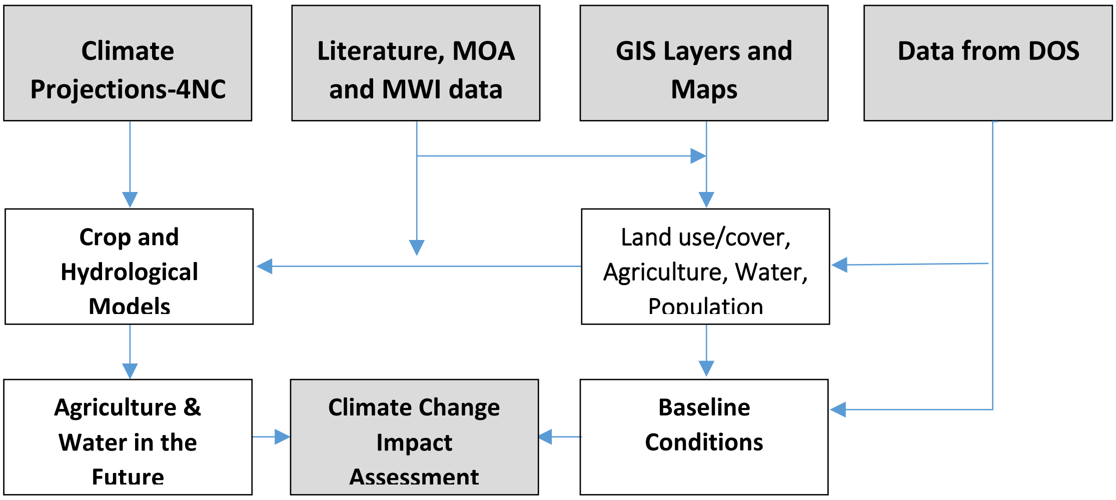


Figure 4.38: Flowchart of the methodology for climate change impact assessment for water and agriculture sectors.

The exposure was calculated from climate change projections at the sub-district level using GIS tools, while other data of sensitivity and adaptation was obtained from DOS and MWI. The indicators for sensitivity were selected after consultation with stakeholders who identified the most important indicators of sensitivity and adaptation for agricultural sector. The main indicators for sensitivity included the areas of rainfed and irrigated crops, livestock numbers, agroforestry and rangeland areas, while adaptation indicators included the available ground and surface water resources, the possible expansion in surface water development and the treated wastewater resources.

[134] Al-Bakri J.T., Shawash S., Ghanim A. and Abdelkhaleq R. 2016. Geospatial Techniques for Improved Water Management in Jordan. Water, 8(4): 132; doi:10.3390/w8040132

[135] Al-Bakri J.T. et al. 2021. Assessment of Climate Changes and Their Impact on Barley Yield in Mediterranean Environment Using NEX-GDDP Downscaled GCMs and DSSAT. Earth Systems and Environment 5(3): 751-766. https://doi.org/10.1007/s41748-021-00238-1.

4.4.1 Impact of Climate Change on Rainfed Agriculture

4.4.1.1 Impacts on Rainfed Olives

Statistical model results show that rainfed olives are ***likely*** to be negatively impacted under the climate change projections. The reduction estimates in yield could reach 50% in the area of the Amman-Zarqa basin and 60% in the area of the Yarmouk basin (Irbid) for RCP 8.5 by year 2100. On average, the reduction in yield of olives would reach 20%. (**Figure 4.39**).

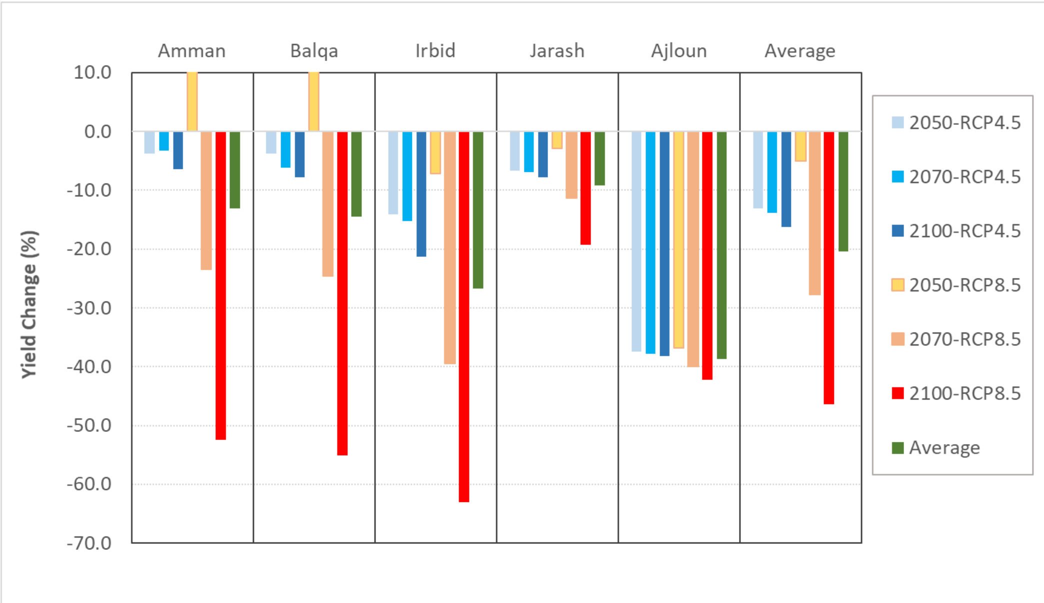
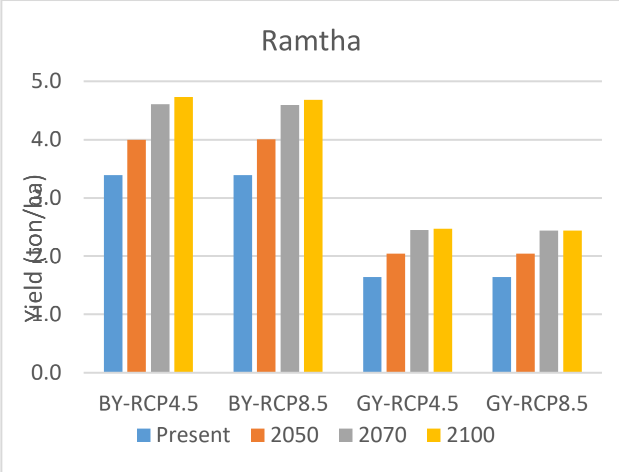


Figure 4.39: Changes in rainfed olive's yield under the different climate change scenarios.

4.4.1.2 Impacts on Rainfed Barley

AquaCrop modeling results show that rainfed barley ***is likely*** to suffer from reductions in yield, if the planting date is not modified. At present, the crop is planted in early to middle of November. Under these conditions, reductions in grain yield and crop failure were reported by the model. These results were consistent with the previous study of Al-Bakri et al. (2021) which showed that reduction in grain yield would be 19% to 30% due to delay in the rainfall season. Since it was assumed that shifts in calendar would occur in the future, planting date was shifted to early December and AquaCrop simulations were obtained for crop management data of Ramtha (Yarmouk Basin) and Mafraq (Amman-Zarqa basin). Results showed that barley yield would benefit from the increase in air temperature even if rainfall amounts decreased (**Figure 4.40**). The increase in yield would be in the range of 18%-25%.



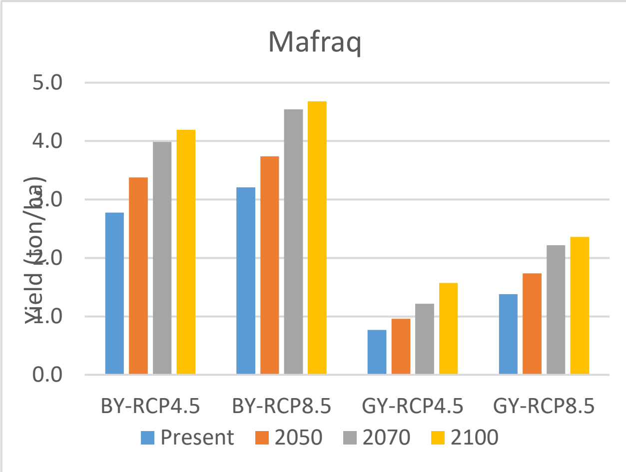


Figure 4.40: Changes in barley yield under climate change projections and seeding in early December.

Although results showed an improvement in barley yield under climate change projections, however, seasonal variations were evident and indicated the inherent risks in crop production under the climate change projections. An example on these variations is summarized in **Figure 4.41** for the area of Ramtha. The fluctuations in yield during the future would be evident and a cycle of crop failure could occur every 5-6 years, except for the period 2060-2075, which showed stable crop yields under the different climate projections.

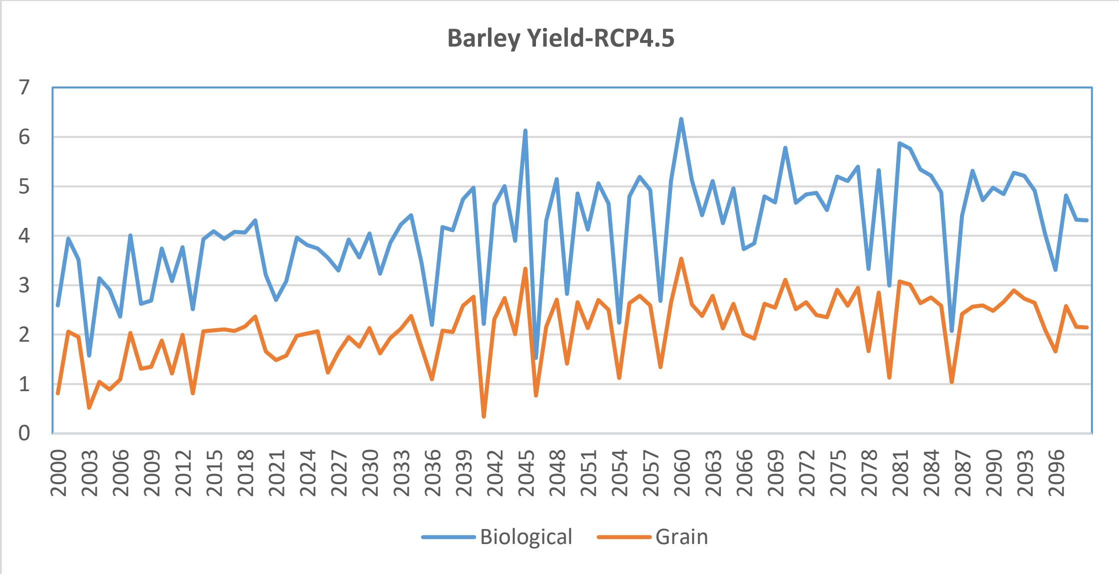


Figure 4.41: Annual variations in biological and grain yield of barley for RCP 4.5 climate projection.

4.4.1.3 Impacts on Rangelands

Climate change has direct and indirect impacts on livestock and animal production. The direct impacts are attributed to the heatwaves, that may result in reduction in production of milk, meat and eggs. Other direct impacts may include the increase in mortality rate, the spread of diseases and the recession of fertility. The indirect impacts, however, could be assessed in terms of the effect of climate on the feed of animals and the supply of grains. In Jordan, assessment of the direct impacts is usually more difficult than the indirect impacts, as the local breeds of browsing sheep and goats are usually adaptable to slow climate changes of temperature increase and rainfall decrease. These impacts were not investigated due to lack of data and were based on previous studies on possible impacts on livestock production.

Native grazing was the major source of feed for sheep and goat flocks in Jordan. However, degradation of rangelands has resulted in using other sources of feed, including the immature (green) barley, barley grain and straw, cereal stubble and vegetable crop residues, particularly during autumn/winter feeding when rangelands are lacking feed resources. Estimates for rangelands contribution to livestock feed showed that the current contribution of these rangelands was only 367 thousand tonnes, forming 14% of the required feed. A summary for feed resources is shown in **Table 4.9**, which was based on estimates and calculations made to update previous work on climate change in Jordan (GCEP, 1999[136]; Harb and Al-Awawdeh, 2008[137]; FAO, 2010[138]).

The present available forage production is estimated at 772 thousand tonnes, which covers 38% of the country's need. The total feed required by livestock is 2,666 thousand tonnes of dry matter (DM). Among this amount, sheep and goats require 55%, poultry sector requires 29%, while 16% is required by cattle. The deficiency in feed is covered by imported barley grain (50%), corn (33%), soybean oil meal (16%) and other concentrates and additives (1%).

Table 4.9: Present and estimated future production (Tonnes Dry Matter) of feed in Jordan.

Feed source	Year 2017	Year 2050
Rangelands	367,164	306,449
Fallow lands	95,968	77,108
Straw and stubble	144,933	120,967
Green fodder	910	779
Vegetable residues	35,600	29,392
Agricultural byproducts	57,850	47,762
Industrial byproducts	18,690	15,431
Barley grains	39,320	37,218
Wheat bran	11,895	8,252
Total	772,329	643,358
Required	2,666,374	4,266,198
Self-sufficiency	31%	15%

Indirect impacts of climate change on animal production were assessed through the estimation of reduction in feed and grain supplies, which were mainly coming from crop production, feed from the rangeland and other agriculture byproducts. The estimates were based on changes in crop production and area and the reduction in rangeland production resulting from reduction in rainfall in the different rangelands in Jordan (FAO, 2010) where 1 mm reduction in rainfall would result in loss of 4 kg DM, out of which about 2 Kg DM would be utilizable with utilizable nutritive value of 0.66 feed unit. Based on these figures, the average reductions in rangelands productivity in Jordan would be 10% and 16% in the rainfall zones of 100 mm and 200 mm, respectively.

Although climate change projections showed possible improvement in biological and grain yield of barley, recession of rainfed areas due to urbanization would outweigh the improvement in yield and production. These trends in land-use changes were discussed in

[136] GCEP (General Corporation for Environment Protection, Jordan), 1999.Jordan's First National Communication to the UNFCCC.GCEP and Al-Shamil Engineering, Amman, Jordan.

[137] Harb, M. and Al-Awawdeh, F. 2008. Forage: situation, challenges, and solutions. Jordanian Agricultural Engineer Magazine. 85:18-23.

[138] FAO (Food and Agriculture Organization), 2010. Assessment of the Risks From Climate Change and Water Scarcity on Food Productivity; Final Report of deliverable FAO/ RFP/ 2010/01; FAO and STRTM: Amman, Jordan.

detailed studies for Jordan (Al-Bakri et al. 2013 a[139]&b[140]; Al-Omari et al., 2018[141]; Khawaldah et al., 2020[142]; Shammout et al., 2021[143]), and showed that most of urbanization was taking place in the high rainfall zones and resulted in permanent loss of rainfed areas and rangelands. Subsequently, self-sufficiency from feed resources would decrease from 31% in 2017 to 15% in 2050. These figures were reflected on the estimated self-sufficiency of red meat that would decrease from 39% at present to 18% in 2050.

4.4.2 Impact of Climate Change on Irrigated Agriculture

4.4.2.1 Impacts on irrigated vegetables

Figure 4.42 and **Figure 4.43** show the results of simulation of yield of vegetables using the AquaCrop model. The simulations were based on crop and climate data for Mafraq, which has 30% of the irrigated vegetables, and the highlands, extending into Yarmouk, Amman-Zarqa and Azraq basins. Results showed that climate change projections would have some positive and some negative impacts on irrigated vegetables. The positive impact would be the increase in yield under all climate change scenarios with an average increase that might reach 17% by the end of century. Results were obtained for the three growing seasons in Mafraq and in the highlands, using the data for tomatoes, which is the main irrigated vegetable crop in the highlands.

[139] Al-Bakri J.T., Salahat M., Suleiman A., Suifan M., Hamdan M.R., Khresat S., Kandakji T. 2013a. Impact of Climate and Land Use Changes on Water and Food Security in Jordan: Implications for Transcending "The Tragedy of the Commons". Sustainability, 5(2):724-748. http://www.mdpi.com/2071-1050/5/2/724

[140] Al-Bakri J.T., Duqqah M. and Brewer T. 2013b. Application of Remote Sensing and GIS for Modeling and Assessment of Land Use/Cover change in Amman/Jordan. Journal of Geographic Information System, 5(5): 509-519.

[141] Al-Omari A., Al-Bakri J., Hindiyeh M., Al-Houri Z., Farhan I., Jibril F., 2018. Integrated hydrologic and quality model for Zarqa River basin in Jordan. Fresenius Environmental Bulletin, 27(2): 4637-4647.

[142] Khawaldah H.A., Farhan I. and Alzboun N.M. 2020. Simulation and prediction of land use and land cover change using GIS, remote sensing and CA-Markov model. Global Journal of Environmental Science and Management 6, 215-232.

[143]Shammout M. W., Shatanawi K., Al-Bakri J., Abualhaija, M. M. 2021. Impact of Land Use/Cover Changes on the Flow of the Zarqa River in Jordan. Journal of Ecological Engineering, 22(10), 40-50..

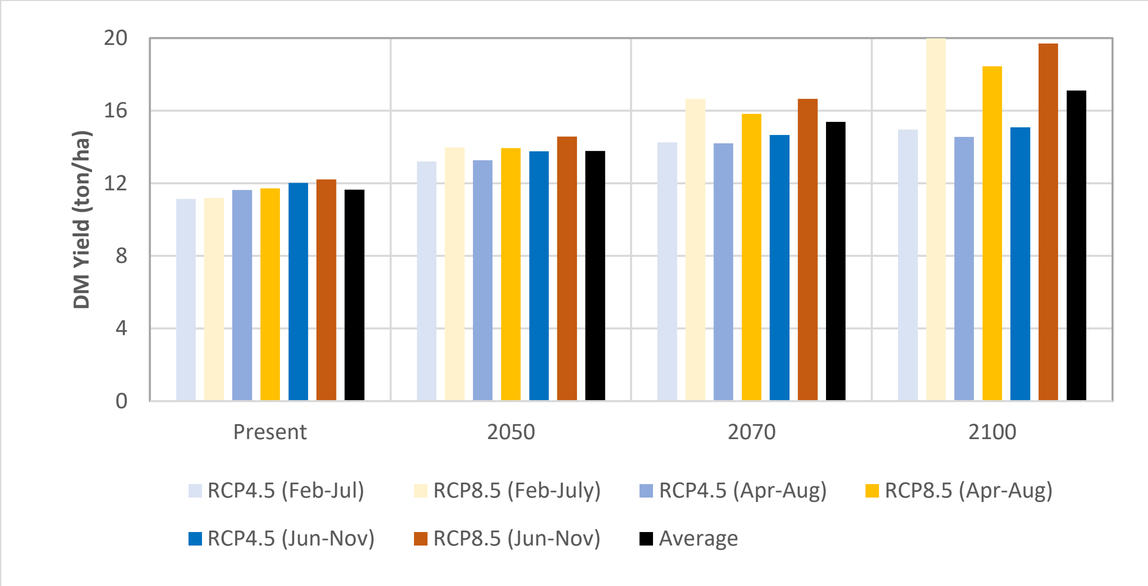


Figure 4.42: Changes in yield of vegetables grown in Mafraq under climate change projections.

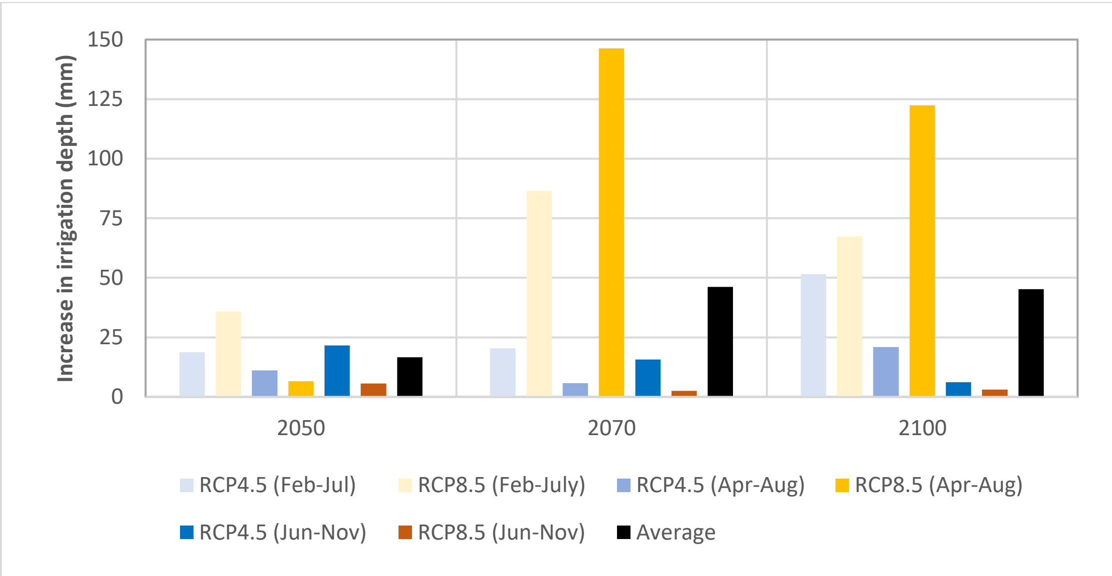


Figure 4.43: Changes in irrigation depth for vegetables grown in Mafraq under climate change projections.

The positive impacts of climate change in the form of possible increases in yield, could be attributed to the increase of carbon fixation by plants, which would result in increasing biomass and DM. This increase, however, would be valid, assuming no changes to other factors that affect crop yield, including possible heatwaves and spread of pathogens. The adverse or negative impacts of climate change are expected to override the positive impacts of yield improvements. Under the conditions of water scarcity in Jordan, the increase of crop water requirements and the required irrigation depth was reflected by the yield simulation results under climate projections (**Figure 4.43**). The increase in irrigation depth could reach

146 mm in year 2070 under the RCP 8.5 climate change projection. On average (for both models) the increase of irrigation depth would range from 17 mm in 2050 up to 47 mm in 2100. Considering that the present irrigation depth is 405 mm, these changes (average 12% increase for both models, by 2070 and 30% by 2100), would have adverse impacts on the water sector, as they would increase the demand on the fragile groundwater resources in the highlands.

4.4.2.2 Impacts on Irrigated Potatoes

AquaCrop modeling results show that climate changes would ***likely*** increase the yield of potato in the Yarmouk basin (**Figure 4.44**). Results are presented for the area of Irbid-Ramtha, known as Huwwara, that had witnessed a significant expansion in cultivation of potatoes during the period 2010-2017. The crop is grown in January to utilize soil moisture stored during the winter, while irrigation is practiced in spring and early summer. Results showed that the average increase in potato yield, in the future would be 18% and 30% under RCP 4.5 and RCP 8.5, respectively, with a trend of increased yield with time, resulting from the increased fixation of carbon dioxide. The adverse impacts of climate change would be the increased irrigation depth from 242 mm at present to 314 mm in year 2100, with an average increase of 24%.

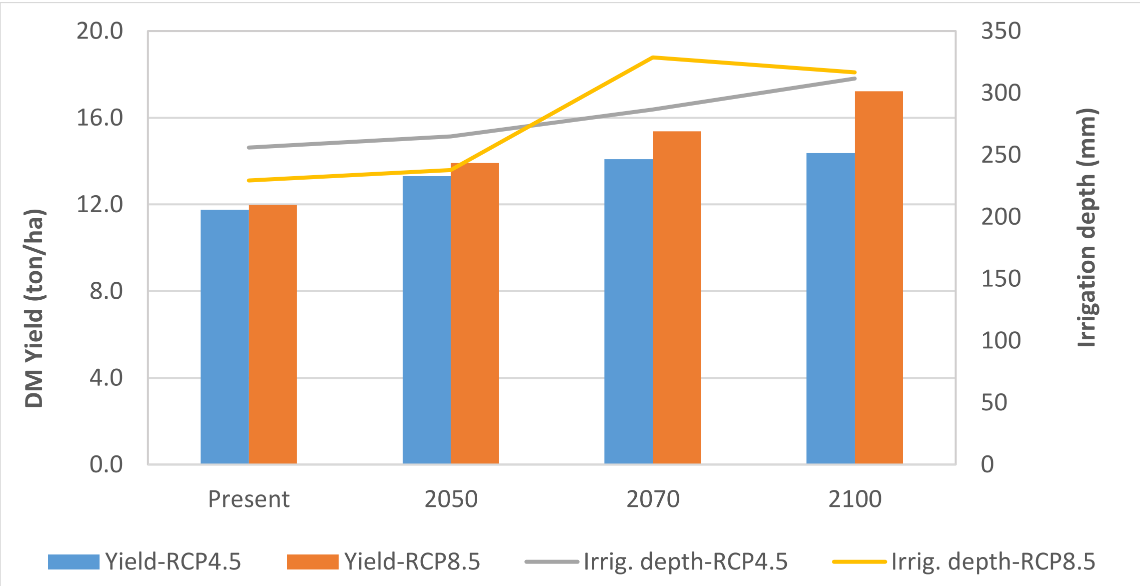


Figure 4.44: Changes in yield and irrigation depth of potatoes in Irbid-Ramtha.

4.4.2.3 Impacts on Irrigated Fruit Trees

Climate change impacts on fruit trees are mainly related to chilling requirements, which are the seasonal sum of hours when air temperature is below 7.2 °C (Díez-Palet et al., 2019[144], Salama et al., 2021[145]). Since hourly data for air temperature was not available, the number of days when the air temperature would be less than 7.2 °C were calculated for Amman-Zarqa and Azraq basins, where most fruit trees were grown. The main irrigated fruit trees in both basins were grapes, which require 150 chilling hours, and peaches which require 400-500 chilling hours. For the worst case climate change projection, i.e., RCP 8.5, results of daily data showed that the number of days with minimum air temperature <7.2 °C would decrease from 103 days at present to 95 days in 2050 and 85 days in 2070 and 2100. Based on these figures, it would be concluded that chilling requirements would not be adversely affected. Some positive impacts on crop yield resulting from high assimilation of carbon (citrus, grapes and peaches) could also occur. However, negative impacts of short growing seasons, early maturity, pathogens and pest outbreak were reported in much literature in the Mediterranean region, which would indicate that irrigated fruit trees in Jordan could be negatively impacted by climate change.

Considering the problem of water scarcity in Jordan, the most important impact of climate change on irrigated crops would be the increase in crop water requirements. Using the approach of FAO-56 for calculation of crop evapotranspiration (ETp) with modifications of crop coefficient (Kc) based on ground data and previous studies (Al-Bakri et al., 2013[146]; Al-Bakri et al., 2016[147]), crop water requirements were calculated for irrigated fruit trees in Mafraq and Azraq. Calculations were also carried out for olives, which constituted about 40% of the irrigated trees farms in Mafraq and Azraq. Results showed that the average increase in crop water requirements for the irrigated fruit trees would be 7.4% by 2050, 11.4% by 2070 and 13.4% by 2100. The rate of change was higher for RCP 8.5 when compared to RCP 4.5. The average net crop water requirements are summarized in **Table 4.10**. The overall average change over the three periods and for both RCP 4.5 and RCP 8.5 was 11%. On average, the increase in irrigation depth would be more than 107mm. Under RCP 8.5, the increase in irrigation depth by 2100 would reach 121mm for grapes, 135mm for peaches and apricots and 136 mm for olives.

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[144] Díez-Palet I., Funes I., Savé R., Biel C., de Herralde F., Miarnau X., Vargas F., Àvila G., Carbó J., Aranda X. 2019. Blooming under Mediterranean Climate: Estimating Cultivar-Specific Chill and Heat Requirements of Almond and Apple Trees Using a Statistical Approach. Agronomy, 9(11):760. https://doi.org/10.3390/agronomy9110760

[145] Salama A-M, Ezzat A., El-Ramady H., Alam-Eldein S.M., Okba S.K., Elmenofy H.M., Hassan I.F., Illés A., Holb I.J. 2021, Temperate Fruit Trees under Climate Change: Challenges for Dormancy and Chilling Requirements in Warm Winter Regions. Horticulturae, 7(4):86. https://doi.org/10.3390/horticulturae7040086

[146] Al-Bakri J.T., Salahat M., Suleiman A., Suifan M., Hamdan M.R., Khresat S., Kandakji T. 2013a. Impact of Climate and Land Use Changes on Water and Food Security in Jordan: Implications for Transcending "The Tragedy of the Commons". Sustainability, 5(2):724-748. http://www.mdpi.com/2071-1050/5/2/724

[147] Al-Bakri J.T., Shawash S., Ghanim A. and Abdelkhaleq R. 2016. Geospatial Techniques for Improved Water Management in Jordan. Water, 8(4): 132; doi:10.3390/w8040132

Table 4.10: Present and future irrigation depth for irrigated fruit trees in Jordan.

Year	Peaches and apricots	Grapes	Olives
Present	1006	905	1014
2050	1080	972	1089
2070	1121	1008	1130
2100	1141	1026	1150

4.4.3 Impacts of Climate Change on Food Sufficiency

Outputs from agricultural and water models under the climate projections were incorporated with figures of future population to assess levels of self-sufficiency degree (SSD) for the main agricultural crops. For livestock sector, no figures were available or were adopted for the future of the livestock sector. Therefore, projections were based on present data for farms and heads of livestock, to assess the deficiency in production in the future. Results of this analysis, presented in **Table 4.11**, showed severe reductions in SSD with time. Among the strategic crops, SSD of olives would be highly affected in the near future and SSD would reach almost half of its present level. Only vegetables would maintain sufficient production in 2050, as expansion in irrigation and increase in yield would occur. In terms of animal production, the levels of production would be adversely affected by the dry conditions that would reduce rangeland contribution to feed to nearly half of its present levels. However, the increase in TWW would provide an opportunity to increase the levels of fodder and forage production and therefore the tradeoff among different crops should be investigated to overcome water shortage problem and SSD for the strategic crops or products.

Table 4.11: Self-sufficiency degree (%) for some agricultural products at present and future.

Category	Present	2050	2070	2100
Plant Production				
1- Vegetables	144	105	72	39
2- Olives	102	55	34	15
3- Fruit trees	97	63	40	20
4- Citrus	67	34	22	12
5- Field crops	4	2.2	<2	<1
Animal and livestock Production*				
6- Chicken meat	81	37	23	12
7- Beef	13	6	4	2
8- Mutton and lamb meat	39	18	11	6
9- Goat meat	100	46	29	14
10- Dairy products and eggs	100	**	**	**

* Based on present number of farms and animal heads.

** Will depend on availability of forage in the international markets and expansion plans for TWW reuse.

4.4.4 Climate Change Vulnerability and Risk Assessment for Agriculture Sector

Results of climate change vulnerability for agricultural sector showed that most of the targeted basins would have medium to high vulnerability resulting from high exposure and medium to low adaptation. On average, Mujib basin had the highest agricultural vulnerability followed by Azraq basin (**Figure 4.45**). Analysis of sub-district data showed the impact of scale on the output vulnerability map, where subdistricts with intensive irrigated and rainfed agricultural activities had the highest vulnerability to climate change as water resources would not provide crop requirements under the increased air temperature and decreased rainfall.

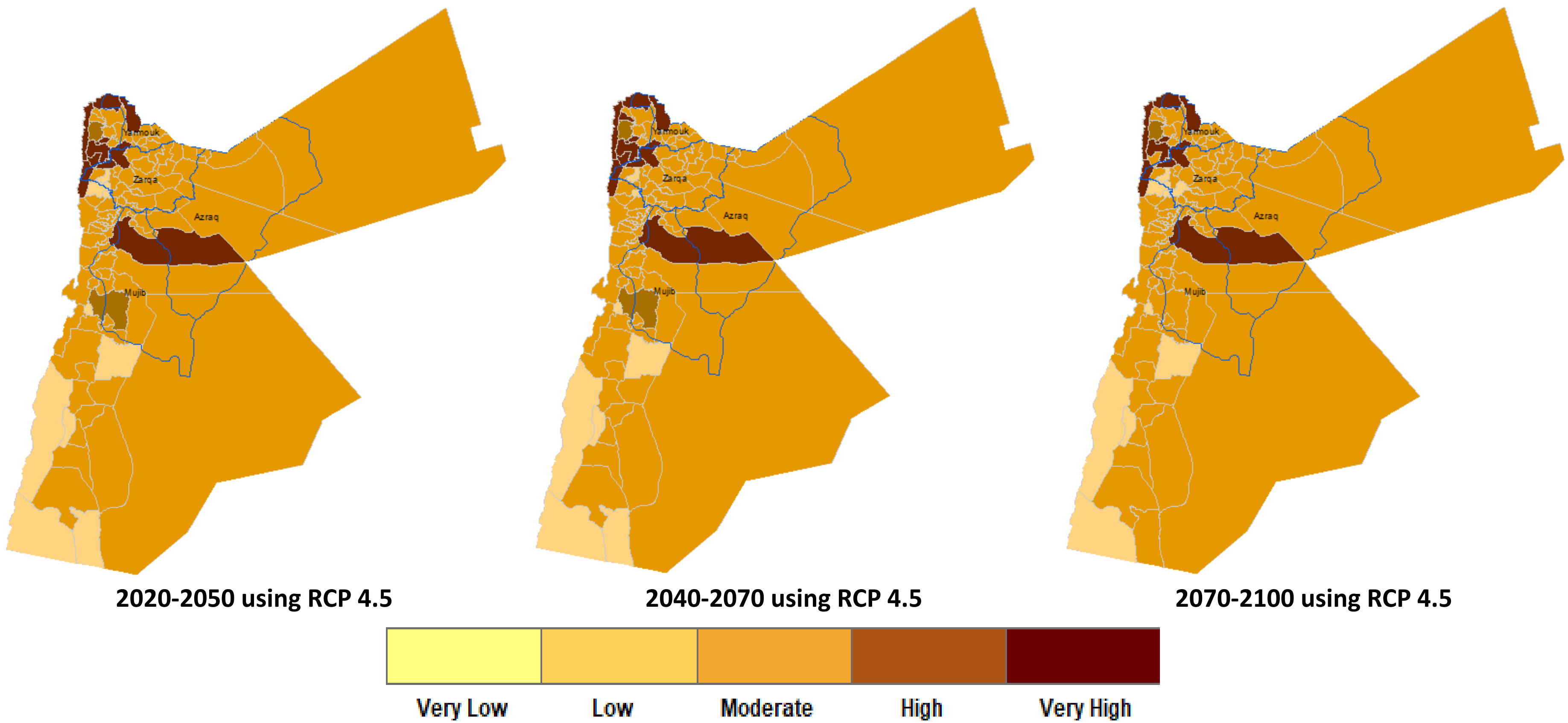


Figure 4.45: Climate change vulnerability maps for agricultural sector in Jordan and in the targeted basins using RCP 4.5.

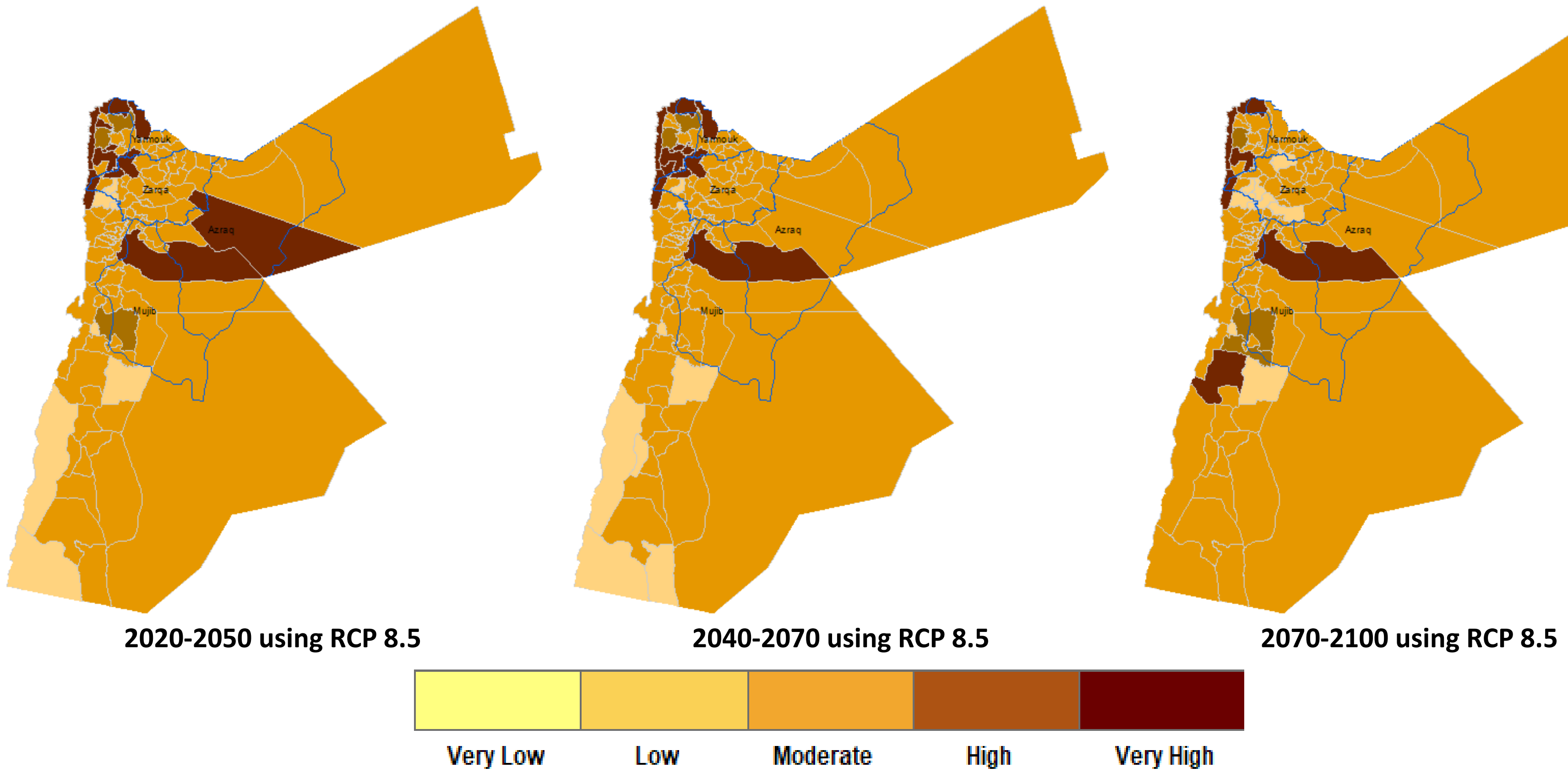


Figure 4.46: Climate change vulnerability maps for agricultural sector in Jordan and in the targeted basins using RCP 8.5.

4.4.5 Adaptation for Agricultural Sector

There are two proposed adaptation policies for the agricultural sector within The Climate Change Policy:

- A1- Promote the use of adaptive agricultural technologies and techniques and provide incentives for the development of green agribusiness.
- A2- Promote integrated land use planning practices.

Based on the MCDA, the list of adaptation was prioritized by stakeholders and groups of experts, as shown in **Table 4.12**, with numbering order similar to the one in the Climate Change Policy.

Table 4.12: List of adaptation measures for agricultural sector as prioritized by stakeholders.

Action List	Time frame	Justification
A1.1. Integrating climate resilience in the policy and institutional reforms in agricultural sector (Management and institutional levels).	Short Term	IO; PP; IC
A1.7. Enhancing drought management systems including capacity building on best practices (Strengthen institutionalization and deployment of existing early warning system).	Medium Term	UP; R&D; IC, PP
A1.4. Shifting to water efficient crops (Extension and on-farm capacity building programs and campaigns).	Medium Term	SA; UP
A1.2. Improving irrigation system efficiency (Community-based).	Short Term	UP; SA
A1.11. Integrating nexus approach to design future, inherently interlinked systems planning in a holistic manner while capturing existing opportunities and exploring emerging ones.	Long Term	IO; R&D; CB
A1.3. Informing and training farmers on cover crops cultivation and diversified crop rotation techniques.	Short Term	UP; SA
A1.14. Enhancing the last mile delivery of climate services tailored to the specific needs and preferences of smallholder farmers to better adapt to climate variability.	Medium Term	IO; SA, SE
A1.5. Supporting conservation agriculture.	Medium Term	IO; CB
A.1.6. Promoting composting and supporting the use of compost as a substitute to traditional fertilizers, in order to enrich soils.	Medium Term	IO; CB
A1.8. Up-scaling locally proven Integrated Pest Management (IPM) technologies, especially for important cash crops.	Medium Term	SE; HC
A1.9. Promoting and incentivizing use of sustainable nutrient inputs in line with agroecological approaches.	Medium Term	SA; PP
A1.10. Improving sustainable productivity of food chains and reduction of post-harvest losses and food waste in a sustainable manner	Medium Term	IO; CB
A1.12. Enhancing productivity of rangeland management	Long Term	HC; SE; CB

A1.13. Promoting urban agricultural practices at both small-scale household level and large-scale commercial level through technology investments, local community engagement, and awareness programs.	Short Term	IO; SA, SE
A2.4. Building capacities of hydrological and meteorological (hydromet) agencies to design and deliver better products and services for smallholders.	Medium Term	IC; SE
A2.2. Promoting the use of GIS and remote sensing for supporting climate information systems in climate-smart agriculture.	Short Term	IO
A2.1. Providing training and educational courses on land use planning at the community level, especially for the development of sustainable urban agriculture.	Short Term	IO
A2.3. Facilitating the introduction of carbon trading in the agriculture sector, as incentive for improving farming practices.	Long Term	PP; IC; CB

4.5 CCIVA for Water Sector

Assessment of climate change impacts on water supply were carried out using the SWAT model which incorporated climate projections, land use and soil maps to obtain different outputs that included volumes of runoff and groundwater recharge. The outputs for average changes under climate projections were calibrated using the data of MWI. Amounts of treated wastewater were calculated based on population growth scenarios and MWI data. Results were then analyzed in terms of trends and water supply. Future water demand, on the other hand, was assessed using AquaCrop that calculated the irrigation depth under the climate change projections. Details on outputs from AquaCrop are included in the agricultural section. Rates of change in agricultural areas and agricultural water requirements were calculated and summarized for the future periods. Domestic water demand was calculated based on the projected population, assumption of constant per capita share (100 lpcd) and the increase of domestic network efficiency from 52% (present) to 75% (Future). Water budget was then calculated based on the outputs from SWAT, AquaCrop and population data.

The sensitivity indicators were mainly related to water demand for both domestic-use and irrigation, water network age for domestic-use, groundwater sensitivity for irrigation and population of each sub-district. The adaptation indicators were mainly the levels of poverty, the capacity for water storage, the billed amounts of water, the availability of ground and surface water in the future and the allocated domestic water. The data for demand (sensitivity) and supply (adaptation) indicators for irrigated areas were based on outputs from AquaCrop and SWAT, in addition to data obtained from DOS, MWI and literature. Assessment was carried out for the sub-district level.

4.5.1 Impacts of Climate Change on Water Supply

Outputs from SWAT showed the adverse impact of the dry climate of the future on water resources in Jordan. In general, trends showed a decrease in surface runoff and groundwater (GW) volumes in the four basins (**Figure 4.47**). Results from SWAT were compared with previous studies and reports (Ta'ani, 2017[148]; Al-Khrabsheh, 2021[149], GIZ, 2021a[150]) for both groundwater and surface runoff. Results from SWAT were also in agreement with the findings of groundwater modeling work (MWI & BGR, 2019[151]) for the A7/B2 aquifer, which covered Yarmouk and Amman-Zarqa basins. Among the four basins, there was a lack of data for

[148] Ta'ani, R. 2017. Development of a National Water Information System- Jordan, A data management report on development, in-stallation, testing and commissioning of the MWI-WIS, EU-ENPI project 2015/366-808, MWI, Amman, Jordan.

[149] Al-Kharabsheh A., 2021. Assessment of Water Resources Management in Azraq Basin, Jordan. Jordan Journal of Earth and Environmental Sciences, 12 (3): 230-240.

[150] GIZ (German Society for International Cooperation), 2021a. Assessment of Surface Water Production, Conveyance and Use in All Sectors in Jordan, Final Report. Third National Water Master Plan (NWMP-3), Volume B – Water Resources, ANNEX B.1., GIZ, Amman, Jordan.

[151] MWI & BGR (Ministry of Water and Irrigation; Bundesanstalt für Geowissenschaften und Rohstoffe), 2019. Groundwater Resource Assessment of Jordan 2017. - 151 p., ISBN 978-9923-9769-0-6.

calibration and validation for Yarmouk basin, due to the fact that 70% of this basin's area was located in Syria, which made calibration and validation difficult. For Mujib basin, outputs from SWAT were compared with inflow volumes to Mujib dam obtained from MWI data. In summary, and excluding the results of Yarmouk, the average rate of change, would be reduction of surface runoff by 10% for Mujib, 23% for Azraq and 21% for Amman-Zarqa. The reductions in groundwater recharge would be 10% for Mujib, 20% for Azraq and 16% for Amman-Zarqa. The average change would be -18% for surface water and -16% for groundwater.

Based on the modeling outputs and plans of MWI, the volumes of the water supply were calculated and summarized (**Table 4.13**). The increase in amounts would come from TWW, the National Desalination Project and some water harvesting projects. The decrease in some sources of supply was based on climate change and reduction of amounts provided by the Disi Conveyor. The volumes of supply assumed no changes to transboundary water and included the water harvesting projects under implementation, at the date of 4NC reporting.

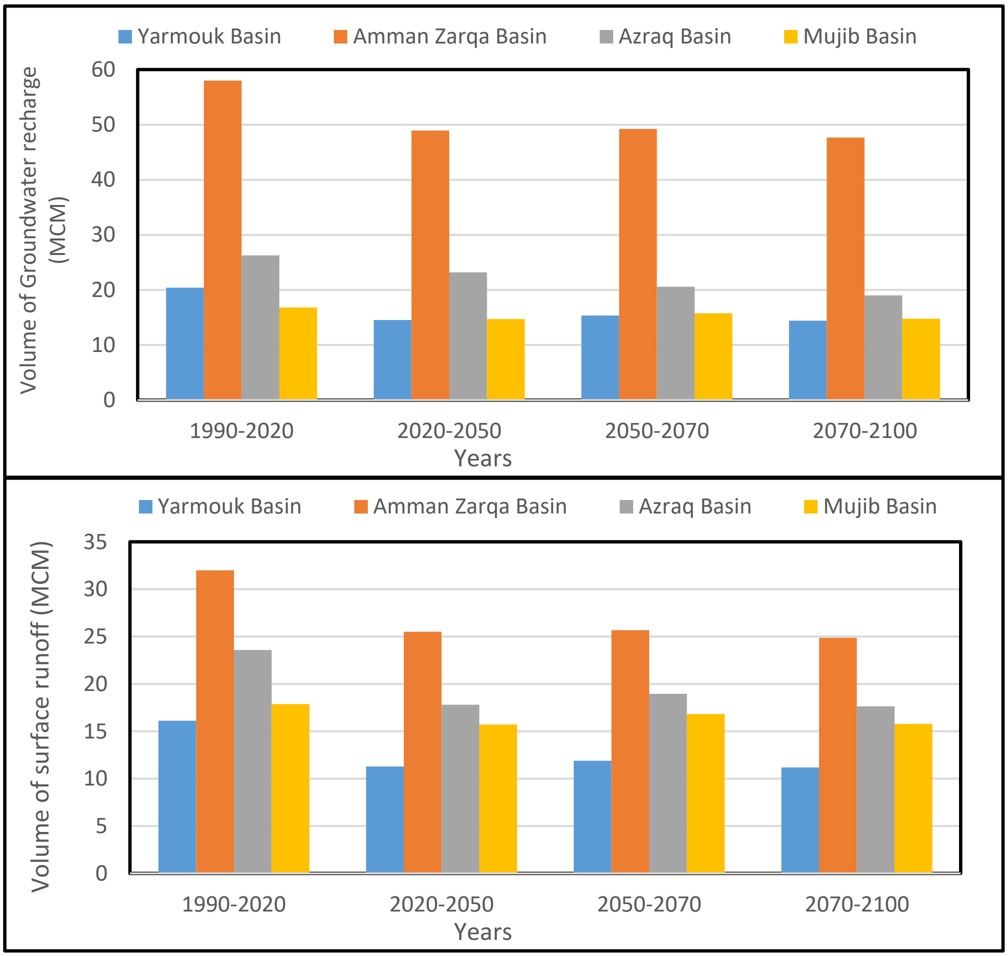


Figure 4.47: Volumes of groundwater (Top) and surface runoff (Bottom) under climate change projections.

Table 4.13: Summary of water supply (MCM) from different sources in the future.

Water Source	Present	2050	2070	2100
1. Surface water	280	273	282	273
2. Surface water - Transboundary	125	125	125	125
3. Renewable groundwater	335	294	314	295
4. Non-renewable groundwater	143	143	100	72
5. Desalinized water	4	354	354	354
6. Treated wastewater	164	301	383	506
Total sources	**1051**	**1490**	**1558**	**1625**

4.5.2 Impacts of Climate Change on Water Demand

Estimation of water demand (**Table 4.14**) was based on population growth for domestic uses and on modeling results for irrigated crops. For industrial activities, figures were based on rates of change adopted by a previous work that projected amounts for every 5 years during 2020-2040 (GIZ 2021b[152]). Projections for domestic-use were based on medium population growth rate and improved efficiency of water networks, that assumed reduction of losses and increasing the efficiency up to 75%. For irrigated agriculture, projection of demand was based on an increase in irrigation depth, obtained from AquaCrop results and possible expansion in irrigated areas, which was restricted by water and available land resources in each irrigated zone, as detailed by the study of Al-Bakri (2021), which formed part of the National Water Master Plan for 2030. The study showed that irrigated lands would not exceed 138 thousand ha by 2050 and the expansion in TWW reuse would be balanced by a decrease in the use of fresh water resources, which would be prioritized for domestic-use. The projections also showed that population will increase from 10 million at present to 22, 35 and 70 million by years 2050, 2070 and 2100, respectively.

Table 4.14: Summary of water demand (MCM) for different sectors in the future.

Water Source	Present	2050	2070	2100
1. Domestic	470	924	1261	1811
2. Irrigated agriculture	658	1072	1097	1201
3. Industrial	32	83	104	125
4. Pastoral	7	15	21	30
Total demand	1167	2094	2483	3167
Total supply	1051	1490	1558	1625
Balance	-116	-604	-925	-1542
Deficit (Considering network losses)	**265**	**835**	**1240**	**1995**

[152] GIZ (German Society for International Cooperation), 2021b. Assessment of Current and Future Water Demand until the Year 2040 for Industrial and Touristic Purposes. GIZ, Am-man, Jordan.

Obviously, water demand would increase and would double by 2050. The supply-demand gap would be aggravated by climate change, which would decrease groundwater recharge and surface water. Detailed analysis of demand and supply showed that 30% of the water deficit could be attributed to climate change impacts on increased demand and decreased supply. Figures also showed that the National Desalination Project would not enable Jordan to overcome water deficiency problem. Therefore, mega projects, of desalination and water re-use would be needed and the water-energy nexus should be emphasized, to develop new resources. The other important point that should be considered in adaptation would be the expansion in TWW reuse. This would require a shift in cropping patterns, towards forage and fodder crops at the expenses of vegetables in Jordan Valley.

4.5.3 Vulnerability Assessment for Water Sector

The climate change vulnerability assessment for the water sector showed that high vulnerability to climate change characterized the basins of Yarmouk, Amman-Zarqa, northern parts of Azraq basin and middle and western parts of Mujib basins **Figure 4.48**).

Generally, high vulnerability to climate change occurs in the northern and north-western parts of Jordan. This results from the high exposure and the low adaptation capacities in these areas. The areas, with high to very high vulnerability, were characterized by high water demand for both domestic and agricultural sectors. In addition, these areas would have limited adaptive capacity resulting from insufficient water resources.

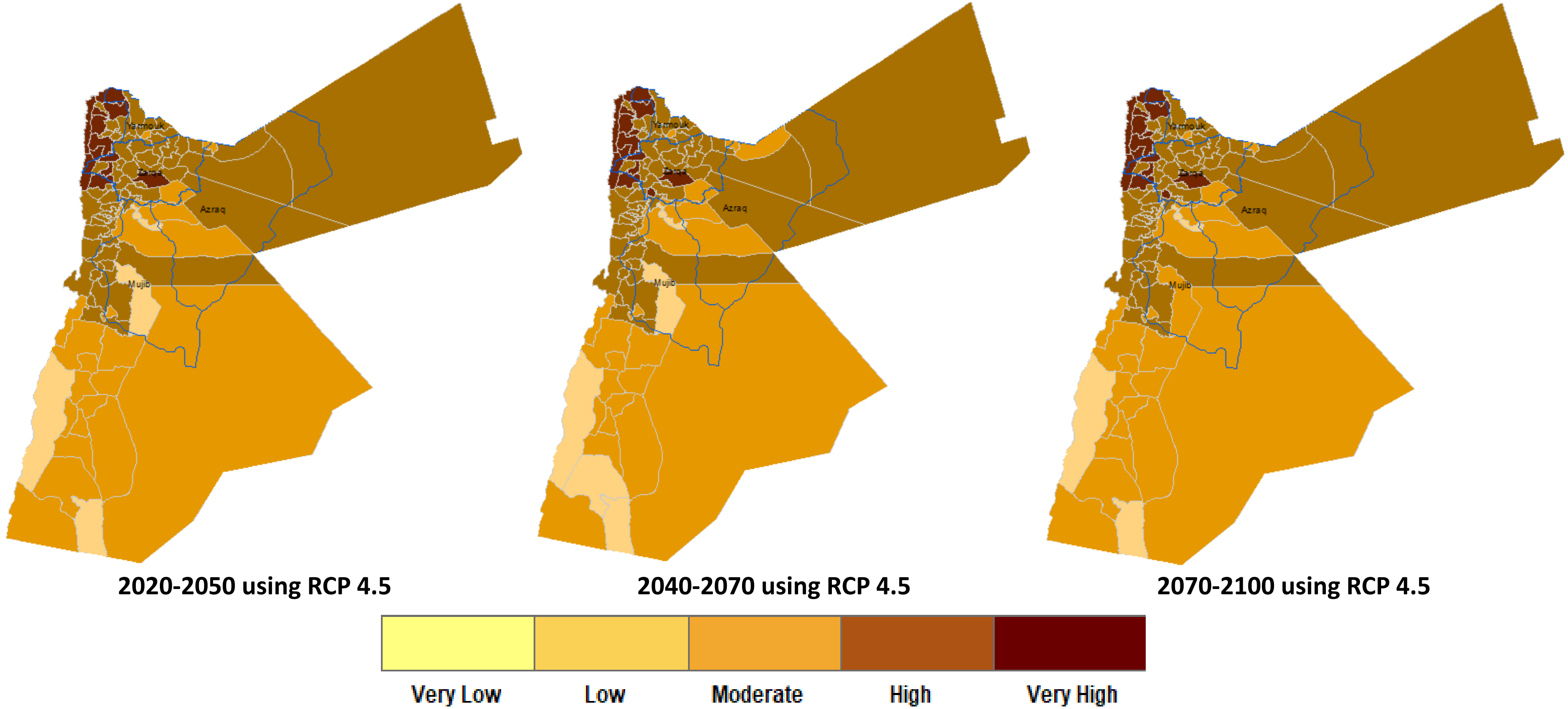


Figure 4.48: Map of climate change vulnerability for the agricultural sector in Jordan and in the targeted basins using RCP 4.5.

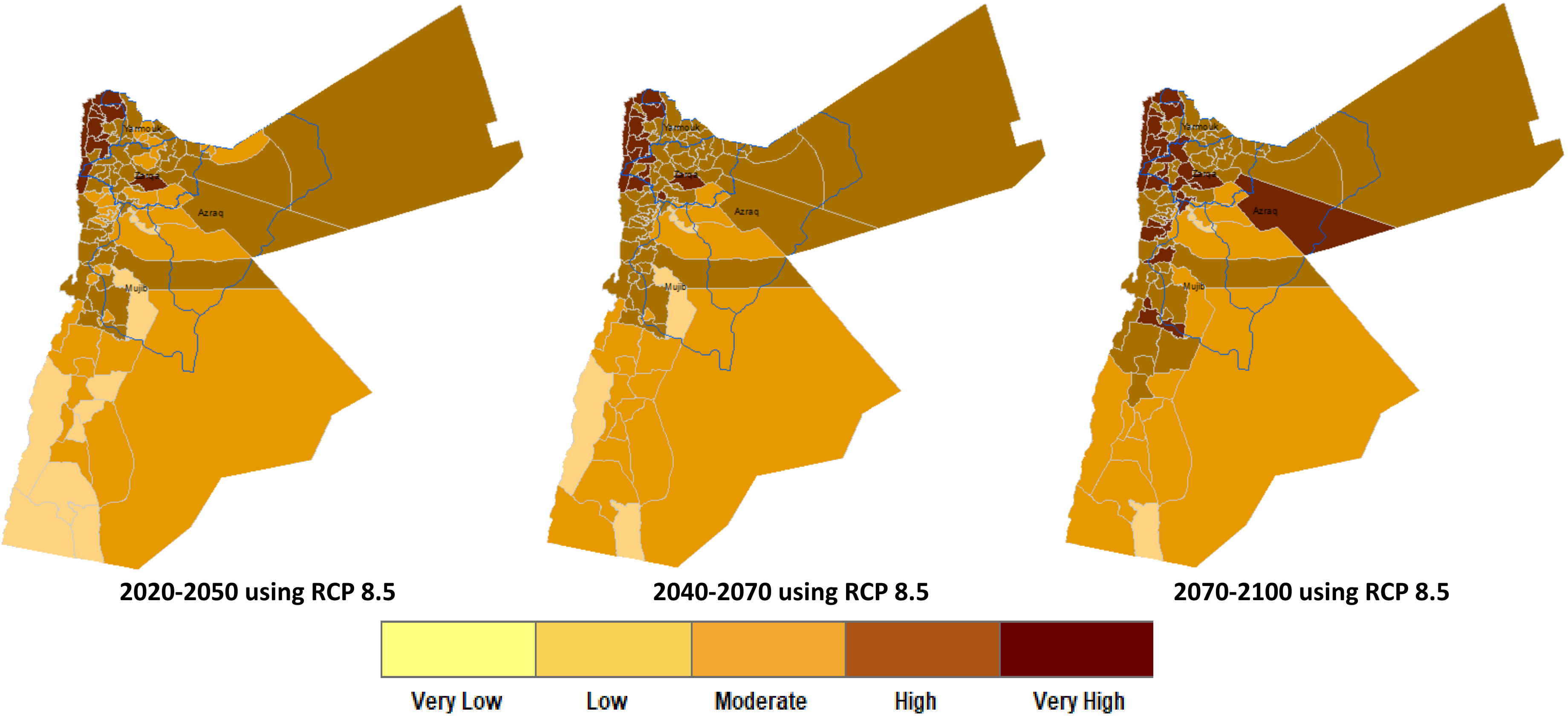


Figure 4.49: Map of climate change vulnerability for the agricultural sector in Jordan and in the targeted basins using RCP 8.5.

4.5.4 Flood Risk Assessment in Aqaba Coastal Zone

Assessment of climate change impacts on risk of flooding in Aqaba, was carried out using outputs from climate projections which were incorporated in SWAT and HEC-RAS hydrological models. The data, for both models, included a 30 m ground resolution of Digital Elevation Model (DEM), soil map, the land-use/cover map prepared for the 4NC and the climate projections data. The DEM was used to delineate the watersheds that were draining into the coastal zone of Aqaba, using the RAS mapper. The geometry data for the watershed was built by using a two-dimensional flow area (2D flow area) and the boundary conditions (Upstream and Downstream) were determined for the watershed of the main Wadi known as Wadi Al-Yutm (**Figure 4.50**).

The outlet for this Wadi is an alluvial fan facing the eastern part of Aqaba Airport. The surface runoff under future climate was generated in HRU by using ArcSWAT based on soil, land cover and topography data. The outputs from ArcSWAT were imported in the flow hydrograph in HEC-RAS model on the form of monthly flow data during the period 1990 to 2100 as shown. The values of water depth, velocity and water surface elevation are considered the main outputs of this model. The outputs from HEC-RAS were plotted for the period 1990-2100 (**Figure 4.51**).

Results showed that a destructive flood event would occur every 25-30 years during 2030-2059. Also, flood frequency would increase after 2059, when compared with the period 2030-2059. Historically, a detailed description of flood and flood risk in Aqaba was included in the work of Schick et al. (1999)[153], who included a detailed geomorphological description of the area. According to Schick (1971)[154] and Schick et al. (1999), a major flood known as the Ma'an flood occurred in 1966 and yielded several peaks, one of which reached a discharge of 500 m^3/s which resulted in a flood volume of 4 MCM. Similar floods, with less flow rates and volumes, were observed in the last 30 years including the ones in 2003 and 2014 (Farhan and Anaba, 2016[155]). These were well simulated by the HEC-RAS. Generally, flow rates of 20 m^3/s would continue to occur in the future and might result in some impacts on the infrastructure in the area, although the Aqaba Special Economic Zone Authority (ASEZA) had constructed some check dams on Wadi Al-Yutum to alleviate the adverse impacts of these floods.

[153] Schick A.P., Grodek T., Wolman M.G. 1999. Hydrologic processes and geomorphic constraints on urbanization of alluvial fan slopes. Geomorphology, 31, 325-335.

[154] Schick A., 1971. A desert flood: physical characteristics, effects of man, geomorphic significances, human adaptation- a case study of the southern Arava Watershed. Jerusalem Studies in Geography 2: 91-155.

[155] Farhan, Y. and Anaba, O. (2016) Flash Flood Risk Estimation of Wadi Yutum (Southern Jordan) Watershed Using GIS Based Morphometric Analysis and Remote Sensing Techniques. Open Journal of Modern Hydrology, 6, 79-100. doi: 10.4236/ojmh.2016.62008.

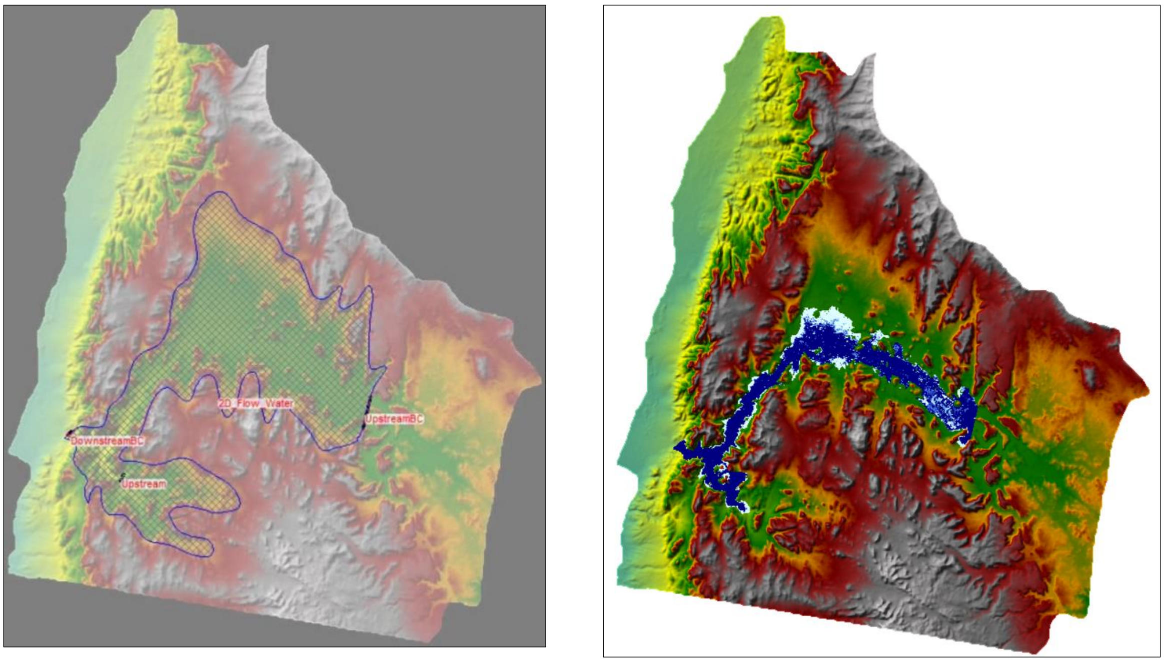


Figure 4.50: Borders of the watershed (Left) and the 2D flow area (Right) during rainfall storms in Wadi Al-Yutm in Aqaba.

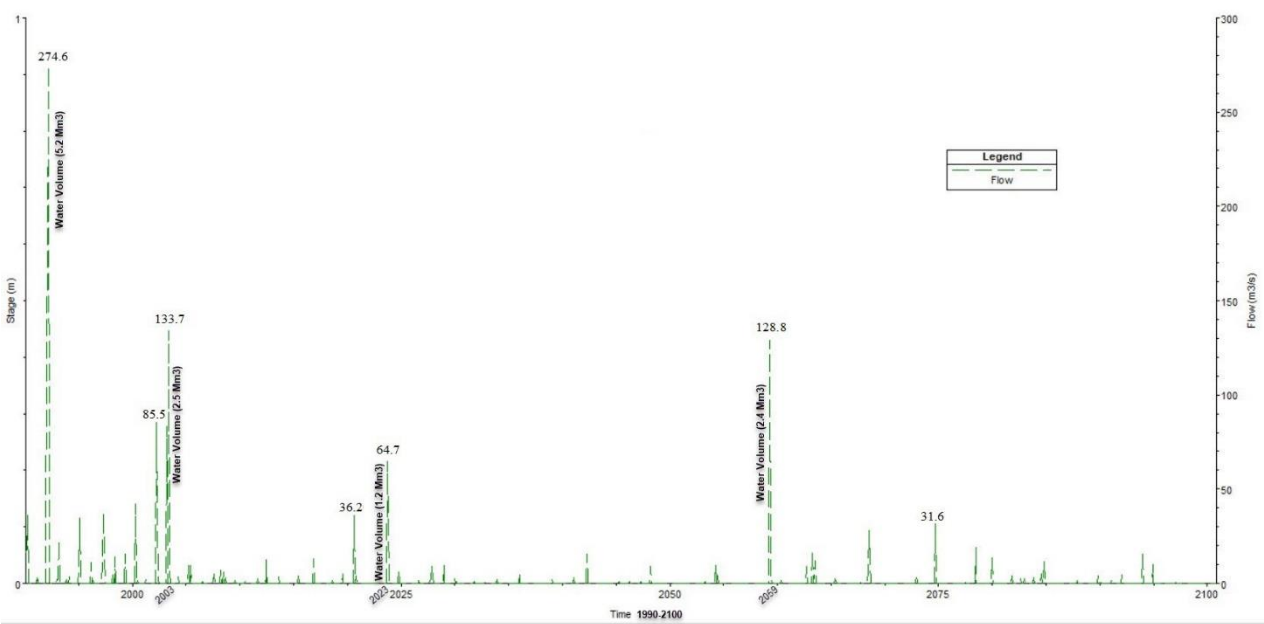


Figure 4.51: Simulated flow rate and flood volumes for Aqaba coastal zone during the period 1990-2100.

4.5.5 Adaptation for Water Sector

The adaptation measures for the water sector would be only based on the policy of supporting water supply, conservation and related infrastructure development, although it contains the components of demand management. The levels to which demand could be controlled would be limited due to population growth and increased agricultural demand. Therefore, the adaptation would be focused on supply augmentation and management that consider the increase of efficiency and conservation of water resources. The list of adaptation measures prioritized by the stakeholders is shown in **Table 4.15**. It should be mentioned that most of the adaptation measures formed part of the National Water Master Plan and Jordan's Water Strategy.

Table 4.15: List of adaptation measures for agricultural sector as prioritized by stakeholders.

Action List	Time frame	Justification
W1.1. Integrating Climate adaptation and resilience in the policy and institutional reforms in the water sector (Policy and Management levels)	Medium Term	IO, UP, IC, PP
W1.5. Improving contribution of non-conventional water resources to the national water budget (Incentive, extension and capacity building)	Medium Term	SE; CB
W1.2. Improving water demand management and reducing the gap between water demand and supply	Medium Term	UP, ID, CB
W1.4. Improve efficiency in water use for sustainable development (Supply augmentation and demand reduction).	Medium Term	SA; CB
W1.3. Improve the adaptive capacity of water utilities (e.g., Conducting climate proofing studies for existing water utilities, risk mapping. etc.).	Medium Term	IO, R&D, SA
W1.9. Support watershed and basin level management including transboundary water (e.g., decentralization of water management).	Long Term	UP; SA; SE
W.1.8. Improve rainfall early warning systems and reducing flood and drought risks (informed decision and disaster management plans).	Medium Term	UP, R&D
W1.6. Water conservation incentives – incentivize water pricing systems that reward conservation, accounting for differences between ecological zones with regards to growing conditions, crops, and other agronomic needs.	Short Term	IO; CB
W1.7. Floodplain Easements - Work with willing sellers to identify voluntary floodplain corridor protection (flowage) easements on agricultural lands to maintain agricultural production that is compatible with flood conveyance.	Medium Term	SE

4.6 CCIVA for Terrestrial Biodiversity Sector

Diverse biological communities and functioning ecosystems are critical to maintaining the ecosystem services (Millennium Ecosystem Assessment, 2005) that support human well-being (Díaz et al., 2019). Jordan's ecosystems and biodiversity components are under severe threats from the anthropogenic activities, which have led to the serious effects on of ecosystems degradation, deterioration, overexploitation, and invasion by alien species. In consequence, individual species and their populations are threatened with extinction.

Climate change is adding another layer of pressures on natural ecosystems processes and properties as well as the individual species and their populations. In particular, climate change affects species behavior, morphology, phenology, structure, range shifting, and genetic composition. In addition, it disturbs ecosystem productivity, species interaction, ecosystem resilient, and causes territorial redistribution of natural ecosystems by changing natural habitats of certain species of plants and animals, as well as contributing to the spread of invasive species and affecting ecosystem services, and so it affects human well-being. Climate change impacts combined with continued and accelerated non-climatic stressors, will cause species extinction and ecosystems loss and degradation.

4.6.1 Exposure Analysis for Terrestrial Biodiversity Sector

In Jordan, two main exposure parameters were used to assess the vulnerability of ecosystems toward climate change, which are the mean annual temperature and the precipitation rate. Based on that, two emission scenarios (RCP 4.5 and 8.5) have been projected for the three intervals for 2050, 2070 and 2100. The resulting projections were normalized and categorized into five scores from 1 (very low) to 5 (very high).

The RCP 4.5 future projections in 2050 suggest that most ecosystems will be exposed to a very low level of climate change trend. The trend in 2070 is showing a shift in exposure in most of the ecosystems of Jordan, but it will remain low, with very low exposure trends in areas located in southwest Jordan, where Acacia, sand dunes and steppe ecosystems occur, and some small spots of mudflat ecosystems existing in the southeast Jordan. The projections remain almost constant, but a moderate exposure trend was reported in the northwestern parts of Jordan, where the forested ecosystems are concentrated (Figure 4.52).

The non-optimistic climate change scenario of RCP 8.5 is predicting a harsher exposure trend with time, where it tends to show low exposure trends in 2050 in almost the entire area of Jordan's ecosystems, with the exception of the Mediterranean non-forest, deciduous oak, evergreen oak, and Aleppo pine ecosystems that will be partially exposed to low exposure trends. However, exposure trends gradually change by 2070, with low exposure trends prevailing over most of the Jordanian ecosystems, and moderate exposure starting to occur in the forested ecosystems in the northwestern parts of Jordan as well as in the sand dune and aquatic ecosystems. The RCP 8.5 future projections in 2100 showed very extreme exposure trends which would affect almost the entire area of Jordan (Figure 3).

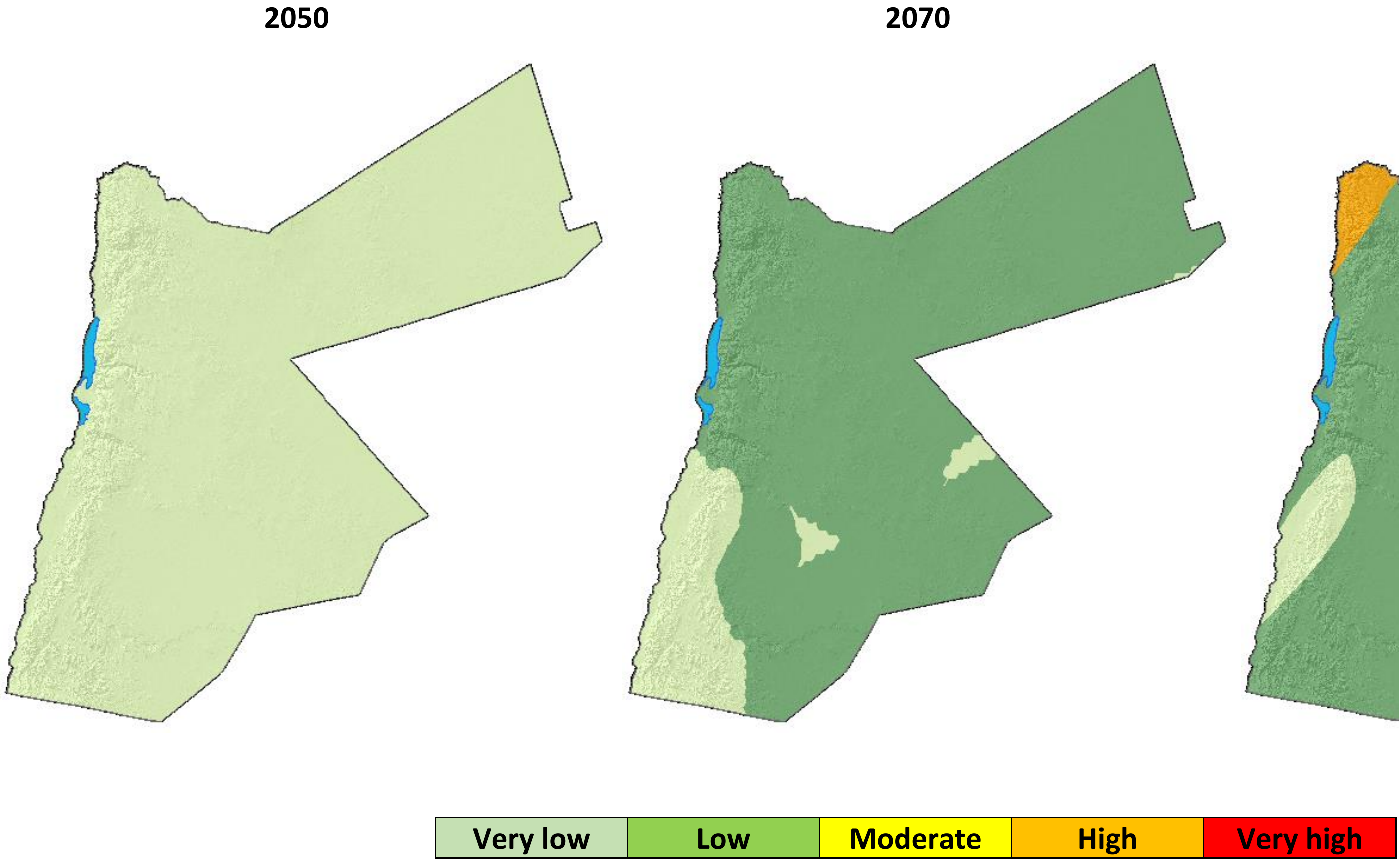


Figure 4.52: Exposure trends according to climate change scenario of RCP 4.5

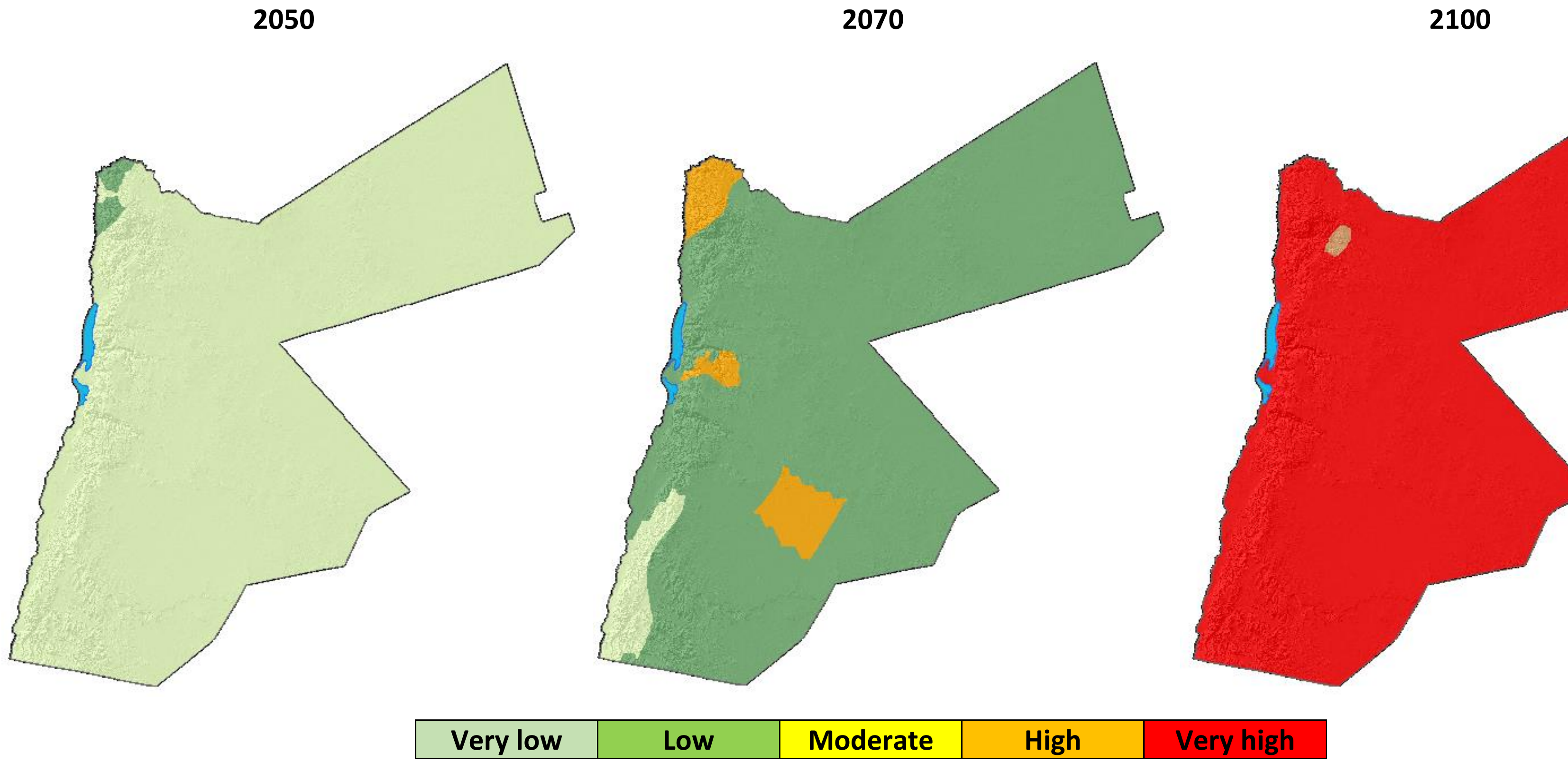


Figure 4.53: Exposure trends according to climate change scenario of RCP 8.5

The exposure trends from the projections are acceptable, and are unlikely to affect Jordan's ecosystems, except for the very extreme projections of RCP 8.5 in 2100. It is suggested that the effects of climate change exposure will be limited to individual species of fauna and flora as well as vegetation cover. The threats to ecosystems and species are attributed to indirect causes of anthropogenic origins such as induced fires, land use and water drainage. If the threats from the anthropogenic origin continue in their current state and acceleration, then they will lead to the loss and/ or degradation of the terrestrial ecosystems before understanding the impact of climate change on them. Therefore, in addition to the proper management of ecosystems and halting the anthropogenic threats, it is recommended to conduct research and monitoring programs on key ecosystems and species, which are most at risk of climate change such as:

- Threatened ecosystems with small extents of occurrence like forests, sand dunes and aquatic habitats.
- Species with specialized habitat and/or microhabitat requirements
- Ecosystems and/ or species with narrow environmental tolerances or thresholds that are likely to be exceeded due to climate change at any stage in the life cycle.
- Ecosystems and/ or species dependent on specific environmental triggers or signs that are likely to be disrupted by climate change.
- Species with poor ability to disperse to, or colonize, a new or more suitable range.

4.6.2 Sensitivity Analysis for Terrestrial Biodiversity Sector

The sensitivity of ecosystems to climate change is the degree to which ecosystems are likely to be affected by or responsive to climate changes. Accordingly, several factors could increase or decrease the sensitivity of ecosystem to climate change such as physiology, habitat specificity, level of impact by other stressors, presence of temperature-sensitive species or ecosystem processes, population size, level of fragmentation, genetic diversity, endemism, and presence of threatened species and phenology (i.e., in seasonal timing of events, including migration, hibernation, flowering, bud burst, spawning, etc.).

Four main indicators were used to assess sensitivity of ecosystems to climate change, which are:

1. Size area of each ecosystem
2. Level of fragmentation
3. Rarity of the ecosystem in Jordan
4. Exposure level to anthropogenic pressures

A scoring system from 1 (very low) to 5 (very high) was used to assess sensitivity of each ecosystem towards climate change (Figure 4-36). It was found that forested ecosystems are by far the most sensitive to climate change in Jordan in two dimensions, where it can be directly affected through several processes acting at various temporal and spatial scales such as tree growth, reproduction, establishment, mortality, species composition, and stand structure. In addition, forests can be affected indirectly by disturbances such as fire, outbreaks of insects, fungi, and other pathogens, wind, and diseases. Jordan is witnessing fires which disturb forests on a continuous basis, where Aleppo pine, evergreen oak, and deciduous oak are the most affected by the danger of fires, while the Phoenician juniper and the Acacia woodland ecosystems are under water drainage threats and drought. It is expected that the frequency and severity of fires will change, and it will intensify (Figure 4.54).

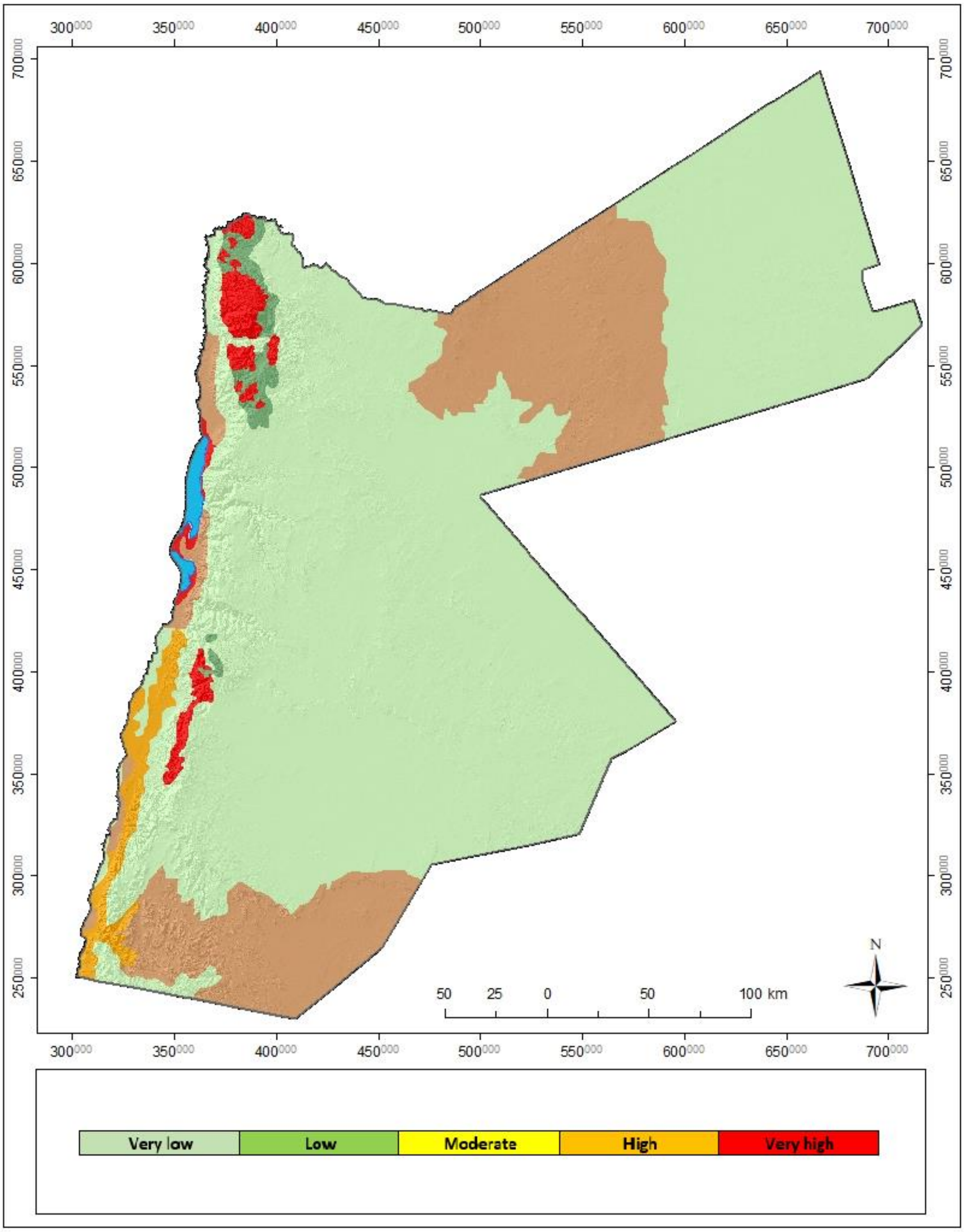


Figure 4.54: Sensitivity of ecosystems to climate change

4.6.3 Impact Analysis for Terrestrial Biodiversity Sector

The impact of climate change on ecosystems was developed through calculating the average of exposure and sensitivity values. Projections showed that forested areas in Jordan will be the most impacted regions. In addition, sand dunes, wetlands and eastern basalt intrusion areas in the eastern desert will be moderately impacted by climate change (Table 4.16). The impact of climate change will affect ecosystems in several ways such as

1. Decrease in ecosystem productivity: this is represented by changes in regeneration ability and growth rate, dieback, and high mortality due to water limitations.

2. Changes in ecosystem structure and species composition: it is known that pioneer species can increase their abundance due to increased disturbance rate, which might affect the ecosystems' structure and composition and lead to the replacement of key species by other species on degraded land.

3. Species invasion: climate change will supply more opportunities for the potential introduction of invasive species especially after causing changes in the distribution of native species. This will certainly affect the ecosystems and change their resilience.

4. Ecosystems resilience: increased disturbance rate will affect ecosystems resilience and lead to critical changes in its composition and structure

5. Ecosystems services: this is mainly due to the decreased viability of ecosystems due to cumulative impacts of multiple stressors including anthropogenic and climate change, which will affect the ecosystem services provided by each ecosystem. It will be limited to soil structure and viability, water purification, biomass and will affect aesthetic values.

6. Increasing costs related to management of disturbances: including but not limited to fire management, logging and invasive species eradication.

Table 4.16 below illustrates the impact analysis of each ecosystem in more detail according to the RCPs 4.5 and 8.5 over the three intervals of 2050, 2070 and 2100.

Table 4.16: Impact of climate change on Jordan's ecosystems

Ecosystems	Exposure						Sensitivity	Impact					
	2050		2070		2100			2050		2070		2100	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5		RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Pine Forest ecosystem	1	2	2	4	2	5	5	3	3	3	4	3	5
Evergreen Oak Forest	2	4	2	4	4	5	5	3	4	3	4	4	5
Deciduous Oak Forest	2	4	2	4	4	5	5	3	4	3	4	4	5
Wild Phoenician Juniper Forest	1	2	2	2	2	5	5	3	3	3	3	3	5
Mediterranean non-forest	1	2	1	4	4	5	2	2	2	2	2	2	3
Steppe	1	4	2	2	2	5	1	1	2	1	1	1	3
Hammada (Stoney desert)	1	1	1	2	1	5	1	1	1	1	1	1	3
Salt and Mudflats	1	1	1	1	2	5	1	1	1	1	1	1	3
Sand dune	1	4	2	4	2	5	4	3	3	3	3	3	5
Acacia woodland	1	4	1	2	1	5	5	3	3	3	3	3	5
Wetland and Aquatic	2	4	2	4	2	5	5	3	3	3	3	3	5
Weathered Sandstone and Granite Scrub	1	2	2	4	2	5	4	2	3	3	3	3	5
Ziziphus spina-christi and *Balanites aegyptiaca* formations	1	2	2	4	2	5	4	2	3	3	3	3	5

Very low (1)	Low (2)	Moderate (3)	High (4)	Very high (5)

4.6.4 Adaptive Capacity Analysis for Terrestrial Biodiversity Sector

The adaptive capacity of ecosystems to cope with the effects of climate impacts depends on the existence of physical, social, political, economic, technological, and institutional capacities to reduce climate-related risks and hence the high-risk vulnerability. The presence of sustainable adaptive capacity interventions is the tool to achieve effective adaptation. Therefore, a set of adaptive capacity indicators were adopted including:

1. Asset base: it is represented by the percentage of ecosystems covered in conserved areas either protected areas, special conservation areas or other forms of protection such as Hima.
2. Economic resource availability for ecosystem conservation.
3. Technology and innovation created or available for ecosystem conservation.
4. Infrastructure availability to support ecosystem conservation.
5. Dedicated institutions established and actively working in ecosystem conservation.
6. Knowledge and information concerning the ecosystems and biodiversity needs to be generated, received, assessed, and disseminated, in order to support proper adaptation options.
7. Flexible decision-making and governance: ecosystems can predict, incorporate, and respond to changes about its governance structures and future planning.

Based on the above criteria, the Adaptive Capacity of Jordan's ecosystems was estimated based on the scoring ranged between 1 (very low) and 5 (very high). **Table 4 17** illustrates ranking results.

Table 4 17: Adaptive capacity of ecosystems toward climate change

Adaptive capacity	1	2	3	4	5
Are ecosystems adequately protected in the conserved areas in Jordan?					
Are sufficient budgets distributed from the country's general budget to protect ecosystems and biodiversity?					
Are there any techniques or innovations that help protect ecosystems and biodiversity?					
Does the country have enough infrastructure (i.e., ex-situ conservation) to sustain ecosystems and biodiversity?					
Are the institutions established for nature conservation capable (technically, financially, politically, etc.) of sustaining ecosystems and biodiversity?					
Is there enough knowledge, research, and monitoring about the relationship between climate change and ecosystems?					
Do the current governance structures and future planning allow the ecosystems to predict, incorporate and respond to climate changes?					

Very low (1)	**Low (2)**	**Moderate (3)**	**High (4)**	**Very high (5)**

4.6.5 Vulnerability Assessment for Terrestrial Biodiversity Sector

The vulnerability of ecosystems to climate change was assessed based on the correlation between impact and the adaptive capacity scores. Accordingly, RCP 4.5 and 8.5 were developed for three periods of 2050, 2070 and 2100 (Figure 4.55). Most ecosystems in Jordan would have low to moderate vulnerability except for all forested ecosystems, sand dunes, wetland, and aquatic ecosystems, which will be under high vulnerability toward climate change.

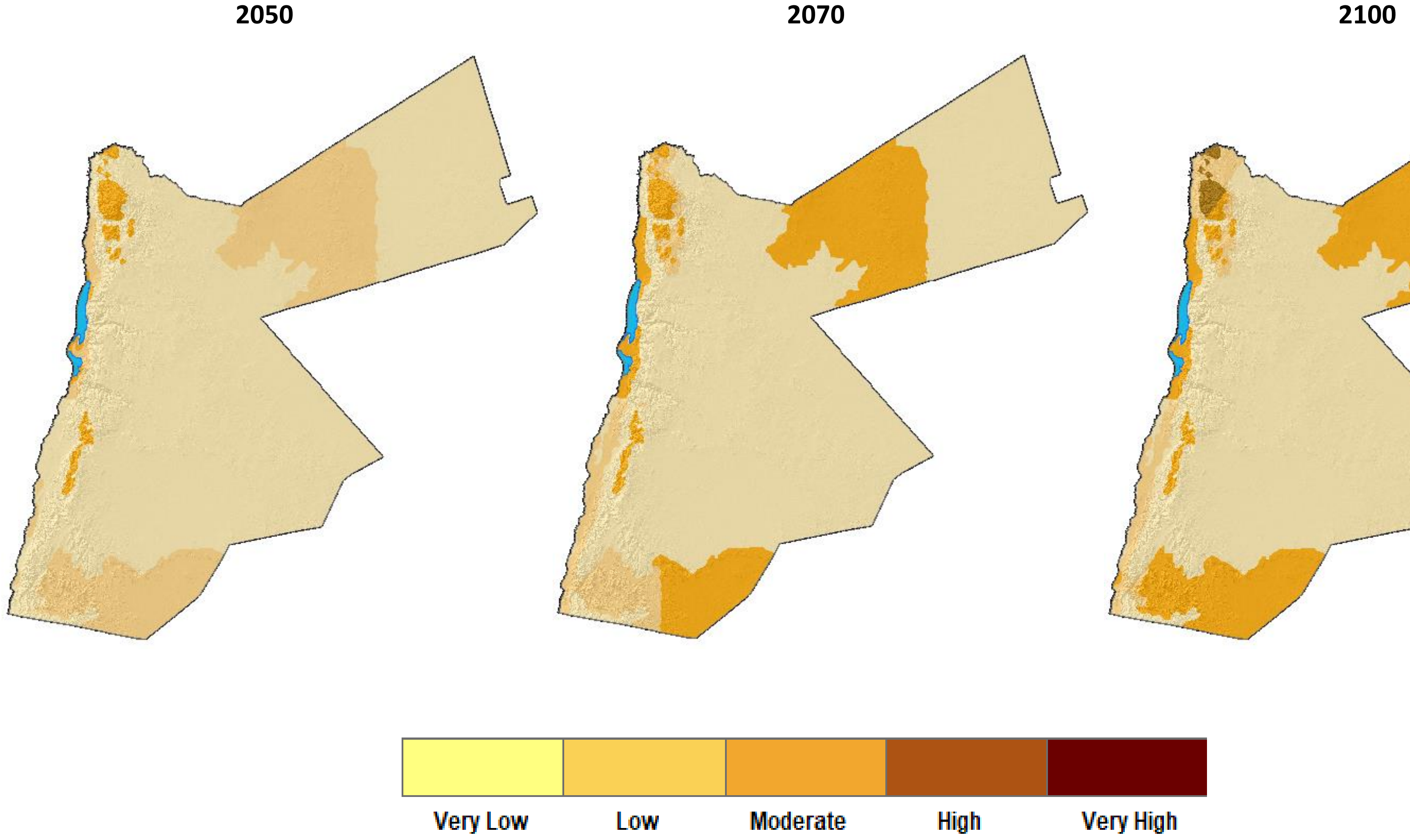


Figure 4.55: Vulnerability of ecosystems to climate change using RCP 4.5

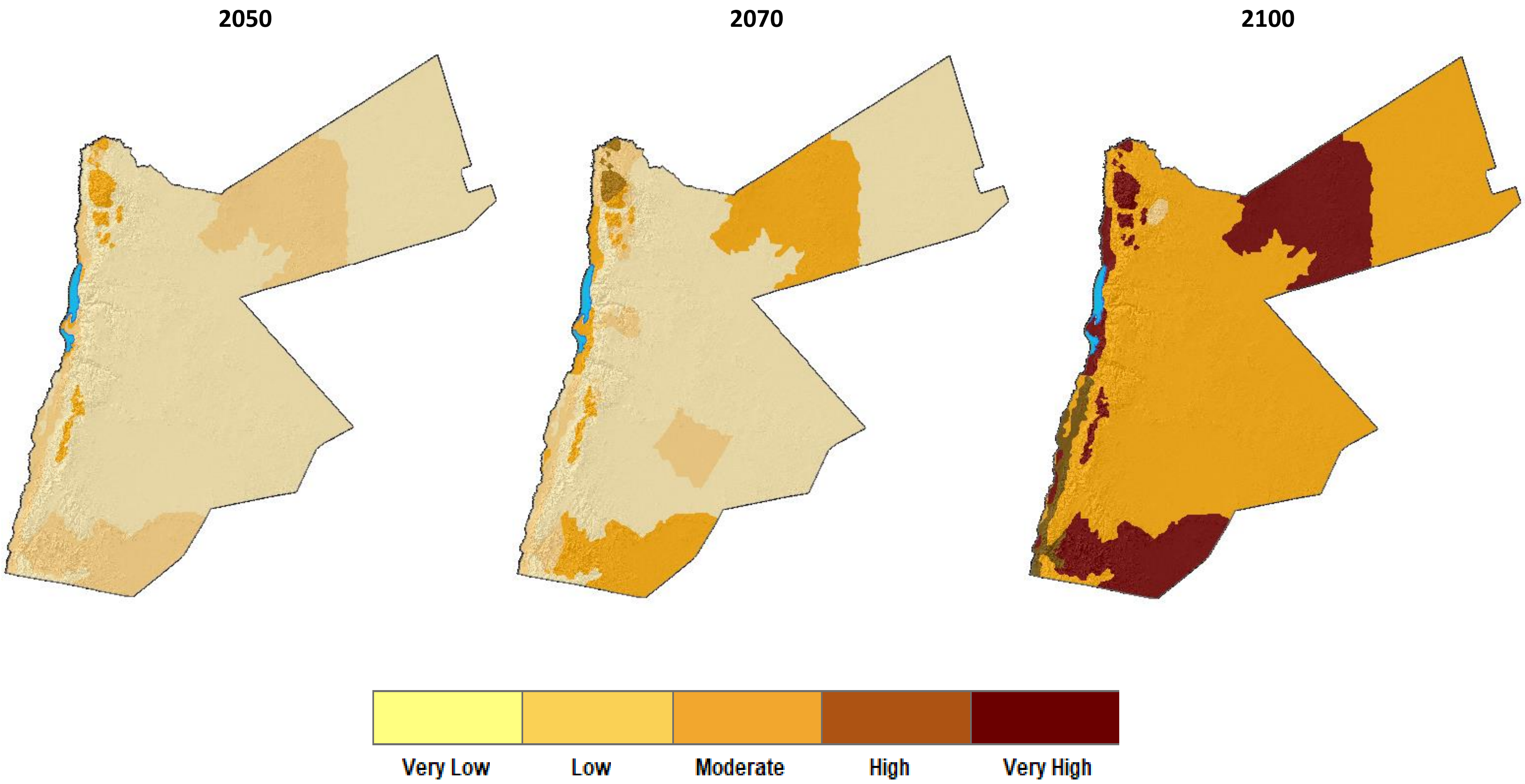


Figure 4.56: Vulnerability of ecosystems to climate change using RCP 8.5

4.6.6 Adaptation Measures for Terrestrial Biodiversity Sector

The implementation of adaptation strategies and measures requires resources, including financial and social capital (e.g., strong institutions, transparent decision-making systems, formal and informal networks that promote collective action), human resources (e.g., labor, skills, knowledge, and expertise) and viable natural resources (e.g., land, water, raw materials, and biodiversity). The resources needed and their relative importance depend on the context in which adaptation is pursued, on the hazards faced, and on the adaptation strategy. In addition, the adaptation strategies to conserve ecosystems and biodiversity will not be successful unless there is a willingness to adapt to those concerned, as well as a degree of consensus about what types of actions are proper.

The updated Climate Change Policy (2020-2050) already proposed the following list of measures (**Table 4.18**).

Table 4.18: Proposed list of adaptation measures for Ecosystems and Biodiversity sector

ECOSYSTEMS AND BIODIVERSITY (EB)				
EB1	Promotion of working landscapes with ecosystem services to improve agrobiodiversity	**EB1.1.** Provide technical and financial aid and incentives for the conservation of "bee pastures" and the use of on-farm planting beneficial to native and non-native pollinators, all with consideration given to crop compatibility (i.e., seedless crop varieties).	Long Term	HC; PP; R&D; CB
		EB1.2. Support knowledge transfer, implementation of knowledge and policy development, and the design of subsidy programmes to integrate functional agrobiodiversity (FAB) in agricultural systems.	Long Term	IC; SE
		EB1.3. Preservation of environmental reservoirs and maintaining an "ecological focus area" through field margins, hedges, trees, fallow land, landscape features, biotopes, buffer strips, and forested area.	Long Term	PP; SA; SE
		EB1.4. Promote natural enemies and potentially reduce pest populations and reduce pesticide drift and nutrient flows into surface waters through strengthening the ecosystem service of pest control.	Long Term	PP; SA; SE
		EB1.5. Guarantee food security by maintaining local breeds and varieties used in agriculture to safeguard the world's plant genetic resources especially well adapted crops, varieties, and landraces to local conditions, to support agrobiodiversity and potentially enhance ecosystem services, including pest and disease suppression, carbon sequestration and soil erosion.	Medium Term	R&D; PP; SE
		EB1.6. Boost the number of pollinating insects on commercial farms by creating specific habitats tailored to local conditions and native insects.	Medium Term	IO; SA; SE
EB2	Enhance climate adaptive capacity in ecosystems and protecting	**EB2.1.** Increasing the scope of ecosystem-based adaptation in protected areas and special conservation areas (e.g., introducing and enhancement of Nature Based Solutions (NBS) through identification and implementation of proper Ecosystem Based Adaptation (EbA) tools especially in Protected Areas buffer zones and special conservation areas (SCAs), etc.).	Short Term	HC; PP, CB

	ecosystem services	**EB2.2.** Promoting ecosystem rehabilitation and restoration and combatting desertification on the margins of existing conservation areas using green infrastructure and community participation (e.g., NGOs and local communities, and private sector) especially in allocating their Corporate Social Responsibility (CSR).	Medium Term	HC; SE; CB
		EB2.3. Enhancing the adaptive capacity of ecosystem services against extreme and long-term climate change impacts (e.g., developing a national plan for mitigating extreme events disasters (e.g., forest fire incidents, and wetlands degradation) can maximize the sustainable use of ecosystem services in key ecosystems and habitats in Jordan).	Medium Term	IO; R&D; CB
		EB2.4. Improving conservation measures for climate threatened species and habitats (e.g., developing recovery and restoration plans for highly threatened ecosystems and species of fauna and flora (including the development of clear ex-situ conservation, captive breeding programs, and restoration of natural habitats programs).	Long Term	IO; IC; ID; PP
		EB2.5. Improving conservation measures against emergence and spread of zoonotic infectious diseases (e.g., mapping and continuous monitoring of all critical habitats that include the presence of species that could act as vectors for zoonotic diseases, in addition to improving habitat connectivity by linking protected areas and special conservation areas through corridors).	Long Term	UP; R&D; CB
		EB2.6. Improving field research and monitoring of ecosystem vulnerability to climate change.	Medium Term	IO; R&D; CB
		EB2.7 Expanding protected areas based on biodiversity hot spots, and ecosystems future dynamics.	Short Term	IO; SE; CB

Where IO is Immediate Opportunity, UP is Urgent Problem, R&D is Research and Development, ID is Infrastructure Development, IC is Institutional Capacity (IC), HC is High Cost, SA is social acceptance, SE is Stakeholder Engagement, PP is Policy Process, and CB is Co-benefits.

Based on above, the following adaptation measures are recommended for implementation[156]:

Programme B1: Increasing the scope of ecosystem-based adaptation and climate-based planning in protected areas and special conservation areas:

This programme aims at introducing and enhancing Nature Based Solutions (NBS) for climate change adaptation and sustainable use of ecosystem services. This would include the identification and implementation of right Ecosystem Based Adaptation (EbA) tools especially in Protected Areas and Special Conservation Areas under adequate management before replicating these solutions in other areas in Jordan. Key measures to be applied under this programme include:

[156] The adaptation measures were obtained from the National Adaptation Plan of Jordan, with some amendments

1. Conducting a comprehensive review of the National Network of Protected Areas. The revision will aim at identifying/validating climate-vulnerable ecosystems, extending conservation efforts in protected areas and designing buffer zones as believed necessary for strengthening the adaptive capacities of key ecological hotspots
2. Identifying and mapping 'climate-vulnerable' species of flora and fauna and their habitat including connections with the need to control invasive species, and create a national plan and monitoring system to support climate vulnerable species
3. Prepare adaptive management programmes for climate sensitive habitats in protected areas and special conservation areas.
4. Protect watersheds and forests to sustain surface water flow and improved groundwater reserves
5. Implement ecosystem-based approaches to adaptation to protect, maintain, and restore degraded habitats with active community

Programme B2: using green infrastructure and community participation for ecosystem rehabilitation and restoration

This programme aims to introduce and implement green infrastructure options for habitat restoration and rehabilitation in climate sensitive areas. Green infrastructure approach is a labor intensive and highly sustainable option that can provide solutions that provide job opportunities while protecting ecosystem services through nature-based solutions. Key measures to be applied under this programme include:

1. Restoration programmes of key sensitive habitats such as forests and coral reefs in the collaboration with NGOs and local communities
2. Strengthen the role of private sector in allocating their Corporate Social Responsibility (CSR) to support green infrastructure measures related to ecosystems and biodiversity adaptation activities
3. Gather, compile, document and analyze the traditional local knowledge on ecosystems and biodiversity in relation to climate forecasting to be used in developing participatory community-based green infrastructure adaptation programmes
4. Develop corridors for species migration and habitat protection; provide buffer zones for adjustment of reserve boundaries

Programme B3: Enhancing the adaptive capacity of ecosystem services against extreme and long-term climate change impacts

This programme aims to maximize the sustainable use of ecosystem services in key ecosystems and habitats in Jordan to enhance their adaptive capacities to climate change impacts. Key measures to be applied under this programme include

1. Develop a national plan for mitigating forests fires incidents including the identification of hazards, training, resources allocation, awareness and knowledge raising and engagement of civil society organizations
2. Protect wetlands and major watershed areas vulnerable to climate change and enhance law enforcement measures
3. Establish protection measures to ensure minimizing extreme events effects on vulnerable ecosystems
4. Conceptual framework combining silvicultural, ecological, and community-based approaches for afforestation & honeybee foraging
5. Maximize forested areas by quickly regenerating any degraded areas

Programme B4: Improving conservation measures and enforcement for climate threatened species and habitats

This programme aims at identifying the key climate sensitive habitats and species in Jordan and developing special conservation measures that take into considerations changes in climate conditions and niches of the different sensitive species to protect them from extinction. Key measures to be applied under this programme include:

1. Update and identify key ecosystems that are highly sensitive to climate change
2. Establish a clear research design to target indicator species of fauna, flora, and ecosystems to better understand the climate effects and apply adaptation measures
3. Develop a recovery and restoration plans for highly threatened ecosystems and species of fauna and flora including the development of clear ex-situ conservation, captive breeding programmes and re-introduction and restoration programmes
4. Strengthen enforcement of planning and biodiversity conservation legal and institutional frameworks, most notably within the Environment Impact Assessment process
5. Mainstream climate change into conserved areas management planning
6. Decreased health and viability of forest ecosystems have occurred, due to cumulative impacts of multiple stressors. These effects can be overcome by:
    - Using forest management as a CO_2 sink
    - Managing tourism, recreation, and grazing impacts
    - Restoring degraded areas to maintain genetic diversity and promote ecosystem health
    - Reducing landscape fragmentation

- Planting seedlings from a range of seed sources, particularly with plants from genetically modified species and identifying more suitable genotypes.
- Avoid practices that generate uniform post-disturbance stands that may be highly vulnerable to future disturbances

Programme B5: Improving conservation measures against emergence and spread of zoonotic infectious diseases as well as Invasive Alien Species

The Covid-19 pandemic has illustrated the high risk of spreading infectious zoonotic diseases from animals to humans through direct interaction under conditions of climate change, increased human settlements and interactions with wild species. This programme aims at anticipating and addressing the serious threat arising from the potential of spreading of zoonotic diseases to human populations due to climate change impacts. Key measures to be applied under this programme include

1. Mapping of all critical habitats that include the presence of species that could act as vectors for zoonotic viral diseases or Invasive Alien Species and apply continuous monitoring of such habitats to minimize the risk of the appearance of more animal-transmitted infectious diseases in the future.
2. Improving habitat connectivity by linking existing protected areas and designing new ones in areas identified as possible animal-/ human interactions.

Programme B6: Improving field research and monitoring of ecosystem vulnerability to climate change

This programme aims at improving the scientific research capacities for observation of ecosystem changes due to climate change and analyzing ecosystem, habitats and species' vulnerability to climate change in Jordan and generating field data as supportive evidence. The measures implemented under this programme will provide adequate information for decision-makers and managers to make the right decisions at the right time. Key measures to be applied under this programme include:

1. Conducting research studies and monitoring programmes on the impacts of climate change on terrestrial and marine ecosystems and biodiversity.
2. Strengthening the current capacities of research institutes for conducting research on climate change impacts on ecosystems and biodiversity in marine and terrestrial parts
3. Establishing a comprehensive programme to monitor climate change impacts on key ecosystems and biodiversity with a focus on using technologies such as GIS
4. Conducting research studies on impact of increased CO2 on natural ecosystems and biodiversity and its effects on biomass production, and invasive alien species
5. Strengthening national research institutions, universities and other NGOs working in the field of ecosystems and biodiversity conservation for facilitation of multidisciplinary research on climate change impacts in this sector
6. Increasing and mobilizing resources available for the implementation, monitoring and enforcement of the NBSAP (National Biodiversity Strategy and Action Plan).

7. Studying the relationship between plants and animals (phenology of the development) both in parasitic and mutualistic relationships with a focus on keystone species
8. Protecting most highly threatened species ex situ
9. Developing a National Learning Program to improve knowledge and support decision-making related to climate change impact on ecosystems and biodiversity

4.7 CCIVA for Marine Biodiversity and Ecosystems Sector

The main climate related hazards to coastal areas in Jordan are represented by increased sea surface temperature, precipitation, and CO_2 concentration in seawater. Extreme rainfall events or droughts in the upstream terrestrial areas will lead to serious run off and flooding events that will affect the coastal areas and marine life of Aqaba. The northern parts of Aqaba are the most vulnerable regions for flashflood hazards, since they are located downstream from areas of major wadis, which discharge water into the Gulf of Aqaba, and will affect areas that hold most of the town residential expansion (See 4.5.4: Flood Risk Assessment in Aqaba Coastal Zone).

The increase in water temperature will increase the ability of certain alien species to be established in the Gulf of Aqaba. 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.

Increased CO_2 fertilization will lead to decreased seawater pH or "increased sea acidification" which will lead to negative impacts, i.e., "bleaching "on coral reefs and other pH sensitive organisms.

The impact of climate hazards on coastal areas could have socioeconomic effects, where any sea level raise or any changes to the sea surface temperature and CO_2 concentration level in the Gulf of Aqaba, could potentially incur property losses, due to the loss of terrain, biodiversity, and ecosystems. It may, therefore, be important to pay attention to the geographical situation of infrastructure, such as hotels and factories, with respect to the Gulf of Aqaba and seashore, as it might be damaged. In addition, other socioeconomic effects might occur such as increased risk of disease, economic losses due to changes in attractiveness for tourism, caused by loss of biodiversity, ecosystem and goods and services, loss of fisheries or changes to their distribution, along the coast of the Gulf of Aqaba.

4.7.1 Climate Exposure Assessment for Marine Environment

The vulnerability assessment was built on the data collected from the Gulf of Aqaba from 2006 until 2020. The data was processed and used to generate parameters per month, depth, and sampling area to quantify the variables for exposure, sensitivity, and adaptive capacity components of Climate Change Vulnerability (CCV).

Exposure was divided into current (historical) exposure to climate change; and predicted future exposure to climate change. Three exposure parameters were tested including marine temperature, pH, and salinity. Data on the historical (current) and future exposure values were analyzed and segregated per month, depth, and sampling areas along the Gulf of Aqaba.

Projection until 2100 has been calculated using multifunction of linear regressions and RCMs with correlations on historical data.

4.7.1.1 Sea Water Temperature

Data on sea temperature in the Gulf of Aqaba were obtained, between 2006 and 2020, from the National Monitoring Program. The information obtained has data on temperature per month and depth, by sampling area. The following is the analysis of the historical data and provides a comparison with the projected data up to 2100. In terms of sea temperature variability per month, the statistical analysis showed an average yearly temperature of 23.17°C, with average monthly data ranging between 21°C reported between February and April and 26°C in August (Figure 4.57). These records are in line with literature, which state that temperature ranges between 20.5°C to 27°C and might reach 31.5°C. **Figure 4-38** illustrates the average monthly temperatures, averaged over the years 2006 to 2020.

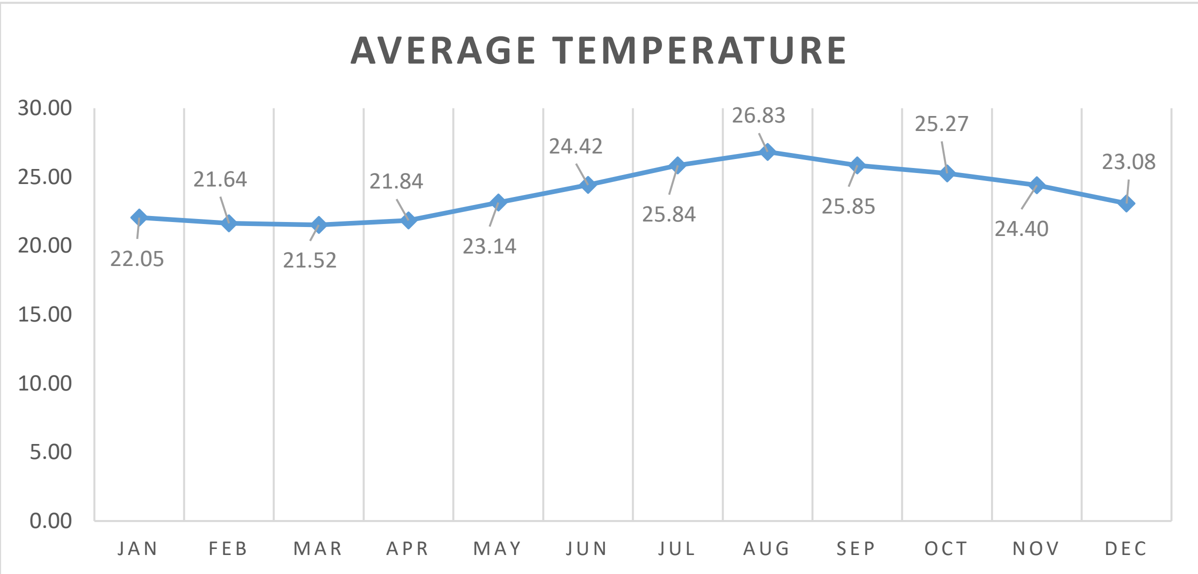


Figure 4.57: Average temperature per month over the period of 2006-2020

The projection of the yearly average temperature until 2100 shows a significant increase in temperature to reach 31.16 ºC. However, this increase is still within the known range of temperature at Aqaba. Accordingly, the projections provide no risks to the Gulf of Aqaba from sea water temperature rise up to 2100.

The sea temperature showed an expected decrease in magnitude with increasing depth. The projection until 2100 showed a significant increase in water temperature at all depths (Figure 4.58). This increase raises concern, especially that the expected rise, which reaches 29.97°C at 125 meter depth, is higher than the rate published in a number of studies, which state that temperature below a depth of approximately 200 m remains at a constant 21.5°C. A study performed in Eilat, showed a positive linear trend in temperature in the upper layer, of 0.02ºC per year based on analysis of historical observations of water temperature, but this trend is not significant at the 95% confidence interval (Gertman and Brenner, 2004). However, they found a significant long-term increase in temperature of about 0.03ºC per year, from 1989, in the lower layer. Temperature changes in the Gulf of Aqaba should be studied further to understand changes over a longer time period.

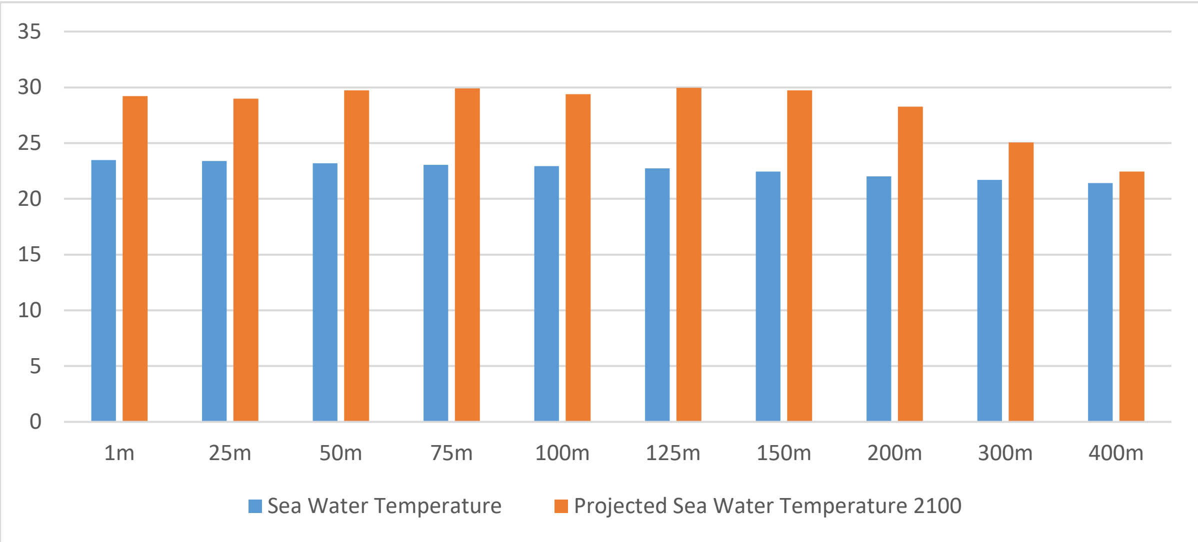


Figure 4.58: Average temperature per month (historical and projected)

Water temperature values were investigated for each sampling site identified in the National Monitoring Program. Sixteen sites were compared, according to the historical data obtained, from 2006-2020, and the projected data up to 2100. Although changes in temperature have been reported from all sites, they are within the known range of temperatures in the Gulf of Aqaba (Figure 4.59).

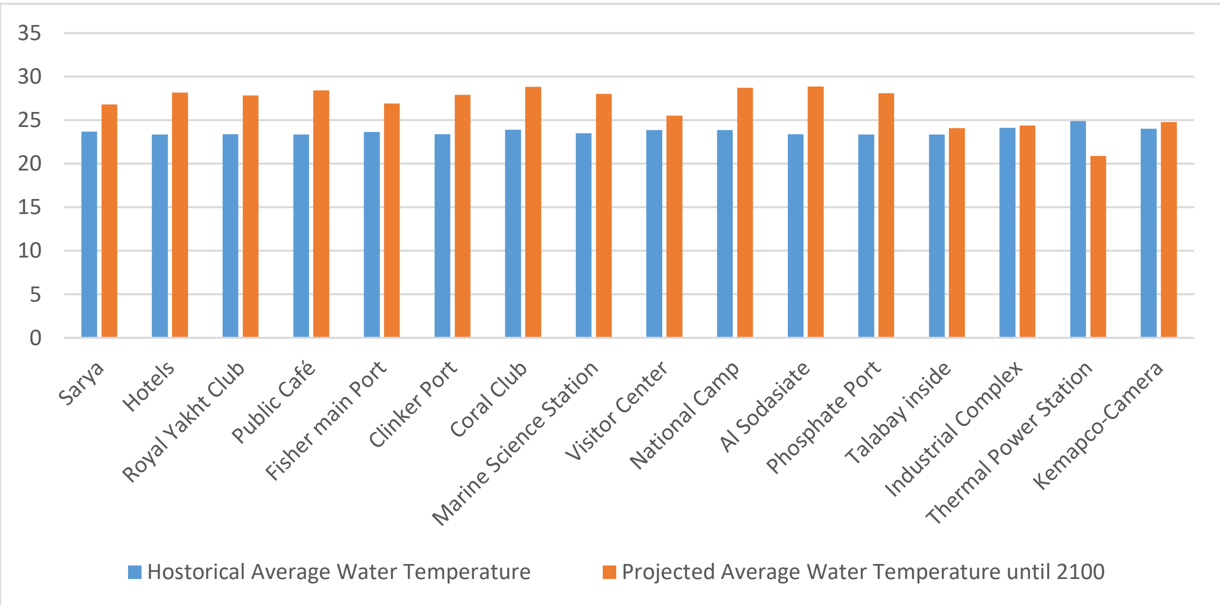


Figure 4.59: Average temperature per sampling area (historical and projected)

4.7.1.2 Sea pH

Data collected over the period 2006 to 2020 showed almost stable results, according to the month, ranging from 8.29 - 8.31 (Figure 4 60). These results are in accordance with the known pH values for the Gulf of Aqaba, that fluctuate around 8.3 with very minor variations (Manasrah et al, 2019).

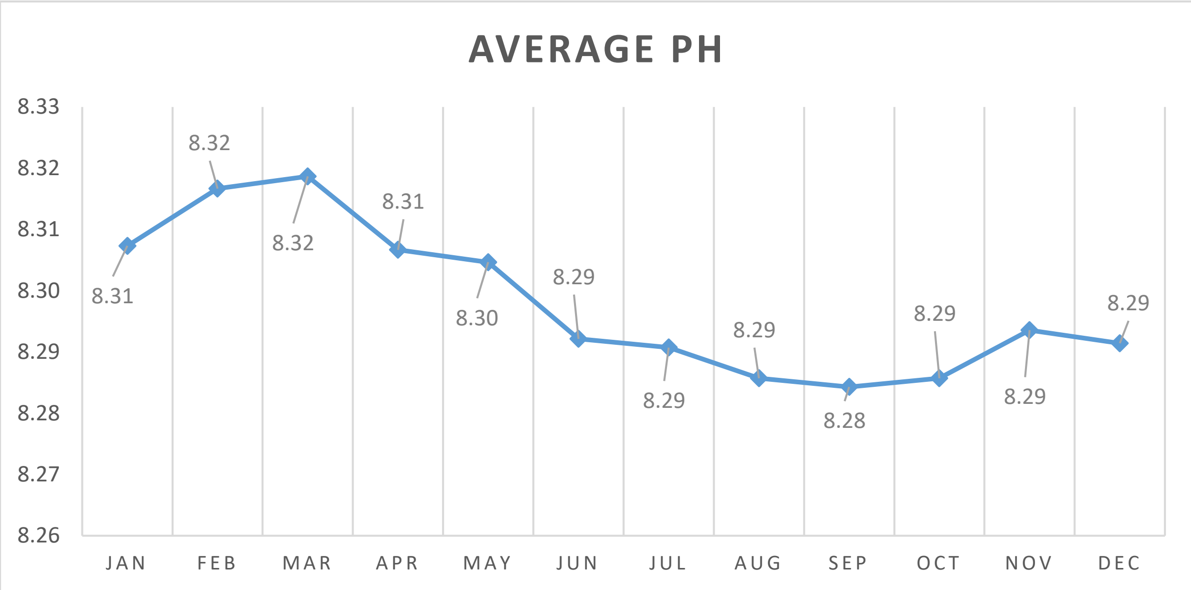


Figure 4 60: Average pH per month over the period of 2006-2020

In terms of sea depth, the pH values projected until 2100 will slightly increase at all depths starting from one meter up to 400 meters. However, they fluctuate around the normal pH value of 8.3 (Figure 4.61).

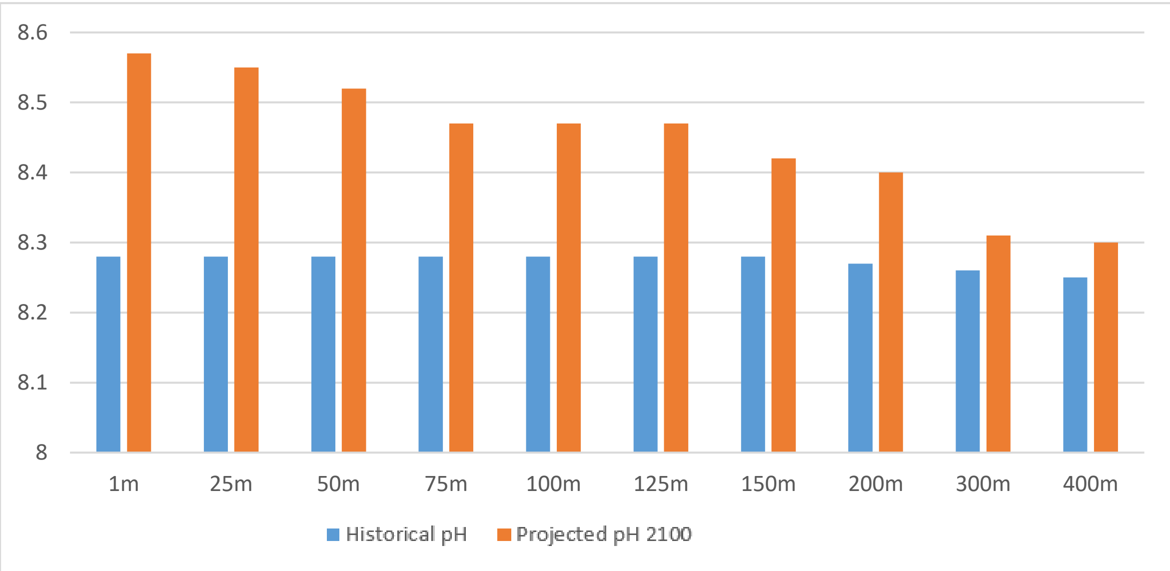


Figure 4.61: Average pH per depth over the period of 2006-2020

The pH values fluctuate around the normal salinity value of the Gulf of Aqaba in all sites except for the coral club and the national camp sites. A significant projected decrease until 2100 was noticed where pH value in 2100 will reach 7.07 at both sites. Change in the pH of seawater can have harmful effects on marine life, impacting chemical communication, reproduction, and growth. Therefore, further investigation is needed from the two areas, with lower pH., in light of the fact, that they are part of the only marine protected area in Jordan (Figure 4.62).

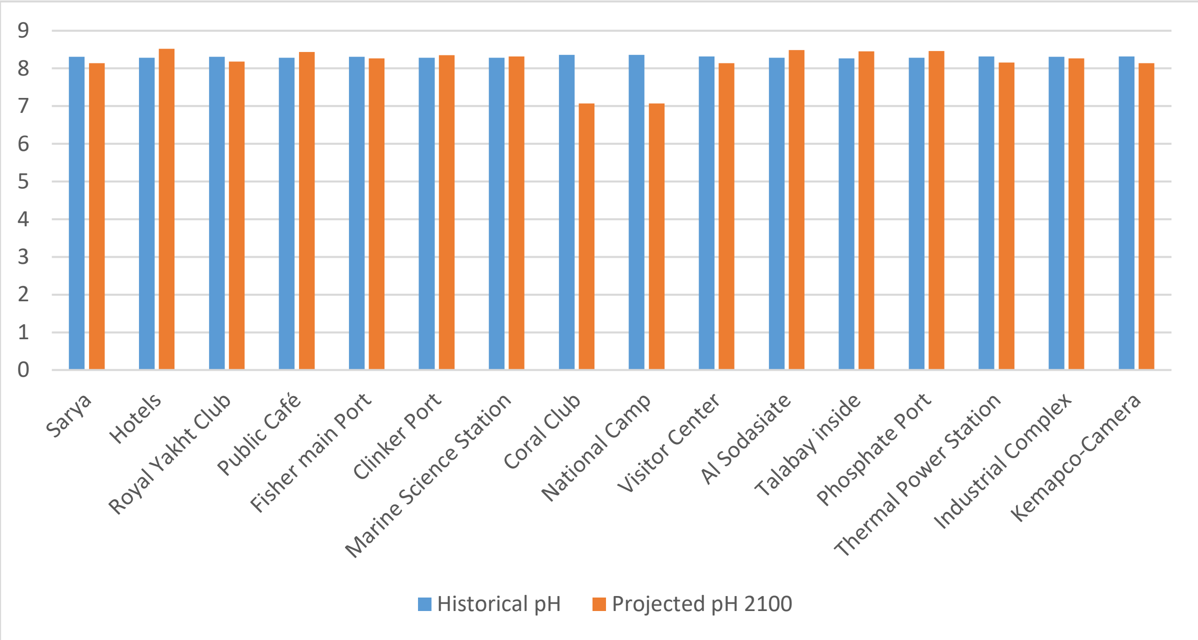


Figure 4.62: Average pH per sampling area over the period of 2006-2020

4.7.1.3 Sea Salinity

Data collected over the period 2006 to 2020 showed almost stable results regarding the monthly values, ranging from 40.54 - 40.65 PSU. These results are in accordance with the salinity range in the Gulf of Aqaba, which ranges from 40.3 to 41.6 PSU (Figure 4.63).

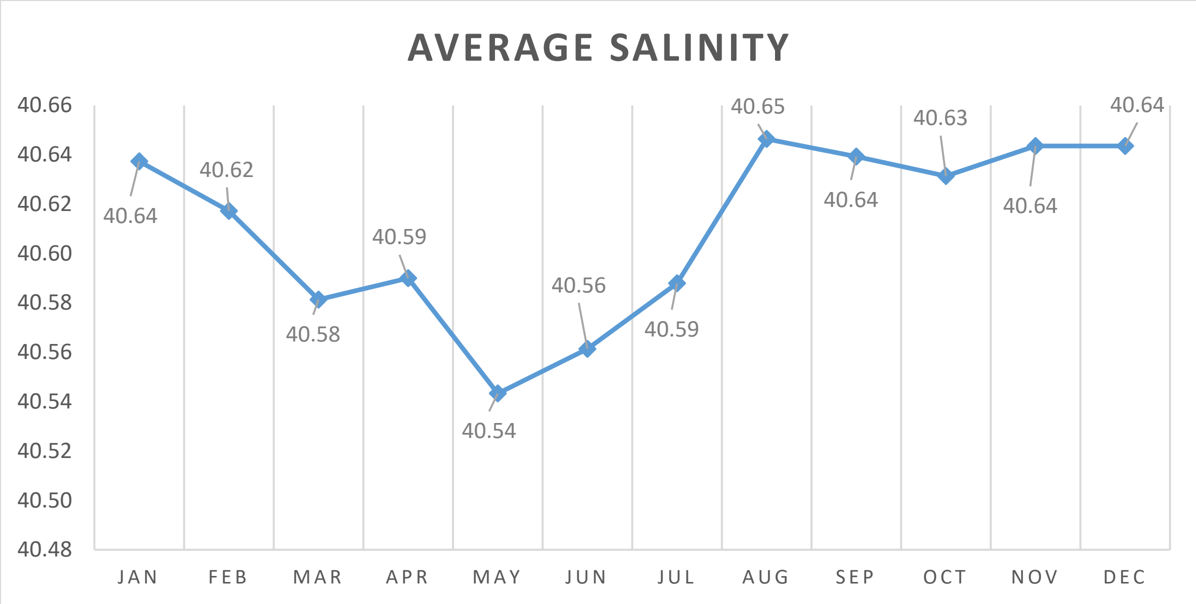


Figure 4.63: Average salinity per month over the period of 2006-2020

The projected salinity values up to 2100 showed a significant decrease in salinity values with sea depth, which ranges from 39.83 to 40.18 PSU. This change although looks limited but it triggers further investigations on the freshwater input and the evaporation rate at the Gulf of Aqaba. In addition, salinity is very low at depth greater than 200m where the projected data showed a range between 40.18 and 40.54 at 200m and 400m respectively compared to homogeneous records at depths greater than 200 at 40.6 PSU (Morcos 1970; Degens & Ross 1969) (Figure 4.64).

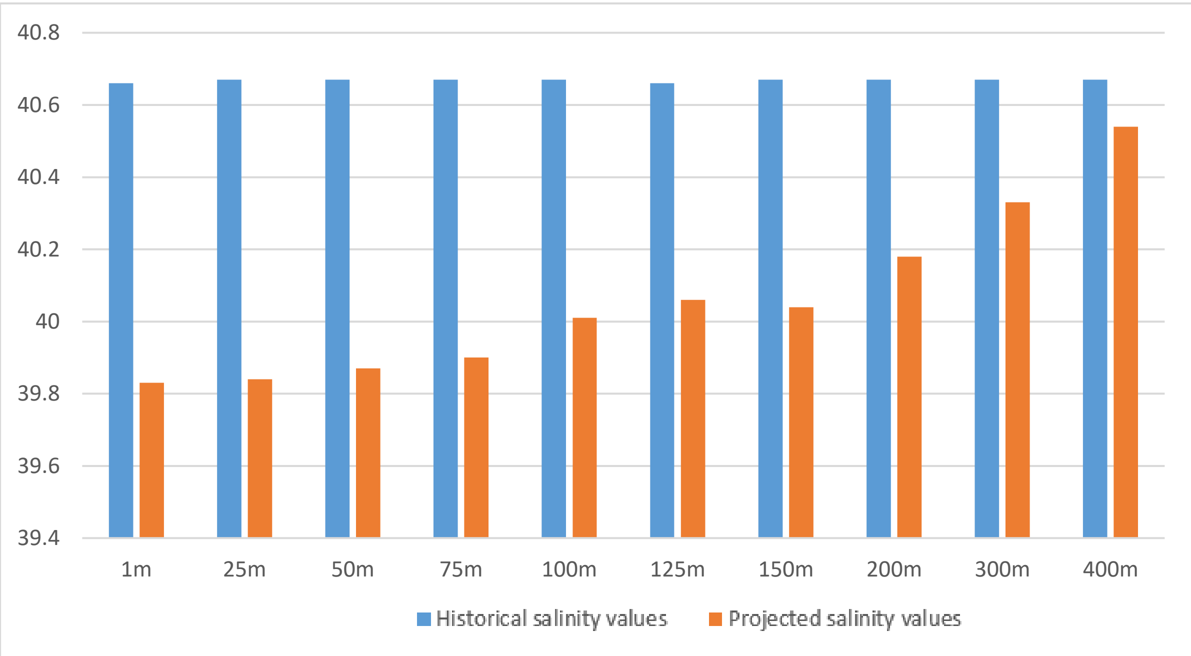


Figure 4.64: Average salinity per depth over the period 2006-2020

In terms of sampling location, the water salinity values fluctuate around the normal values in the Gulf of Aqaba, except for Al Sodasiate, Talabay Inside, and the Phosphate Port that reported projections by 2100, of 39.81, 36.44 and 39.99 respectively. The semi-closed port and its activities may affect salinity. However, further studies are required to understand the existing situation (Figure 4.65).

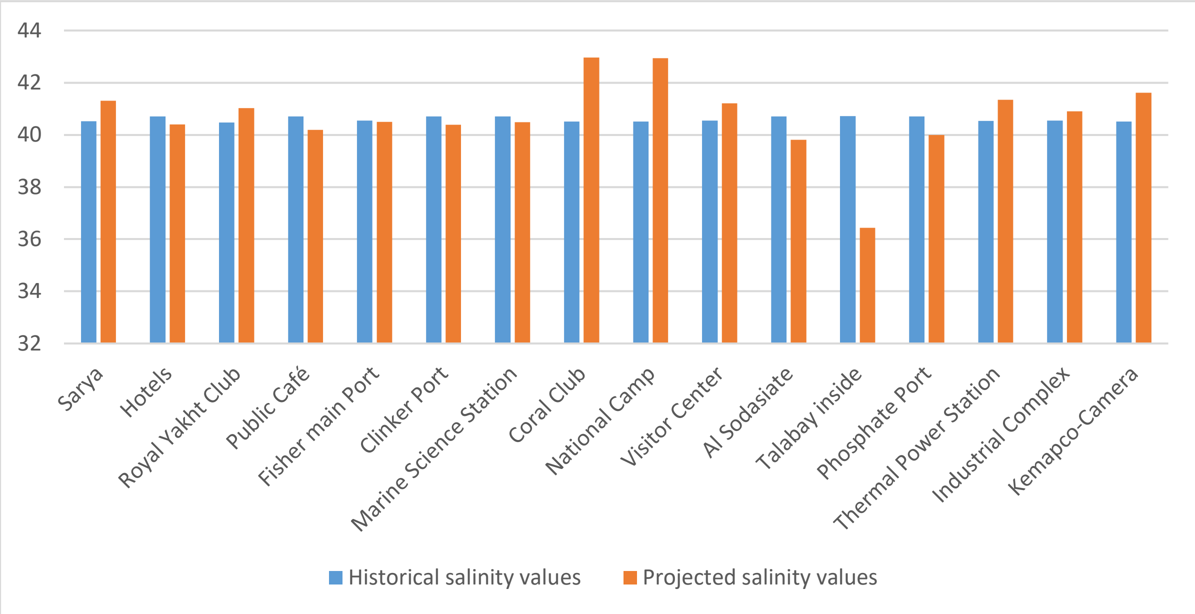


Figure 4.65: Average salinity per sampling area over the period of 2006-2020

Overall, exposure of ecosystems and biodiversity to changes in sea water temperature, pH and salinity is low, and this is unlikely to affect their sustainability.

4.7.2 Assessment of Climate Sensitivity for Marine Environment

Sensitivity to current (historical) and future climate change was quantified in reference to the ecosystems in the Gulf of Aqaba. It was assumed that all ecosystems would be the most sensitive to changes in the climate (as reflected in increasing sea surface temperatures, increase in salinity and pH as marine ecosystems are inherently climate dependent And therefore, the sensitivity will be high.

Table 4.19 shows the results of the scoring for the three selected marine environment parameters.

__Table 4.19: The obtained Sensitivity scoring for the three selected marine environment parameters__

<table>
<tr><th>Exposure indicator</th><th>Sensitivity indicator</th><th>Impact</th><th>Exposure level</th><th>Sensitivity level</th><th>Total impact</th></tr>
<tr><td>Sea temperature</td><td>• Ecosystems and biodiversity
o Threatened species
o Endemic species
o Economic species
o Fisheries
• Extent of occurrence of ecosystems and species
• Disease spread
• Ecosystems phonological traits</td><td rowspan="2">• Increased probability of the invasion of marine alien species
• Coral bleaching in the Gulf of Aqaba
• Alteration of growth rates and other physiological functions of the seagrass meadows
• Decrease in fisheries' production
• Trophic structure and food web
• Effects on tourism
• Increased probability of losing the only protected areas
• Loss of species and chance of exposing several threatened and endemic species to the risk of extinction</td><td>Low (average score = 1.3)</td><td>High (average score = 4)</td><td>Moderate (average score = 2.7)</td></tr>
<tr><td>pH</td><td>• State of the water basin
o Hydro-geological features of the catchment
o Amount of groundwater storage</td><td>Very Low (average Score = 1)</td><td>High (average score = 4)</td><td>Moderate (average score = 2.5)</td></tr>
<tr><td>Salinity</td><td>• Ecosystems and biodiversity
o Seagrasses
o Coral reef
o Fisheries</td><td>• Increased probability of the invasion of marine alien species
• Coral bleaching in the Gulf of Aqaba
• Decrease in fisheries' production
• Trophic structure and food web
• Effects on tourism
• Increased probability of losing protected areas
• Sea level raise</td><td>Very Low (average Score = 1)</td><td>High (average score = 4)</td><td>Moderate (average score = 2.5)</td></tr>
</table>

4.7.3 Assessment of Adaptive Capacity for Marine Environment

The adaptive capacity of marine ecosystems has followed the same criteria, set for the terrestrial ecosystems, where criteria related to asset base, availability of economic resources, technology and innovation, infrastructure availability, institutions established, which are dedicated and actively working on ecosystem conservation and knowledge and information. The adaptive capacity was assessed based on a scoring system of five categories; 1: very low; 2: low; 3: moderate; 4: high; and 5: very high. Based on the scoring system, the adaptive capacity of ecosystems and biodiversity in the Gulf of Aqaba showed low capacity

4.7.4 Overall Climate Change Risk and Opportunities Assessment

Total score for both Impact and Adaptive capacity factors was calculated by averaging the scores of individual indicators under each factor. The impacts were categorized into five themes based on a scoring matrix. **Table 4.20** shows the final vulnerability matrix. The results indicate that the vulnerability of marine ecosystems and biodiversity is moderate. The main threat to these ecosystems is derived from anthropogenic activities. Therefore, continuous efforts must be made to prevent and/ or minimize the anthropogenic threats and halt their risks to ecosystems. The establishment of the Aqaba Marine Reserve is a step in the right direction, to protecting representative ecosystems and the associated species, at Aqaba.

Table 4.20: Overall Vulnerability Matrix for Marine Ecosystem and Biodiversity Sector

			Impact				
		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		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

4.7.5 Climate Change Adaptation Strategies and Measures

The updated Climate Change Policy (2020-2050) proposed a list of adaptations for marine zones (**Table 4.21**). These sets were reviewed and updated based on stakeholder and expert group meetings.

Table 4.21: Proposed Adaptation Measures List for Marine Ecosystem and Biodiversity Sector

COASTAL ZONES (CZ)				
CZ1	Improving the social, natural and economic resilience of coastal areas to climate change impacts	**CZ1.1.** Enhancing the sustainable use of marine protected areas for climate change adaptation (e.g., conducting site-specific research on the carrying capacity for critical and marine protected areas, and modifying management plans to include climate change adaptation measures).	Medium Term	IO; R&D; PP; CB
		CZ1.2. Building on recent scientific findings of distinguished resilience of coral reefs in the Gulf of Aqaba to climate change impacts and enhance scientific research in Aqaba as a global coral reef refuge.	Medium Term	IO; SE
		CZ1.3. Using integrated coastal zone management (ICZM) within the broader ambit of sustainable land use planning for enhancing resilience of marine ecosystems (e.g. enhancing and strengthening awareness programs on climate change impacts on coastal areas, developing vulnerability assessment of ecosystems to extreme events in the Gulf of Aqaba, modifying the climate change requirements in the EIA conditions for coastal development, creating a central database, modifying and enforcing land-use planning to protect marine environments).	Medium Term	IO; IC; SE, PP
		CZ1.4. Enhancing coastal aquaculture as an alternative livelihood to exhausting fishing stocks and developing approaches of integrated seawater culture joining mariculture and agriculture of crops tolerant to salinity (e.g., Sahara Initiative)		
		CZ1.5. Enhancing the culture of light marine transportation: Marine Taxi / Bus along the Jordanian coast at less cost, less energy consumption and less emissions		
		CZ1.6. Improving monitoring capacities for the state of marine ecosystems (e.g., Enhancing current monitoring stations at Aqaba, strengthening the database on coastal areas' ecosystems, habitats and species, strengthening the early warning systems, and monitoring sea level rise along the coast of the Gulf of Aqaba).	Medium Term	IO; IC; PP
AC1	Improving the adaptive capacity of social capital at national and local levels to climate change impacts	**CZ2.1.** Integrating climate resilience in green economic recovery and development plans and initiatives through exploration and innovative financing options for addressing climate adaptation and resilience projects and programmes.	Short Term	IO; SE, PP; CB
		CZ2.2. Enhancing local adaptive capacity to climate change impacts through local climate action plans at municipality and/or district level (i.e., community participatory approach for planning and designing of local climate change adaptation (and mitigation) plans in coordination with local authorities), and through WASH to strengthen social cohesion and trust between community and water utilities in service delivery and community climate adaptation initiatives. Emphasis is placed on the inclusion of vulnerable groups as targets or beneficiaries for climate finance opportunities.	Medium Term	IO; SE, CB
		CZ2.3. Integrating climate adaptation (and mitigation) into national poverty reduction policies through improving the existing social	Medium Term	IO; SE,

		protection system to cope with climate change consequences for the most vulnerable segments of society; adopting poverty alleviation programs providing housing for poor people and supporting micro-projects for poor communities in light of the unusually severe seasonal cold and hot weather conditions that have prevailed in the last decade; and developing emergency relief and aid, etc.		PP; CB

Where IO is Immediate Opportunity, UP is Urgent Problem, R&D is Research and Development, ID is Infrastructure Development, IC is Institutional Capacity (IC), HC is High Cost, SA is social acceptance, SE is Stakeholder Engagement, PP is Policy Process, and CB is Co-benefits.

In addition to the above, it is important to consider the strategic direction of the coastal areas that have been adopted in the National Adaptation Plan and as Sectoral Strategic Objective for improving the social, natural and economic resilience of coastal areas to climate change impacts. The significance of aligning the updated Climate Change Policy (2020-2050) with the strategic directions of the coastal areas that have been adopted in the National Adaptation Plan helps to prioritize the most effective adaptation measures, and avoid duplication of effort, ensuring the efficient use of resources and increasing the chances of success in achieving the goals of protecting coastal communities and ecosystems.

Programme C1: Enhancing the sustainable use of marine protected areas for climate change adaptation

This programme aims at enhancing management structures and objectives of marine protected areas to improve resilience to climate change as an integral component of its management plans. Key measures to be applied under this programme include

1. Conduct site-specific research on the carrying capacity of critical and marine protected areas.
2. Modification of the management plans of the Aqaba Marine Reserve to include climate change adaptation measures.

Programme C2: Support resilience of coral reefs to climate change impacts.

This programme aims at increasing the resilience of coral reef habitats in Aqaba to the observed and potential impacts of climate change including coral bleaching and increasing acidity of marine water. Key measures to be applied under this programme include:

1. Increasing knowledge of factors determining resilience and adaptive capacity of the Reef Ecosystem to climate change.
2. Increase the capacity of managers of the reef ecosystems to maximize reef resilience and adaptive capacity, through application of research outcomes

Programme C3: Use of ICZM for enhancing resilience of marine ecosystems.

This programme aims at improving the use of Integrated Coastal Zone Management (ICZM) as a tool for marine environment protection, as well as increased resilience to climate change impacts in both Aqaba and the Dead Sea. Key measures to be applied under this programme include:

1. Enhancing and strengthening awareness programmes on climate change impacts on coastal areas, and empowering communities to cope with adverse effects of climate change.
2. Identifying vulnerable ecosystems to extreme events in the Gulf of Aqaba, and preparing the necessary response and emergency strategies.
3. Including climate change requirements in the Environmental Impact Assessment conditions for coastal development.
4. Creating a central database that includes potential climate change adaptation strategies, plans, programmes and measures applied, as well as investments made in Aqaba. This database should be freely accessible to the public and interested organizations
5. Avoiding marine pollution from land sources in the Gulf of Aqaba, in order to reduce the stress on coral reefs and make them less vulnerable

Programme C4: Improving monitoring capacities for the state of marine ecosystems:

This programme aims at improving the existing scientific research and management capacities for monitoring of environmental indicators for the health of marine ecosystems, in terms of climate change vulnerability and impacts. Key measures to be applied under this programme include:

1. Enhancing current monitoring stations at Aqaba, by increasing their numbers, by ensuring a continuous flow of information and by adding sea level rise to their parameters.
2. Strengthening the database on coastal areas’ ecosystems, habitats and species.
3. Strengthening early warning systems.
4. Monitoring sea level rise along the coast of the Gulf of Aqaba

4.8 CCIVA for the Socio-economic Sector

4.8.1 Overview

Differences in human vulnerability to environmental hazards result from a range of social, economic, historical, and political factors, all of which operate at multiple scales. While adaptation to climate change has been the dominant focus of policy and research agendas, it is essential to ask as well, why some communities and peoples are disproportionately exposed to and affected by climate threats[157]. Climate change influence on gender and vulnerable groups is linked largely to its socio-economic impacts. Yet in Jordan, the socio-economic impacts of climate change are not well-addressed, by special attention from relevant research and policy-related activities, that are performed locally. For example, very limited analysis has been done on socio-economic issues like the impact of climate change on population, related to poverty, employment, social welfare and gender.

Understanding people's vulnerability to climate change is complex because this depends on both biophysical and socioeconomic drivers of climate change impact, that determine the capacity to cope. Vulnerability is defined in many ways and it has different meanings when used in different disciplines and contexts. The vulnerability of a society to climate disasters such as drought depends on several factors such as population, technology, policy, social behavior, land-use patterns, water use, economic development, and diversity of economic base and cultural composition. Individual (or household) vulnerability is determined by access to resources and the diversity of income sources, as well as by social status of individuals or households within a community. Potential household or individual vulnerability may include: increased cost of living; decreased Purchasing Power Parity (PPP), per capita income; child malnutrition, disorder, disability and morbidity, poverty, household expenses, social welfare, and home devices, air-conditioning etc.). On other hand, communal vulnerability (at national, regional or community level) may include: food security (food availability, local production, distribution, affordability); income distribution; food price instability; malnutrition; poverty; employment; gender inequality; and rural migration (urbanization).

Substantial progress has been made in evaluating the socio-economic consequences of climate change, including changes in variability and extremes. In general, the results show that socio-economic costs will likely escalate as a result of climate change. The effects of climate change and extreme weather events accelerate poverty and food insecurity, while also having a negative effect on overall development efforts. Economic sectors that largely depend on weather conditions – either directly or indirectly – most notably agriculture, are increasingly

[157] THOMAS, K., HARDY, R. D., LAZRUS, H., MENDEZ, M., ORLOVE, B., RIVERA-COLLAZO, I., ROBERTS, J. T., ROCKMAN, M., WARNER, B. P. & WINTHROP, R. 2019b. Explaining differential vulnerability to climate change: A social science review. . WIREs Climate Change., 10, e565.

subject to the impacts of climate change. Moreover, the depletion of natural resources, as a result of increased environmental and demographic pressures, tend to aggravate the severity of climate change impacts. All in all, there are increasing concerns about the rising threats to current income and consumption patterns of households and individuals that earn their livelihoods from these sectors.

Many of the research and assessment activities to date have focused on the development of climate change scenarios, the impact of climate change on the water budget and agricultural aspects, without taking fully into account the socioeconomic aspects of vulnerability, that inherently change with time and as a result of policies implemented. There are gaps in methodological and evidence with regard to the down-scaled assessment of the impacts at the household level and community level. These constraints limit our understanding of the channels through which climate-related changes and extreme events affect vulnerable households. This lack of understanding further reduces our ability to design and implement effective policy measures aimed at assisting at-risk households to either prevent or mitigate negative impacts of future shocks or implement other risk management strategies, such as adapting their livelihoods, or responding appropriately to the burden of future shocks.

The following sections aim to present the interrelationship between climate change and social vulnerability in Jordan, focusing particularly on changes in precipitation (drought), increase of temperature and heatwaves, indicated by change in wind speed. A range of multi-sectoral and composite indicator indices using GIS-based mapping at sub-district level were used to determine hotspots of both climate change and social vulnerability, by ensuring that climate risk analyses assign greater weight to social indicators. This report contributes to a better understanding of the degree to which socially vulnerable populations may be more exposed to the highest impacts of climate change. Geo-referenced data on population, poverty, land-use types, hazards, and climate change scenario outputs, can help us in our understanding of climate change impacts and vulnerability, and in turn inform where adaptation may be required.

4.8.2 Selection of Socio-economic Vulnerability Indicators

Social vulnerability to climate change is increasingly being acknowledged by researchers (Nguyen et al., 2017), and proposals to measure and manage it are emerging. Studies on social vulnerability and climate change suggest a variety of indicators and proxies to measure social vulnerability, that consider multi-sectoral indicator sets, including the so-called Social Vulnerability Index (SVI), as a multidimensional scale dependent for quantifying the relative socio-economic and demographic quality of a place as a means of understanding vulnerability (AWC and WFP, 2022). The target is to identify factors within three components of an SVI in Jordan. To achieve this goal, a combination of techniques, including a literature review and focus group discussions, were used to identify factors in the three components: exposure, sensitivity and adaptive capacity.

For this study on climate change and livelihood vulnerability, a composite index was developed, comprised of the following indicators: socio-demographic profile, livelihood strategies, social networks, health, food, water, natural disasters, and climate variability. Gender is another indicator that plays an important role in determining the social vulnerability (but also the resilience and adaptive capacity) of communities.

The classified vulnerability indicators, as socioeconomic indicators and political indicators are shown in (**Table 4.22**). After applying a five-class evaluation scheme, the most positive conditions, represented by the lowest class and the most negative represented by the highest class, were identified.

The socioeconomic variables were collected at sub-district level from the official sources, and then converted to a composite index. The composite indicator (also called index) is evaluated by combining several (weighted) individual sub-indicators and socioeconomic variables. Composite indicators are able to measure multi-dimensional concepts (exposure, sensitivity, adaptive capacity and vulnerability, against climate change effects) which cannot be captured by a single indicator. Equation No (1) was used to derive a composite index for vulnerability, and equation No (2) was used to derive the Climate Risk Index, by sub-district.

Table 4.22: Socioeconomic indicators used to assess socioeconomic vulnerability at sub-district level

Indicators	Sub-Indicators	Variables
Poverty	Poverty Ratio	Poverty [2010],
		Poverty [2017}
	Food and non-Food Expenditure	Food Expenditure, 2017
		Non-Food Expenditure, 2017
		Total Expenditure, 2017
Vulnerable group	Poverty 2017	Poverty Rate 2017 (%)
		Poverty Gap Ratio
		Poverty line 2017
	Age <15 & >65 years	Vulnerable Age
		Dependency rates 2015
		Net migration 2015
Income	Income Level, Source of income	Incomes from Own Private Work
		Income from Employment
		Transactions Incomes
		Property Incomes
		Rentals Incomes
		Average Total Income
	Variance of Income	Variance of Income
Employment	Unemployment rate	Unemployment Percent Male, Normalize Male
		Unemployment Percent Female, Normalize Female
	Unemployment rate 2021	Unemployment Percent Male, 2021
		Unemployment Percent Female, 2021
	Unemployment - Female headed household	Unemployment Percent Female 2020
		Unemployment Percent Female headed household 2020
Total Agricultural Labor	Total Agricultural Labor	Total Agricultural Labor
		Jordanian Agricultural Labor
		Non-Jordanian Agricultural Labor
		Agricultural Female Labor
		Agricultural Male Labor
	Horticulture Labor	Total Horticulture Labor
		Jordanian Horticulture Labor
		Non-Jordanian Horticulture Labor
		Horticulture Female Labor
		Horticulture Male Labor
	Livestock Labor	Total Livestock Labor
		Jordanian Agricultural Labor
		Non-Jordanian Agricultural Labor
		Agricultural Female Labor
		Agricultural Male Labor
Health	Disability Indicators	Percentage of prevalence of disability
		Percentage of the Disabled, without health insurance status
		Prevalence of disability (Illiteracy) by educational level
		Percentage Disability unemployment (persons seeking work)
		Percent of Individuals with difficulties
Irrigated and Rainfed Areas	Areas	Sum of Total Area
		Sum of Rainfed Area
		Sum of Irrigated Areas

	Irrigation Technology	Sum of irrigated areas using Surface irrigation
		Sum of irrigated areas using Drip irrigation
		Sum of irrigated areas using Sprinkler irrigation
		Sum of Areas of Protected agriculture PH
Child Mortality	Child Mortality Rate	Mortality under 5 Years
		Child Mortality of below 2 years
		New Born Mortality
Population	Population characteristics	Population 2018
		Household size
		No of Household
		Female
		Male
		Female To Male Ratio
		Total Population [DOS 2019]
		Syrian Population (DOS 2019)
		Percent of Syrian Refugee
Food Security	Food Security 2020	Food insecure
		Vulnerable to Food Security
		Used Mechanism to adopt food
		Receive Food Help
Coverage of Health Insurance	Percent of non-Insurance	Percent Non-Health Insured of Total Jordanian
		Percent Non-Health Insured of Total Non-Jordanian
Household Endowments	Household Socioeconomic indicators	Household Size
		No of Household
		Average Areas of House
		Rented House- House ownership
		Source of Drinking water (tankers, water harvesting, wells, spring) not network, bottled or filters
		Source of Heating (wood, Jift, etc.)
		Existence of Cesspit waste disposal,
		Average room numbers
		Average household expenditure
		Average household income
		Female head of household
		Marriage status of household head
		Educational level of household head, illiterate
		Household head not working
		Farming job of Household Head
		Percentage of Main Source of Heating Wood/ Charcoal/ Jift

Multiple data sources were used to collect the sub-component of social indicators: DOS data based on the Agricultural Census and the -was used. All social data was drawn from the Department of Statistics. Water related information was provided by MWI. This analysis relied on nationally representative surveys conducted by the government and other agencies: Department of Statistics (DOS), (a) Household Expenditure and Income Survey (2017-2018), (B) Demographic and Health Survey (2017-2018), (C) Final Results of Agricultural Census, and (D) Employment and Compensation of Employees.

A composite socio-economic indicator was derived using a normalization[158] scheme, as presented in Equation (7), followed by an aggregation process[159] [160].

$$\text{Indicator Score (X normalized)} = \frac{(\text{X indicator value} - \text{X minimum value})}{(\text{X maximum value} - \text{X minimum value})} \qquad \text{Eqn. (7)}$$

4.8.3 Assessment of Socio-economic Exposure

Socio-economic exposure refers to the "physical presence of people, livelihoods, infrastructure or other assets in places that could be adversely affected by hazards"[161]. Climate change hazard can affect environmental functions, services and resources, as well as economic, social and cultural assets. Typical socioeconomic exposure factors include population density, household characteristics, percent of refugees in the community, horticultural production system, i.e., irrigated and rainfed agriculture, and irrigation water livestock production system. All of these indicators are expected to influence exposure to climate change.

Table 4.23 show the detailed list of exposure indicators and their weight, used to aggregate into one index for climate change exposure. All of the exposure indicators were normalized and multiplied by assigned weight, to derive the overall exposure index.

[158] the term 'normalization' refers to the transformation of indicator values measured on different scales and in different units into unit-less values on a common scale.
[159] Aggregation: is the process of combining different data from different measurements into a composite indicator. The process of aggregation requires the normalization and (if applicable) weighing of the data to avoid distortion effects when aggregating the several factors.
[160] FRITZSCHE, K., SCHNEIDERBAUER, S., BUBECK, P., KIENBERGER, S., BUTH, M., ZEBISCH, M. & KAHLENBORN, W. 2014. The Vulnerability Sourcebook: Concept and guidelines for standardised vulnerability assessments.
[161] GERLAK, A. K. & GREENE, C. J. C. C. 2019. Interrogating vulnerability in the global framework for climate services. 157**,** 99-114.

Table 4.23: List of Socioeconomic exposure indicators

Sub-indicators	Unit	Weight	Source	Reference Date	Resolution
Population Density, Normalize	Persons per km^2	0.1	DOS	2019	sub-district
Household size	Persons per household	0.05	DOS	2019	sub-district
No of Household	households per sub-district	0.05	DOS	2019	sub-district
Female To Male Ratio	Ratio of female to male	0.05	DOS	2019	sub-district
Total Population	Persons	0.05	DOS	2019	sub-district
Syrian Population	Persons	0.05	DOS	2019	sub-district
Percent of Syrian Refugee	Percent of Syrian to Total Population	0.1	DOS	2019	sub-district
Total Cultivated Areas	dunum	0.05	DOS	2019	sub-district
Rainfed Agricultural Areas	dunum	0.1	DOS	2019	sub-district
Rainfed Olive Trees	dunum	0.05	DOS	2019	sub-district
Rainfed Wheat Areas	dunum	0.05	DOS	2019	sub-district
Rainfed Barley Areas	dunum	0.05	DOS	2019	sub-district
Livestock population	head	0.05	DOS	2021	sub-district
Number of Livestock Breeders	Persons	0.1	DOS	2019	sub-district
No. of Sheep	head	0.025	DOS	2019	sub-district
No. of Goats	head	0.025	DOS	2019	sub-district
Small Ruminant Population	head	0.05	DOS	2019	sub-district

The highest exposed districts and sub-districts to climate change are Irbid Qasabah District, Ramtha District, Badia Sh.Gh. Sub-District, Karak Qasabah District, Jizah Sub-District and Quaismeh District as shown in (**Table 4.24**), where the lowest sub-district exposed to climate change are Mahes & Fuhais District, Aqaba Sub-District illustrated in (**Table 4.25**).

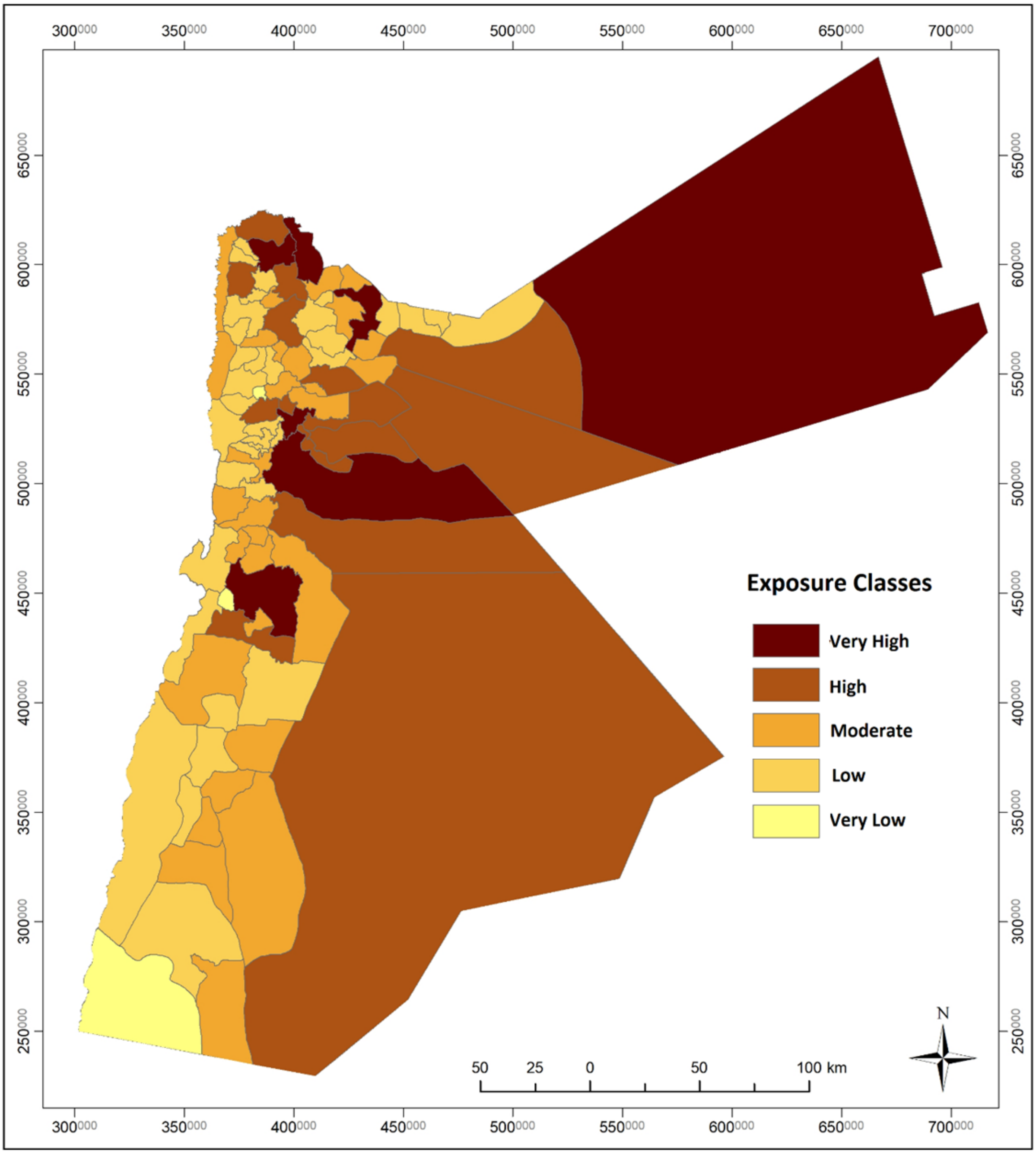


Figure 4.66: Overall Socioeconomic Exposure Map

Table 4.24: Top Ten sub-districts Most Exposed to climate change

no	Sub-District	Normalize Exposure	Classification
1	Irbid Qasabah District	1.000	Very High Exposure
1	Ramtha District	0.942	Very High Exposure
3	Badia Sh. Gh. Sub-District	0.863	Very High Exposure
4	Karak Qasabah District	0.856	Very High Exposure
5	Jizah Sub-District	0.835	Very High Exposure
6	Quaismeh District	0.822	Very High Exposure
7	Rwaished District	0.752	High Exposure
8	Muaqqar Sub-District	0.664	High Exposure
9	Salhiya Sub-District	0.649	High Exposure
10	Sahab District	0.633	High Exposure

Table 4.25: Top Ten sub-districts Least Exposed to climate change

no	Sub-District	Normalize Exposure	Classification
1	Na'oor Sub-District	0.166	Very Low Exposure
1	Jrainah Sub-District	0.163	Very Low Exposure
3	Um-Elqotain Sub-District	0.159	Very Low Exposure
4	Wadi Araba Sub-District	0.155	Very Low Exposure
5	Alan & Zayy Sub-District	0.148	Very Low Exposure
6	Hosba'n Sub-District	0.146	Very Low Exposure
7	Um Elbasatien Sub-District	0.144	Very Low Exposure
8	Ayy Qasabah District	0.088	Very Low Exposure
9	Mahes & Fuhais District	0.007	Very Low Exposure
10	Aqaba Sub-District	0.000	Very Low Exposure

4.8.4 Assessment of Socio-economic Sensitivity Composite Index

Poverty in Jordan is more pronounced in rural areas than in urban areas, and about 9% of Jordanians live in rural areas. The cited poverty rate was 15.7% for 2019[162] and the unemployment rate was 23.3%, as reported by DOS in 2021[163]. However, according to the World Bank (2020), approximately 19% of the rural population are classified as poor. Urban areas are also increasingly struggling with poverty, particularly neighborhoods hosting large numbers of refugees. Poverty issues are also present in Jordan's refugee camps. Because of the arid conditions and lack of water for irrigation, many of the rural poor cannot grow enough

[162] AWC & WFP 2022. Climate Change and Social Vulnerability: Using Multi-Sectoral Indicators to Assess Compound Drought Risk and Social Vulnerability in Jordan. . In: COUNCIL, A. W. & PROGRAMME, W. F. (eds.). A Publication of the SDG-Climate Facility. Cairo.

[163] http://dosweb.dos.gov.jo/ar/

crops to feed themselves and their families. People who find other ways to supplement their incomes generally earn very little.

Women have a workload varying from planting, harvesting, and dealing with agriculture issues and tools, to food processing. Rural women help in securing food for their families - they manage home gardens to produce vegetables for family use and medical herbs. UN-Women (2017) report noted that women in rural areas are more vulnerable to the effects of climate change, particularly because women constitute the majority of the poor and are dependent for their livelihoods on natural resource. In Jordan, almost 9.1% of female-headed households are food insecure or vulnerable to food security, compared to 5.7% of male-headed families.

The main sensitivity indicators include poverty sub-indicators, such as unemployment, gender, health, household characteristics, income, literacy, ages, inequality in receiving public services, water, agricultural production systems i.e., the areas of rainfed and irrigated crops, livestock numbers, agroforestry and rangeland areas. The proposed weight of each sub-indicators used to derive the normalized sensitivity index is presented in **Table 4.26**.

Table 4.26: List of Socioeconomic sensitivity indicators

	SENSITIVITY	Unit	WEIGHT	SOURCE	REFERENCE DATE	RESOLUTION
1	Prevalence of Poverty	Percent	0.05	DOS	2017	sub-district
2	Prevalence of Poverty Gap	Percent	0.05	DOS	2017	sub-district
3	Prevalence of Poverty line	Percent	0.05	DOS	2017	sub-district
4	Prevalence of Illness and Disability	Percent	0.1	DOS	2017	sub-district
5	Prevalence of Unemployment	Percent	0.1	DOS	2017-2020	sub-district
	A- Unemployment Percent Male, Normalized Males	Percent		DOS	2017-2020	sub-district
	B- Unemployment Percent Female, Normalized Females	Percent		DOS	2017-2020	sub-district
	C- Unemployment Percent Male, Normalized Males, 2021	Percent		DOS	2017-2020	sub-district
	D- Unemployment Percent Female, Normalized Females, 2021	Percent		DOS	2017-2020	sub-district
	E- Unemployment Percent Females, 2020	Percent		DOS	2017-2020	sub-district
	F- Unemployment Percent Female-headed households 2020	Percent		DOS	2017-2020	sub-district

6	Prevalence of Child Mortality	Percent	0.05	DOS	2017	sub-district
	A- Mortality under 5 Years	Percent		DOS	2017	sub-district
	B- Child Mortality below 2 years	Percent		DOS	2017	sub-district
	C- New-Born Mortality	Percent		DOS	2017	sub-district
7	Prevalence of Dependency Rates	Percent	0.05	DOS	2017-2020	sub-district
8	Prevalence of Female-Headed Households	Percent	0.05	DOS	2017-2020	sub-district
9	Prevalence of Vulnerable Age <15 & >65	Percent	0.05	DOS	2017-2020	sub-district
	Vulnerable Age Less than 15 Years	Percent		DOS	2017	sub-district
	Vulnerable Age, 65+	Percent		DOS	2017	sub-district
10	Food Insecurity, Composite (a-d) Normalized	Percent	0.1	DOS	2017	sub-district
	A- Food insecure	Percent		DOS	2017-2020	sub-district
	B- Vulnerable to Food insecurity	Percent		DOS	2017-2020	sub-district
	C Use of Mechanism to adapt to food scarcity	Percent		DOS	2017-2020	sub-district
	D- Receive Food aid/ Help	Percent		DOS	2017-2020	sub-district
11	Prevalence of Unimproved Source of Drinking Water	Percent	0.05	DOS	2018	sub-district
12	Primitive Type of Heating System	No.	0.05	DOS	2017	sub-district
13	Avg. Consumption of water, 2018, per capita per day (LCD)	L/C/D	0.05	MWI	2018	sub-district
14	Imported water,2018	M3	0.05	MWI	2018	sub-district
15	Total Water Demand	M3	0.05	MWI	2018-2020	sub-district
16	Agricultural Labor	Number	0.05	DOS	2017	sub-district
	A- Total Horticulture Labor	Number		DOS	2017	sub-district
	B- Total Livestock Labor	Number		DOS	2017	sub-district
17	Livestock Mortality	Percent	0.05	DOS	2010-2019	sub-district
	a Sheep Mortality	Percent		DOS	2010-2020	sub-district
	b Goat Mortality	Percent		DOS	2010-2021	sub-district

The results show that the sub-districts in the Central Governorate (Amman, Madaba, Balqa) and Karak in the south are the most sensitive to climate change, as shown in (**Table 4.27**). The overall socioeconomic sensitivity map is displayed in (**Figure 4.67**).

Table 4.27: List of the most Highly Sensitive sub-districts

loc_Nr	Governorate	District	Sub-District	Sensitivity	Classification
62	Ajlun Governorate	Ajlun Qasabah District	Sakhrah Sub-District	1	Very Highly Sensitive
63	Ajlun Governorate	Ajlun Qasabah District	Orjan Sub-District	0.91	Very Highly Sensitive
61	Ajlun Governorate	Ajlun Qasabah District	Ajlun Sub-District	0.83	Very Highly Sensitive
48	Mafraq Governorate	Badia Shamaliyah District	Salhiya Sub-District	0.82	Very Highly Sensitive
58	Jerash Governorate	Jerash Qasabah District	Jerash Sub-District	0.78	Very Highly Sensitive
41	Irbid Governorate	Mazar Shamali District	Mazar Shamali District	0.78	Very Highly Sensitive
60	Jerash Governorate	Jerash Qasabah District	Borma Sub-District	0.778	Very Highly Sensitive
59	Jerash Governorate	Jerash Qasabah District	Mestabah Sub-District	0.74	Very Highly Sensitive
35	Irbid Governorate	Irbid Qasabah District	Irbid Qasabah District	0.73	Very Highly Sensitive
64	Ajlun Governorate	Kufranjah District	Kufranjah District	0.72	Very Highly Sensitive
81	Ma'an Governorate	Ma'an Qasabah District	Mraighah Sub-District	0.72	Very Highly Sensitive
57	Mafraq Governorate	Rwaished District	Rwaished District	0.71	Very Highly Sensitive
22	Zarqa Governorate	Zarqa Qasabah District	Zarqa Sub-District	0.70	Very Highly Sensitive
51	Mafraq Governorate	Badia Shamaliyah District	Dair Al Kahf Sub-District	0.70	Very Highly Sensitive
38	Irbid Governorate	Bani Kenanah District	Bani Kenanah District	0.70	Very Highly Sensitive
39	Irbid Governorate	Aghwar Shamaliyah District	Aghwar Shamaliyah District	0.70	Very Highly Sensitive

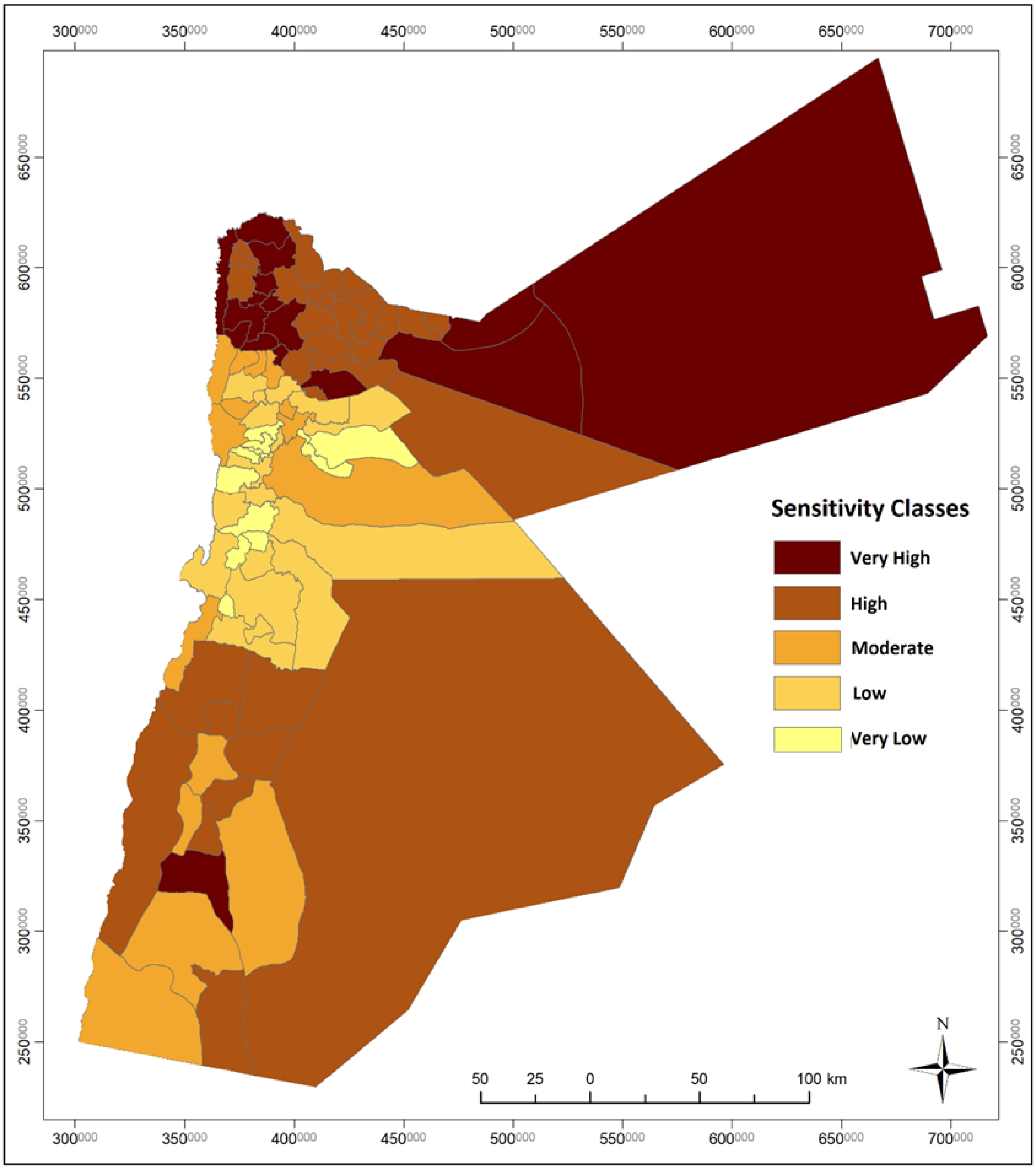


Figure 4.67: Overall Socioeconomic Sensitivity Map

4.8.5 Socio-economic Adaptive Capacity Index

Climate change effects arrive on an already complex social landscape, populated by groups with different access to resources. Access to resources or, the ability to derive benefits from natural and human resources influences vulnerability, by augmenting or reducing exposure, sensitivity, and adaptive capacity. Relevant resources comprise tangible and intangible, and private and public goods. These include private capital, liquid assets, alternative housing, insurance, food stores, migration support, durable infrastructure, transportation, and information and communication networks[164].

The socio-economic adaptive capacity refers to the ability of a system (in various socio-economic, structural, institutional and technological abilities of a human system) to produce adaptation measures 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[165]. However, the availability of these resources in any one place does not necessarily mean that people have access to them, or that they may be utilized to reduce vulnerability[166]. Access to these resources entails complicated social relationships and power structures, many of which marginalized and poor populations struggle to navigate[167].

The main indicators for adaptive capacity indicators included education level, level of income, varied sources of income, employment, receipt of governmental services, ownership of household assets, food and non-food expenditure, water and wastewater systems, agricultural production system, available ground and surface water resources, the possible expansion in surface water development and the treated wastewater resources.

The socioeconomic indicators for adaptive capacity are illustrated in **Table 4.28**. The calculated adaptive capacity indicators show that the sub-districts of Orjan, Sakhrah, Rwaished, Bsaira, Borma, Faqo'e, Mraighah, Kufranjah, Qatraneh, Wadi Araba, Hasa District and Mestabah are characterized by the lowest adaptive capacity as shown in (**Table 4.29**). The geo-spatial distribution of the adaptive capacity is shown in (**Figure 4.68**) at sub-district level. From a policy perspective, these maps generate an important insight into where there is a need for additional policy intervention to lower sensitivity and boost adaptive capacity.

[164] THOMAS, K., HARDY, R. D., LAZRUS, H., MENDEZ, M., ORLOVE, B., RIVERA-COLLAZO, I., ROBERTS, J. T., ROCKMAN, M., WARNER, B. P. & WINTHROP, R. 2019a. Explaining differential vulnerability to climate change: A social science review. WIREs Climate Change, 10, e565.

[165] PARRY, M. L., CANZIANI, O., PALUTIKOF, J., VAN DER LINDEN, P. & HANSON, C. 2007. Climate change 2007-impacts, adaptation and vulnerability: Working group II contribution to the fourth assessment report of the IPCC, Cambridge University Press.

[166] EPA 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. US.: Environmental Protection Agency, EPA 430-R-21-003.

[167] ADGER, W. N., BARNETT, J., BROWN, K., MARSHALL, N. & O'BRIEN, K. J. N. C. C. 2013. Cultural dimensions of climate change impacts and adaptation. 3, 112-117.

Table 4.28: List of socio-economic adaptive capacity indicators

	Socioeconomic Adaptive Capacity to Climate Change	Unit	WEIGHT	SOURCE	REFERENCE DATE	RESOLUTION
1	Educational Level of Household Head	Years of Education	0.05	DOS	2018	Sub-District
2	Level of Income	JD/ household	0.1	DOS	2017	Sub-District
3	Varied sources of Income, (composite).	JD/ household	0.05	DOS	2017	Sub-District
	A Income from Own Private Work	JD/ household		DOS	2017	Sub-District
	B Income from Employment	JD/ household		DOS	2017	Sub-District
	C Transaction Incomes	JD/ household		DOS	2017	Sub-District
	D Property Incomes	JD/ household		DOS	2017	Sub-District
	E Income from rent	JD/ household		DOS	2017	Sub-District
	F Average Total Income	JD/ household		DOS	2017	Sub-District
4	Household Asset Ownership	Ownership of Household Assets	0.1	DOS	2017	Sub-District
5	Prevalence of Health Insurance, Jordanian	Yes, insured	0.030	DOS	2017	Sub-District
6	Prevalence of Health Insurance, Non-Jordanian	Yes, insured	0.020	DOS	2017	Sub-District
7	Household Food Expenditure	JD per household	0.03	DOS	2017	Sub-District
8	Household Non-Food Expenditure	JD per Household	0.02	DOS	2017	Sub-District
9	Total Household Expenditure	JD per Household	0.05	DOS	2017	Sub-District
10	Migration	No. leaving	0.05	DOS	2017	Sub-District
11	Access to Water for Household (Composite Indicator)	Household use of improved water sources	0.05	MWI	2017	Sub-District
12	Per Capita Water Supply	(l/c/d)	0.05	MWI	2018	Sub-District
13	Percentage of Population connected to Sewer System	Percent of Sewer Connections	0.05	MWI	2020	Sub-District
14	Total Number of Groundwater Wells	Number Count	0.025	MWI	2020	Sub-District
15	Total Water Wells Abstraction in m^3	m^3	0.025	MWI	2020	Sub-District
16	Number of Active Water Springs	Number Count	0.025	MWI	2020	Sub-District
17	Exported water [2018] to other sub-districts	m^3	0.025	MWI	2018	Sub-District
18	Water network Subscribers 2018	No of subscribers	0.05	MWI	2020	Sub-District
19	Total Irrigated Areas	Dunum	0.05	DOS	2017	Sub-District
20	Total Areas with Drip Irrigation	Dunum	0.05	DOS	2017	Sub-District
21	Total Areas with Drip Plastic Houses	Dunum	0.05	DOS	2017	Sub-District

Source: Compiled and aggregated by consultant

Table 4.29: List of the lowest adaptive capacity sub-districts

ID	Gov	District	Sub-District	Adaptive Capacity Score	Classification
63	Ajlun	Ajlun Qasabah	Orjan	0.000	Very Low Adaptive Capacity
62	Ajlun	Ajlun Qasabah	Sakhrah	0.033	Very Low Adaptive Capacity
57	Mafraq	Rwaished	Rwaished District	0.088	Very Low Adaptive Capacity
76	Tafiela	Bsaira	Bsaira District	0.108	Very Low Adaptive Capacity
60	Jerash	Jerash Qasabah	Borma	0.122	Very Low Adaptive Capacity
73	Karak	Faqo'e	Faqo'e District	0.126	Very Low Adaptive Capacity
81	Ma'an	Ma'an Qasabah	Mraighah	0.133	Very Low Adaptive Capacity
64	Ajlun	Kufranjah	Kufranjah District	0.133	Very Low Adaptive Capacity
74	Karak	Qatraneh	Qatraneh District	0.136	Very Low Adaptive Capacity
87	Aqaba	Aqaba Qasabah	Wadi Araba	0.137	Very Low Adaptive Capacity
77	Tafiela	Hasa	Hasa District	0.142	Very Low Adaptive Capacity
59	Jerash	Jerash Qasabah	Mestabah	0.150	Very Low Adaptive Capacity
69	Karak	Qasr	Mowjeb	0.153	Very Low Adaptive Capacity
61	**Ajlun**	**Ajlun Qasabah**	**Ajlun**	0.154	Very Low Adaptive Capacity
70	Karak	Aghwar Janoobiyah	Safi	0.155	Very Low Adaptive Capacity
72	Karak	Ayy	Ayy Qasabah District	0.156	Very Low Adaptive Capacity
56	Mafraq	Badia Sh.Gh.	Khaldiyah	0.169	Very Low Adaptive Capacity
82	Ma'an	Ma'an Qasabah	Athroh	0.177	Very Low Adaptive Capacity
68	Karak	Qasr	Qasr	0.180	Very Low Adaptive Capacity
41	Irbid	Mazar Shamali	Mazar Shamali District	0.180	Very Low Adaptive Capacity
85	Ma'an	Huseiniya	Huseiniya District	0.186	Very Low Adaptive Capacity
67	Karak	Mazar Janoobee	Mo'aab	0.187	Very Low Adaptive Capacity
54	Mafraq	Badia Sh.Gh.	Serhan	0.192	Very Low Adaptive Capacity
88	Aqaba	Quairah	Quairah	0.197	Very Low Adaptive Capacity
37	Irbid	Koorah	Koorah District	0.199	Very Low Adaptive Capacity

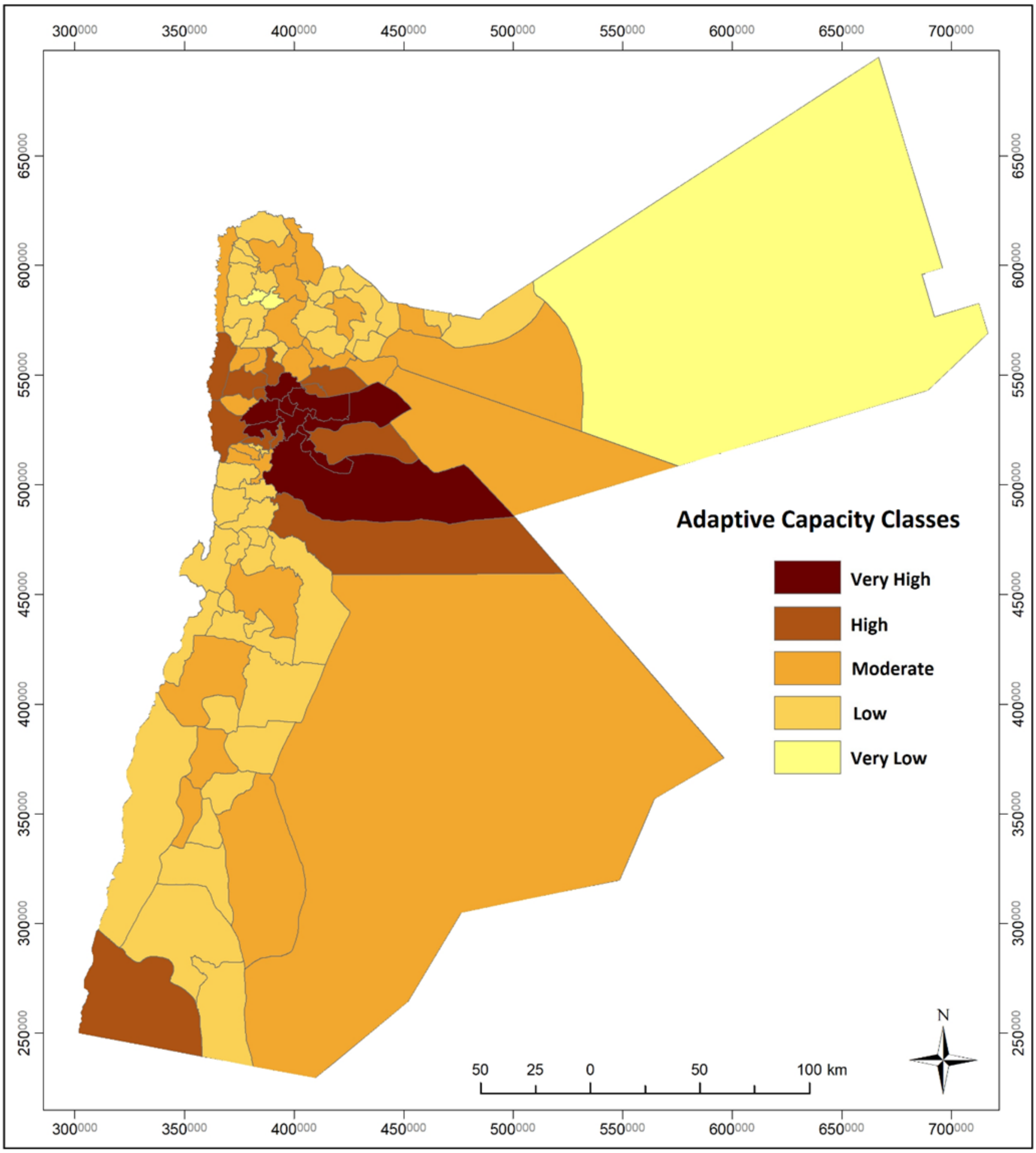


Figure 4.68: Overall socioeconomic adaptive capacity based on all adaptive capacity indicators

4.8.6 Vulnerability Assessment for the Socio-economic Sector

Vulnerability may be defined as the extent to which a natural or social system is susceptible to sustaining damage from climate change. It is generally perceived to be a function of two components, i.e., the effect that an event may have on humans, referred to as capacity or social vulnerability, and the risk that such an event may occur. Vulnerability has two aspects, an external risk (shock to which an individual or community is subject) and internal risk (lack of means to cope). The net impact may be positive for resilience or negative to become vulnerable. Among the human activities, agricultural activities are considered to be the most sensitive to climatic conditions and to climatic variability.

The starting point is that in order to effectively address social vulnerability, it must be understood in sufficiently analytical detail, in order to provide confidence about likely outcomes of particular actions. Moreover, the assessment of social vulnerability should be undertaken at a sufficiently local and fine-grained scale, to allow for differentiation of local factors in vulnerability. While a number of conceptual, methodological and practical efforts have been made[168], there is still little consensus on quantitative methodologies. There is, however, more consensus on the intended outcome of such assessments, namely that they are intended to help researchers and decision-makers understand the social dimensions of vulnerability in the context of implementing governance and policy frameworks for climate change adaptation.

This multidimensional vulnerability will look at the several aspects of the well-being by using socioeconomic indicators to assess the risks faced by the communities and the population when deprived of essential services and adequate living conditions. This analysis will also cover multidimensional socioeconomic vulnerabilities for designing appropriate adaptation and mitigation policies for poor and vulnerable populations in Jordan.

Quantitative Vulnerability assessment was developed as a cumulative result based on the categories: exposure, sensitivity, and adaptive capacity. The sub-district vulnerabilities were scored and ranked based on five categories; very high, high, moderate, low, and very low. The detailed results of vulnerability scores (exposure, sensitivity, adaptive capacity and vulnerability for each sub-district are displayed in (**Table 4.30**).

[168] NGUYEN, C. V., HORNE, R., FIEN, J. & CHEONG, F. J. C. C. 2017. Assessment of social vulnerability to climate change at the local scale: development and application of a Social Vulnerability Index. 143**,** 355-370.

Table 4.30: Results of climate change socioeconomic indicators for exposure, sensitivity, adaptive capacity and vulnerability

ID	Gov.	District	Sub-District	Exposure	Sensitivity	Adaptive Capacity	Vulnerability Score	Vulnerability Classification
1	Amman	Amman Qasabah	Amman Qasabah District	0.628	0.322	0.852	0.186	Low Vulnerability
2	Amman	Marka	Marka District	0.450	0.252	0.939	0.106	Low Vulnerability
3	Amman	Quaismeh	Quaismeh District	0.822	0.341	0.835	0.254	Low Vulnerability
4	Amman	Al-Jami'ah	Al-Jami'ah District	0.395	0.191	1.000	0.075	Very Low Vulnerability
5	Amman	Wadi Essier	Wadi Essier District	0.526	0.233	0.868	0.133	Low Vulnerability
6	Amman	Sahab	Sahab District	0.633	0.143	0.849	0.144	Low Vulnerability
7	Amman	Jizah	Jizah Sub-District	0.835	0.354	0.724	0.296	Low Vulnerability
8	Amman	Jizah	Um Al-Rasas Sub-District	0.598	0.189	0.572	0.209	Low Vulnerability
9	Amman	Muaqqar	Muaqqar Sub-District	0.664	0.079	0.679	0.169	Low Vulnerability
10	Amman	Muaqqar	Rajm al-Shami Sub-District	0.595	0.000	0.723	0.121	Low Vulnerability
11	Amman	Na'oor	Na'oor Sub-District	0.166	0.084	0.737	0.029	Very Low Vulnerability
12	Amman	Na'oor	Um Elbasatien Sub-District	0.144	0.134	0.614	0.041	Very Low Vulnerability
13	Amman	Na'oor	Hosba'n Sub-District	0.146	0.012	0.610	0.026	Very Low Vulnerability
14	Balqa	Salt Qasabah	Salt Sub-District	0.230	0.280	0.554	0.100	Low Vulnerability
15	Balqa	Salt Qasabah	Al-Ardha Sub-District	0.183	0.408	0.398	0.135	Low Vulnerability
16	Balqa	Salt Qasabah	Allan & Zayy Sub-District	0.148	0.364	0.408	0.107	Low Vulnerability
17	Balqa	Salt Qasabah	Ira &Yargha Sub-District	0.200	0.366	0.367	0.145	Low Vulnerability
18	Balqa	Shoonah Janoobiyah	Shoonah Janoobiyah District	0.244	0.496	0.516	0.151	Low Vulnerability
19	Balqa	Dair Alia	Dair Alla District	0.319	0.453	0.677	0.141	Low Vulnerability
20	Balqa	Ain Albasha	Ain Albasha District	0.215	0.308	0.552	0.099	Very Low Vulnerability
21	Balqa	Mahes & Fuhais	Mahes & Fuhais District	0.007	0.162	0.618	0.000	Very Low Vulnerability
22	Zarqa	Zarqa Qasabah	Zarqa Sub-District	0.588	0.704	0.607	0.343	Moderate Vulnerability
23	Zarqa	Zarqa Qasabah	Bierain Sub-District	0.264	0.522	0.505	0.169	Low Vulnerability
24	Zarqa	Zarqa Qasabah	Dhlail Sub-District	0.434	0.557	0.344	0.339	Moderate Vulnerability
25	Zarqa	Zarqa Qasabah	Azraq Sub-District	0.583	0.509	0.329	0.426	Moderate Vulnerability
26	Zarqa	Russeifa	Russeifa District	0.414	0.576	0.503	0.259	Low Vulnerability
27	Zarqa	Hashemiyah	Hashemiyah District	0.293	0.518	0.454	0.198	Low Vulnerability
28	Madaba	Madaba Qasabah	Madaba Sub-District	0.345	0.118	0.417	0.142	Low Vulnerability
29	Madaba	Madaba Qasabah	Jrainah Sub-District	0.163	0.088	0.263	0.100	Very Low Vulnerability
30	Madaba	Madaba Qasabah	Maeen Sub- District	0.186	0.063	0.285	0.099	Very Low Vulnerability
31	Madaba	Madaba Qasabah	Faisaliah Sub-District	0.190	0.084	0.391	0.082	Very Low Vulnerability
32	Madaba	Dieban	Dieban Sub-District	0.319	0.092	0.247	0.179	Low Vulnerability
33	Madaba	Dieban	Areedh Sub-District	0.321	0.170	0.271	0.193	Low Vulnerability
34	Madaba	Dieban	Mlaih Sub-District	0.283	0.173	0.235	0.190	Low Vulnerability
35	Irbid	Irbid Qasabah	Irbid Qasabah District	1.000	0.725	0.432	0.706	High Vulnerability
36	Irbid	Ramtha	Ramtha District	0.942	0.630	0.347	0.702	High Vulnerability
37	Irbid	Koorah	Koorah District	0.532	0.653	0.199	0.565	High Vulnerability
38	Irbid	Bani Kenanah	Bani Kenanah District	0.567	0.702	0.256	0.556	High Vulnerability
39	Irbid	Aghwar Shamaliyah	Aghwar Shamaliyah District	0.457	0.701	0.482	0.324	Moderate Vulnerability
40	Irbid	Bani Obeid	Bani Obeid District	0.545	0.587	0.338	0.425	Moderate Vulnerability
41	Irbid	Mazar Shamali	Mazar Shamali District	0.229	0.778	0.180	0.352	Moderate Vulnerability
42	Irbid	Taybeh	Taybeh District	0.248	0.578	0.209	0.294	Low Vulnerability
43	Irbid	Wastiyyah	Wastiyyah District	0.176	0.561	0.254	0.210	Low Vulnerability
44	Mafraq	Mafraq Qasabah	Mafraq Sub-District	0.459	0.549	0.364	0.341	Moderate Vulnerability
45	Mafraq	Mafraq Qasabah	Bal'ama Sub-District	0.296	0.546	0.244	0.300	Moderate Vulnerability
46	Mafraq	Mafraq Qasabah	Irhab Sub-District	0.278	0.575	0.229	0.304	Moderate Vulnerability
47	Mafraq	Mafraq Qasabah	Manshiyah Sub-District	0.281	0.555	0.249	0.288	Low Vulnerability
48	Mafraq	Badia Shamaliyah	Salhiya Sub-District	0.649	0.822	0.348	0.585	High Vulnerability
49	Mafraq	Badia Shamaliyah	Sabha Sub-District	0.259	0.600	0.324	0.246	Low Vulnerability
50	Mafraq	Badia Shamaliyah	Um Al-Jemal Sub-District	0.233	0.692	0.230	0.299	Low Vulnerability
51	Mafraq	Badia Shamaliyah	Dair Al Kahf Sub-District	0.290	0.703	0.208	0.365	Moderate Vulnerability
52	Mafraq	Badia Shamaliyah	Um-Elqotain Sub-District	0.159	0.637	0.233	0.223	Low Vulnerability

53	Mafraq	Badia Sh.Gh. District	Badia Sh.Gh. Sub-District	0.863	0.685	0.256	0.787	Very High Vulnerability
54	Mafraq	Badia Sh.Gh. District	Serhan Sub-District	0.371	0.619	0.192	0.421	Moderate Vulnerability
55	Mafraq	Badia Sh.Gh. District	Hosha Sub-District	0.430	0.506	0.202	0.417	Moderate Vulnerability
56	Mafraq	Badia Sh.Gh. District	Khaldiyah Sub-District	0.384	0.624	0.169	0.455	Moderate Vulnerability
57	Mafraq	Rwaished	Rwaished District	0.752	0.712	0.088	1.000	Very High Vulnerability
58	Jerash	Jerash Qasabah	Jerash Sub-District	0.502	0.782	0.323	0.477	Moderate Vulnerability
59	Jerash	Jerash Qasabah	Mestabah Sub-District	0.401	0.735	0.150	0.536	High Vulnerability
60	Jerash	Jerash Qasabah	Borma Sub-District	0.419	0.777	0.122	0.608	High Vulnerability
61	Ajlun	Ajlun Qasabah	Ajlun Sub-District	0.268	0.828	0.154	0.429	Moderate Vulnerability
62	Ajlun	Ajlun Qasabah	Sakhrah Sub-District	0.314	1.000	0.033	0.720	High Vulnerability
63	Ajlun	Ajlun Qasabah	Orjan Sub-District	0.265	0.906	0.000	0.667	High Vulnerability
64	Ajlun	Kufranjah	Kufranjah District	0.209	0.722	0.133	0.354	Moderate Vulnerability
65	Karak	Karak Qasabah	Karak Qasabah District	0.856	0.126	0.340	0.384	Moderate Vulnerability
66	Karak	Mazar Janoobee	Mazar Sub-District	0.602	0.142	0.279	0.316	Moderate Vulnerability
67	Karak	Mazar Janoobee	Mo’aab Sub-District	0.485	0.120	0.187	0.304	Moderate Vulnerability
68	Karak	Qasr	Qasr Sub-District	0.394	0.129	0.180	0.263	Low Vulnerability
69	Karak	Qasr	Mowjeb Sub-District	0.376	0.093	0.153	0.255	Low Vulnerability
70	Karak	Aghwar Janoobiyah	Safi Sub-District	0.230	0.329	0.155	0.242	Low Vulnerability
71	Karak	Aghwar Janoobiyah	Ghawr Almazra'a Sub-District	0.247	0.148	0.224	0.168	Low Vulnerability
72	Karak	Ayy	Ayy Qasabah District	0.088	0.092	0.156	0.094	Very Low Vulnerability
73	Karak	Faqo'e	Faqo'e District	0.327	0.050	0.126	0.228	Low Vulnerability
74	Karak	Qatraneh	Qatraneh District	0.329	0.156	0.136	0.262	Low Vulnerability
75	Tafiela	Tafiela Qasabah	Tafiela Qasabah District	0.480	0.545	0.322	0.378	Moderate Vulnerability
76	Tafiela	Bsaira	Bsaira District	0.275	0.539	0.108	0.382	Moderate Vulnerability
77	Tafiela	Hasa	Hasa District	0.229	0.511	0.142	0.304	Moderate Vulnerability
78	Ma'an	Ma'an Qasabah	Ma'an Sub-District	0.305	0.422	0.364	0.215	Low Vulnerability
79	Ma'an	Ma'an Qasabah	Iel Sub-District	0.310	0.503	0.214	0.316	Moderate Vulnerability
80	Ma'an	Ma'an Qasabah	Jafr Sub-District	0.628	0.567	0.340	0.470	Moderate Vulnerability
81	Ma'an	Ma'an Qasabah	Mraighah Sub-District	0.351	0.719	0.133	0.498	Moderate Vulnerability
82	Ma'an	Ma'an Qasabah	Athroh Sub-District	0.350	0.605	0.177	0.411	Moderate Vulnerability
83	Ma'an	Petra	Petra District	0.281	0.490	0.442	0.190	Low Vulnerability
84	Ma'an	Shobak Qasabah	Shobak Qasabah District	0.275	0.464	0.329	0.222	Low Vulnerability
85	Ma'an	Huseiniya	Huseiniya District	0.445	0.558	0.186	0.465	Moderate Vulnerability
86	Aqaba	Aqaba Qasabah	Aqaba Sub-District	0.000	0.303	0.563	0.012	Very Low Vulnerability
87	Aqaba	Aqaba Qasabah	Wadi Araba Sub-District	0.155	0.551	0.137	0.252	Low Vulnerability
88	Aqaba	Quairah	Quairah Sub-District	0.176	0.386	0.197	0.196	Low Vulnerability
89	Aqaba	Quairah	Diesah Sub-District	0.394	0.668	0.253	0.407	Moderate Vulnerability

The most vulnerable sub-districts are (Rwaished, Badia Sh. Gh., Sakhrah, Irbid Qasabah, Ramtha, Orjan, Borma, Salhiya, Koorah, Bani Kenanah and Mestabah) as shown in (**Table 4.31**) and the vulnerability map is presented in **Figure 4.69**.

Table 4.31: Top 10 most highly vulnerable sub-districts.

SUBDIST_ID	Governorate	District	Sub-District	Vulnerability Score	Vulnerability Classification
57	Mafraq	Rwaished	Rwaished	1.000	Very High Vulnerability
53	Mafraq	Badia Sh.Gh.	Badia Sh.Gh.	0.787	Very High Vulnerability
62	Ajlun	Ajlun Qasabah	Sakhrah	0.720	High Vulnerability
35	**Irbid**	**Irbid Qasabah**	**Irbid Qasabah**	0.706	High Vulnerability
36	Irbid	Ramtha	Ramtha	0.702	High Vulnerability
63	Ajlun	Ajlun Qasabah	Orjan	0.667	High Vulnerability
60	Jerash	Jerash Qasabah	Borma	0.608	High Vulnerability
48	Mafraq	Badia Shamaliyah	Salhiya	0.585	High Vulnerability
37	Irbid	Koorah	Koorah	0.565	High Vulnerability
38	Irbid	Bani Kenanah	Bani Kenanah	0.556	High Vulnerability
59	Jerash	Jerash Qasabah	Mestabah	0.536	High Vulnerability

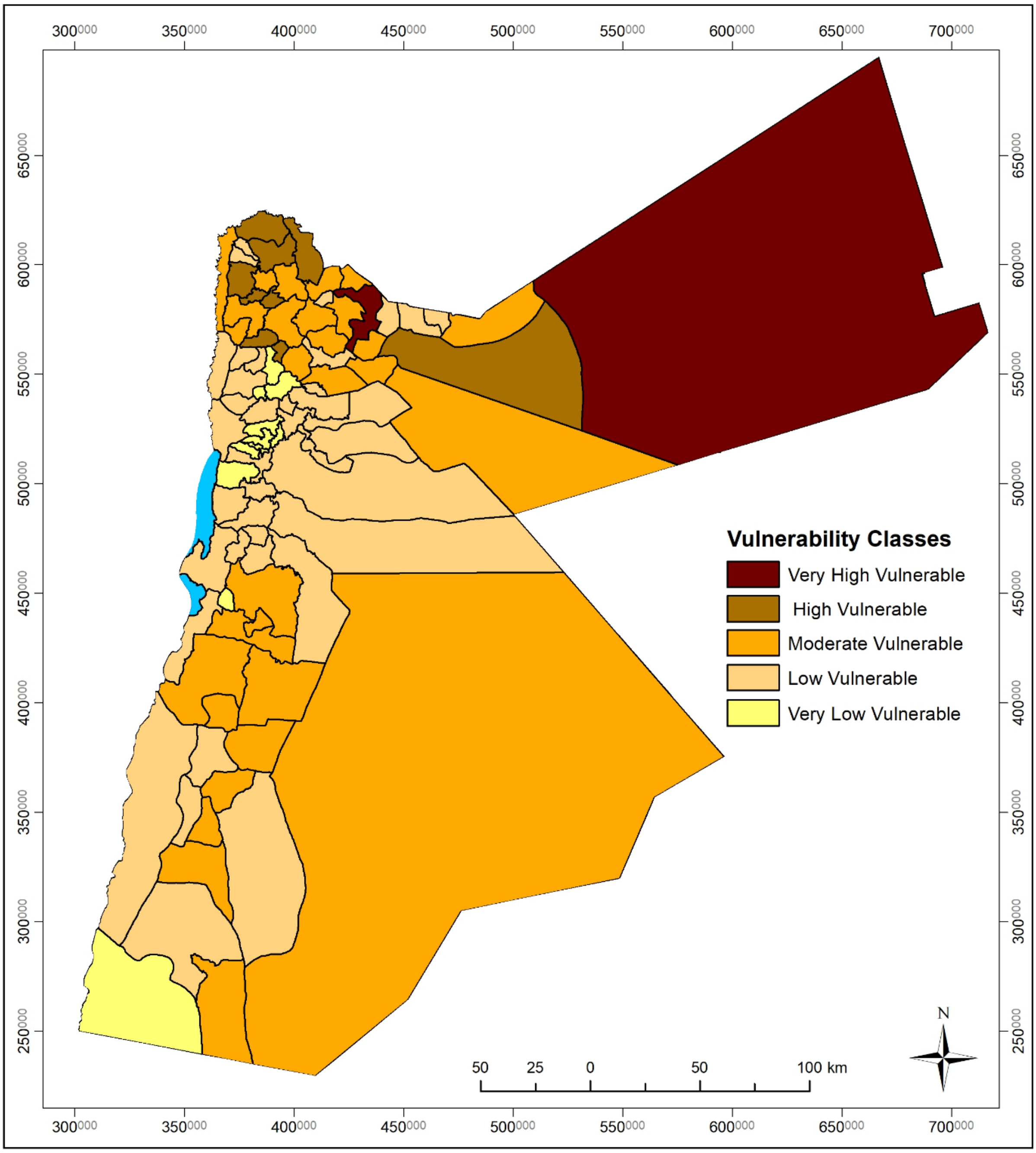


Figure 4.69: Overall Socioeconomic Vulnerability Map

4.8.7 Climate Change Risk/ Hazard Index

Climate change increases the likelihood of natural hazards occurring in many areas, which thus makes different communities' vulnerability and ability to cope with such incidents highly relevant.[169] [170]. In this study, three climate hazards were investigated; drought, temperature increase, and heatwaves. Two GHG emissions scenarios were tested; RCP 4.5 and RCP 8.5 and, for the period up to 2050, 2070 and 2100. The three hazard indices were aggregated into one index with a weight of 0.5 for drought, 0.3 for average temperature and 0.2 for heatwaves.

Climate change influences on gender and vulnerable groups is linked largely to its socio-economic impacts. Yet in Jordan, the socio-economic impacts of climate change are not addressed, with any special attention, by relevant research and policy-related activities, that are performed locally. For example, very limited analysis was done on socio-economic issues, like the impact of climate change on poverty, employment, social welfare, gender.

In this study, the climate risk was determined by the climate and weather events (hazards) and vulnerability to these hazards (**Table 4.32**). The climate change hazards assessed are drought, temperature increase and heatwave. The severity of the impacts of extreme and non-extreme weather and climate events depends strongly on the level of vulnerability and exposure to these events. Trends in vulnerability and exposure are major drivers of change in disaster risk, and of impacts, when risk is realized. However, understanding the multi-faceted nature of vulnerability and exposure is a prerequisite for determining how weather and climate events contribute to the occurrence of disasters, and for designing and implementing effective adaptation and disaster risk management strategies.

Table 4.32: Climate Change Hazards used to assess socioeconomic risk in Jordan

<table>
<tr><th>HAZARD: Climate Change Hazard</th><th>Weight</th><th>Source</th><th>Reference Date</th><th>Resolution</th></tr>
<tr><td>NPD - Projected Differences in Annual Precipitation</td><td>0.5</td><td rowspan="3">4NC projection chapter</td><td rowspan="3">2050, 2070, 2100</td><td rowspan="3">CHIRPS</td></tr>
<tr><td>NTD - Projected Differences in Average Maximum Air Temperature</td><td>0.3</td></tr>
<tr><td>NHWD - Projected Differences in Average Wind Speed</td><td>0.2</td></tr>
</table>

[169] https://www.ipcc.ch/

[170] https://www.noaa.gov/education/resource-collections/climate/climate-change-impacts

The maps shed light on how the different elements contribute to the overall result. It can be seen that there are parts of the country that do not experience a serious climate change hazard, while the parts of the country that are colored in darker shades are more at risk for hazards and exposure. This is significant for climate change planning, and an argument for an oriented adaptation measure for the districts, which are more affected. It can be seen that, besides the Northern and Northwestern Governorates of the country, the Governorates Mafraq, Jerash, and Irbid show high sensitivity to climate change.

However, risks are not static but dynamic, varying across temporal and spatial scales, and depend on economic, social, geographic, demographic, cultural, institutional, governance, and environmental factors. Furthermore, communities are differently exposed and vulnerable, based on factors such as wealth, education, endowments, gender, age, disability, and health status[171].

Generated risk maps indicate that Borma sub-district, Jerash governorate, Bani-Kenanah, Irbid and Al-Badia Ash-Shamaliyah Al-Gharbia, Mafraq are faced with a high climate hazard, as well as Rwaished Sub-District, Mafraq, and Jerash and Ajlun Qasabah districts, which have high average hazard scores, as shown in (**Table 4.33**).

[171] CARDONA, O. D., VAN AALST, M. K., BIRKMANN, J., FORDHAM, M., MC GREGOR, G., ROSA, P., PULWARTY, R. S., SCHIPPER, E. L. F., SINH, B. T. & DÉCAMPS, H. 2012. Determinants of risk: exposure and vulnerability. Managing the risks of extreme events and disasters to advance climate change adaptation: special report of the intergovernmental panel on climate change. Cambridge University Press.

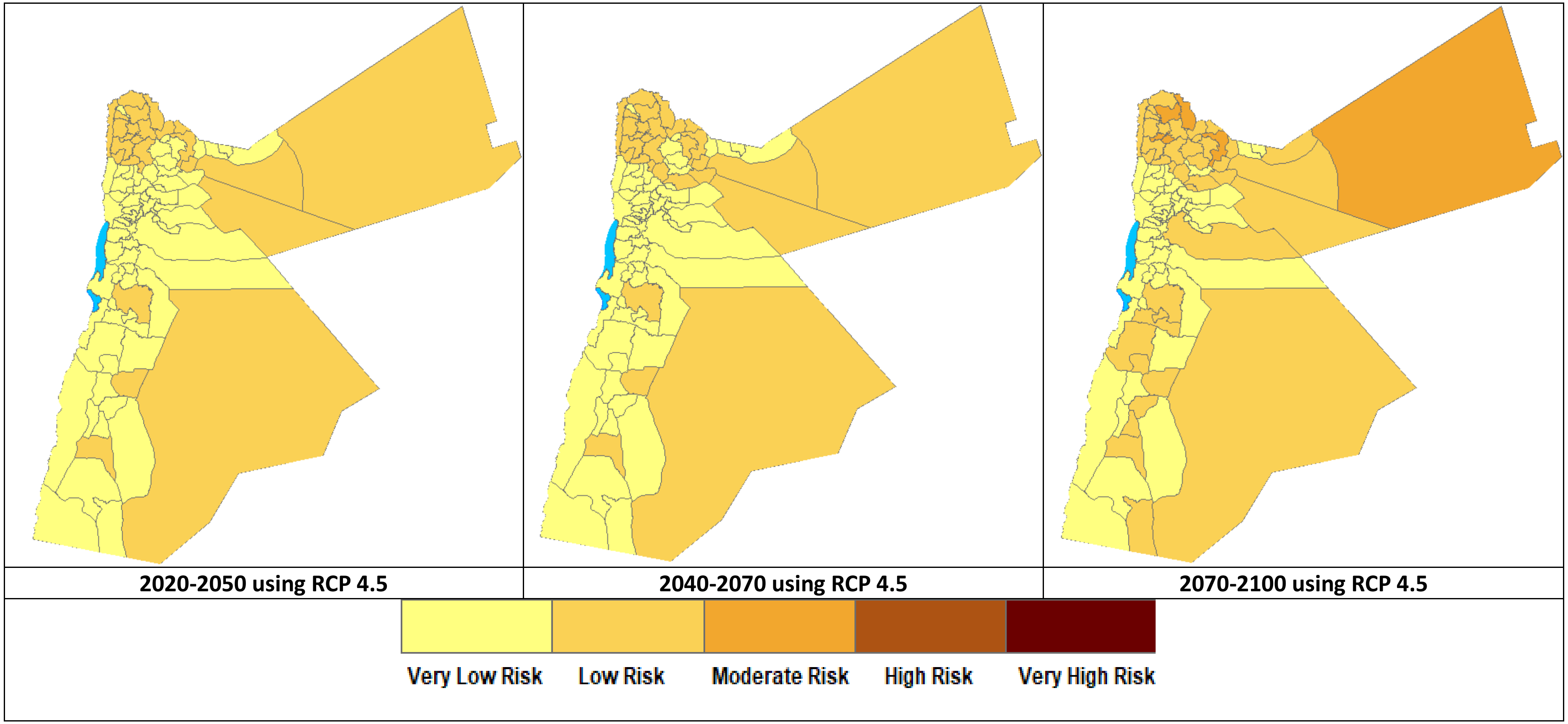


Figure 4.70: Projected Socio-economic Risks, for the three time-horizons using RCP 4.5

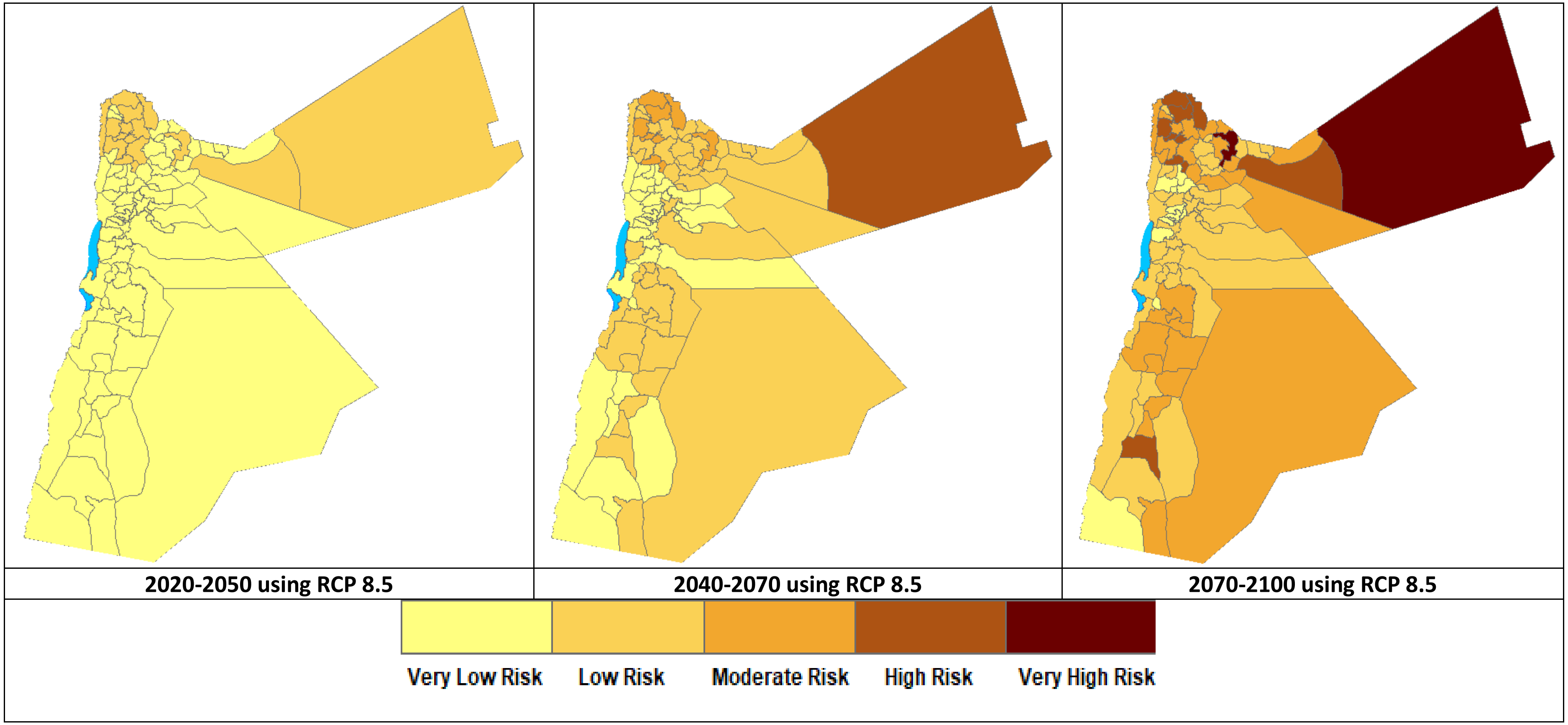


Figure 4.71: Projected Socio-economic Risks, for the three time horizons using RCP 8.5

Table 4.33: Top twelve highest-risk districts in Jordan

Governorate	District	Sub-District	Risk_2050_RCP 4.5	Risk_2070_RCP 4.5	Risk_2100_RCP 4.5	Risk_2050_RCP 8.5	Risk_2070_RCP 8.5	Risk_2100_RCP 8.5
Jerash	Jerash Qasabah	Borma	HR	VHR	HR	HR	HR	MR
Irbid	Bani Kenanah	Bani Kenanah	HR	VHR	HR	VHR	HR	MR
Mafraq	Badia Sh.Gh.	Badia Sh.Gh.	VHR	VHR	VHR	HR	VHR	HR
Ajlun	Ajlun Qasabah	Sakhrah	VHR	VHR	VHR	VHR	VHR	HR
Ajlun	Ajlun Qasabah	Orjan	VHR	VHR	VHR	VHR	VHR	HR
Irbid	Ramtha	Ramtha	VHR	VHR	VHR	VHR	HR	HR
Irbid	Irbid Qasabah	Irbid Qasabah	VHR	VHR	VHR	VHR	VHR	HR
Irbid	Koorah	Koorah	VHR	VHR	VHR	VHR	HR	MR
Mafraq	Rwaished	Rwaished	VHR	VHR	VHR	VHR	VHR	VHR
Ajlun	Ajlun Qasabah	Ajlun	HR	HR	MR	MR	MR	MR
Jerash	Jerash Qasabah	Jerash	MR	HR	MR	MR	MR	MR
Jerash	Jerash Qasabah	Mestabah	MR	HR	MR	MR	MR	MR

4.8.8 Adaptation Measures for the Socio-economic Sector

Climate change indirectly disrupts life's intangible aspects, including social systems, cultural behavior and knowledge. The loss of intangible cultural heritage involves the related loss of cultural and social significance, that is often invisible to those calculating climate change impacts. Social vulnerabilities to climate change are both tangible and intangible. Consistent with disaster preparedness, assessments of climate change vulnerability tend to focus on the tangible: infrastructure based on engineering-works, such as housing, roads and dwellings, and the material bases for survival and health, such as food supply, water supply and wastewater treatment. Food security under climate change typically focuses on physiology and nutrition, while other aspects of individual and community health that are met by food and food culture, such as psychological and psychosocial needs, remain understated or absent.

Populations are not uniformly vulnerable to climate change. The reasons for vulnerability are largely social and economic, not merely a matter of different exposure to climate-related and environmental hazards. We have identified several factors responsible for differences in local-scale vulnerability to climate change and suggested a number of actions to reduce it. Access to resources is one critical factor that shapes communities' ability to plan for and respond to the impacts of climate change. Addressing unequal access to resources involves a twofold challenge: it requires both action on a community or project basis, and larger-scale structural change to reduce poverty and political marginalization

Populations will adapt to climate change in many ways, with some actions reducing impacts, and others potentially exacerbating impacts. The timeliness and effectiveness of adaption efforts depend on a variety of factors, including socioeconomic status, the condition and accessibility of infrastructure, the accessibility of health care, specific demographic characteristics, and other institutional resources. To conclude with, considering the ever-increasing vulnerability to climate change, it is of foremost importance to develop various tools like mapping and indices for mitigation and adaptability on a frequent basis and use these for policy-making and implementation.

In practice, there is often no clear distinction between development activities and climate change adaptation interventions, since many adaptation measures contain a “development” component, whether implicitly or explicitly. Conversely, climate change adaptation concerns can be mainstreamed into development efforts. Because adaptation measures are applied in anticipation of future climate change impacts, they are accompanied by a high level of uncertainty. Adaptation strategies can potentially undermine the resilience of communities and cultures, particularly when they promote private interests at the expense of public goods, such as cultural heritage or community cohesion. Socioeconomic and cultural factors shape how people support adaptation interventions, and their motivation to respond to them.

Building the resilience of current and planned health programs includes strengthening coordination across departments in ministries of health mandated to manage climate-sensitive health outcomes (including vector-borne diseases, diarrheal diseases, food and water safety, non-communicable diseases, and nutrition), and across ministries and departments whose policies and programs can affect these health outcomes. Coordination with sectors such as agriculture, water, and disaster risk management will facilitate identifying potential synergies and promote health co-benefits. For example, choices made on enhancing crop yields through use of drought tolerant crops, or through water-saving irrigation water technology which could not only reduce food insecurity, but could also reduce other water borne diseases.

The proposed adaptions measures and options to reduce socioeconomic vulnerability and risk are illustrated in (**Table 4.34**) based on MCDST and meetings with groups of experts.

Table 4.34: Proposed adaptions measures and options to reduce socioeconomic vulnerability and Risk

Adaptation Measure	Description
Poverty Alleviation and Income Diversification	• Climate change adaptation and poverty alleviation call for an integrated strategy, because poverty exacerbates the vulnerability to climate change and vice versa. • Increasing the adaptive capacity of a community. ○ Increasing household income may reduce the risk of famine in case of drought, and raise household education levels, which may make a household more likely to benefit from early warnings. • Adjustment of cultivation, and lifestyle adjustments, in households and communities. • Economic transformation towards sustainable development. • Financing mainstreaming adaptation into poverty reduction. • Economic diversification to assist in reducing poverty and generate employment in the long run.
Access to basic services	• Planning and implementing resilient basic service delivery • Provide basic services to rural and vulnerable communities to reduce the negative impact of expected climate change effects.
Improving Nutritional Status	• Reducing chronic malnutrition by special programs and food additives • Reducing nutritional inadequacies

Income Generating Activities and employment	• The potential income generating activities include, for example,
	    ○ Food drying,
	    ○ Preparation and marketing of dairy products,
	    ○ Diverse agricultural production,
	    ○ Establishment and improvement of livestock and small ruminants raising,
	    ○ Other value chain activities relevant to agricultural and livestock production,
	    ○ Handicrafts, and shopkeeper activities.

Gender Equality	• Climate change is expected to exacerbate current gender inequalities. • Depletion of natural resources and decreasing agricultural productivity may place additional burdens on women's health and reduce time available to participate in decision-making processes and income-generating activities. Therefore, promotion of gender equality and empowerment of women is a necessary program in the Climate Change Adaptation Plan
Food Security	• It is necessary to develop national and local capacities to deal with food security-related climate change challenges, including • Improving extension services, and making available and accessible, weather and climate forecasting and risk management tools. • Promoting efficiencies in the food chain and the reduction of post-harvest losses and food waste in a sustainable manner, to include increasing the efficiency of nitrogen use, improving livestock productivity.
Reduce Rural Migration	• On top of the human cost, rapid urbanization and increasing socioeconomic activity, coupled with climate extremes and disasters, are putting at risk decades of development gains in infrastructure and service delivery. • The direct and indirect effects of climate change and their interaction with other vulnerabilities and environmental exposures may lead to mass migrations, as crucial resources become degraded and livelihoods are threatened
Urban/Rural Planning & Infrastructure	• Climate extremes in rural areas, resulting in urban impacts, connections of resources and migration streams mean that climate extremes in non-urban locations, with associated shifts in water supply, rural agricultural potential, and the habitability of rural areas will have downstream impacts in cities.
Enhance Social Safety Nets	• Jordan has a functioning social protection system that was traditionally developed to serve certain segments of society including the poor, orphans, elderly, abused women and children among other vulnerable groups and individuals. However, over the past decade, mounting economic and social challenges facing the country – including high poverty rates, high unemployment rates, budget deficit, and most recently, the influx of Syrian refugees – have put the system under additional pressures. • Social safety nets activities are occasional and not conducted on a regular basis and most of the activities are conducted on the initiative of non-governmental organizations. Public social safety net programmes need to be improved, in terms of coverage and quality of provision.

4.9 CCIVA for Health Sector

4.9.1 Overview

Climate change may affect health through a range of exposure pathways, for example, because of increased frequency and intensity of heatwaves, reduction in cold-related deaths, increased floods and droughts, changes in the distribution of vector-borne diseases and effects on the risk of disasters and malnutrition. Overall, the effects of climate change on health are likely to be negative, with populations in low-income countries being mostly vulnerable.

The sixty-first session of the World Health Assembly (WHA) held in May 2008 identified climate change as a fundamental threat to public health and adopted a resolution urging Member States to take decisive action to address health impacts from climate change. Later in October 2008, the World Health Organization (WHO) Eastern Mediterranean Regional Committee issued, at its fiftieth session, a Regional Committee Resolution (EM/RC55/R.8). The resolution on Climate Change and Health aims at protecting health from the effects of climate change. It also urges Member States to implement the endorsed Regional Framework for Health Sector Action to Protect Health from the Effects of Climate Change. Significant focus of the resolution is on capacity-building of the health sector in the Member States, encouraging the health systems to undertake assessment of health vulnerability to climate change to proactively prepare and address the health impacts of climate change.

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 also 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.

According to the National Climate Change Health Adaptation Strategy and Action Plan of Jordan, Ministry of Health Jordan (2012), the following risks are expected:

- Vector-Borne Disease (VBD) risk is expected to increase with 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) causing 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 industry) workers and farmers may be exposed to higher levels of air pollutants due to increased temperatures.

The "Climate Change Adaptation To Protect Human Health" Project is a global initiative jointly implemented by the World Health Organization (WHO)[172] and United Nations Development Program (UNDP). The seven pilot countries were Barbados, Bhutan, China, Fiji, Jordan, Kenya, and Uzbekistan. The project was co-funded by the Global Environment Facility (GEF) Special Climate Change Fund (SCCF). The overall project goal, which was achieved through a series of pilot projects, aimed to "increase adaptive capacity of national health system institutions, including field practitioners, to respond to climate sensitive health risks". WHO/UNEP studies have shown a strong link between per capita water availability and the incidence of diarrhea. Even though the government has given priority to domestic use of clean water, the proposed increase in reuse of wastewater for agriculture is likely to pose health risks (especially if untreated rather than treated wastewater is used), particularly intestinal diseases and exposure to toxic chemicals for farmers, neighboring communities, and consumers.

Significant barriers related to data accessibility, limited number of climate and health models, uncertainty in climate projections, and lack of funding and expertise, particularly in developing countries, challenge health authority efforts to conduct rigorous assessments and apply the findings. Greater capacity-building that facilitates assessments from local to national scales will support collaborative efforts to protect health from current climate hazards and future climate

[172] www.who.int/phe/en/

change. Health sector officials will benefit from additional resources and partnership opportunities to ensure that evidence about climate change impacts on health is effectively translated into needed actions to build health resilience[173].

The main climate-related hazards affecting the health sector are represented by temperature and precipitation. 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. Based on the National Climate Change and Health Adaptation Strategy and Action Plan[174], which was developed by the Ministry of Health in 2012, six climate-sensitive health issues were identified including air-borne and respiratory diseases, water and food-borne diseases, vector-borne diseases, nutrition, heat waves, and occupational health. Climate change effects on respiratory diseases include chronic respiratory diseases such as bronchial asthma.

Many recent studies have linked the emergence of the COVID-19 outbreak with the impacts of climate change and the closer associations between humans and animals as well as degradation of habitats. It is expected that diseases that are more infectious can emerge due to climate change impacts. This threat needs to be addressed seriously at national and global levels, thus it has become part of the National Priority Strategic Objectives for Adaptation in the Health Sector, as “Improved understanding of the potential risk on health sector due to climate change after COVID19 and the possibility of having emerging infectious diseases due to climate change” and “Enhancing the adaptive capacity of the health sector under current and future climate change conditions”[175].

The global evidence base of information about climate change impacts on health has grown over the last few decades, as shown through publications from the Intergovernmental Panel on Climate Change (IPCC) and the special climate change issue of International Journal of Environmental Research and Public Health 2018, which provide analysis of the global burden of disease from climate change. Direct and indirect health impacts associated with climate change are caused by rising temperatures, altered precipitation patterns as well as increasingly severe and frequent extreme weather events. Direct health impacts arise from hazards such as heatwaves, droughts and storms, and indirect impacts come from exposures to disease vectors and air and water pollution. Rising carbon dioxide levels, which contribute to climate change, may also reduce the nutrient value in staple crops. This could increase food insecurity among some populations, particularly those in developing countries. A range of social factors can act to

[173] Assessing Health Vulnerabilities and Adaptation to Climate Change: A Review of International Progress Peter Berry 1 , Paddy M. Enright 1,*, Joy Shumake-Guillemot 2 , Elena Villalobos Prats 3 and Diarmid Campbell-Lendrum 3 Nov 2018

[174] The National Climate Change and Health Adaptation Strategy and Action Plan (201). The Ministry of Health, Jordan.

[175] UPDATED SUBMISSION OF JORDAN’S 1st NATIONALLY DETERMINED CONTRIBUTION (NDC) October 2021.

either exacerbate the health impacts of the environmental effects of climate change or to help mitigate them with public health interventions. Knowledge gaps about the impacts of climate change on public health, food distribution, poverty, rural communities and indigenous groups and marginalized people exist.

The National Center for Disease Control and Prevention, in the USA, have produced a detailed chart representing the "Primary Climate Risks to Bloomington Climate change"[176] health impacts. It illustrates the most significant climate change impacts (rising temperatures, more extreme weather, rising sea levels, and increasing carbon dioxide levels), their effect on exposure, and the subsequent health outcomes that can result from these changes in exposure.

The World Health Organization (WHO) office in Geneva, in 2021, issued a detailed summary for national planning for mitigating climate change impacts on health sector[177]. The report describes the vulnerability factors (demographic, geographic, biological and health status, socio-political conditions and socio-economic). In addition, it lists the exposure pathways (extreme weather events, heat stress, air quality, water quality and quantity, food security and safety, and vector borne distribution and ecology), in addition to the adaptive capacity of the health system and its resilience (leadership and governance, health workforce, health information systems, essential medical products and technologies, service delivery and financing). The main climate-sensitive health risks (injury and mortality from extremes, health-related illness, respiratory illness, water-borne diseases and other water-related health impacts, zoonosis, vector-borne diseases, malnutrition and food-borne diseases, non-communicable diseases (NCDs), and mental and psychosocial health).

4.9.2 Selection of Health Indicators Identification of Health Impacts

According to National Climate Change Health Adaptation Strategy and Plan of Action (2012), and based on other studies, the Expected Impacts of Climate Change on Health in Jordan care and the factors governing the health vulnerability in Jordan in terms of exposure, sensitivity, and adaptive capacity are summarized at **Table B.7 Annex B**. However, due to lack of data on many climate-health related aspects, the team of experts decided to shorten the vulnerability/risk matrix as presented at **Table 4.35**.

[176] Bloomington a 00 01 02 03
[177] Quality Criteria for Health National Adaptation Plan. Geneva, World Health Organization, 2021.

Table 4.35: Adopted Vulnerability/ Risk Matrix for the Health Sector

Category	Factor	Description	Source
Exposure	Climate Factors	Increase in Temperature	4NC Projection Results
	Climate Factors	Decrease in Precipitation	4NC Projection Results
	Climate Factors	Increase in Heatwaves	4NC Projection Results
	Climate Factors	Increase in Sandstorms	4NC Projection Results
	Climate Factors	Increase in Humidity	4NC Projection Results
Sensitivity	Demographic	Population Density	DOS, 2019
	Demographic	Household size	DOS, 2019
	Demographic	Female to Male Ratio	DOS, 2019
	Demographic	Syrian Refugee population	DOS, 2019
	Demographic	Infants and children	DOS, 2019
	Demographic	Older	DOS, 2019
	Expenditure	Poverty Rate	DOS, 2017
	Agriculture	Agricultural Labor	DOS, 2018
	Agriculture	Total Horticulture Labor	DOS, 2018
	Agriculture	Total Livestock Labor	DOS, 2018
	Food Security	Food insecure	DOS, 2019
	Food Security	Vulnerable to Food insecurity	DOS, 2019
	Food Security	Used Mechanism to adopt food	DOS, 2019
	Food Security	Receive Food Help	DOS, 2019
	Water	Sewer System Coverage	MWI, 2020
	Demographic	Pregnant women	DOS, 2019
	Demographic	Poor communities/ income	DOS, 2017
	Health	Populations with high chronic disease burden	DOS, 2018
	Health	Mortality under 5 Years	DOS, 2018
	Health	Child Mortality below 2 years	DOS, 2018
	Health	New Born Mortality	DOS, 2018
	Health	Prevalence of Illness and Disability	DOS, 2018
Adaptive Capacity	Expenditure	Educational Level of Household Head	DOS, 2018

	Expenditure	Level of Income	DOS, 2018
	Expenditure	Variance of Income	DOS, 2018
	Expenditure	Household Asset Ownership	DOS, 2018
	Health	Health Assured	DOS, 2018
	Migration	Net migration	DOS, 2018
	Physical	Diversification for improved water resources	MWI, 2020
Hazards	Physical	Sanitation Vulnerability	UNICEF 2018
	Physical	Flood Hazard Zones	WFP, 20119
	Physical	Drought Hazard Zones	WFP, 20119

4.9.3 Assessment of Health Exposures Factors

Health Exposure to Climate Change included five factors; Increase in Temperature, Decrease in Precipitation, Increase in Heatwaves, Increase in Sandstorms, and Increase in Humidity. These factors were obtained from the exposure section developed in this 4NC study. The exposure weights were determined equally, since all factors have similar magnitudes of effects based on health impacts. On the other hand, the overall exposures are given in three time horizons and for two concentration pathways (RCP 4.5 and RCP 8.5) as seen at Figure 4.72.

Based on the exposure maps, the northern region followed by southern Ghor and North-eastern Badia are the most impacted regions to future climate changes. The degree of impacts intensifies by the end of the century to cover the whole country. This illustrates the critical stages that Jordan is facing in future.

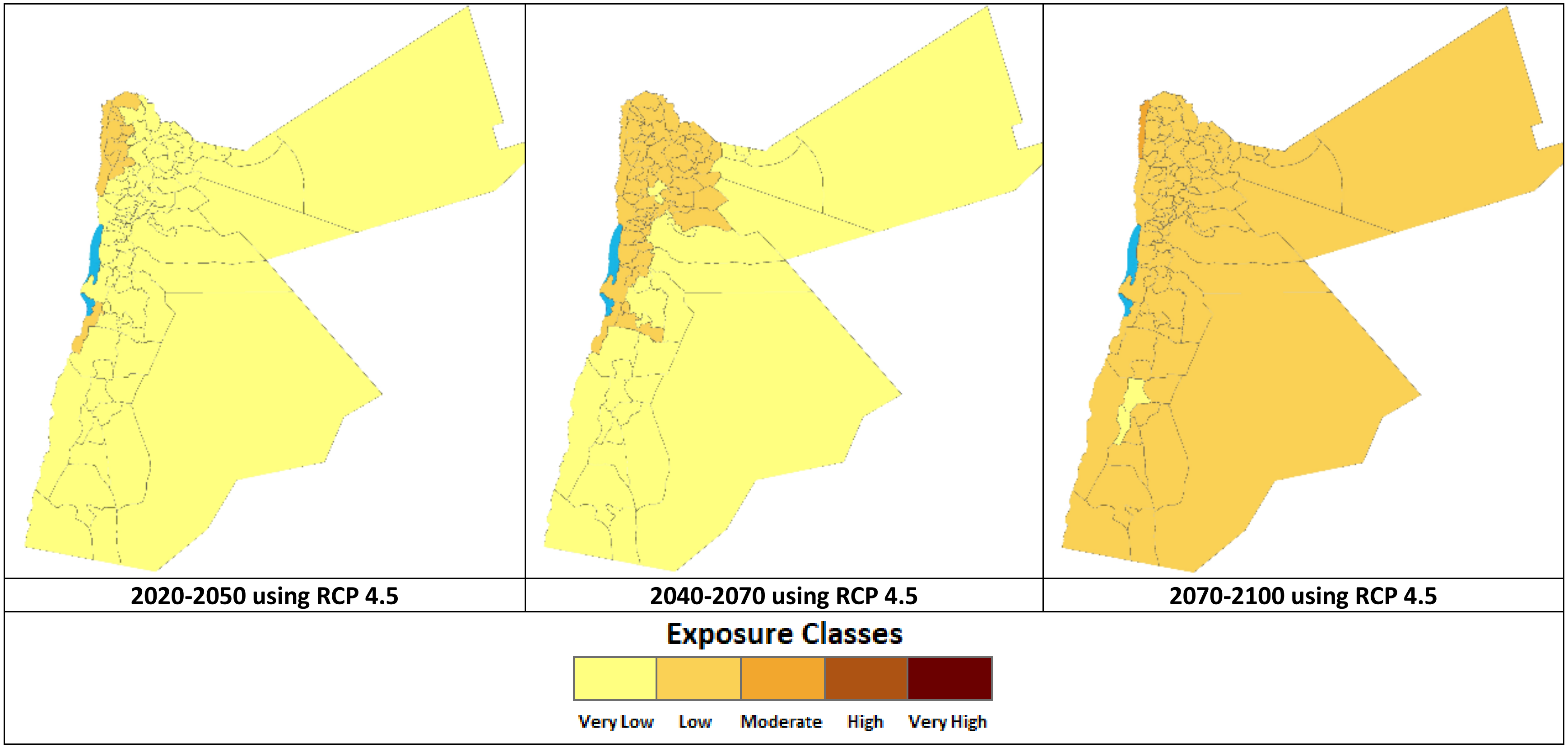


Figure 4.72: The selected climate exposure maps for the health sector using RCP 4.5

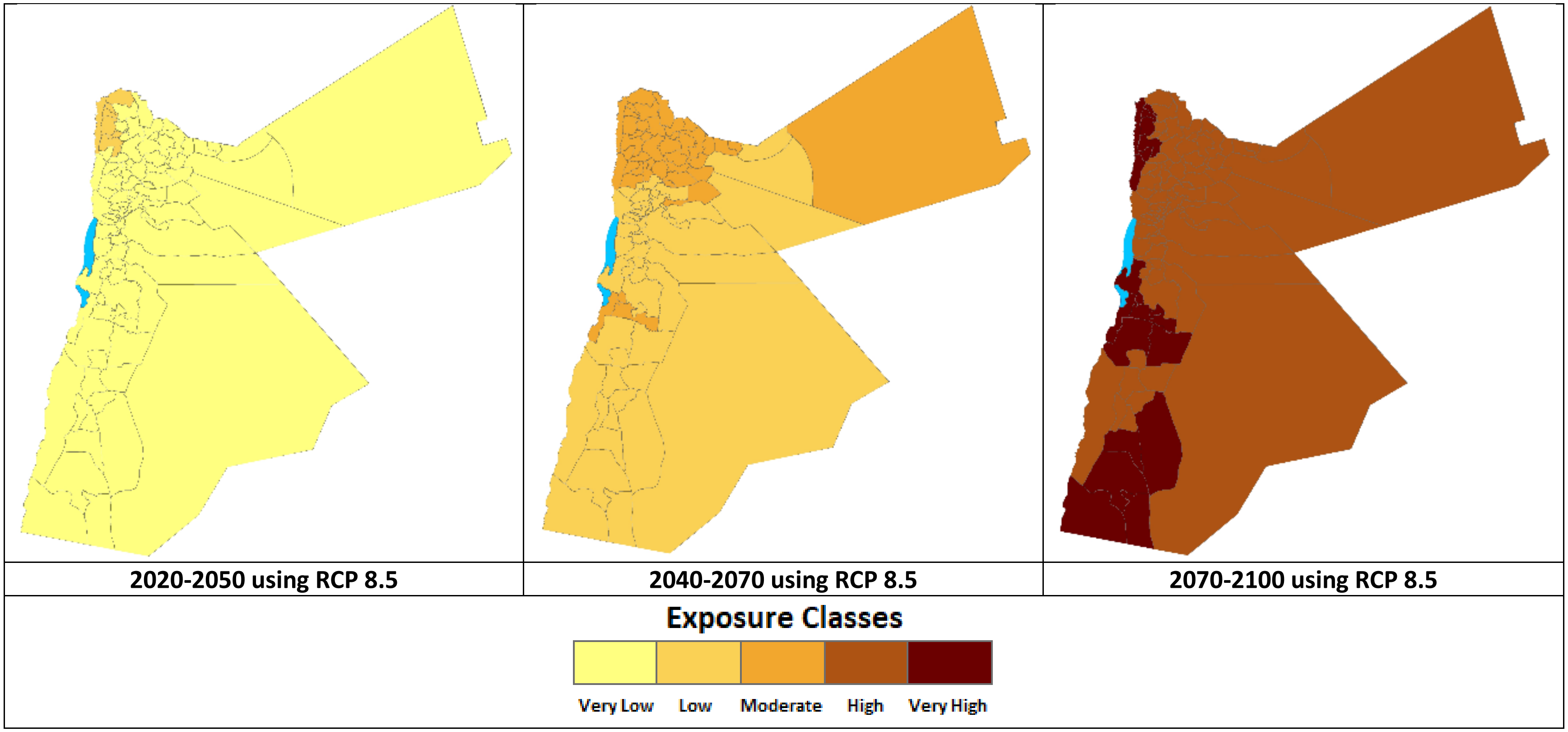


Figure 4.73: The selected climate exposure maps for the health sector using RCP 8.5

4.9.4 Assessment of Health Sensitivity Composite Index

A composite sensitivity factor was derived from several demographic, agriculture, water, expenditure, and health factors. The data were weighted based on expert group meetings, and aggregated to provide a normalized sensitivity factor.

As shown in **Figure 4.74**, the sensitivity varies by sub-district level even within the same governorate. The highest sensitivity was detected at Zarqa Sub-District followed by Irbid Qasabah District, and Badia Sh.Gh. Sub-District. Generally, high sensitivity is related to poverty rate and the prevalence of illness and disability that were high for those regions.

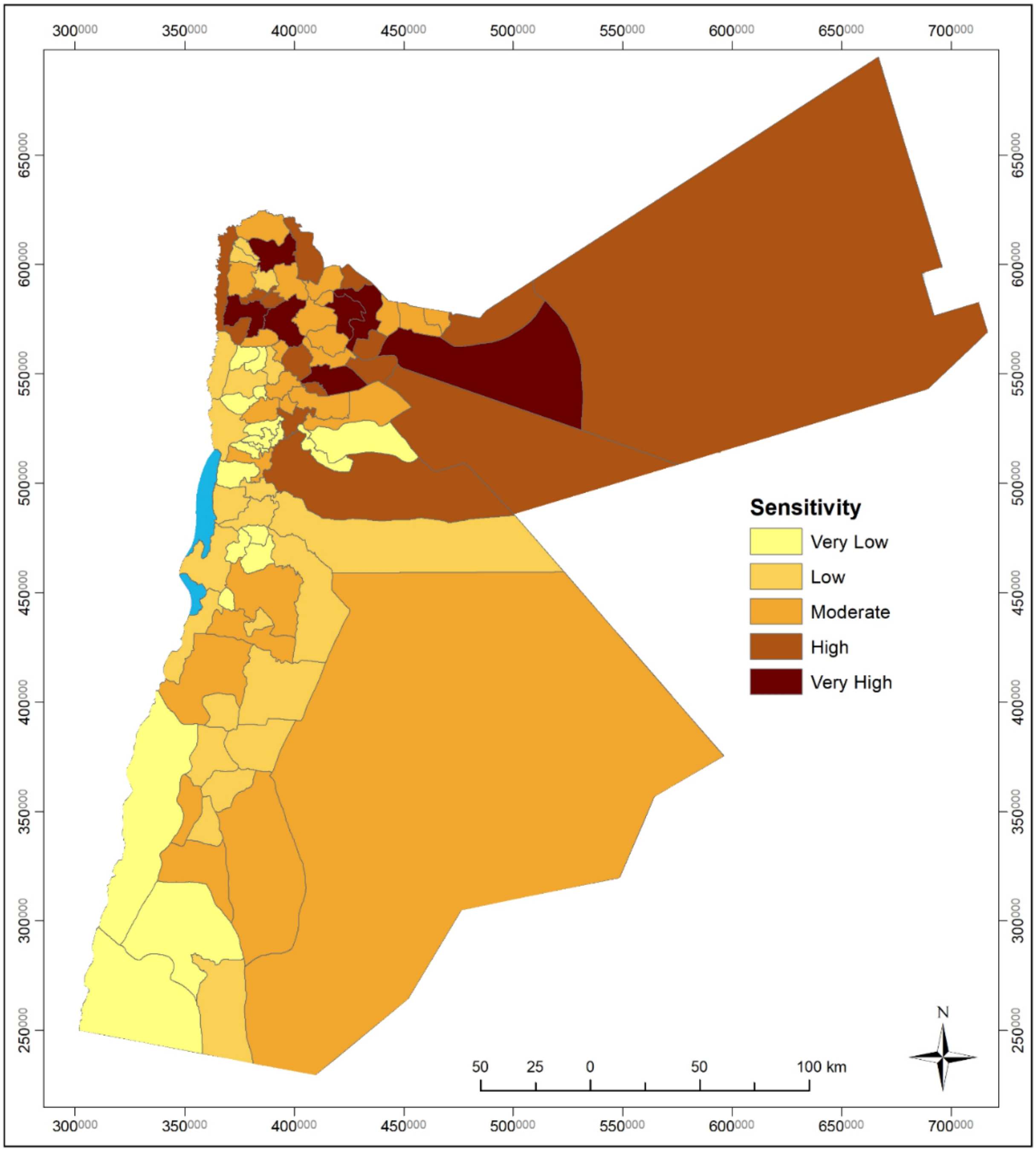


Figure 4.74: The aggregated Sensitivity Factors for the health sector

Table 4.36: The top ten sub-districts, with the highest weights for sensitivity factors

Governorate	District	Sub-District	Sensitivity
Zarqa Governorate	Zarqa Qasabah District	Zarqa Sub-District	1.0000
Irbid Governorate	Irbid Qasabah District	Irbid Qasabah District	0.9697
Mafraq Governorate	Badia Sh.Gh. District	Badia Sh.Gh. Sub-District	0.9214
Ajlun Governorate	Ajlun Qasabah District	Ajlun Sub-District	0.8283
Jerash Governorate	Jerash Qasabah District	Jerash Sub-District	0.8175
Mafraq Governorate	Mafraq Qasabah District	Mafraq Sub-District	0.8147
Mafraq Governorate	Badia Shamaliyah District	Salhiya Sub-District	0.8024
Mafraq Governorate	Rwaished District	Rwaished District	0.7897
Irbid Governorate	Aghwar Shamaliyah District	Aghwar Shamaliyah District	0.7706
Irbid Governorate	Ramtha District	Ramtha District	0.7150

4.9.5 Assessment of Health Adaptive Capacity Index

The normalized adaptive capacity was aggregated from seven factors including Educational Level of Household Head, Level of Income, Variance of Income, Household Asset Ownership, Health Assured, Net Migration, and Diversification of Improved Water Resources. Based on the generated map (**Figure 4.75**), the most adaptive sub-districts are located within Amman Governorate, which is an accurate assessment, since the capital city provides all means of assurance concerning water, health, education, etc. On the other hand, the least adaptive sub-districts were identified in Ajlun Governorate, followed by Mafraq, Karak, and Tafiela Governorates.

Table 4.37 and **Table 4.38** show the top ten highest and lowest adaptive capacities for the health sector, respectively. These sub-districts require more attention than others to enhance their resilience concerning health aspects. The lowest adaptive capacity exists at Kufranjah District, Ajloun.

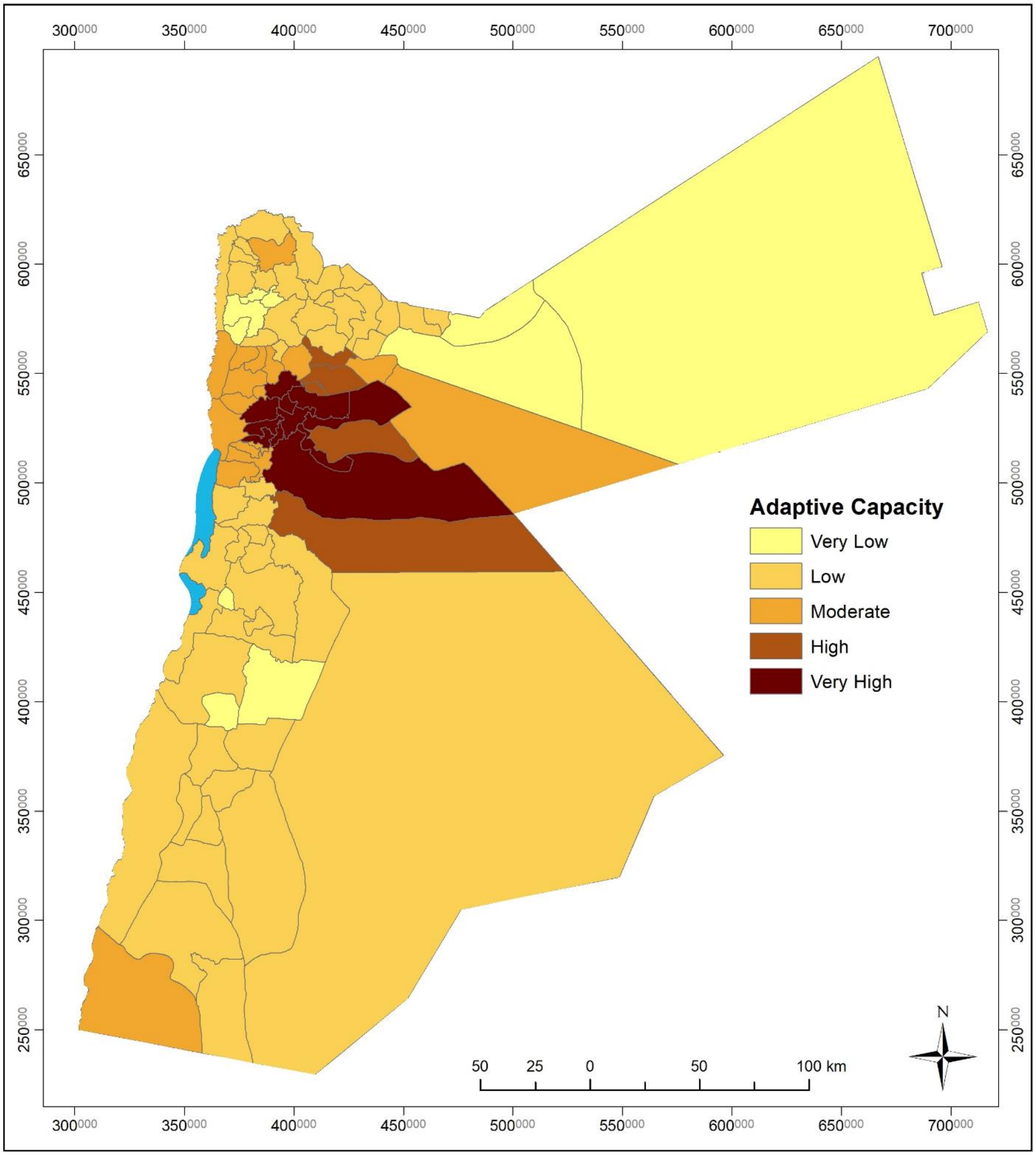


Figure 4.75: The generated normalized adaptive capacity related to climate change in the health sector

Table 4.37: The top ten sub-districts, with the best adaptive capacity, for the health sector, based on the highest sensitivity factor weights

Governorate	District	Sub-District	Adaptive Capacity
Amman Governorate	Al-Jami'ah District	Al-Jami'ah District	1.0000
Amman Governorate	Quaismeh District	Quaismeh District	0.9989
Amman Governorate	Marka District	Marka District	0.9952
Amman Governorate	Amman Qasabah District	Amman Qasabah District	0.9841
Amman Governorate	Wadi Essier District	Wadi Essier District	0.9647
Amman Governorate	Na'oor District	Na'oor Sub-District	0.9171
Amman Governorate	Sahab District	Sahab District	0.8999
Amman Governorate	Muaqqar District	Rajm al-Shami Sub-District	0.8129
Amman Governorate	Jizah District	Jizah Sub-District	0.8104
Amman Governorate	Na'oor District	Um Elbasatien Sub-District	0.8095

Table 4.38: The top ten sub-districts, with the lowest adaptive capacity, for the health sector, based on the lowest sensitivity factor weights

Governorate	District	Sub-District	Adaptive Capacity
Ajlun Governorate	Kufranjah District	Kufranjah District	0.0356
Ajlun Governorate	Ajlun Qasabah District	Sakhrah Sub-District	0.0732
Ajlun Governorate	Ajlun Qasabah District	Ajlun Sub-District	0.0863
Ajlun Governorate	Ajlun Qasabah District	Orjan Sub-District	0.1000
Mafraq Governorate	Rwaished District	Rwaished District	0.1401
Mafraq Governorate	Badia Shamaliyah District	Salhiya Sub-District	0.1669
Mafraq Governorate	Badia Shamaliyah District	Dair Al Kahf Sub-District	0.1752
Karak Governorate	Ayy District	Ayy Qasabah District	0.1889
Tafiela Governorate	Bsaira District	Bsaira District	0.1914
Tafiela Governorate	Hasa District	Hasa District	0.1971

4.9.6 Health Sector Hazard Factors

Three hazard factors were of concern, these are Sanitation, Flood, and Drought. The zone maps were generated by the World Food Programme. The maps were re-classified and aggregated to represent the country at sub-district level. The final risk map indicates that sub-districts of Al-Jami'ah in Amman Governorate, Qasr Sub-District in Karak Governorate, and Ajlun Sub-District in Ajlun Governorate are considered the riskiest zones within the country, in terms of the three aggregated factors of drought, sanitation, and floods (**Figure 4.76**). These regions require special adaptation practices in the form of improved sanitation programs, flood controls, and drought mitigation practices, to reduce further risks and improve their resilience. **Table 4.39** shows the top ten highest sub-districts, concerning high-risk in the health sector.

Table 4.39: The top ten sub-districts of high-normalized hazard weights

Governorate	District	Sub-District	Hazards
Amman Governorate	Al-Jami'ah District	Al-Jami'ah District	1.0000
Karak Governorate	Qasr District	Qasr Sub-District	0.9545
Ajlun Governorate	Ajlun Qasabah District	Ajlun Sub-District	0.9091
Karak Governorate	Mazar Janoobee District	Mazar Sub-District	0.8864
Karak Governorate	Qasr District	Mowjeb Sub-District	0.8864
Ajlun Governorate	Kufranjah District	Kufranjah District	0.8864
Amman Governorate	Amman Qasabah District	Amman Qasabah District	0.7727
Ajlun Governorate	Ajlun Qasabah District	Orjan Sub-District	0.7636
Amman Governorate	Marka District	Marka District	0.7500
Karak Governorate	Aghwar Janoobiyah District	Ghawr Almazra'a Sub-District	0.7500

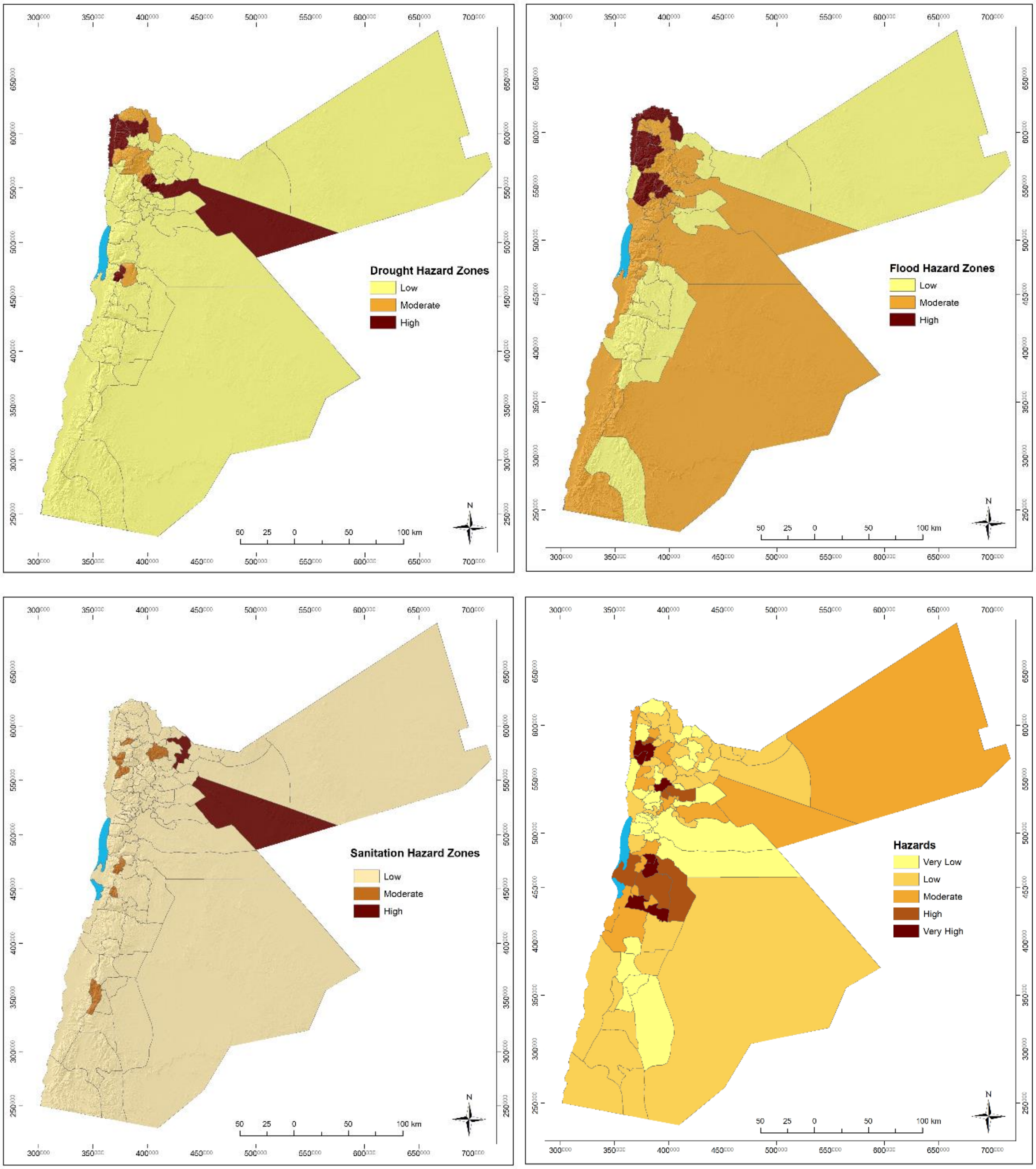


Figure 4.76: Sanitation, Flood, Drought and composite risk maps of Jordan

4.9.7 Climate Change Risk Assessment for Health Sector

Through assessing the risks, as derived from multiplication of the health vulnerability with the normalized composite hazard weight, the future health risk maps are presented in **Figure 4.77**. The health risks tend to converge at Ajlun Governorate, followed by Northeastern Badia Rwaished District. The risks are derived from the high sensitivity and low adaptive capacity of those regions. **Table 4.40** shows the top ten risk sub-districts, of which Kufranjah, Ajlun, and Orjan Sub-Districts are currently impacted by climate changes which are predicted to intensify in the future. Thus, immediate health adaptation actions and measures are required as top priority areas.

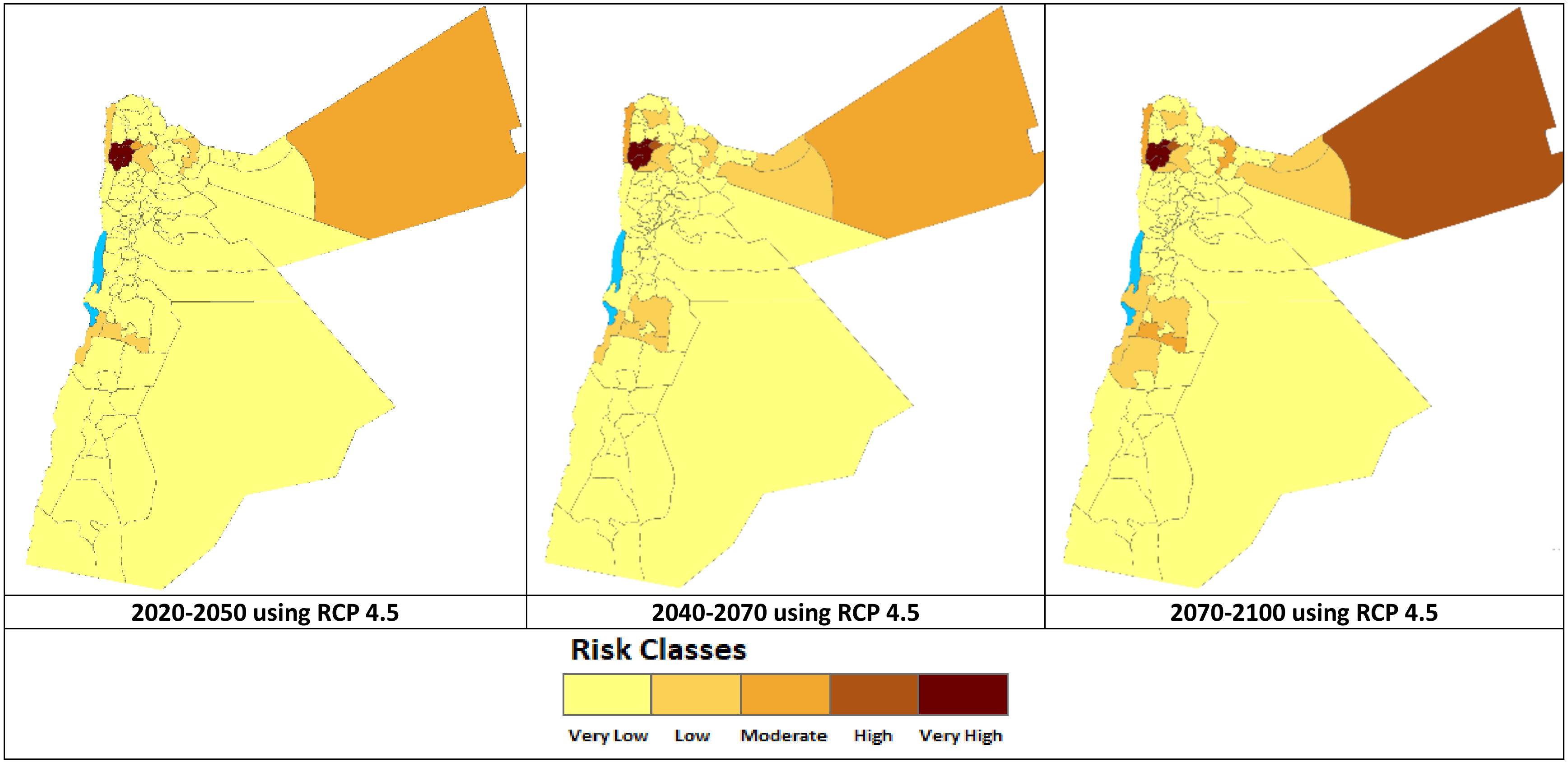


Figure 4.77: Health Risk maps regarding Future Climate Change Impacts Using RCP 4.5

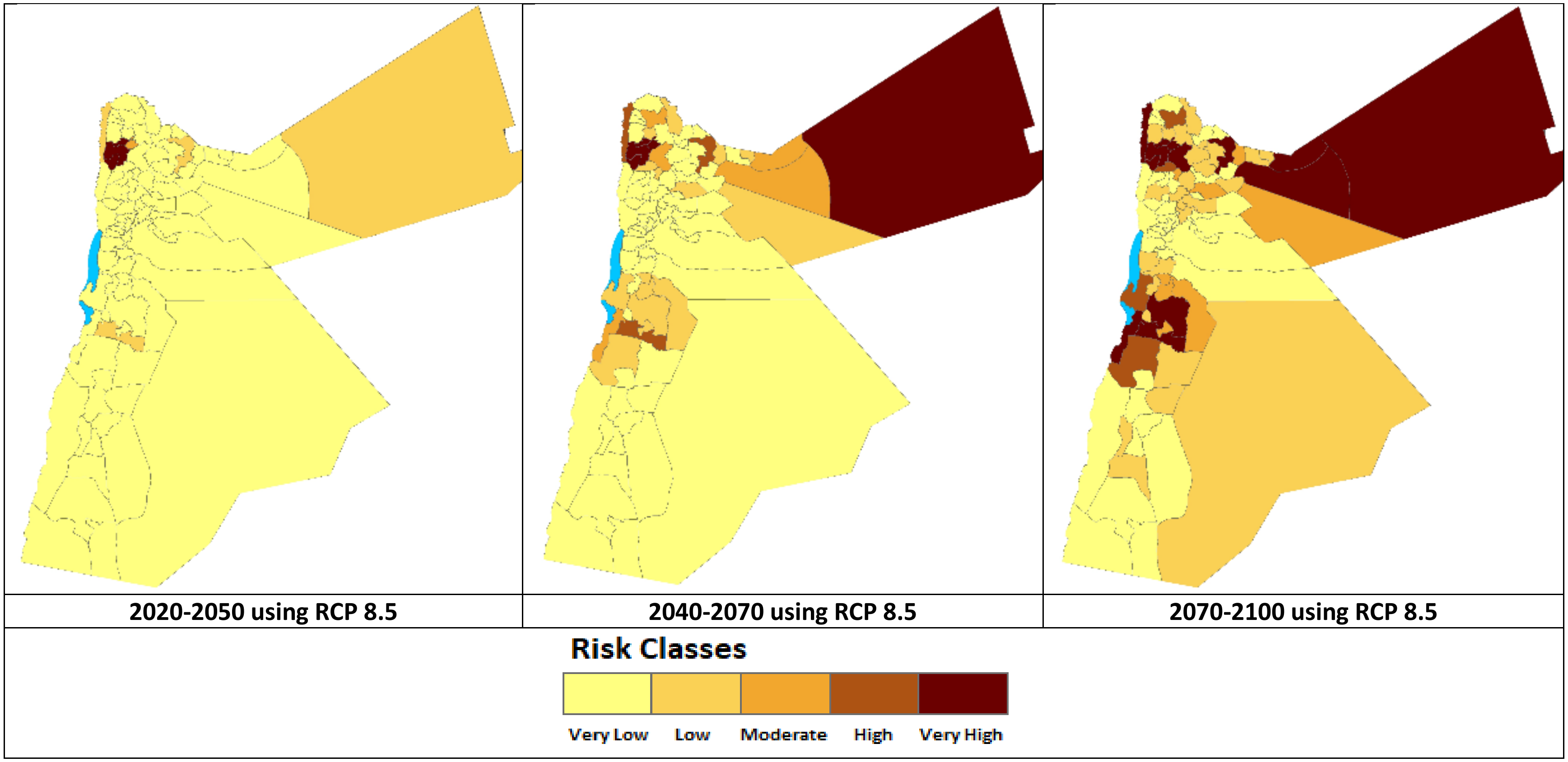


Figure 4.78: Health Risk maps regarding Future Climate Change Impacts Using RCP 8.5.

Table 4.40: The top ten sub-districts for High Risk to Climate Change Impacts related to Health

Governorate	District	Sub-District	Normalized Climate Change Risk
Ajlun Governorate	Kufranjah District	Kufranjah District	0.9329
Ajlun Governorate	Ajlun Qasabah District	Ajlun Sub-District	0.9269
Ajlun Governorate	Ajlun Qasabah District	Orjan Sub-District	0.8882
Mafraq Governorate	Rwaished District	Rwaished District	0.4138
Ajlun Governorate	Ajlun Qasabah District	Sakhrah Sub-District	0.4761
Karak Governorate	Mazar Janoobee District	Mazar Sub-District	0.3025
Irbid Governorate	Aghwar Shamaliyah District	Aghwar Shamaliyah District	0.3813
Mafraq Governorate	Badia Sh.Gh. District	Badia Sh.Gh. Sub-District	0.2556
Mafraq Governorate	Badia Shamaliyah District	Salhiya Sub-District	0.1988
Karak Governorate	Aghwar Janoobiyah District	Safi Sub-District	0.2187

4.9.8 Adaptation Measures for the Health Sector

Based on the Updated Climate Change Policy (2020-2050), the National Adaptation Plan, and the National Climate Change Health Adaptation Strategy and Action Plan of Jordan (2012), the proposed set of adaptation measures for the health sector were identified, reviewed, and updated. **Table 4.41** shows the prioritized adaptation measures based on stakeholder engagement and of experts group meetings.

In addition to the table, the group of experts suggested the following key adaptation points:

- Updating the Climate Change and Health Vulnerability and Adaptation Assessment (V&A) that was conducted in 2012.
- Enhancing the adaptive capacity of the health sector under current and future climate change conditions to address the impacts of COVID-19, with additional knowledge and capacity to contain the current and expected health impacts resulting from climate change either through extreme weather impacts or the possibility of spreading of climate-related infectious diseases.

Table 4.41: Prioritized Climate Change Adaptation List for Health Sector

	Policies	Action List	Time Frame	Reasons	Rank
HEALTH (H)					
H1	Enhancing the adaptive capacity of the health sector to address climate induced health impacts[178] and emerging infectious diseases	**H1.1.** Improved understanding of the potential risk on the health sector, including impacts on early childhood development due to climate change through mobilization of related institutions and experts to conduct studies and observations of climate impacts on health, also covering short-lived climate pollutants (SLCP).	Short Term	IO; R&D; CB	1
		H1.2. Carry out economic analyses of the costs of climate-induced health impacts to inform effectiveness and efficiency of health-related decision making.	Short and Medium term	IO; R&D; CB	8
		H1.3. Enhancing the adaptive capacity of the health sector (e.g., building capacities to conduct health vulnerability assessments, developing climate-informed disease control programs and surveillance systems using meteorological services, introducing new indicators that are useful for protecting health, developing early warning systems based on environmental information, increasing emergency room capacities, etc.).	Medium Term	IO; IC; PP; CB	2
		H1.4. Educating and informing the public of the needed measures to protect health from the adverse impacts of climate change and air pollution.	Medium Term	IO; IC; SE	3
		H1.5. Developing climate-informed disease control programs and surveillance systems using meteorological services to target vector control in time and space.	Medium Term	IO; R&D; PP	4
		H1.6. Adopting more effective and rapid electronic exchange of surveillance data for rapid intervention, and establish, with the relevant ministry(ies), access to real-time air quality monitoring data to establish the link between respiratory diseases and air pollution and climate change.	Medium Term	IO; R&D; CB	5
		H1.7. Introducing new indicators that are useful for protecting health, such as Air Quality Index and ultraviolet (UV) index, in cooperation with the relevant institutions.	Medium Term	IO; R&D	6
		H1.8. Utilizing effective tools (e.g., GIS or Health Mapper) to link environmental and climatic factors to health outcomes.	Medium Term	IO; R&D	7

Where IO is Immediate Opportunity, UP is Urgent Problem, R&D is Research and Development, ID is Infrastructure Development, IC is Institutional Capacity (IC), HC is High Cost, SA is Social acceptance, SE is Stakeholder Engagement, PP is Policy Process, and CB is Co-benefits.

[178] https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health - accessed 16 June 2021.

4.10 CCIVA for Urban Sector

4.10.1 Overview

Urban areas are more exposed to climate change, as the concentration of citizens, buildings, and economic and industrial activities is within cities. Despite the importance of infrastructure agglomerations within specific areas, urban growth and exacerbation of socio-economic activities irritate infrastructure and pressurize services.

The vulnerability assessment of urban areas was conducted by identifying exposures to climate change, sensitivity, and adaptive capacity. The exposures were analyzed using spatial overlay data using GIS software. The climate change projections of RCPs 4.5 and 8.5 for three main timespans of 2020-2050, 2040-2070, and 2070-2100 were applied to understand patterns at districts and sub-districts levels. Qualitative data analysis from DOS, MoT, and MWI, in addition to 4NC projections results, was adopted for sensitivity and adaptive capacity assessments. Consequently, consultations with experts and stakeholders were conducted to agree on relevant indicators.

This assessment highlights the observed and anticipated direct impacts of climate change on the exposure of people, infrastructure, buildings, and systems to risks. The prominent exposure of Jordanian cities to climatic events are urban temperature variations, changing precipitation patterns, heatwaves, sandstorms, and humidity. For measuring urban systems' vulnerability to climate exposures, the sensitivity assessment pivoted around the socio-economic, physical/spatial, and governmental aspects. Consequently, socio-economic, spatial/physical, and governmental perspectives also informed adaptive capacity measures. Further, the climate change hazards assessment on urban areas explored two main spatial hazards: drought and flash floods.

4.10.2 Selection of Urban Indicators for Assessing the Climate Change Impacts

Based on data availability and stakeholder meetings, the Climate Change Vulnerability and Risk factors were identified as listed below in Table 4.42. The exposure factors were mainly climatic and presented for two RCPs 4.5 and 8.5 for the three time horizons of 2050, 2070, and 2100. The sensitivity factors included several demographic and physical factors, in addition to water and land-use land cover (LULC). The adaptive capacity factors included socioeconomic, governmental, physical, and services. Drought and flash floods are the two main hazards investigated in this study.

Table 4.42: Adopted Vulnerability/Risk Matrix for Urban Sector

Category	Factor	Description	Source
Exposure	Climate Factors	Increase in Temperature	4NC Projection Results
	Climate Factors	Decrease in Precipitation	4NC Projection Results
	Climate Factors	Increase in Heatwaves	4NC Projection Results
Sensitivity	Demographic	Population Density	DOS, 2019
	Demographic	Household size	DOS, 2019
	Demographic	Number of Households	DOS, 2019
	Demographic	Percent of Syrian Refugee	DOS, 2019
	Demographic	Poverty Rate	DOS, 2019
	Demographic	Prevalence of Unemployment	DOS, 2019
	Migration	Net migration	DOS, 2018
	Water	Avg. Consumption per capita per day - LCD	MWI, 2018
	Water	Water Demand	MWI, 2020
	LULC	Urban fabric percentage	4NC Projection Results
	LULC	Green coverage percentages	4NC Projection Results
Adaptive Capacity	Water	Sewer System Coverage	MWI, 2020
	Water	Water network Subscribers	MWI, 2018
	Water	Percentage of Population Connected to Sewer System	MWI, 2020
	Expenditure	Educational Level of Household Head	DOS, 2018
	Expenditure	Level of Income	DOS, 2018
	Expenditure	Variance of Income	DOS, 2018
	Expenditure	Household Asset Ownership	DOS, 2018
	Health	Health Assured	DOS, 2018
	Urban	Percentage non-urbanized cover	4NC Projection Results
	Transportation	Percentage of transportation (length and number)	MoT, 2020
	Physical	Diversification for improved water resources	MWI, 2020
Hazards	Physical	Drought Hazard Zones	WFP, 20119
	Physical	Flood Hazard Zones	WFP, 20119

4.10.3 Assessment of Urban Exposures Factors

Urban exposure to climate change includes three factors: an increase in temperature, a decrease in precipitation, and intense and more frequent heatwaves. These factors were obtained from the exposure section developed in this 4NC study. The exposure weights were determined equally since all factors have similar magnitudes of effects based on the health impacts. Besides, the overall exposure is stated for three time horizons and for two concentration pathways: RCP 4.5 and RCP 8.5, as reflected in Figure 4.79.

Based on the exposure maps, the projection of using RCP 4.5 has a moderate impact; the furthermost northern part is more exposed to climate change effects up to 2050, whereas the exposure between 2040 and 2070 is forecast to expand to cover the whole northern region. The vulnerability would stay moderate, when using 4.5 RCP for 2070 to 2100, for the Kingdom, except for the Petra and Shobak Qasabah Districts. The projection of RCP 8.5 shows that the northern region, followed by southern Ghor and northeastern Badia, is the most impacted by future climate changes. The degree of impact intensifies by the end of the century to cover the whole country. It thus illustrates the critical stages that Jordan is facing in the future.

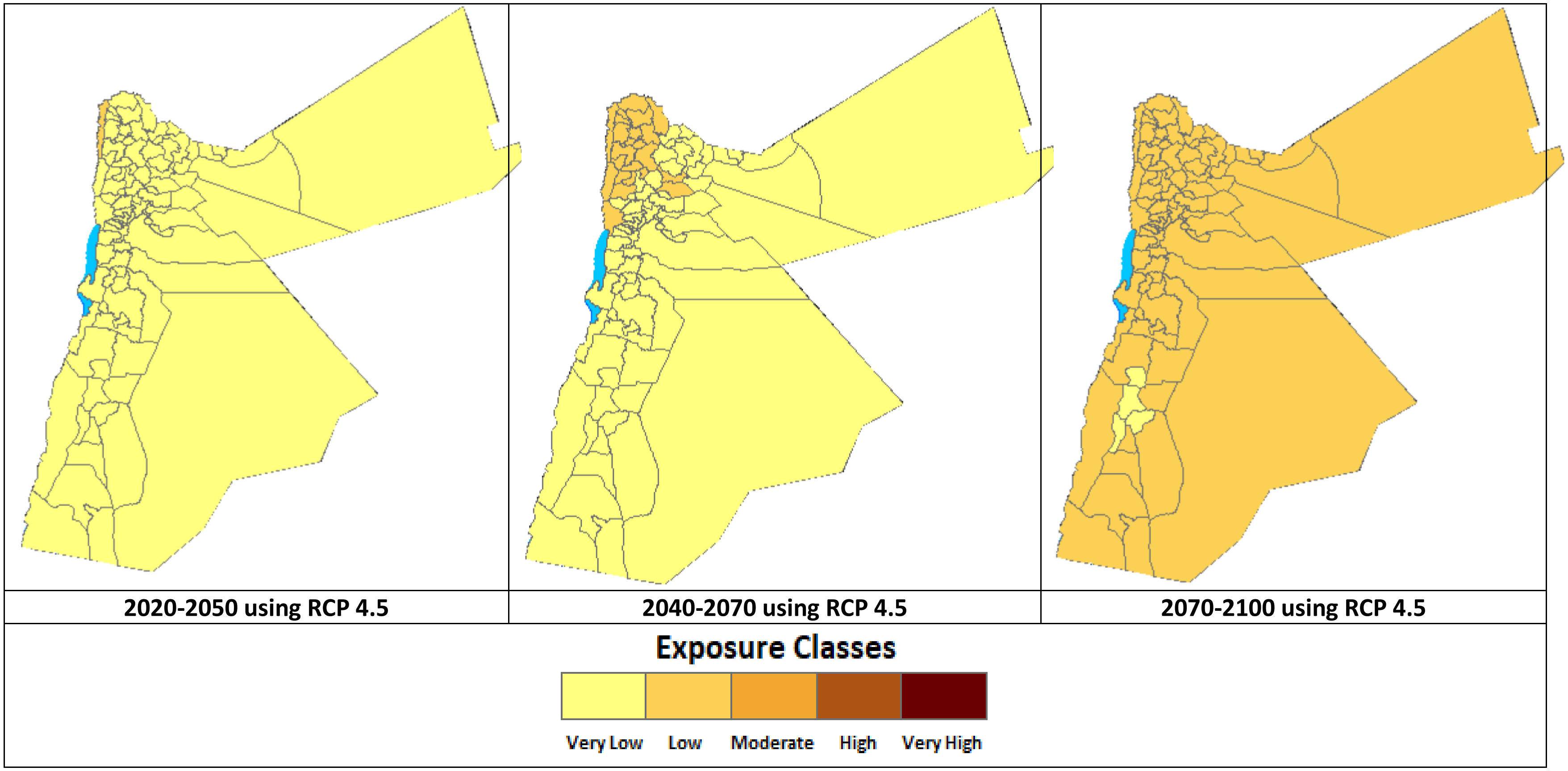


Figure 4.79: The selected climate exposure maps for urban sector using RCP 4.5

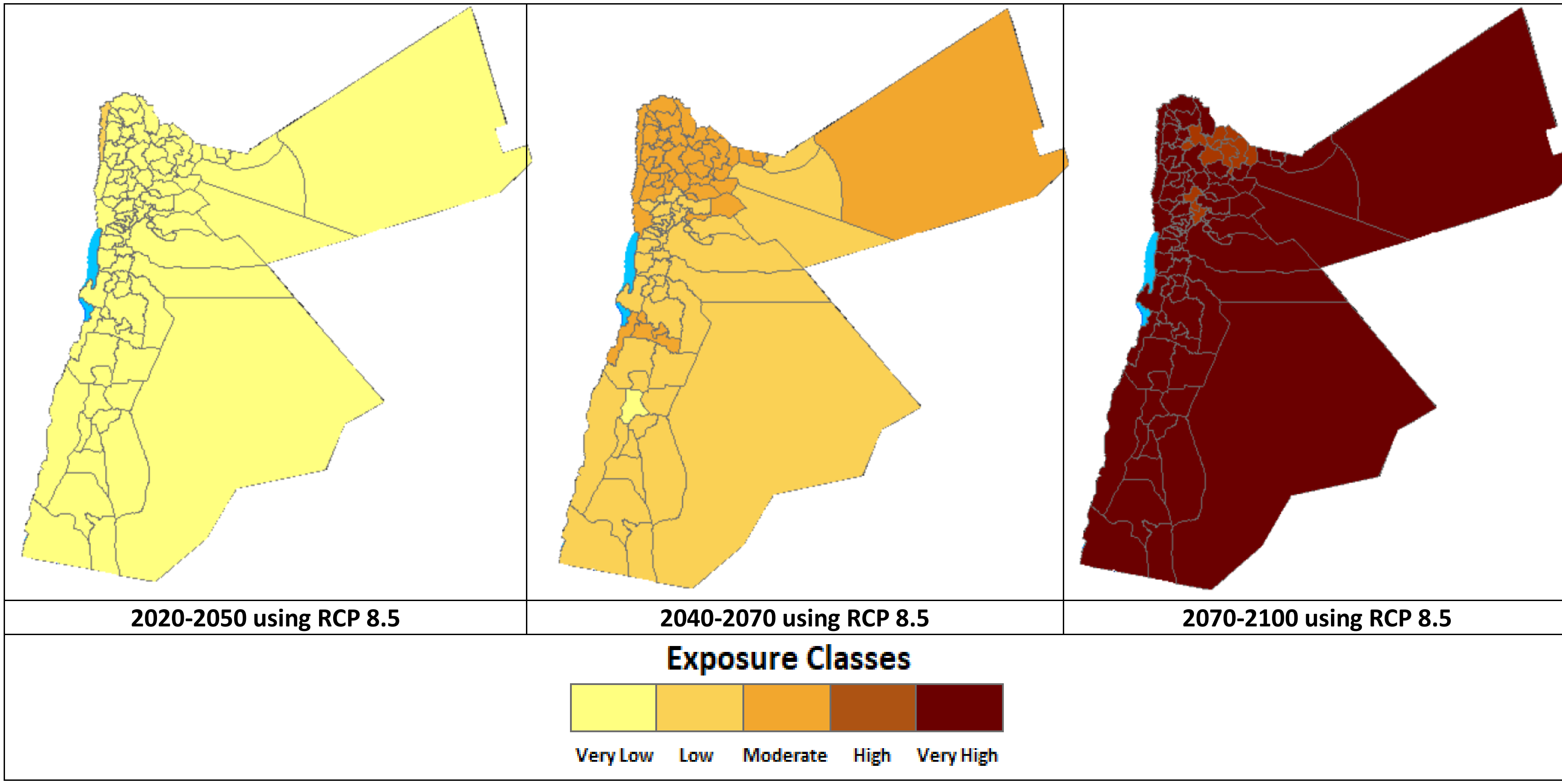


Figure 4.80: The selected climate exposure maps for the urban sector using RCP 8.5

4.10.4 Assessment of Urban Sensitivity Composite Index

A composite sensitivity factor was derived from several demographic, socio-economic, and physical factors. The data were weighted based on expert group meetings and aggregated to provide a normalized sensitivity factor.

The sensitivity around the kingdom varies between very low, low, moderate, and very high. Although, it fluctuates between districts and sub-districts within the same governorate. Overall, most areas have very low and low sensitivity to climate change. Yet, as illustrated in Figure 4.81, the highly vulnerable cities are concentrated in the central and northern areas as the population, economic activity, and urbanization rate are high compared with areas towards the south.

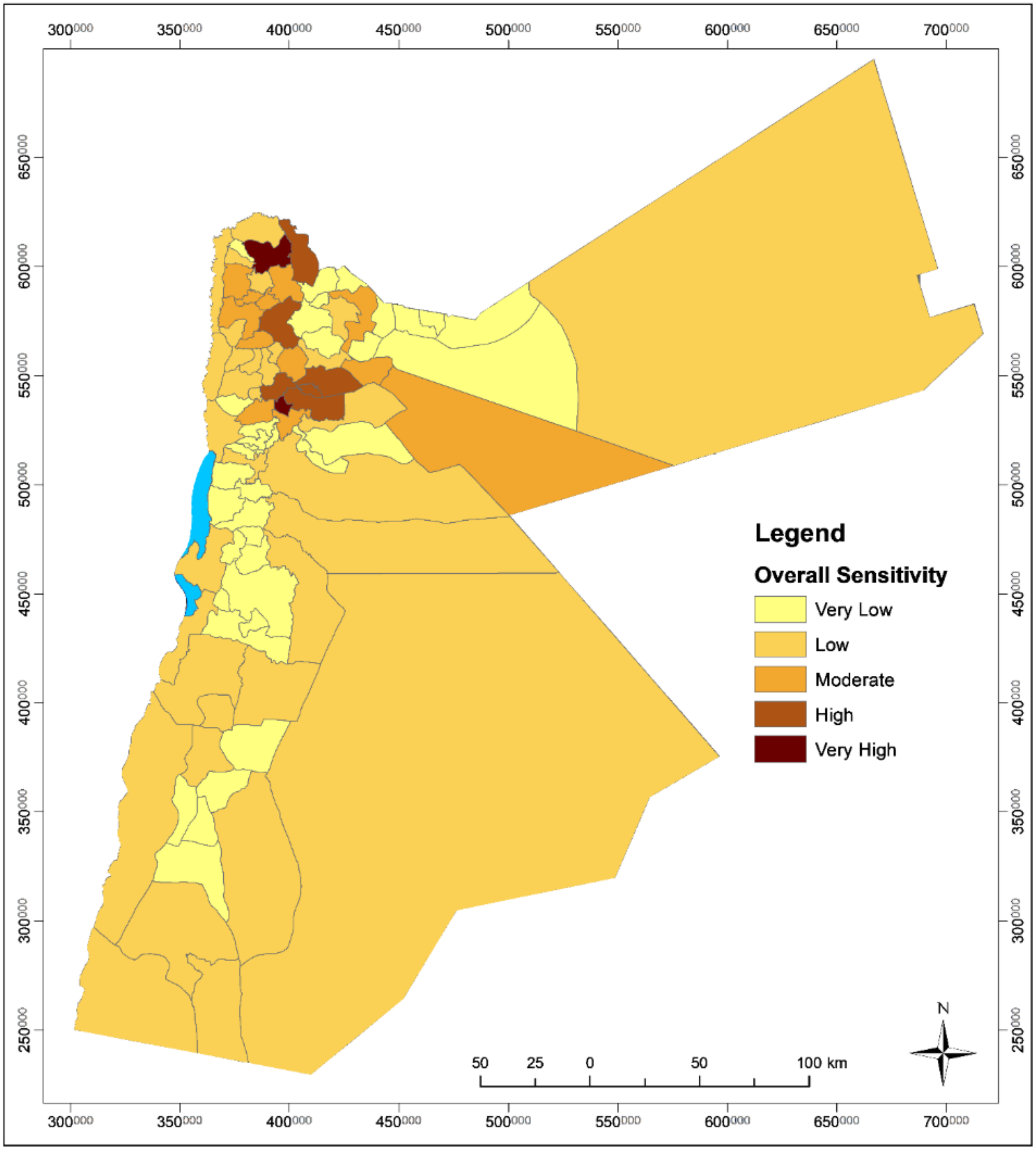


Figure 4.81: The selected climate exposure maps for the urban sector

Table 4.43 highlights the overall sensitivity weights and the most vulnerable districts and sub-districts.

Table 4.43: The top ten sub-districts, according to high-normalized sensitivity weights

Rank	Governorate	District or Sub-district	Sensitivity
1	Amman Governorate	Amman Qasabah District	1.000
2	Irbid Governorate	Irbid Qasabah District	0.949
3	Amman Governorate	Marka District	0.724
4	Zarqa Governorate	Russeifa District	0.666
5	Amman Governorate	Al-Jami'ah District	0.660
6	Jerash Governorate	Jerash Sub-District	0.628
7	Zarqa Governorate	Zarqa Sub-District	0.614
8	Irbid Governorate	Ramtha District	0.605
9	Ajlun Governorate	Sakhrah Sub-District	0.579
10	Azraq Governorate	Azraq Sub-District	0.539

4.10.5 Assessment of Urban Adaptive Capacity Index

The examination of adaptive capacity in urban areas delves into fourteen indicators within socioeconomic, spatial, governmental, and services factors, which are: Urban land-use planning, imported and exported water, water supply and demand, sewer system coverage and percentage of the population connected to the sewer system and public transportation coverage which are related to spatial factors. The socioeconomic factors were studied by exploring the level of income, variance of income sources, household income assets, and health insurance coverage. All indicators were normalized and aggregated to indicate the adaptive capacity amongst sub-districts of all governorates (Figure 4.82).

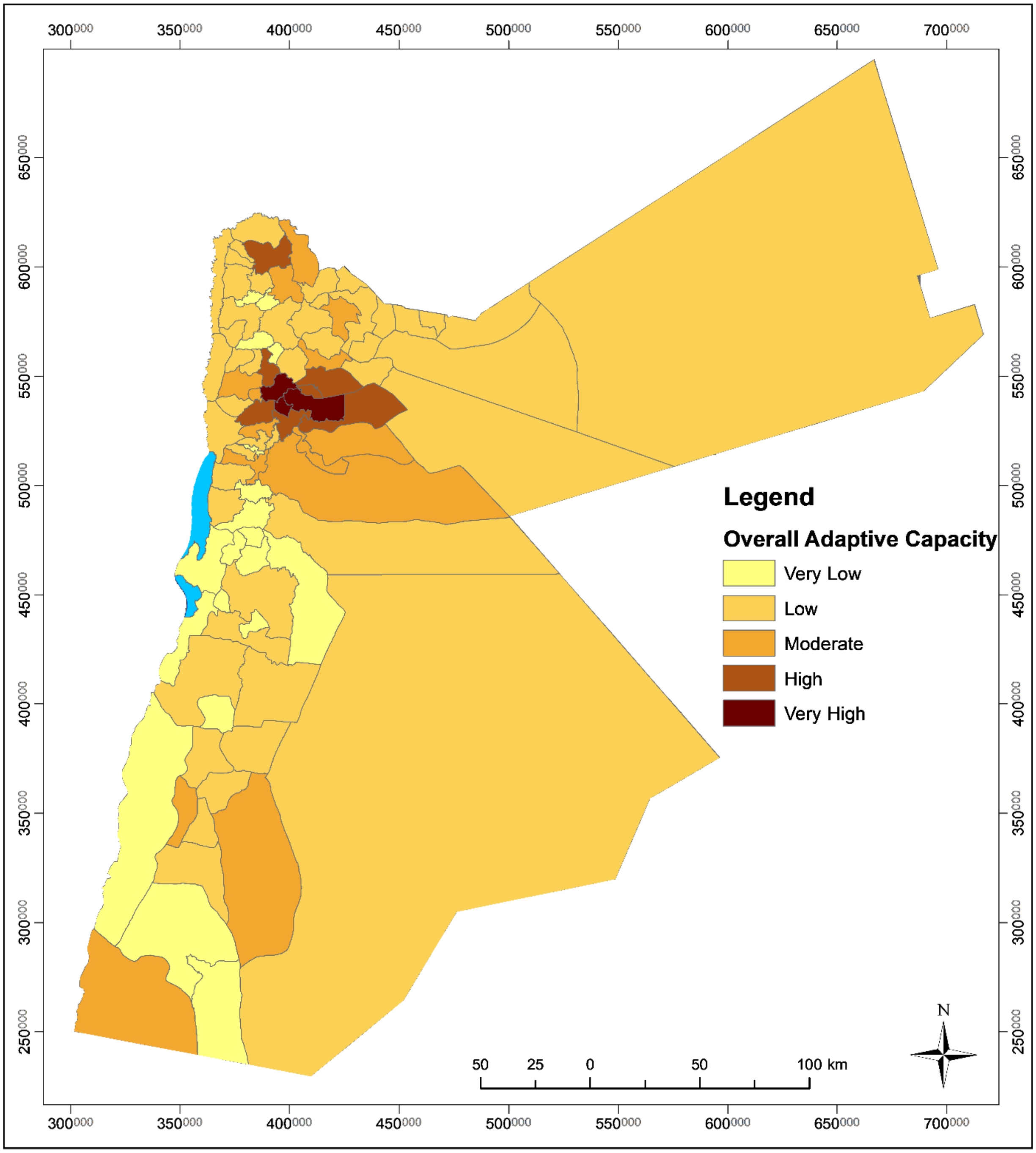


Figure 4.82: The generated normalized adaptive capacity for assessing climate change in the urban sector

Based on the generated map – figure 3- the most adaptive sub-districts are located within Amman Governorate, followed by those in Irbid Governorate, while the lowest adaptive capacity is in Aqaba Governorate, followed by Ajlun, Jerash, and Karak, as demonstrated in Table 4.44.

Table 4.44: least adaptive districts and sub-districts with low normalized weights

Rank	Governorate	District	Sub-district	Adaptive Capacity
1	Aqaba Governorate	Quairah District	Diesah Sub-District	0.189
3	Ajlun Governorate	Ajlun Qasabah District	Orjan Sub-District	0.209
2	Ajlun Governorate	Ajlun Qasabah District	Sakhrah Sub-District	0.230
3	Aqaba Governorate	Aqaba Qasabah District	Wadi Araba Sub-district	0.244
	Karak Governorate	Ayy District	Ayy Qasabah District	0.246
	Jerash Governorate	Jerash Qasabah District	Borma Sub-district	0.246
4	Jerash Governorate	Jerash Qasabah District	Mestabah Sub-district	0.247
5	Karak Governorate	Aghwar Janoobiyah District	Safi Sub-District	0.254
6	Karak Governorate	Mazar Janoobee District	Mo’aab Sub-District	0.255
7	Tafileh Governorate	Bsaira District	Bsaira District	0.262
8	Madaba Governorate	Dieban District	Mlaih Sub-District	0.263
9	Madaba Governorate	Dieban District	Dieban Sub-District	0.269
10	Madaba Governorate	Madaba Qasabah District	Jrainah Sub-District	0.272

4.10.6 Climate Change Vulnerability Assessment for Urban Sector

The Comprehensive Urban Vulnerability Assessment on Exposure, Sensitivity, and Adaptive Capacity revealed that the most vulnerable districts are in Ajlun Governorate, (namely, Orjan Sub-District and Sakhrah Sub-District), followed by Borma Sub-District and Mestabah Sub-District, in Jerash Governorate, in addition to Diesah Sub-District and Wadi Araba Sub-District in Aqaba, and Safi Sub-District and Qatraneh District in Karak (Figure 4.83).

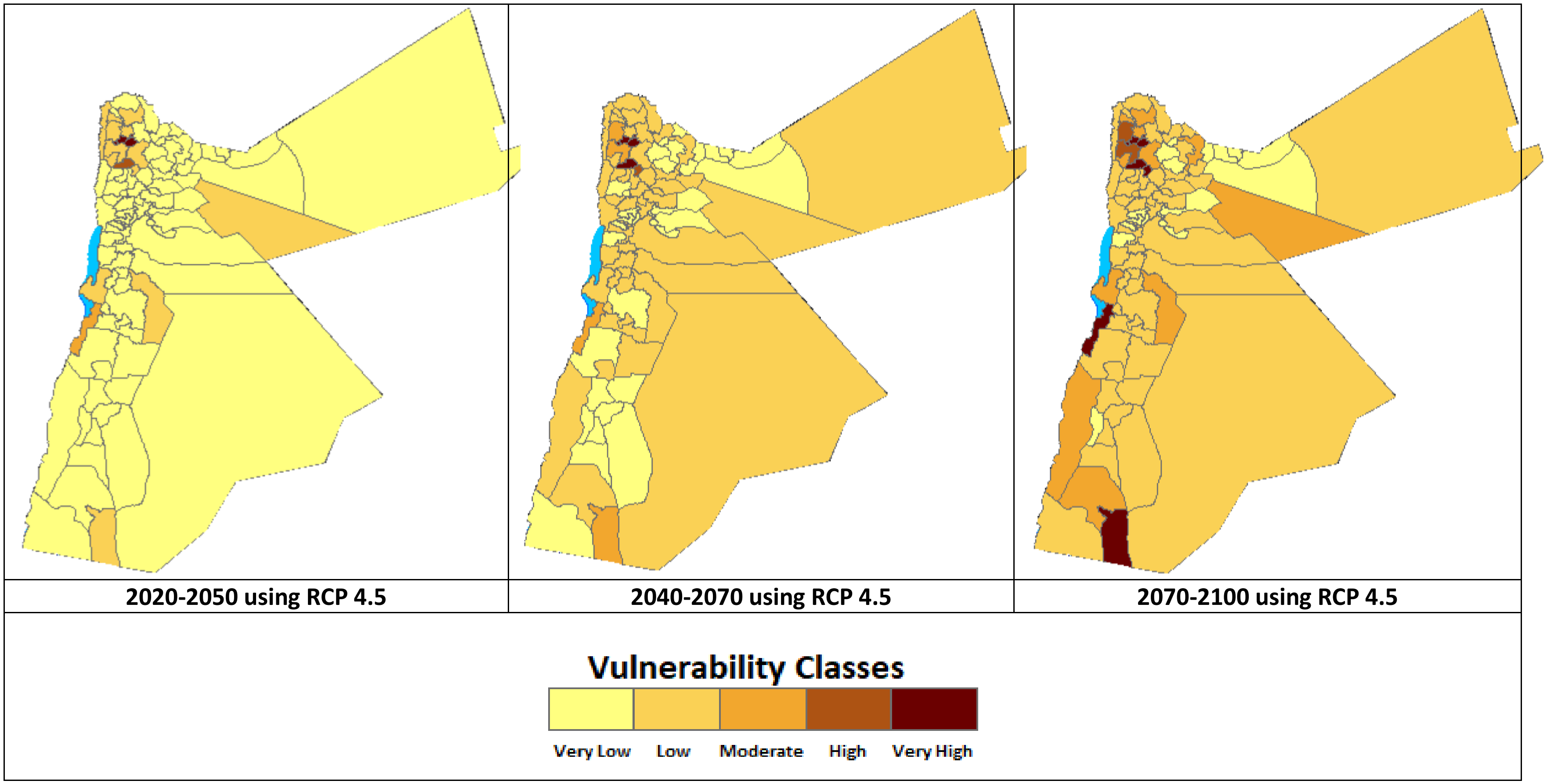


Figure 4.83: The Climate Change Vulnerability maps for an urban sector using RCP 4.5.

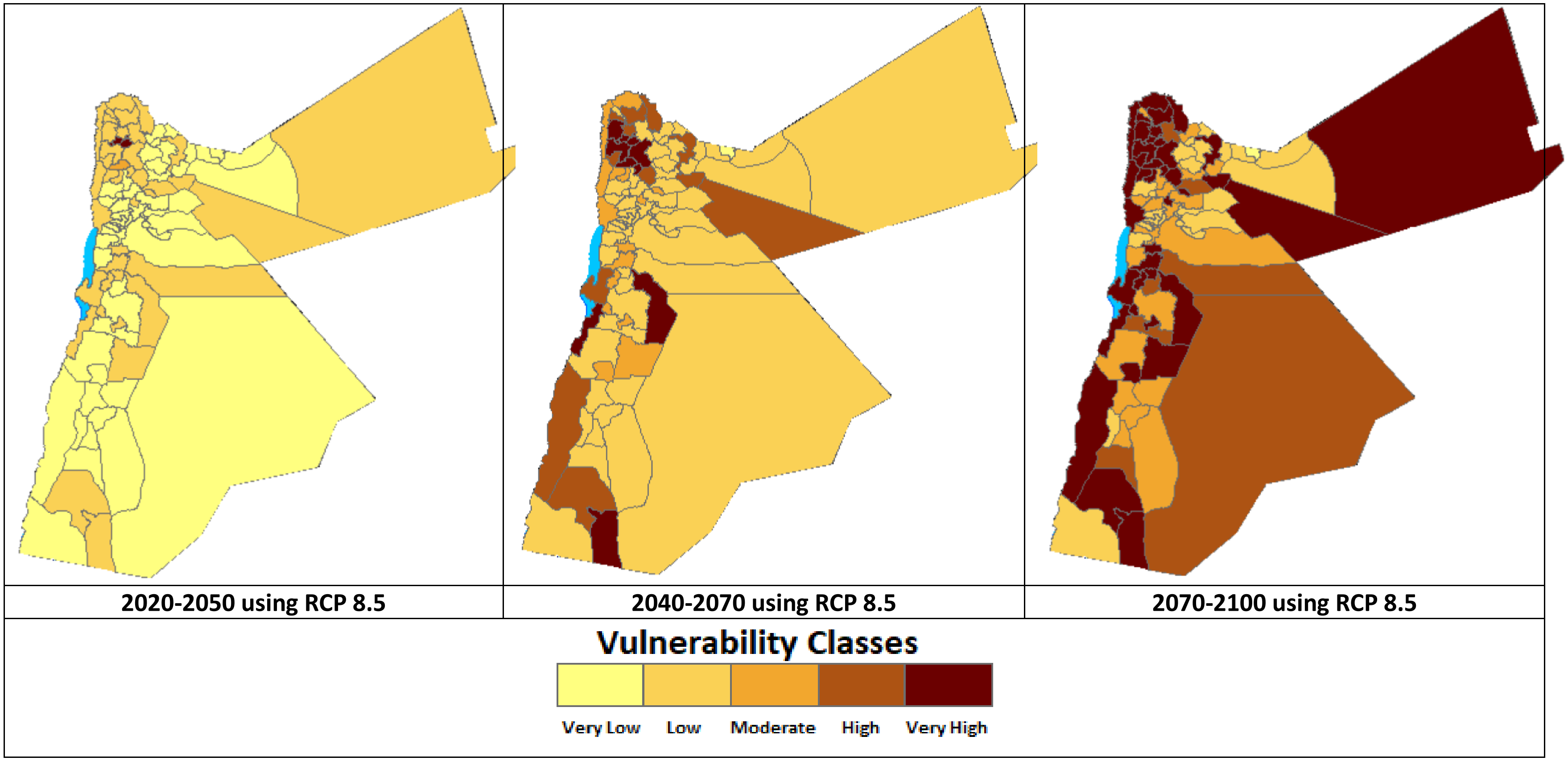


Figure 4.84: The Climate Change Vulnerability maps for an urban sector using RCP 8.5.

4.10.7 Climate Change Hazard Assessment for Urban Sector

Drought and floods were the two hazards investigated for urban areas. Based on the overall hazard map, the most impacted areas are disseminated between north, central, and central-eastern cities, namely Amman, Ajlun, and Karak. The precise affected subdistricts are Al-Jami'ah District, Qasr Sub-District, Ajlun Sub-District, Kufranjah District, Mazar Sub-District, Mujeb Sub-District, Amman Qasabah District, Oran Sub-District, Ghawr Almazra'a Sub-District, and Marka District respectively (Figure 4.85).

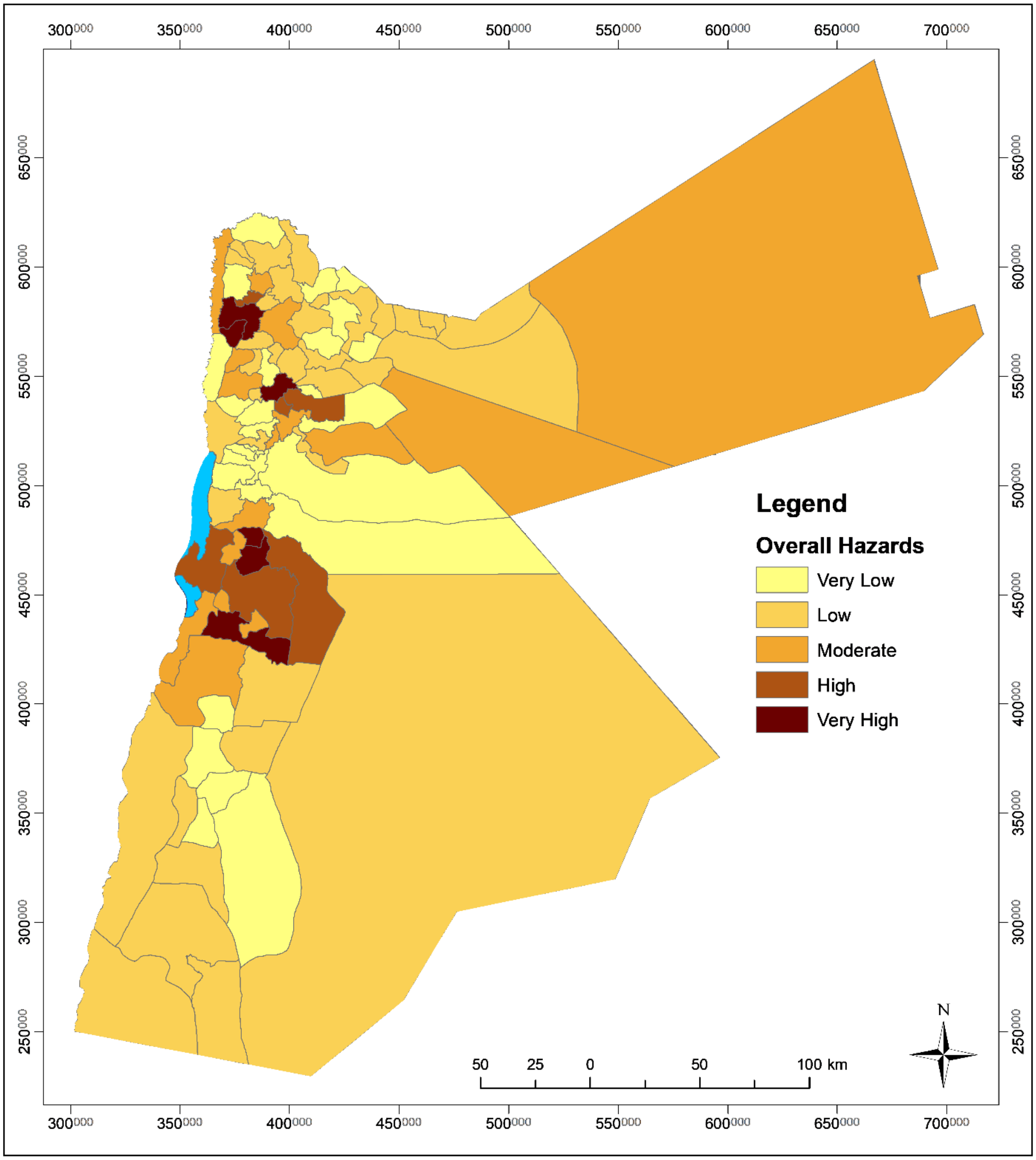


Figure 4.85: The Overall Hazard maps for urban areas.

To enable the forecast of future projected risks between 2030-2100, an overlapping between vulnerability and hazard maps was employed, as demonstrated in Figure 6. Based on these maps, the most vulnerable subdistrict for flood and drought hazards are Orjan Sub-District, Sakhrah Sub-District, and Ajlun Sub-District within Ajlun Governorate, followed by Safi Sub-District, Ghawr Almazra'a Sub-District, Qatraneh District, and Kufranjah District in Karak Governorate. Also, Borma Sub-District in Jerash Governorate is highly vulnerable to such risks (Figure 4.86).

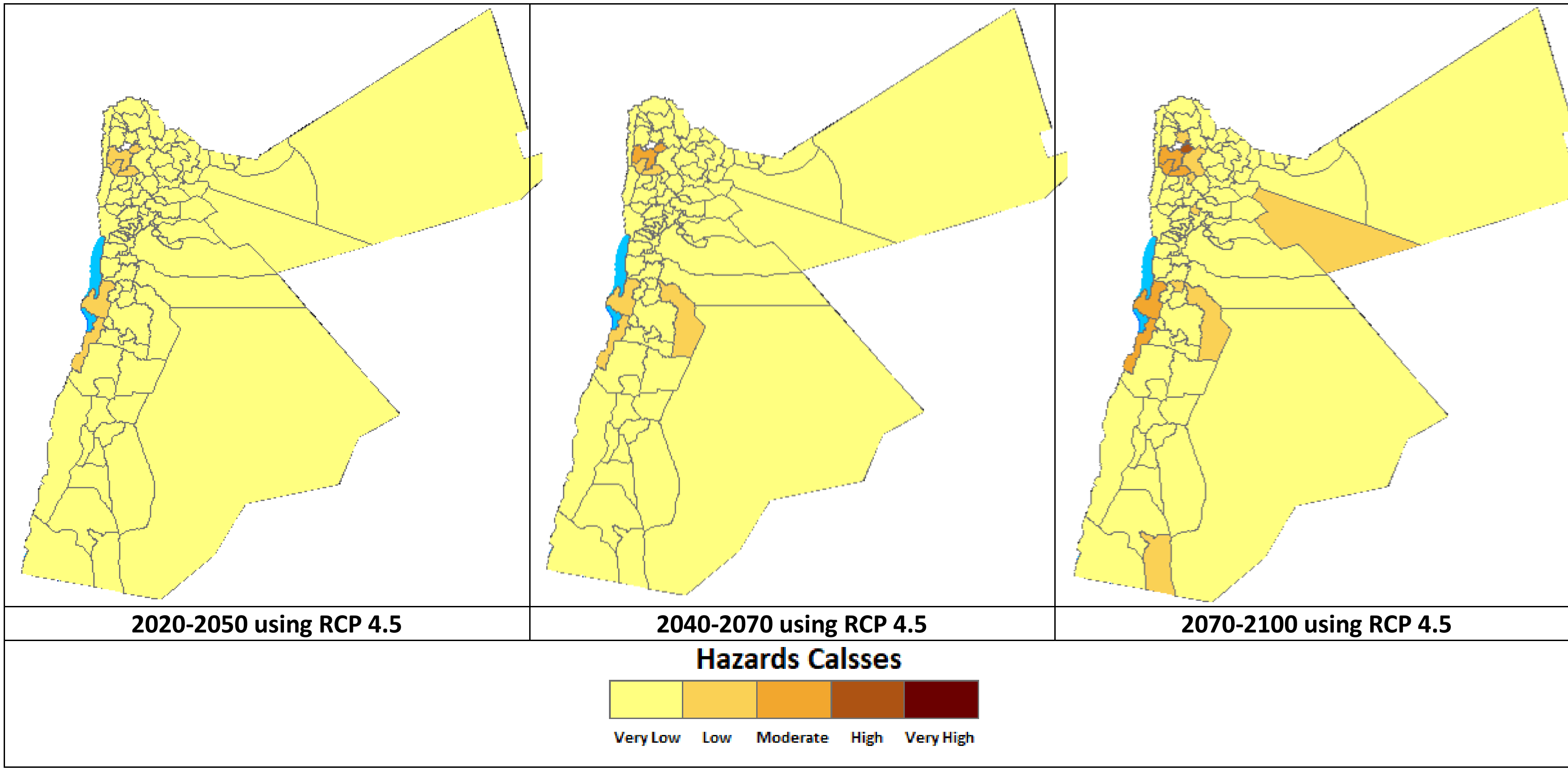


Figure 4.86: Urban Risk maps of Future Climate Change Impacts using RCP 4.5.

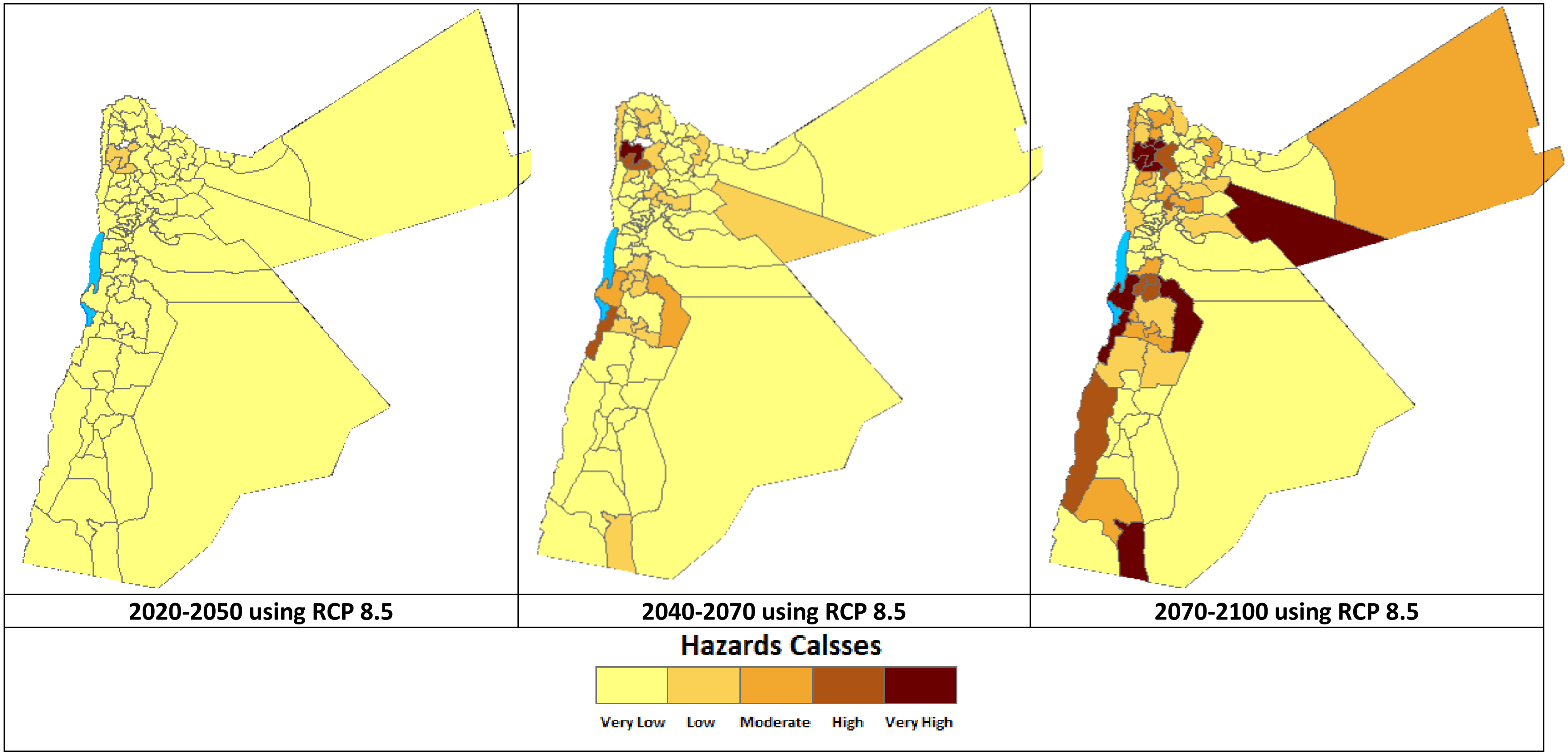


Figure 4.87: Urban Risk maps of Future Climate Change Impacts using RCP 8.5.

4.10.8 Adaptation Measures for the Urban Sector

The Updated Climate Change Policy (2020-2050), the National Adaptation Plan, and the updated submission of Jordan's 1st Nationally Determined Contribution (NDC), the Jordan National Strategy for Disaster Risk Reduction (2019-2022) and other policies have proposed a set of adaptation measures for the Urban sector. **Table 4.45** thus summarizes the prioritized adaptation measures based on stakeholder engagement and of experts' group meetings.

Table 4.45: Adaptive measures within policy directives

	Policies	Action List	Time Frame	Reasons	Rank
UD1	Enhancing the resilience of urban structure to climate change impacts and supporting sustainable urbanization	**UB1.1.** Supporting urban green infrastructure interventions for climate resilience (e.g. preserving natural watercourses, climate-responsive building techniques, integrated land-use planning, promoting rainwater-harvesting, establishing recreational parks, and integrating the use of shading elements (native trees) in walkways and streets).	Medium Term	IO; ID; PP; CB	1
		UB1.2. Improving readiness for climate-related disaster risk reduction in urban areas, to mitigate impact of extreme weather events on urban livelihoods.	Medium Term	UP; R&D	2
		UB1.3. Enhancing community participation at the local urban level, for climate change resilience (e.g., implementing existing local organizations and neighborhood networks to identify and respond to climate risks in urban areas, based on participatory consultation, supporting joint actions, and mandating urban municipalities to lead community-based initiatives for responding to climate risks through institutional restructuring and capacity development).	Medium Term	IO; SE; CB	3
		UB1.4. Improving building efficiency for adapting to increased heat in urban centers through enforcement of green-building codes and enhancing retrofitting of existing buildings.	Medium Term	IO; ID; CB	3
AF2	Enhancing restoration and conservation of biodiversity and sustainable land use co-benefits	**AF2.5.** Promote urban green infrastructures (e.g., tree plantation and ecosystem restoration) as part of urban planning.	Short Term	IO; SE; CB	4
IMPROVING ADAPTIVE CAPACITY (AC)					
AC1	Improving the adaptive capacity of social capital at national and local	**CZ2.1.** Integrating climate resilience in green economic recovery and development plans and initiatives through exploring innovative financing options for addressing climate adaptation and resilience projects and programmes.	Short Term	IO; SE, PP; CB	5

	levels, to climate change impacts	**CZ2.2.** Enhancing local adaptive capacity to climate change impacts through local climate action plans at municipality and/or district level (i.e., community participatory approach for planning and designing of local climate change adaptation (and mitigation) plans in coordination with local authorities), and through WASH to strengthen social cohesion and trust between community and water utilities in service delivery and community climate adaptation initiatives. Emphasis is placed on the inclusion of vulnerable groups as targets or beneficiaries for climate finance opportunities.	Medium Term	IO; SE, CB	6
		CZ2.3. Integrating climate adaptation (and mitigation) into national poverty reduction policies through improving the existing social protection system to cope with climate change consequences for the most vulnerable segments of society; adopting poverty alleviation programs providing housing for poor people and supporting micro-projects for poor communities in light of unusually severe seasonal cold and hot weather conditions that prevailed in the last decade; and developing emergency relief and aid, etc.	Medium Term	IO; SE, PP; CB	7
		CZ2.4. Mobilization of social capital for climate change adaptation through investment in youth in the present and as future decision makers and key stakeholders and as agents of change; enhancing capacity of Ministry of Social Development (MoSD), Ministry of Health (MoH) and Ministry of Education (MoE) staff to design and deliver climate resilient services to women and the poor; enhancing leadership capacity of community-based organizations (CBOs) to address climate change; developing an inventory of climate resilient traditional techniques in natural resources management in water and agriculture sectors and utilizing traditional knowledge for local adaptation measures.	Medium Term	IO; SE, PP; CB	8
URBAN RESILIENCE AND DISASTER RISK REDUCTION					
	Integrating and mainstreaming disaster risk reduction and crisis management concepts into sustainable development plans and programs and	Promoting the mainstreaming of disaster risk assessments, mapping and management into land-use policy development and implementation, including urban planning and into rural development planning and management.	Long Term		9

	climate change adaptation.				

Prioritize most vulnerable districts and sub-districts

It worth mentioning that in 2022, during COP27, Jordan revealed the Climate-Refugee Nexus Initiative and called for the prioritization of its endorsement within the country and the region. Also, in June 2022, the Hashemite Kingdom of Jordan launched the Economic Modernization Vision, that focuses on eight economic Drivers of Growth. The Green Jordan Driver contains three sectors including Green Urban Development, which has six initiatives, including creating & deploying Jordan-specific green urban concepts, integrating green elements into land-use planning, and launching 'net-zero buildings' initiative.[179]

4.10.9 Adaptation measures to Cultural Heritage

Jordan has recognized and complied to the challenge of climate change on cultural heritage, by endorsing the Climate Heritage Initiative aiming to protect tangible and intangible cultural heritage and adapt to climate change through integrated culture-based solutions.[180] Despite that, neither the Green Growth National Action Plan 2021-2025 for the Tourism Sector, nor the Jordan Tourism Strategy 2021-2025 reflect the degradation of cultural heritage assets resulting from climate change. Yet, the National Climate Change Policy (2022-2050) highlights adaptation measures on cultural heritage as shown in the table below.

[179] https://www.jordanvision.jo/en
[180] https://www.climateheritage.org/press/culture-outcomes-at-cop27

__Table 4.46: Adaptive measures within the Cultural Heritage__

<table>
<tr><th colspan="5">CULTURAL HERITAGE (CH)</th></tr>
<tr><td rowspan="4">CH1</td><td rowspan="4">Enhance the resilience of cultural and heritage values and assets to the detrimental impacts of climate change</td><td>CH1.1. Improving the preparedness of tangible and intangible cultural and heritage values and assets through climate change vulnerability analysis, risk assessment, and understanding the underlying causes of vulnerability and develop appropriate and systematic response system</td><td>Medium Term</td><td>UP</td></tr>
<tr><td>CH1.2. Integrating culture-based measures, accumulated traditional knowledge and technologies in the adaptation programs/plans across the development sectors</td><td>Medium Term</td><td>SE</td></tr>
<tr><td>CH1.3. Enhancing and capacitating the governance management system of cultural and heritage values and assets to allow proper coordination, collaboration, communication, and knowledge exchange</td><td>Short Term</td><td>IO; IC; PP</td></tr>
<tr><td>CH1.4 Improving, monitoring and mapping systems of the cultural and heritage sites to identify and integrate the climate change variable risks, and to inform the international conventions, agreements and systems.</td><td>Long Term</td><td>ID</td></tr>
<tr><th colspan="5">IMPROVING ADAPTIVE CAPACITY (AC)</th></tr>
<tr><td rowspan="4"></td><td rowspan="4">Enhancing the adaptive capacity of cultural heritage sites and infrastructure</td><td>Initiatives and studies to provide the required data and improve understanding of each heritage resource and its vulnerability to climate change.
Developing and mainstreaming sustainable policies and plans for climate-change adaptation of built and archaeological heritage</td><td rowspan="4">Short Term</td><td rowspan="4">IO; IC; PP</td></tr>
<tr><td>Developing and mainstream policies and plans for protection and climate-change adaptation of intangible cultural heritage and for the support of local communities whose livelihoods and wellbeing depend on cultural heritage resources.</td></tr>
<tr><td>Exploiting the opportunities for built and archaeological heritage and for intangible heritage to demonstrate value and secure resources</td></tr>
<tr><td>Engagement and coordination among the various stakeholders in the field, including government and nongovernmental organizations as well as international institutions.</td></tr>
<tr><td rowspan="2"></td><td rowspan="2">Integration of climate adaptation measures in the tourism supply chain and infrastructure</td><td>Introduction of water saving measures and systems in the tourism infrastructure landscape in Jordan especially hotels and restaurants.</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Safeguarding tourism sites from the impacts of climate change, especially floods and heatwaves through climate proofing studies for existing sites and climate impact prevention for sites to be constructed.</td></tr>
</table>

Where IO is Immediate Opportunity, UP is Urgent Problem, R&D is Research and Development, ID is Infrastructure Development, IC is Institutional Capacity (IC), HC is High Cost, SA is Social acceptance, SE is Stakeholder Engagement, PP is Policy Process, and CB is Co-benefits.

5 Means of Implementation

This chapter aims to provide a description of the current and proposed enabling environment for the implementation of the Fourth NC 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 also provides 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 Fourth NC 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

With the Paris Agreement (PA) and its Article 13, the Enhanced Transparency Framework (ETF) for action and support was established. The modalities, procedures and guidelines (MPG) for Article 13 provide operational details on how to report on the information on national GHG inventories, tracking of progress of implementation and achievement of NDCs, climate change impacts and adaptation efforts, support provided and received for implementing the PA, and general functioning of the ETF. The updated climate change policy included sets of policies and actions to achieve these reporting requirements through enhancing the Transparency Framework of the reporting to UNFCCC. While the focus of the policy is on the requirements under the UNFCCC, the actions are supportive of cooperation and data sharing with other institutions such as the International Renewable Energy Agency (IRENA), the International Energy Agency (IEA) and United Nations Economic and Social Commission for Western Asia (UNESCWA), among others. These policies are:

1. Online portal for reporting on the implementation of adaptation and mitigation contributions for the NDC, and support received, is established by building on the existing multi-tiered integrated MRV system
2. Capacity building of institutional stakeholders to use the online portal
3. Human and institutional strengthening, to produce Biennial Transparency Reports (BTRs)

The Government of Jordan has achieved cumulative experiences and knowledge in the GHG inventory with the development of the Jordan's NCs and BURs. However, working to collect, process, archive, monitor and report on the sources of GHG emissions and their sinks is still a "project based" intervention. In addition, the MRV system has not yet been activated to guarantee and facilitate the production, exchange and analysis of GHG inventory data, in order to comply with the current developments, within the UNFCCC negotiations.

Despite the efforts of the 4NC team to enable the institutions to practice the inventory estimation on their own, the process of the GHG inventory is not yet institutionalized and is mostly built around individual arrangements and exchanges between the MoEnv and the stakeholders generating GHG emissions. This is linked to the necessity of improving the capacities of the MoEnv and other key stakeholders on the technical and technological aspects, to be able to process the data into the required reporting format, using emissions factors, and ensure the continuous delivery of data, in the right format, adopted by the IPCC.

Working protocols and guidelines are developed within the GHG inventory process, including the quality assurance and 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 Ministry of Environment, should be also explored.

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 is necessary, 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 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. Data quality, completeness, and accuracy were a primary concern. In addition, most data were available in a format not suitable for GHG inventory estimation. The lack of disaggregate data was a barrier to improving the bottom-up estimation. In addition, there was a lack of institutional arrangement to support collection of data needed for estimating the national GHG inventory, particularly from the private and industrial sector.

In order to overcome this gap, a national effort should be established and led by the MoEnv to create a national system to collect, store, monitor and validate the GHG inventory data. This system should be institutionalized and governed through legal mechanisms and clear institutional mandates. The GHG inventory system should be modeled as a 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, land-use and waste). The development of a sustainable system for the 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.

As per Decision 17/CP.8, non-Annex I Parties are encouraged, as appropriate, to report on anthropogenic emissions of indirect GHGs and other gases not controlled by the Montreal Protocol, at the discretion of the Parties. Also, in Decision 2 CP.17, each non-Annex I Party is encouraged to provide a consistent time series back to the years reported in the previous NCs. Unfortunately, the National GHG Inventories of 2010 and 2012 have been estimated using the 2006 IPCC Guidelines, which have structural and methodological differences from the Revised 1996 IPCC Guidelines, used in estimating GHG emissions inventories for earlier national communications (NCs), which made it difficult to provide a consistent time series. Also, the National GHG Inventories of 2010 and 2012 did not provide emission estimates for indirect GHGs, such as carbon monoxide (CO), nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC), and other gases not controlled by the Montreal Protocol, such as Sulphur Oxides (SOx) because the 2006 IPCC Software does not support the estimation of those gases.

The fourth NC suggests to following steps to create, institutionalize and sustain a national GHG inventory system:

1. Create a single dedicated entity at the climate change directorate in the Ministry of Environment to act as a hub to collect, process, archive, validate and report GHG inventories. This requires setting up institutional arrangements, clear responsibilities, and mandates.
2. Develop a legal structure that "requires" activity data producers to submit information to the MoEnv. The hub can use an online portal for collecting, processing, and reporting all UNFCCC obligations, and support received is established building on existing multi-tiered integrated MRV system. This shall ensure the continuous and sustainable flow of data from all governmental and private data providers to be used for periodical BURs, NCs, and GHG inventory estimation as well as for any other purposes.
3. Identify all sources of data, their measurement units and sources that are required by an GHG inventory using 2006 IPCC guidelines and software, and arrange for a sustainable flow of information from source to MoEnv.
4. Exploring the potential to develop national emission factors for major GHG sources like energy, waste and industrial processes based on available capacities.

5. The suggested MRV system for GHG emissions will ensure verification of data to ensure quality, accuracy, and completeness. The next step is to expand the MRV system to other governmental and private agencies, with intensive trainings on their use and capabilities, to become a national tool for monitoring, reporting and verification of emissions and mobilized finance.
6. There are no available studies on developing national emission factors. This requires the research orientation to be towards estimating real emissions factors based on actual measurements and monitoring actions. Unfortunately, default emission factors (EFs) were used in preparing all GHG inventories so far. It is recommended that Jordan search for alternatives to gradually apply in future inventory submissions, to the extent possible and based on software readiness and national circumstances, and use Tier 2 methods in the categories identified as key. Thus, research should be directed to develop national emission factors to be able to use higher tiers for key categories.
7. Conduct an intensive training program on the development of a GHG inventory including detailed use of IPCC guidelines, data sheets and calculations. This will widen the base of national experts.
8. In order to report on anthropogenic emissions of indirect GHGs and other gases not controlled by the Montreal Protocol, at the discretion of the Parties, it is important to estimate the emissions of these gases using EMEP/EEA air pollutant emission inventory guidebook, and to use the 2006 IPCC Software to revise and re-report the previous national communications' inventories.
9. Build the technical capacity that is required to estimate the emissions of Short-Lived Climate Forcers (SLCFs) and the assessment of their climate impacts to include them in the national inventories and mitigation measures as a way of enhancing the NDC ambition in the future.

5.1.2 GHG Mitigation Assessment

Developing a mitigation assessment requires strategic information from a variety of institutions. Thus, the data required for mitigation assessment is more readily available than that 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.

There were few mitigation options added to the mitigation chapter due to unclear investments in new technologies at the institutional level. The emerging issues of geopolitical instability and the COVID-19 pandemic hindered the dynamic context of the imported technologies implementation and its incorporation into the institutional action plans.

The updated Climate Change Policy proposed a long list for mitigation policies for all related sectors with the aim of achieving the vision of a global carbon neutral economy by 2050. These mitigation policies and actions are not meant to be exhaustive, but to serve as guidance for developing coherent cross-sectoral mitigation planning. For instance, as new technologies develop and mature, or the country development context changes, the enabling factors will need to be established to pursue the mitigation policy statement.

In addition, the updated NDCs suggested new emerging opportunities in GHG mitigation policies and technologies that could be further implemented over the next years. Among these are enhancing renewable energy storage; stepping up hydrogen production; adopting a “compact city” urban planning approach; adopting climate-sensitive urban design / green infrastructure and increasing green spaces; and investment in green buildings.

The GHG mitigation analysis, however, suffers from key gaps in data collection and processing and reliance on long-term planning. As such, data gaps can be fixed and improved, and other external factors negatively impacting the quality can be addressed. The following are the main gaps in the mitigation analysis:

1. Limited experience in mitigation model analysis. Although there were many trainings achieved in terms of mitigation assessment using LEAP, stakeholders still hold limited expertise in and knowledge capacity for conducting mitigation analysis especially in the transportation, IPPU, AFOLU, and waste sectors, stemming from a lack of ongoing practice and opportunities to conduct mitigation analyses.
2. The Jordanian mitigation analysis, using the LEAP model, has been developed as project-based, rather than as a program-based scenario.
3. Data quality, completeness, and accuracy are of primary concern when it comes to establishing the baseline and mitigation analysis. Data are not up to date, nor are they readily available in one place. In preparing the mitigation chapter, all sectoral data used in the mitigation analysis for residential buildings, transportation, agriculture, and off-road vehicles were obtained from relatively old surveys, and there were gaps in the availability of some data.
4. There is a need to have a dependable mitigation tracking system for planning, implementation, and verification of emissions reduction. Having such a system in place will facilitate access to international and national funds and grants.
5. 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.

6. Fluctuating policies in renewable energy development and energy efficiency plans which reduced investment opportunities and blur the distinction between baseline and mitigation scenarios in the assessment.
7. 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.
8. The “complex” and “uncertain” nature 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 Fourth NC 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 model use, 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.
4. The Jordanian case built in BURs and the Fourth NC, using the LEAP model, should be adopted and further developed in upcoming national communications and BURs. It is also recommended to start using LEAP to generate program-based scenarios, rather than project-based scenarios, to improve coverage and generate more impact.
5. Raise awareness on international mitigation mechanisms and initiatives among all decision-makers and stakeholders, to benefit from those mechanisms. It is also recommended that the MoEnv continue to provide support for technical capacity building related to accessing those mechanisms.
6. Conduct continuous and up-to-date surveys to provide quality and accurate data to be used for analysis.

Also based on conducted BURs, a framework for a domestic MRV system for GHG Mitigation has been suggested that addresses most of the above gaps, constraints, and needs, as follows:

- It is suggested to create a dedicated entity to oversee collection and processing of data for GHG estimation, by setting up institutional arrangements and clear responsibilities and mandates.
- The suggested MRV system for GHG emissions will ensure verification of data, to ensure quality, accuracy, and completeness.
- A national effort is ongoing, supported by the Partnership for Market Readiness, to design and implement a detailed multi-level MRV system.

5.1.3 Vulnerability & Adaptation

Recently, the updated climate change policy provided a long list of policies, actions, enabling factors or drivers of change, to support the adaptation policy statement that aims at reducing vulnerability and increasing resilience to the impacts of climate change and climate variability in a proactive manner.

Generally, the 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, and identified impacts on various sectors, with a high level of certainty and proposed proper adaptation measures that respond directly to identify risks/impacts.

As opposed to the TNC, the Fourth NC assessed the future climate exposure through the 5th experiment dynamic downscaled regional climate models for the MENA region. Using long historical local climate data, the regional climate models were analyzed based on several statistical criteria, including calibration, validation, and de-biasing processes.

Instead of traditional expert judgment scoring technique, the climate change impacts on each sector were quantitatively determined using several advanced model approaches (e.g., Aquacrop, SWAT, etc.). The new adopted methodologies for V&A assessment are considered highly intensive expert-work that requires a lot of details, programing and interpretation. Also, the area of interest covered the whole Kingdom, as in the case of socio-economic characteristics, health, and biodiversity, while covering the four largest major national groundwater basins, that are located in more than 8 governorates, in addition to city of Aqaba for the agriculture and water sectors.

In addition, the sensitivity and adaptive capacity were determined separately for each sector based on available data at the national sub-district level, thus providing more details on delineation of vulnerable groups. All vulnerability scores were normalized and mapped using advance GIS technologies.

The Fourth NC project also succeeded in capacity building through conducting intensive trainings for related institutions' employees. For each sector, a group of experts was created to guide and validate the CCVIA process as a TOT protocol, thus learning the V&A assessment process by practice.

In terms of adaptation measures assessment, the Fourth NC team used the suggested long list of policies within the updated Climate Change Policy, however they weren't prioritized. The prioritization of adaptation measures was achieved using the Multi-Criteria Decision Analysis (MCDA) tool, based on meetings with specialized sector specific stakeholders through assigning weights and formulating the final prioritized list, based on section 4.26 and Figure 4.3.

The fourth NC project strived to address all gaps and constraints that are described in detail in Chapter 4. However, certain gaps and future challenges remain for the upcoming NCs and sectoral studies on V&A:

Meteorology and Climate Data:

- Climate data are provided by the Jordanian Meteorology Department (JMD), Ministry of Water and Irrigation (MWI), and the Ministry of Agriculture. The time series records of historical meteorological data are moderately consistent and sometimes absent, creating some gaps in the flow of climate measurements that require filling procedures. Although the Jordanian Meteorology Department (JMD) holds an agreement with WMO to perform data quality control, it is recommended to have a dedicated unit to combine and assess all climate data in one unit to provide a consistent, validated, viable climate data bank.
- The availability and accessibility of meteorological data has improved during Fourth NC project implementation. The Fourth NC project has facilitated the development and adoption of an Understanding (MoU) between the Jordanian Meteorology Department (JMD) and the Ministry of Environment (MoEnv). This MoU will regulate the flow of data from JMD 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 Fourth NC, a paradigm shift was achieved from statistical downscaling using GCM to dynamic downscaling using RCM system to 25km resolution then downscaling through co-kriging interpolation to 1 km resolution. The future plan is to use the 6th IPCC AR6 latest generation of climate models, coordinated by the World Climate Research Programme's Coupled Model Inter-comparison Project, version 6 (CMIP6), therefore resulting in more **Shared Socioeconomic Pathways** (SSPs) rather RCPs. The expertise for achieving such an endeavor is still weak in Jordan.

- The national team of experts need to undergo an extensive and in-depth training programme for conducting the downscaling exercise at the local level, however this requires more trainings for all related institutions and research agencies and could be driven into graduate scientific curricula.

Climate Impact and Response:

- The Fourth NC has introduced new advanced methodologies for identification and quantification of climate exposure, sensitivity, impact, and risk responses that were 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 and integrated analysis.
- The development of a baseline for socio-economic and other sectoral data was difficult due to the complexity and interchangeability of measurements related to socioeconomic conditions especially income, livelihood practices, gender disaggregation of data and other factors.
- Also, the development of biodiversity and marine V&A assessment encountered limitations and constraints regarding availability of quantitative data required for modelling, uncertainties in the available information, and uncertainty around climate scenarios, particularly at ecosystems level (marine and terrestrial). A gap was identified in the historical data availability for the ecosystems and biodiversity component (at temporal level) and there is an absence of climate scenarios following RCPs projections on the marine environment. Therefore, it is necessary to design research programs to collect data that can support vulnerability assessment of ecosystems and biodiversity components, both on the terrestrial and marine sides.
- Similarly, the development of health V&A assessment encountered many limitations and constraints. Most of these limitations were related to local data availability at district level that is required for performing the necessary vulnerability assessment due to absence of climate-informed disease control programs and surveillance systems using meteorological services to target vector control in time and space. Thus, most of the impacts were associated with high uncertainties.

The Fourth NC suggests the following activities to address the gaps in the Vulnerability and Adaptation issues in the National Communications:

1. Enhancing the capacity of all related agencies in expanding the scope of climate indices recorded and the distribution of monitoring stations and improvement of equipment performance.
2. 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.
3. 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.
4. Investing in building the capacities of the focal points acting in the technical groups and researchers to support the NCCC to ensure improving competencies for future sustainability.
5. Ensuring all data required for V&A assessment are available and exchanged through governmental linkages between the climate change units and the climate change technical committee focal points to ensure the sustainability of the assessment.
6. Integrating nexus approach in future vulnerability assessments to design future, inherently interlinked systems planning in a holistic manner while capturing existing opportunities and exploring emerging ones.
7. Enhancing the last mile delivery of climate services (e.g., strengthening the credibility of the information that national meteorological services provide, establishment of climate service interventions, strengthening the linkages between climate services, inclusiveness, adoption of climate smart agriculture (CSA) practices, scale up the use of information and communication technologies (ICT) to manage climate risks, etc.).
8. Promoting the use of GIS and remote sensing for supporting climate information systems in all sectors (e.g., climate-smart agriculture, drought and flood risk mapping, Health Mapper, etc.).
9. Building capacities of hydrological and meteorological (hydromet) agencies to design and deliver better products and services for smallholders.
10. Improving early warning systems regarding flood and drought risks to be used in further vulnerability analyses.
11. Creating a dedicated unit at the Ministry of Health to monitor and report health status, incidences and health indices at dub-district level,
12. Enhancing the adaptive capacity of the health sector to conduct health vulnerability assessments, develop climate-informed disease control programs and surveillance systems using meteorological services, develop new indicators that are useful for protecting health, and develop early warning systems based on environmental information.

13. Creating more effective and rapid electronic exchange of surveillance data for rapid intervention, and establishing, with the relevant ministries, access to real-time air quality monitoring data to establish the link between respiratory diseases and air pollution and climate change.
14. Performing detail-oriented research for providing a clear understanding and in-depth social and environmental analysis of the current and potential impacts of climate change on most vulnerable groups in Jordan including women, children, poor, disabled and the unemployed.
15. Improving field research and monitoring of vulnerability to climate change for all sectors especially the ecosystem and health sectors.
16. Building on recent scientific findings of distinguished resilience of coral reefs in the Gulf of Aqaba to climate change impacts and enhancing scientific research in Aqaba as a global coral reef refuge.
17. Using integrated coastal zone management (ICZM) within the broader ambit of sustainable land-use planning for enhancing resilience of marine ecosystems through developing vulnerability assessment of ecosystems to extreme events in the Gulf of Aqaba, modifying the climate change requirements in the EIA conditions for coastal development, creating a central database, and modifying and enforcing land-use planning to protect marine environments.
18. Improving monitoring capacities for the state of marine ecosystems (e.g., enhancing current monitoring stations at Aqaba; strengthening databases on coastal areas ecosystems, habitats, and species; strengthening the early warning systems; and monitoring sea level rise along the coast of the Gulf of Aqaba).
19. Conducting 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 on farming 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.
20. Conducting studies and observations of climate impacts on health, also covering short-lived climate pollutants (SLCP).

5.2 Institutional Arrangements for Climate Change

Realizing both the threats and opportunities resulting from global impacts and outcomes of climate change, the GoJ is continuously setting the proper arrangements 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 may ratify. The following sections summarize the new institutional arrangements developed over the last few years.

5.2.1 Climate Change Mainstreaming into Jordan's Ministries and Organization

Based on the first National Climate Change Policy recommendations issued in 2013, the Ministry of Environment paved the road for Policy implementation through establishing its first directorate for climate change in August 2014. The directorate acts 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. The established directorate has a positive and direct impact on organizing the national efforts on climate change and manages to maximize the benefits from various activities for a concerted and visionary approach. It also strengthens the internal capacity of the Ministry of Environment concerning climate change by addressing its existing and new tasks under the Climate Change Policy. This directorate is currently incorporating both the high-level policymaking/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. Other main 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 educational, scientific, research, training, and awareness programmes on climate change, consistent with Article 6 of the Convention, among various stakeholders and guide public participation.

In addition, other governmental organizations have established their climate change directorates, including:

- The Environmental and Climate Change Directorate and the Drought-Monitoring Unit at the Ministry of Water and Irrigation.
- The Climate Directorate at the Meteorological Department and the Environment Unit at the Civil Aviation Regulatory Authority, both under the Ministry of Transport.
- The Climate Change Committee at the Greater Amman Municipality.
- Agricultural and Environmental Statistics Directorate at the Department of Statistics.
- The Commissioner for Environment and Regional Affairs at the Aqaba Special Economic Zone Authority.
- Department of Climate Change and Environment under the Directorate of Studies and Production Chains at the Ministry of Agriculture
- Climate Change and Drought Research Department at the National Agriculture Research Center.

5.2.2 The National Committee on Climate Change

A National Climate Change Committee (NCCC) was established by a decree issued by the Prime Minister in 2001. The NCCC is the owner of Jordan's National Climate Change Policy and has the main role in the supervision of its implementation. The Ministry of Environment has the special role of Chair of the NCCC and its Secretariat. The main responsibilities of the NCCC are:

- Supervising and supporting implementation of the UNFCCC in Jordan, in accordance with national interests.
- Supervising and ensuring the development and execution of required legal, regulatory and institutional arrangements and frameworks.

- Acting as a national advisory body, by providing overall institutional and technical guidance
- Leading climate change adaptation and mitigation efforts and ensuring the integration of adaptation within other national development strategies and plans and enhancing the integration of gender dimension in these strategies.
- Overviewing and providing opinion and feedback on climate change programmes and projects, in terms of institutional and technical aspects.

5.2.3 The Climate Change Bylaw No.79, 2019

The MoEnv issued the Climate Change Bylaw No.79, 2019 that mainly aims to regulate the coordination of national efforts among relevant stakeholders to implement mitigation and adaptation measures. This Act, consisting of 9 articles and III Annexes, aims at implementing article 30 of the Environmental Protection Law of Jordan, promulgated in 2017 by (i) providing for the detailed tasks and powers of the Ministry of Environment; (ii) designating the Ministry of the Environment as a contact point regarding the United Nations Framework Convention on Climate Change (UNFCCC); and (iii) establishing at the Ministry a National Committee for Climate Change (NCCC), responsible for oversight and coordination, chaired by the Minister of Environment, who specifies the tasks and powers of the committee.

Based on the updated Climate Change Policy, and in order to foster the principles of subsidiarity and inclusiveness (Principle 10) and partnerships (Principle 27) of the Paris Agreement, and to better define the roles and responsibilities of stakeholders, as per the requirements of the Paris Agreement, the following proposed policies and actions are recommended to improve climate governance in Jordan. Institutional arrangements should allow for stakeholders to be coordinated in two distinct processes, namely: (i) processes related to UNFCCC initiatives (e.g., national communication, biennial update reports and nationally determined contributions) that are under the oversight of the National Climate Change Committee; and (ii) processes related to the formulation of sectoral adaptation and mitigation strategies and action plans. Plans to engage stakeholders in the two processes are likely to be distinct as well.

1. Update the Climate Change Bylaw No. 79 of 2019 to (1) stipulate the obligations, roles and responsibilities of institutions / stakeholders; (2) establish formal sectoral institutional arrangements for mainstreaming climate change in sectoral policies, strategies and action plans; (3) propose establishment of a Technical Advisory Body to support the National Climate Change Committee (NCCC); and (4) formalize a stakeholder engagement mechanism at and below the Governorate level, as well as means to

strengthen the participation of the private sector and vulnerable groups (e.g. children, women, youth, and people living with disabilities or in poverty).

2. Update the Environment Protection Law no.6 of 2017 and amendments of all other related governmental sectoral policies, legislations, strategies, and action plans to mandate detailed vulnerability assessments to climate change (including climate variability and natural disasters) and accompanying adaptation and mitigation for infrastructure and land use change projects.
3. Strengthen laws & regulations such as creating legal code for defining the responsibilities of main emitters, introduction of extended producer responsibility, adoption of novel market-based tools to support adaptation and mitigation actions, defining the roles of all stakeholders in monitoring and evaluation of adaptation and mitigation contributions, among others.
4. Develop a Code of Corporate Governance for public interest entities to mandate sustainability reporting, including climate change (adaptation and mitigation).
5. Regulatory change to enshrine climate change through (1) Initiation of national dialogue for amending regulations to enshrine the government duty to address issues related to climate change to enhance the wellbeing of all, and (2) Capacity building of legislators and the judiciary on the implications of enshrining the government duty to address issues related to climate change to enhance the wellbeing of all, including vulnerable groups.
6. Improving stakeholder coordination for climate inclusiveness through (1) Developing detailed Operational Guidelines for supporting institutions to carry out their obligations and responsibilities, (2) Providing technical capacity building of stakeholders to fulfil their respective roles and responsibilities in relation to developed Operational Guidelines following detailed capacity needs gaps analyses, and (3) Developing Stakeholder Engagement Plan (SEP) for engaging all key stakeholders (including children, women, youth, and vulnerable stakeholders) in dialogues on climate change and for the formulation of sectoral strategies, action plans and projects/programmes.
7. Institutional strengthening of public institutions to integrate the function of climate change through (1) Scaling up efforts to establish and operationalize Climate Change Units / Directorates in public institutions, most notably line Ministries, particularly in the Ministries of energy, transport, local administration, water, agriculture, as well as, at Governorates; (2) Human capacity building of Climate Change Units / Directorates following needs gaps analyses; (3) Establishing a formal advisory body to the NCCC to enhance the science-policy interface; and (4) Establishing a work programme under the aegis of the NCCC that will culminate in the setting up of a formal institutional mechanism for taking the views of all groups in public decision-making related to climate change.
8. Institutional strengthening for enhanced regional and international climate dialogues through establishing a work programme under the aegis of the NCCC that will enhance

the capacity of Jordan to contribute to regional and international climate dialogues for enhanced climate governance.

5.2.4 Other Arrangements

The MoEnv revised the Environment Protection Law, no. 52 of 2006 to include and strengthen the articles of the law related to climate change. The new Environment Protection Law no.6 of year 2017, includes provisions on climate change goals. This Law consisting of 33 articles aims at protecting the environment providing that (i) the Ministry of Environment is the authority responsible for environmental protection; (ii) the Ministry together with the related parties shall develop the policies and prepare the plans and programs, work on forecasting climate change identifying the involved sectors, follow the implementation of international environmental agreements, protect the biodiversity identifying areas that need special attention, protect water sources, issue environmental permits for activities that have a strong impact on the environment, establish the principles governing use and circulation of hazardous substances, gather environmental information and establish a national environmental database, and prepare emergency and disaster management plans. The Law deals also with permits for facilities; harmful substances and rules for their entry, import, storage, circulation and use; management of hazardous waste; management of liquid and solid waste; and the establishment of an environmental protection Fund.

Environmental Protection Fund Regulation and its amendments No. (81) was issued by the Ministry of Environment in 2011 to support any activity that contributes to the protection of the environment and the preservation of its components and development, encouraging developmental initiatives aimed at the optimal use of the elements of the environment and natural resources, contribute to spreading environmental awareness and building capacities in the fields of environmental protection and sustainable development, focusing on sectors of national priority in terms of compliance with environmental requirements and providing support to them, and to encourage leadership and innovation in the fields of environmental protection, in a way that will positively affect society.

5.3 Climate Change Mainstreaming in Development Policies

Jordan is signatory to the UNFCCC, the government ratified, inter alia, the Convention in 1993, the Kyoto Protocol in 2004, and the Paris Agreement in 2016. Moreover, Jordan joined the Climate & Clean Air Coalition in 2012 and produced several policies, pieces of legislation and national reports in response to the obligations of the global collective collaboration frameworks. Jordan started its efforts by building national capacity in documenting national emissions of greenhouse gases and preparing Jordan's national communications to the UNFCCC.

In line with all the other national efforts, the Government of Jordan was able to manage, coordinate, and adopt climate change into national and sectoral plans and strategies, with targets consistent with the mitigation and adaptation options stated in national communications reports. In addition, the Ministry of Environment developed a National Strategic Plan (2020-2022)[181] with six main goals, including (1) Protection and sustainable use of ecosystem services. (2) Prevention of pollution and addressing its adverse impacts; (3) Addressing climate change, with the aim of mitigating its causes and adapting to its negative effects, through various executive mechanisms, including financial tools and technology transfer, (4) Transitioning toward a Green Economy; (5) Disseminating environmental culture and promoting sound environmental behavior; and (6) Developing institutional performance and promoting a culture of excellence, innovation and gender mainstreaming.

The following section shows the progress achieved:

- Three National Communication Reports, with the support of GEF: First National Communication (FNC) (1998), Second National Communication (SNC) (2009), and Third National Communication (TNC) (2014).
- First Biennial Update Report (FBUR) (2017), and the Second Biennial Update Report (SBUR) (2021).
- National Climate Change Policy in (2013) and the updated Climate Change Policy (2020-2050),
- Nationally Determined Contribution (NDC) submitted to the UNFCCC in November 2016, and the updated submission of Jordan's 1st Nationally Determined Contribution (NDC) issued in 2021,
- Jordan 2025 - a National Vision and Strategy,
- National Green Growth Plan in Jordan,
- Jordan Economic Growth Plan (2018 – 2022),
- SDG Implementation in Jordan: Water, Energy, and Climate Change, and Jordan's Way to

[181] ministry_of_environment_strategy_2020-2022.pdf (moenv.gov.jo)

Sustainable Development - First National Voluntary review on the implementation of the 2030 Agenda,

- National Adaptation Plan (NAP) issued by 2021,

5.3.1 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 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 summarized description of the state of each sector.

The MoEnv has revised its Climate Change Policy into the Climate Change Policy of Jordan for the years 2022-2050 and will be issued soon. This policy is directed towards Jordan's important development sectors, policymakers, climate practitioners, as well as the general public interested in understanding Jordan's approach towards climate change and the institutional framework and plans in place to mitigate and adapt to it over the next 28 years. The CCP 2022-2050 calls for a new paradigm of climate action, formulated based on a "Theory of Change" with the following vision: "*By 2050, Jordan will be better prepared and more resilient to the impacts of climate change. It will achieve a high level of energy security commensurate with an eye on approaching or reaching carbon neutrality through ramping up clean energy domestic use and export. Investments in low-carbon and climate-responsive initiatives will drive the green economy for the wellbeing of all, including vulnerable communities, using the principles of inclusiveness and fairness, while simultaneously contributing to the global effort of stabilizing the climate system under the principle of common-but-differentiated responsibilities and respective capabilities*".

The proposed policies (and accompanying actions and instruments) are expected to contribute to (a) Climate change mitigation, through the reduction of GHG emissions and the promotion of a low carbon economy; (b) Climate change adaptation, through the adoption of practices that reduce climate vulnerabilities and increase climate resilience; (c) Sustainable development, through the promotion of inclusive and sustainable growth, the creation of employment and the overall improvement of the quality of life of individuals (i.e., food and water security, access to clean energy, health conditions etc.). Investments in climate change adaptation and mitigation can today be also seen as a meaningful way for post-COVID-19 recovery.

5.3.2 Mitigation Policy

A comprehensive mitigation policy has not yet been developed for Jordan, other than the updated NDCs. However, there are several sectoral strategies and policies, which have been developed with the aim of reducing and mitigating GHGs through various measures, such as, the promotion of renewable energy and energy efficiency in Jordan, green buildings codes; energy efficiency and low carbon transportation modes, solid waste and wastewater policies, forest and rangelands management, green growth plans and smart cities, etc.

5.3.3 Adaptation Policy

In 2021, the GoJ developed the National Adaptation Plan (NAP), which consolidated the country's vision on adaptation, supported by the prioritized adaptation actions that link the economic sectors and country level vulnerabilities, to enhance long-term resilience and adaptive capacity, with consideration for gender and the needs for the most vulnerable groups. The NAP identified seven sectors vulnerable to climate change. These are: agriculture, water, urban, biodiversity, coastal, socioeconomic development, and health. The plan includes a sectoral vulnerability analysis, sectoral adaptation measures and a roadmap for implementation. The participatory approach that was followed in developing the plan, assured that its objectives are embedded in the country's fabric of development. The programmes are flexible and open to many measures that can be implemented as either:

1. Policy-based measures.
2. Technology-based measures.
3. Social mobilization-based measures.
4. Nature-based measures.
5. Economic development-based measures.

5.3.4 Nationally Determined Contributions (NDCs)

Jordan submitted its Intended Nationally Determined Contributions (INDCs) global assessments in Nov 2016 with the support of The German International Cooperation Agency (GIZ). Jordan nationally determines to reduce its greenhouse gas emissions by a bulk of 14 % by 2030. The contribution of GHG emissions reduction that will be unconditionally fulfilled by Jordan, based on the country's own means compared to a business-as-usual scenario level is 1.5%. Conditionally, however, and subject to availability of international financial aid and support for means of implementation, Jordan commits to reduce its GHGs emissions by an additional, 12.5% by 2030.

The (conditional & unconditional) targets will be achieved based on implementing at least 70+ projects (43 sectoral projects resulted from the mitigation scenario assessment articulated in the 2014 Third National Communication Report (TNC) to UNFCCC and around 27+ other sectoral priority projects proposed concurrently or newly planned and not listed in the TNC Report, i.e., proposed after the development of the TNC. The latter group of projects was disseminated to the NDC document by involved stakeholder line ministries and organizations in response to the NDC formulation process.

In October 2021, Jordan updated its submission of Jordan's 1st Nationally Determined Contribution (NDC). The updated NDC aims at driving Jordan's post COVID-19 recovery process into a lower carbon and more climate resilient development pathway steered by national green growth priorities, while fully committing to the provisions of the UNFCCC and the Paris Agreement. The document enhances Jordan's commitment to the international climate change governance system by raising its macroeconomic GHG emission reduction target to 31%, compared to Business-As-Usual (BAU) scenario. The document introduced 22 measures with a total estimated cost for the mitigation actions of about 7.60 billion USD. The new GHG emission reduction target is based on a combination of national policies, programmes and actions as well as international support and finance. The adaptation vision and objective of the updated NDC is directly linked to the recently launched National Adaptation Plan (NAP). The updated NDC aims at driving Jordan's post COVID-19 recovery process into a lower carbon and more climate resilient development pathway, steered by national green growth priorities while fully committing to the provisions of the UNFCCC and the Paris Agreement and paving the way for a future Climate Change Long Term Strategy (LTS).

5.3.5 NDC-Partnership Support

Jordan joined the NDC Partnership in March 2017 and requested support in five areas: transport, water, agriculture, energy, and waste management. The partnership provides technical support, through partners, by the Climate Action Enhancement Package (CAEP). The CAEP is delivering targeted, fast-track support to countries to enhance the quality, increase the ambition, and implement nationally determined contributions (or NDCs), as part of the 2020 update process, and fast-track implementation of NDCs, including provision of in-country technical expertise and capacity building. Partners (Ricardo, IRENA, and World Bank) offer support for government in NDC revision.

To motivate the progression in NDC implementation, the GoJ developed and validated the NDC Action Plan in 2019. It is a results-based implementation plan that emphasizes adaptation and mitigation actions, prioritized in key sectors, that were already covered in the First NDC, namely transport, energy, agriculture, health, water, and waste management. The Action Plan was then circulated through the NDC Partnership's network to seek international support for implementation.

In year 2020, with the support of the Partnership's Climate Action Enhancement Package (CAEP), the government worked further to prioritize 35 actions out of the whole actions included in the NDC Action Plan and to prepare a cost-benefit analysis for them, in addition to developing a Climate Finance Strategy to facilitate securing funding sources.

Currently, the government is working to integrate the sectoral actions included in the NDC Action Plan with the Government Executive Development Program (EDP) which will improve their national-priority levels for allocating financial resources and readiness for implementation in the next three years of the government plan.

5.3.6 Partnership for Market Readiness (PMR)

Jordan submitted its organizational framework to the Partnership for Market Readiness (PMR) in June 2012, the GoJ with the support of the World Bank has submitted its Market Readiness Proposal (MRP) to the Partnership for Market Readiness (PMR) initiative in 2016. Jordan's MRP outlined a plan for implementing the market readiness components that will be necessary to support the development of appropriate market-based instruments. The PMR initiative in Jordan is led by the Ministry of Environment, in collaboration with an inter-ministerial technical working group. At the current phase, the PMR initiative, has identified the energy and water sectors as priority sectors for mitigation actions (with energy efficiency (EE) and renewable energy (RE) identified as pilot cross-sector interventions). The initiative aimed at fulfilling three components:

- A national MRV system and registry for climate mitigation measures.
- Designing a platform for private sector financing in EE and RE.
- Exploring the potential for market-based instruments for climate mitigation measures.

In February 2018, the first milestone was achieved with the development of a multi-tiered integrated MRV system. The first version of the system - still in the experimental phase - covers the public sector energy projects (RE and EE); adding GHG data and support data at sectoral and national level from different sectors and will serve in tracking progress towards Nationally Determined Contribution (NDC) commitments.

It was planned for Jordan's National MRV system and the registry of climate mitigation measures to be fully functional by the end of the year 2020, covering transport and waste sectors in addition to the energy sector. However, this was not completed, mainly due to the COVID-19 pandemic.

5.3.7 Jordan Future Carbon Market

Delegates at the 2021 global Climate Change Conference, COP26, in Glasgow, approved Article 6 – the Paris Agreement's rulebook governing global carbon markets. This approval gave the green light to a market where countries can trade carbon credits, generated by the reduction or removal of greenhouse (GHG) emissions from the atmosphere -- such as by switching from fossil fuel to renewable energy or by increasing or conserving carbon stocks in ecosystems such as a forest.

Under Article 6, countries will be able to cooperate in different ways to achieve their climate goals. The key to successfully reducing global GHG emissions through carbon markets could be digital infrastructure, which keeps verified data secure and ensures that reductions are accurately accounted and tracked.

In 2021, the COP 26 meeting on climate change set the rules for an international carbon market. Jordan has become the first developing country to build end-to-end digital infrastructure to track and transact reductions in global greenhouse gas emissions[182].

Jordan was the first developing country to build MRV and GHG Registry systems to international standards, that are the key building blocks for future emissions trading, working with the World Bank's Climate Warehouse program and Partnership for Market Implementation (PMI) to develop and test this digital infrastructure.

5.3.8 Jordan's Sustainable Development Goals

The main current policy-guiding framework in Jordan after the National Agenda (2005-2015) is the "Vision 2025". Under the "Vision 2025" [183] document, climate change was stated clearly under the Environment Sector as priority initiative to develop a legislative framework for the organization of climate change to maximize the benefits, minimize the negative impacts and build national capacity. This is considered as a promising entry point to initiate a national dialogue to develop a climate change legislative framework. However, no specific key performance indicators, under the environment sector, targeted the climate change issue.

182 Climate Stories | Carbon Markets (worldbank.org)
183 JORDAN) Jordan 2025 Part I.pdf (greengrowthknowledge.org)

The three years Executive Development Program (EDP) is considered the main planning mechanism in Jordan. The EDP incorporates national development vision, and priorities through translating the national policies and strategies into applicable work procedures. Several programs, projects, legislations, and activities linked to the goal of each sector are to follow, until the national goals of the vision are implemented on the ground. In the EDP (2013-2016), climate change was integrated for the first time as one of four pillars of the Environment sector.

Jordan adopted the 2030 Agenda and developed a Roadmap for Sustainable Development Goals (SDGs) implementation[184], mainstreaming the SDGs into national/subnational planning, budgetary and monitoring frameworks and institutional mechanisms put in place to achieve its commitment to leaving no one behind.

Jordan focused on ensuring efficient alignment by incorporating the SDGs in national frameworks, including "Jordan 2025: A National Vision and Strategy", the Government Executive Development Program (EDP), the Governorate Development Programs, the Jordan Response Plans for the Syria Crisis as well as all the national plans and strategies.

Moreover, to avoid overlapping mechanisms during the implementation of 2030 Agenda, the government opted to build upon the existing institutional frameworks. Where the National Higher Committee for Sustainable Development provides guidance and follow up on all decisions, priorities and recommendations related to the 2030 Agenda. The committee, which was established in 2002, following the announcement of MDGs, and was expanded in 2017 to include broader government and civil society participation.

Since the inception of the 2030 Sustainable Development Goals, there has been some proof of the Jordanian government's commitment to their achievement. Yet, few programs have entered the implementation phase, and most efforts have thus far have been fundamentally theoretical and preparatory, rooted in policy-drawing and strategy development, and have yet to materialize into concrete measures[185].

Currently, the government is focusing on strengthening linkages between planning, budgeting and financing for climate, which is a key priority, with the potential to have a transformative impact on all other SDGs. It is found that investing in adapting to and mitigating climate change has the potential to accelerate progress in many other SDGs, with the available potential to work with public and private investors on aligning their business models and investments to the SDGs that will lead to more effective resource allocation and catalyze additional financing for national SDGs priorities.

[184] 16289Jordan.pdf (un.org)
[185] Pursuing-the-SDGs-2030-jordan2017.pdf (phenixcenter.net)

5.3.9 Long Term Strategy (LTS)

Decision 1/CP.21 (paragraph 35) invites Parties, to communicate by 2020, mid-century long-term low greenhouse gas emission development strategies (LTS). Parties should strive to formulate and communicate these LTS considering the objectives of the Paris Agreement (article 2), taking into account their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances (article 4, paragraph 19). Thus, the LTS focuses on the necessary transformations and steps intended to secure progress and eventually reach, by 2050, a nationally determined low-carbon and resilient development vision, that is compatible with the Paris Agreement goals.

The Ministry of Environment is currently developing a Long-Term Strategy (LTS), in the form of a New Climate Change Policy for 2050. The new climate change policy will introduce long-term targets and measures for enhancing adaptive capacity within the context of a climate vision that aims to move towards a net zero carbon economy.

5.3.10 National Green Growth Plan (NGGP)

Green growth is an approach for achieving a number of simultaneous objectives that brings Jordan closer to its sustainable development ambition. The National Green Growth Plan (NGGP)[186], which was developed in 2017, applies green growth to Jordan as a practical approach that builds upon existing government strategies, primarily Vision 2025, and demonstrates pathways to achieving them in a sustainable way taking into account the factors that impact on the country's economic, social and environmental development in the longer term.

This NGGP focuses on 6 priority sectors that provide coverage of key green growth issues and opportunities for Jordan to outline green growth frameworks and actions for energy, water, agriculture, tourism, transport and waste. They include sectors identified as high potential growth areas, such as tourism, and sectors that threaten to inhibit Jordan's development if not properly managed, such as the water sector.

The plan identifies the interlinking desired outcomes of green growth opportunities in Jordan to be;

- Sustained growth for the Jordanian economy
- Maintaining and enhancing Jordan's biodiversity and ecosystems services
- Inclusive and equitable growth for Jordan's population
- Reducing GHG Emissions from Jordan-

[186] A National Green Growth Plan for Jordan.pdf

- Ensuring Jordan's environmental and economic resilience into the future

The NGGP introduced the concept of clusters to demonstrate the mutually reinforcing benefits derived from grouping green growth interventions. Three clusters have been identified; Green Growth Corridor, Smart Urban and Rural Resilience. The green growth corridor has a specific geographic focus, being the important north-south route between Aqaba and Amman. In contrast, the smart urban and rural resilience clusters are thematic, and could be applied to a range of rural and urban areas in Jordan.

In late 2018 as a next step toward implementation of the recommendations in the National Green Growth Plan, under the request of the Cabinet of Ministers, the Green Growth National Action Plan 2021-2025 was developed The Green Growth National Action Plan (GG-NAP) outlines sector-level green growth frameworks and actions for Agriculture[187], Energy[188], Tourism[189], Transport[190], Waste[191]. and Water[192] sectors to support implementation of Jordan's green growth vision and strengthen future ability to recovery and contain shocks from catastrophic events such as COVID-19.

5.3.11 Government Executive Programme, Work Plan, & Economic Priorities Program

One of the main policy and planning tools in Jordan is the Government Executive Programme (GEP)[193] 2013-2016 which is based on the National Agenda of 2005 that 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 Government Work Plan (GWP)[194] 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.

The Government's Economic Priorities Program (2021-2023)[195]issued by Ministry of Planning in 2020 is designed as an economic recovery Program. The 24-month Program strives to help place the economy on a trajectory for recovery and growth, after it was hit hard by the pandemic. It

187 20022_Jordan_Agriculture_v07_HL_Web.pdf (gggi.org)
188 20022_jordan_energy_v03_rc_web.pdf (moenv.gov.jo)
189 20022_Jordan_Tourism_v03_HL_Web.pdf (gggi.org)
190 www.moenv.gov.jo/ebv4.0/root_storage/ar/eb_list_page/20022_jordan_transport_v10_rc_web.pdf
191 20022_jordan_waste_v02_rc_web.pdf (moenv.gov.jo)
192 20022_Jordan_Water_v03_HL_Web.pdf (gggi.org)
193 Goverment Action Plan (mop.gov.jo)
194 government_work_plan_(2013-2016).pdf (mop.gov.jo)
195 https://mop.gov.jo/EBV4.0/Root_Storage/EN/EB_Info_Page/english_final_16-9_website.pdf

comprises of focused priority policies and reforms that strive to achieve three main objectives: (1) Enabling the private sector to create jobs for Jordanians; (2) Stimulating local and foreign investments; and (3) Increasing national exports of goods and services. 53 priorities have been selected across three pillars: (1) Improving the Business and Investment Environment; (2) Enhancing Competition and Increasing Employment; and (3) Supporting Priority Sectors (Tourism, IT, Agriculture and Industry).

The most recently published GIEP (Government Indicative Executive Program) (2021-2024) represents the governmental planning framework, that focuses on sector strategies and fiscal reforms as well as taking into consideration the existing government projects, including the Public Investment Management Program, the Five-Year Reform Matrix, and the Public-Private Partnership (PPP), which will have a positive impact on future socio-economic planning, prioritizing objectives and allocating financial resources for these priorities. The program integrated the Sustainable Development Goals (2030) into the national priorities, as part of Jordan's roadmap for the future.

In the GIEP (2021-2024), the government stresses on the future opportunities for stimulating green growth and implementing the climate change measures as sustainable solutions to address the country's economic vulnerability. The program indicated supportive measures to enhance the implementation of the NDC Action Plan and Green Growth Action Plan including harmonizing the national policies to maximize the benefits of transitioning to low carbon economy, among others, to attract foreign investment, create job opportunities, and mobilize the international climate finance and the new international carbon market instruments.

5.3.12 Other Updates on Climate Change within Sectoral Policies, Strategies, and Action Plans

Several national sectoral policies, strategies, and action plans were updated to mainstream climate change actions into their context. Please see **Table C.1 Annex C** for more details about the sectoral updates.

5.4 Gender and Youth Mainstreaming

Climate change is not gender neutral and neither should climate action be. Understanding that women not only have a role to play in tackling the climate change threats but also their knowledge, experiences and views can better guide the actions adopted. Excluding women from the process and overlooking their needs, interests, and creativity, isolates fifty percent of the world and marginalize potential innovative solutions that can generate environmental justice while bridging gender gaps and overcoming gender specific barriers. The impacts of climate change on Jordan are significant, which consequently threatens the livelihoods and health of the vulnerable communities, particularly women and girls. Communities relying on agriculture, food production and livestock farming are at considerable risk of climate displacement as they witness ecosystem and biodiversity degradations. Men and women within vulnerable communities, experience climate change differently and have varying coping mechanisms that are restricted by social norms and values, particularly for women and girls.

Jordan developed a Jordan's Climate Change Gender Action Plan (ccGAP)[196] in 2010 to ensure that national climate change efforts mainstream gender considerations so that women and men can have access to, participate in, contribute to, and hence optimally benefit from climate change initiatives, programs, policies, and funds. Jordan was the first country globally to develop a gender and climate change strategy. This factsheet explains the priority areas of this plan: water, energy, agriculture and food security, and waste reduction and management.

A Programme for Mainstreaming Gender in Climate Change Efforts[197] in Jordan was developed by IUCN in 2010 to ensure that national climate change efforts in Jordan mainstream gender considerations so that women and men can have access to, participate in, contribute to, and hence optimally benefit from climate change initiatives, programs, policies and funds."

The U.S. Agency for International Development (USAID) developed the Gender Mainstreaming Policy adopted by the government in 2020[198]. The goal of this Policy is to improve the lives of people around the world by advancing gender equality and empowering women and girls to participate fully in, and equally benefit from, the development of their societies on the same basis as men.

Recently, a National Strategy for Jordanian Women (2020-2025)[199] was developed by the GoJ. The strategy constitutes a roadmap for Jordan towards gender equality and the empowerment of women It focuses on several goals to ensure gender equality without gender discrimination, and to realize justice between men and women who can enjoy equal participation in the development process, leading to Jordan's renaissance and prosperity. The strategy earmarked internal funding from the country's general budget, while external funding will be channeled through assistance from donor countries and organizations to ensure complementarity and inclusiveness towards the NSW's goals, as well as to steer clear of duplication and dissipation of

[196] https://www.climatelinks.org/sites/default/files/asset/document/2010_IUCN_Climate-Change-Gender-Action-Plan-Jordan_Fact-Sheet.pdf
[197] Programme for Mainstreaming Gender in Climate Change Efforts in Jordan
[198] Gender Equality and Women's Empowerment 2020 Policy (usaid.gov)
[199] The National Strategy for Women 2020 - 2025 01122021 (2).pdf

resources, and to reaffirm the national vision, which guides all other actions towards justice, equality and equal opportunities.

In 2021, the Ministry of Environment and the United Nations Development Programme issued an Exploratory Gender Analysis under the title of "Gender Equity and Climate Change in Jordan"[200]. The aim is to support Jordan advance its gender equality commitment through exploring gender issues and considerations in climate change and sectors that are affected by it. The assignment was also launched in lieu of the preparation of the 4th National Communication on Climate Change Report and the Nationally Determined Contributions (NDCs). It is important to highlight that Jordan is the first country in the region to integrate a gender equality perspective in its National Climate Change Policy. A Road Map for Gender Equality and Climate Change was outlined in detail for action in each sector.

The Ministry of Youth developed the National Youth Strategy (2019-2025)[201], which stands out as a positive response to the great political, social, economic, and cultural changes that have had a great impact on the Jordanian youth (12–30-years old), which – with its different segments – accounts for 35.78% of Jordanian society. The strategy focuses on partnership and networking, and through youth centers spread throughout the Kingdom, encouraging and promoting the concepts of voluntary work, engagement, building young peoples' abilities and skills, and improving and developing the Ministry's programs in this regard, working with youth according to their interests, priorities, age and geographic regions. Several initiatives have been raised for youth engagement in CC actions, especially adaptation.

UNICEF recognizes climate change as a direct threat to girls' and boys' ability to survive, grow, and expand their opportunities to reach their full potential. Youth engagement in Climate Action programmes[202] takes part in the Youth Engagement Pathway, aimed to involve and support youth to take the lead on positive initiatives in their society by providing them with skills and knowledge that can also help them with future job opportunities. The goal of the UNICEF Youth Engagement in Climate Action Programme is to increase awareness of climate change and engage young people as agents of change, to take action on environmental issues in Jordan and contribute to the Kingdom's overall environmental sustainability.

The International Union for Conservation of Nature (IUCN) demonstrated the strength of women's ability to enact social change utilizing their knowledge, skills, and capacities, thus informing Jordan's climate change policies. The resulting gender-sensitive *Climate Action Plan* (ccGAP)[203] outlined a framework for integrating a gender perspective into climate change efforts,

[200] https://www.jo.undp.org/content/dam/jordan/2022/GenderEqualityonline.pdf
[201] كتيب وزارة (moy.gov.jo)
[202] Climate Action.pdf (unicef.org)
[203] programme_for_mainstreaming_gender_in_climate_change_efforts_in_jordan_1.pdf (iucn.org)

acknowledging the fundamental role of women in the sectors of water, agriculture, energy, and waste management and the vast contribution that women could make to climate change adaptation and mitigation.

A policy brief was prepared within the framework of the UN Women's project of "Strengthening Women Leadership in Agricultural and National Advocacy in Jordan (2016- 2017)", launched in partnership with ACTED with funding from the Government of Japan. This Rural Women and Climate Change in Jordan brief [204] is based on a field study on rural women's leadership and climate change, launched during the last quarter of 2016 in cooperation with AWO and the Center for Women Studies of the University of Jordan (CWS). The main findings included the following:

- Rural women's existing theoretical knowledge and understanding of climate change and adaptation remain limited, impeding their ability and willingness to act and find long term adaptive solutions,
- Rural women rely on their existing field experience and coping mechanisms to deal with changing climate conditions, but they are not yet capacitated to build on their traditional knowledge to develop appropriate sustainable adaptation strategies,
- Rural women consider the lack of awareness raising, networking opportunities and leadership capacities as the main obstacle to their participation in addressing climate change in their communities,
- Rural women lack a clear vision regarding their role, real or prospective, in decision-making for climate change adaptation, limiting their ability to advance community resilience as potential actors of change.

UNICEF is offering capacity building and social innovation through Participatory Action Research (PAR) program, Social Innovation Incubators, as well as WASH Innovation Hubs, to train and support young people with their green initiatives to implement pilot designs on interventions and new technologies with a focus on vulnerable areas including, water and climate change, Amaluna economic engagement programme provides youth in Jordan with 3 to 6-month accredited scholarships in sectors to support WASH and climate action efforts.

In terms of national support for youth in action, the UNICF provided Local Conference of Youth (LCoY) platform for children and youth to come together to share ideas, resources, and experiences, as well as potential solutions, in order to make a generational movement of young people in taking positive action on climate change. Young climate activists will unite in a call for urgent action through a Youth Declaration on Climate Change and the outcomes of the conference will set the foundations of knowledge and awareness for participation in the

[204] https://data2.unhcr.org/en/documents/download/66494

Conference of Parties (COP). In addition, Nahno innovative online tool was supported to allow youth to register and be matched to relevant engagement opportunities near them. Moreover, UNICEF is expanding its support to green social enterprises, which both link young people with income-generation through self-employment and contribute to community efforts with a focus on women employment and green entrepreneurship.

Green Generation Foundation (GCF) implemented a Youth Engagement in Jordan's National Climate Policy Project[205] in 2017, supported by Friedrich-Ebert-Stiftung (FES). The project aimed to prepare a generation of young Jordanians to have a conscious commitment to environmental issues and will focus on building the skills and capacities of young leaders in debates, research, and leadership on contemporary environmental issues to be future climate negotiators representing Jordan. Participants received several and varied trainings focusing on their knowledge as well as their skills (e.g., General Environmental skills, Public speaking skills, advocacy campaign skills, research skills, debate skills and climate policy & negotiation skills). Debates were used as a tool for negotiations to deploy rational, reasoned arguments and compelling evidence in action, and to elucidate their standpoint through utilizing rhetorical eloquence.

[205] FINAL-REPORT-for-Youth-Engagement-in-Jordans-National-Climate-Policy-Project.pdf (ggfjo.org)

5.5 Public Awareness

Based on the TNC project (2013) recommendations derived from the first public opinion survey and the TNC Learning and Outreach Plan, several national outreach and awareness programs were developed 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. Thousands of awareness programs as a capacity building were promoted, developed and achieved at institutional and local community levels through governmental institutions, NGOs, environmental associations, funding agencies and academia.

In recognition of the local associations' importance and their significant role in collaborating, supporting, negotiating, educating, advocating, and enabling the growth, development and maturation of societies; especially for youth and women, and the private sector's importance in terms of environmental leadership, conservation of Jordan's environment and its natural resources, technology and innovation assessment, good governance, and providing capacity building and awareness programs targeting resilient and sustainable nature, more than 60 environmental organizations[206] were developed.

In addition, a Jordan Environmental Union (JEU)[207] was established as a national advocacy front and a coalition of ten of Jordan's most active environmental NGOs, who cover all of Jordan's environmental sectors and whose projects span Jordan and beyond, promoting environmental stewardship and conservation, as well as economic and social development.

JEU aims to promote its values of stakeholder participation, transparent dialogue, and CSO-public partnership. JEU has fostered strategic partnerships with the Jordanian Parliament and Ministry of Environment that focuses on legislative and regulatory changes. JEU's vision is to become a leading advocate for environmental sustainability that can be a conduit for economic and social development, as well as stakeholder engagement and transparent dialogue. Its mission is to create resourceful coordination and cooperation mechanisms among member NGOs to achieve effective engagement and participation in solving national environmental challenges and issues. JEU partners are UNDP, Friedrich Ebert Stiftung (FES), and the European Union (EU). The JEU issued the fifth edition (2022) of Who's Who in Jordan's Energy, Water & Environment (EWE)[208], as a book and website with the support of EDAMA and the Jordan Green Building Council (JGBC).

In 2018, the Ministry of Environment with support from the United Nations Development Program (UNDP) and fund from the Global Environment Facility (GEF) prepared the First

[206] Environmental Organizations, Civil Society Organizations in Jordan, Phenix Center for Economics and Informatics Studies (civilsociety-jo.net)
[207] Jordan Environmental Union (JEU) - | Who's Who in Jordan's Energy, Water & Enviroment 2019 (jordanewe.com)
[208] pdf_whos_who_jordan_energy_water_environment_ewe_2022.pdf (jordanewe.com)

National Conference on Environment & Development in Jordan[209]. The conference addressed (1) Jordan's Environment in the Global Context, including the development of the national environment management system in Jordan, the global environmental governance, the Climate change in Jordan from a global perspective, Jordan's efforts in biodiversity conservation from a global view, land degradation and desertification in Jordan from a global view, and sustainable Development Goals in Jordan from a local perspective;
(2) The environmental dimension in the national development agenda of Jordan (followed by Panel Discussion) including the national planning for sustainability (Policies, Strategies & Initiatives), innovation & Creativity as important source for sustainability, the gender equality and environment, and environmental research & the role of education;
(3) Success stories & best practices for sustainable development in Jordan including sustainable use of biodiversity, co-management & community- based natural resources management, Integrated Coastal Zone Management, Drought management, Building resilience and adaptive capacity to climate change in Jordan, Role of private sector in green growth, and Environmental law enforcement; and
(4) Barriers that hinder the linkages of the local-global environment management system including four parallel sessions to discuss the policy-regulatory, institutional, financial and technical barriers

In 2021, the Generations for Peace and the United Nations Children's Fund (UNICEF) in Jordan co-hosted the first-ever Local Conference of Youth (LCoY)[210] held in Jordan, engaging 100 young people with climate experts and giving voice to youth perspectives on the climate emergency and opportunities for climate action.

Several climate-change related obligatory and elective courses were developed as undergraduate and graduate levels to ensure the largest benefits of the awareness. In addition, several climate change hubs within universities were developed to establish a student commitment towards achieving environmental sustainability and climate change resilience.

Several brochures and stories, related to climate change challenges and solutions were issued for kids. In addition, several simplified scientific programs, sessions and videos for children were designed and implemented through social media.

Although there are several partnerships and outreach programs have been developed, however, more Climate Change outreach programmes is still required. The fourth NC team recommend the following:

[209] Register Now: The First National Conference On Environment & Development in Jordan Kick-Starts on November 6th | UNDP in Jordan
[210] Youth participate in Jordan's first-ever climate action "Local Conference of Youth", co-hosted by Generations For Peace and UNICEF - Generations For Peace

1. Further advocated stakeholders to mobilize and establish partnerships aimed to address the current and projected impacts of climate change in their programmes.

2. 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.
3. Build active networks for organizations and individuals involved in the implementation of climate change activities.
4. 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.
5. Initiate national competitions on climate change for various target groups.
6. Develop attractive smart phone applications that includes climate change and other environmental concerns to be used by youth and kids.
7. 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.
8. 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.
9. 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.

Based on Climate Change Policy (2020-2050), Jordan possesses certain national capabilities to implement the Policy, but it is recognized that these will not be sufficient to achieve the long-term policy objective and the policy vision. The following recommendations are suggested:

1. Develop a communication strategy based on the Stakeholder Engagement Plan (SEP) and Women and Youth Action Plan developed at LI3.3 and GY1.2, respectively.
2. Carry out outreach activities to cover communication and awareness raising on all climate-related issues with stakeholders at all geographical levels of governance.
3. Build partnerships between public, private, NGOs and CSOs to deliver the most effective and efficiency sensitization campaigns at all levels.
4. Awareness raising among parliamentarians and legislators to enhance cross-sectoral integration of climate in public policies.

5. Capacity building of journalists and influencers on the science of climate change, national vulnerabilities to the impacts of climate change, climate variability and natural disasters, and the sustainable development benefits of adaptation and mitigation
6. Establish focal points in traditional media outlets and engage them on a regular basis to communicate on all climate-related initiatives
7. Enhance the capacity of government to utilize emerging digital media platforms to carry out large-scale outreach activities related to climate change to reach all stakeholders
8. Government to ensure that appropriate media and outreach approaches are used to target children, young people and other vulnerable groups that do not have access to traditional media or digital media

5.6 Education and Capacity Building

Based on TNC recommendation (2013), the GoJ is 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. The school curricula were re-evaluated for 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. Climate change science is being comprehensively and progressively mainstreamed into existing curricula starting with elementary schools up through secondary schools and universities. Currently, school curricula include environmental concepts and national priorities and challenges in general and climate change issues in particular, at some degree, in certain grades. Moreover, in most of the Jordanian Universities, specialized undergraduate and graduate programs were established for teaching environmental sciences and management in various fields, tackling research-oriented national demands related to climate change aspects.

The Ministry of Education developed an Education Strategic Plan (2018 – 2022)[211] that aims to improve the climate change awareness concept through imbedding climate change concepts within education material at most educational levels. The Ministry of Higher Education's role in climate change is to increase both awareness and research in the fields of climate change mitigation and adaptation. Several bachelor and master programs have been developed.

The universities' role, for both awareness and research in the fields of climate change vulnerability, mitigation and adaptation in all related sectors, were substantially improved. More than 20 bachelor and master programs were developed, extending to several research programs and initiatives related to CC and sustainable development. Several research and consultation

[211] https://moe.gov.jo/sites/default/files/esp_english_final.pdf

centers were also established to aid the increase in CC knowledge and provide sustainable solutions.

The Climate Change Policy (2020-2050) suggested the following recommendations:

1. Strengthen the integration of the science of climate change, climate change adaptation and mitigation in primary and secondary school curricula, including adequate pedagogical tools for learning-by-doing and interactive approaches.
2. Strengthen outreach of climate change (science, impacts, adaptation, and mitigation) in non-formal education to ensure that vulnerable children and young people (and any other individual) are not left behind.
3. Support the development of undergraduate and postgraduate courses in areas of climate change.
4. Review and update / develop vocational training courses for supporting climate change adaptation and mitigation based on needs gaps analyses, in conjunction with the private sector.
5. Support the establishment of environmental clubs within schools at all levels to incentivize students to participate in climate action.

5.7 Knowledge Management

The process of the preparation of National Communications and other activities in the Climate Change landscape are data intensive tasks. They require a high-level knowledge of scientific research, processing, archiving and retrieval of data.

The process of data collection and analysis is still 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, create a national hub for climate change data and information systems 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 fourth NC 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.

5.8 Scientific Research and Innovation

With the increased pressure on natural resources, growing size of population, and the harder global competition; Jordan is realizing that its prosperity relies on harnessing its human capital and young population to address development challenges. Jordan – despite the low and public sector led research and development 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 regional and international competitiveness. Green innovation and entrepreneurship are practiced but still 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 will 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.

The Higher Council for Science and Technology prepared a national policy and strategy for Science, Technology, and Innovation (STI) for 2013 - 2017[212]. 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).

[212] sti_policy_and_strategy_2013-2017_executive_summary.pdf (hcst.gov.jo)

- 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).

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 million JD budget. Among several activities addressing energy and other technologies within this project, one key activity was identified as 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).

In 2011 and based on UNDP CB-2 project "Developing Policy-Relevant Capacity for Implementation of the Global Environmental Conventions in Jordan", a study on "Potential International Mechanism for Future Collaboration Between Policy and Research Institutions in Relation to Rio Conventions" developed a research map for the three Rio conventions, identifying several institutions and researchers in Jordan. A collaboration mechanism was identified to strengthen the research in the three Rio conventions, and a hub was generated as a first step for further collaboration between the policy institution and research institutions. However, this hub needs to be updated.

In 2012, a detailed comprehensive report "Oriented Research Guidelines, Procedures and Tools to Support Rio Conventions in Jordan" was developed. The document outlines the research activities and needs to fulfil the obligations of the three Rio Conventions, UNCCD, CBD and UNFCCC. Priority research areas were identified by the stakeholder evaluation analysis. Different research tools were drafted including models, methods, activities, instruments, and devices used to facilitate implementing the sought policy-oriented research. Numerous opportunities for funding from international sources for the three Rio Convention thematic areas were also documented. Furthermore, a framework was suggested to improve government decision making through providing a robust framework of guidelines, procedure and tools for promoting and supporting policy-oriented environmental research on topics of national priorities on the themes and obligations of the three Rio Conventions.

The universities' role in research within fields of climate change vulnerability, mitigation, and adaptation in all related sectors, were substantially improved. More than 17 master's programs were developed extending to several research programs and initiatives towards climate change and sustainable development. Several research and consultation centers were also established to aid the increase in CC knowledge and provide sustainable solutions.

In addition, climate change was listed among the top priorities within the Scientific Research Priorities for 2021[213] for the basic sciences sector, engineering sciences, nanotechnology and biotechnology sector, medical and pharmaceutical sciences sector, agricultural and veterinary sciences sector, energy sciences sector, water and environmental sciences sector, communication sciences and information technology sector, human, social and economic sciences sector, and innovative and entrepreneurial projects sector.

Environmental axes, included maximizing the use and management of water resources, natural and artificial feeding methods for groundwater, techniques for using nanotechnology in water and the environment, innovative methods of waste recycling, use of technology for early warning of floods, development of vehicles with industrial and environmental applications, applied research of economic, scientific, or industrial feasibility, circular economy with directed production and waste management, the integration of water use and renewable energy and recycling, food security and the development and marketing of national agricultural products, raising the efficiency of water use in irrigation, energy storage efficiency technology, the efficiency of the use of renewable energy and its storage methods, the uses of renewable energy in Water and environment fields, smart phone applications in (education, health, water, agriculture, technology, energy, industrial revolution, tourism, human resources, financial technology, industry, customer management and financial solutions), renewable energy systems and efficiency and its entrepreneurial projects, innovative technologies to exploit water.

Research on climate change effects on habitats has been published recently, where the habitat suitability modelling was performed for four feline species. Three of these are categorized as critically endangered, according to the latest red list assessment of mammals in Jordan (Eid et al, 2022, Eid, 2020). Predictions on habitat suitability showed an alarming decline in suitable habitats for all species according to the two Representative Concentration Pathways (RCPs). In addition, a book was published recently showing the future projections of 36 snake species in Jordan using habitat suitability modelling (Eid, 2022).

The National Climate Change Policy (2020-2050) in Jordan identifies the following main recommendations for education and capacity building:

- Create or update existing research hub for collaboration between policy institutions and research institutions for climate change related issues;
- Update the “Oriented Research Guidelines, Procedures and Tools to Support Rio Conventions” to ensure all new obligations and mandates are covered with latest technical tools and guidelines.

[213] defining_scientific_research_priorities_in.pdf (hcst.gov.jo)

- 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.
- Provide support to tertiary institutions for the development of poles of excellence in different areas of climate science, vulnerability assessments, mitigation scenarios analyses and technology development and transfer in coordination with the Higher Council for Science and Technology (HCST) and the Royal Scientific Society (RSS) and not-for-profit organizations (e.g., RSCN) to support the science-policy interface through the Climate Change Research Group.
- Establish collaborations between local research institutions and regional and international counterparts to strengthen local institutional capabilities in all aspects of climate research.
- Establish a dedicated funding scheme for prioritizing research on climate change in support of the science-policy interface.
- Encourage tertiary institutions to network with overseas research partners to access international research funding and to bridge gaps in climate research capabilities to enhance the national science-policy interface.

5.9 Financial Resources

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

- Preparation of the First National Communication (FNC), prepared by the General Corporation for Environment Protection (GCEP) (which later became the Ministry of Environment), 1996-1997.
- Vulnerability and adaptation to climate change, prepared by MoEnv in 2000 to complete the FNC.
- Establishing a pilot biogas facility at Russeifa domestic landfill site, implemented by the Greater Amman Municipality and commissioned in 2000.
- Technology needs assessment (TNA) and technology transfer (TT), prepared by MoEnv, 2004-2005.
- National Capacity Self-Assessment for Global Environmental Management (NCSA), implemented by MoEnv in 2005 to assess the capacity constraints and potentials for implementing the three international environmental conventions on biodiversity, climate change, and desertification.

- Enabling Activities for the Preparation of Jordan's Second National Communication to the UNFCCC, implemented by MoEnv, 2006-2009.
- National Environmental, Economic, and Development Study (NEEDS) for Climate Change, prepared by the Ministry of Environment, 2010.
- Developing Policy-relevant Capacities for the Implementation of Global Environmental Conventions, implemented by the Ministry of Environment in cooperation with UNDP and with support from GEF, 2010.
- Enabling Activities for the Preparation of Jordan's Third National Communication to the UNFCCC, implemented by MoEnv, 2012-2015.
- Jordan Climate Change Policy, supported by UNDP/GEF, 2013.
- Enabling Activities for the Preparation of Jordan's First Biennial Update Report to the UNFCCC, implemented by MoEnv, 2015-2017.
- Mainstreaming Rio Convention into National Sectoral Polices in Jordan Project, 2015-2018.

The above projects have been implemented with UNDP support, and with technical support from other United Nations organizations including UNEP and UNFCCC. In addition, UNEP/UNDP National Communication Support Programme and the UNDP/UNEP Global Support Programme (GSP) have provided technical support for the preparation of Jordan's National Communications and the BURs on climate change through training workshops, provision of guidelines and guidance materials, review of studies and reports and provision of online support and tele-conference calls.

According to the National Environmental and Economic Development Study for Climate Change (NEEDS) study published in Jordan in 2010, both mitigation and adaptation measures in Jordan will require substantial financial resources. The studies estimates that USD 3.5 billion will be needed for mitigation until 2020. With only 0.5% of the public budget allocated to projects in the environmental sector (apart from infrastructure investments in water and energy), considerable fundraising targets are required.

The Government of Jordan has proposed sectoral mitigation policies and programs to achieve a 14% reduction in GHG emissions by 2030 compared to the baseline scenario. The 14% reduction of GHG emissions is divided into two parts. The first part seeks to achieve a 1.5% reduction in GHG emissions through unilateral actions, while the remaining 12.5% reduction is contingent and conditional on receiving international financial support. In its INDCs, Jordan put the estimate of reducing GHG emissions by 14% at USD 5.7 billion.

To finance mitigation measures in the energy sector, Jordan will require USD 5,158 million to meet its conditional mitigation targets. While a significant proportion of this is likely to come from international sources of finance, one of the key sectoral actions for the energy sector is attracting private sector finance and reducing administrative obstacles in order to enable JREEEF to support investments at early stages.

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.

The key challenges in financing climate change projects, particularly EE and RE

- Banks in Jordan, in general, are interested in providing finance to RE and EE projects.
- Banks prefer financing RE projects, particularly those which are of a larger size and linked to their existing client base. EE and smaller sized projects are less preferred.
- To minimize risks, financiers need access to an independent, credible reference body for the accreditation of climate change projects, particularly RE and EE projects. However, technical verifiers are unavailable, and financiers lack technical capacity.
- There is a lack of appropriate financial products.
- Project developers lack technical capacity.

The work of public financing institutions, such as JREEEF and JEF, although small scale, could play a crucial role in promoting early-stage investments, particularly for public private partnership (PPP) projects, and for projects with co-financing. The Jordan Environment Fund (JEF) lacked the needed financial and administrate autonomy to be able to carry out its mandate effectively and efficiently. JREEEF is now active and has full and adequate institutional, technical, and financial capacity to manage the fund, buttressed by a management committee, supportive legislation (JREEEF By-Law), a transparent and effective governance structure, a strategic business plan, and financial support windows. For JEF to fund mitigation activities will require a widening of its current role to include a specific focus on mitigation activity, and the development of project selection criteria including an assessment of projects' impact on GHG emissions. In addition, JEF currently lacks adequate human, technical, and financial capability to perform its current role, let alone an expanded role.

Most climate initiatives and projects in Jordan are still donor driven and the pledged emissions reductions will require substantial international financial support and a shift in national planning and budgeting that includes the allocation of domestic resources for mitigation and adaptation. 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. The donor community is supportive of a public registry of projects which would allow transparency and coordination of ongoing activities, as well as the assessment of their cost effectiveness. In addition, these donors are particularly supportive of developing strong GHG MRV frameworks, believed to be key to demonstrating the effectiveness climate financing.

The GoJ is proactively seeking international climate funds. It established a National Designated Authority (NDA), the Ministry of Environment, for the Adaptation Fund and the Green Climate Fund (GCF) and has received approval of Adaptation Fund projects and GCF grants to strengthen its readiness to prepare a proposal for the GCF. Financial institutions and banks are interested in entering this new sector. Several green loans and programs are being established and green suppliers and manufacturers are growing in number. However, the market lacks proactive marketing and public outreach.

Jordan has submitted nine NAMAs (National appropriate mitigation actions) to the UNFCCC for support[214]. Six proposals are for support for the preparation of projects for rehabilitation of landfill, fuels and emissions savings, energy efficiency in the water sector, and mitigation actions for industrial sector and national domestic waste management. Three proposals are seeking support for implementation of projects for energy efficiency in the water sector, a thermal power station, and a wastewater treatment plant.

Currently, there is 112 million JD available for RE and EE financing in Jordan. Of this amount, 76 million JD is available through the four commercial banks using the Central Bank of Jordan's window for RE and EE, and 36 million JD is available through the Agence Français de Development (AFD) facility. Key challenges in disbursing these funds include the lack of credible market references and a short credit history. This is particularly a relatively new field and while some banks have already established designated credit lines, other banks are still on the fence. A particular challenge for them is the lack of sufficient knowledge to verify project assumptions, technologies, or risks. They need access to an independent, credible reference body for the accreditation of RE and EE projects.

[214] Public NAMA - Home (unfccc.int)

Jordan recognized climate change mitigation and adaptation as an integral part of the much broader strategy for green growth. A National Green Growth Plan for Jordan was developed, thus start pushing the financing outreach faster. 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. Jordan has mainstreamed the green economy potential into those sectors. However, private partnership well as civil society organizations is still weak.

The following are suggested actions and recommendations to address those gaps and needs:

- A framework for a domestic MRV system for Received Support was suggested that addresses most of the above gaps, constrains, and needs by:
  - Establishing a dedicated entity to oversee collecting and verifying received support information related to climate change.
  - Designing and implementing a national multi-level MRV system, supported by the Partnership for Market Readiness.
- It is recommended to raise the capacities of stakeholders to produce bankable viable projects.
- It is recommended to raise the awareness of bankers of technical projects evaluation and assessment.

Based on GCF, there are currently 9 projects running with a total grant sum of 99.4 M USD in addition to 4 readiness projects with a total grant of 2.3 M USD. Moreover, Table 1 Annex s shows the list funds received from 2015 till 2020.

International and bilateral funding for Jordan is primarily focused on refugee and humanitarian support. The Jordan Response Platform (JRP) for the Syrian Crisis[215], for example, seeks to compensate Jordan for hosting the refugees and aims to secure sufficient grants and concessional financing to address the general budget needs over the next three years for humanitarian assistance and to build the resilience of Jordanian communities. The JRP has received an endorsement of 7.3 billion in February 2018 from the international community. Although the refugee crisis is receiving most of international and national attention, Jordan has also been successful in obtaining finance for climate projects from international and multilateral funds. See

215 http://www.jrpsc.org/

Table C.2, **Table C.3**, **Table C.4**, **Table C.5**, **Table C.6**, **Table C.7**, **Table C. 8**, **Table C. 9**, **Table C.10**, **Table C.11 Annex C** for climate projects.

Lately, the MoEnv in cooperation with MOPIC has proposed a World Bank project "Jordan Inclusive, Transparent and Climate Responsive Investments Program For Result" to improve accountability to foster climate responsive investments and growth, through:

1. Investment is defined as public and private investment
2. Climate responsive investments refer to public sector and private sector opportunities in Jordan's NDC and measured by the MRV System
3. Accountability rests on a framework of enhanced transparency and feedback loops that inform investment and policy decisions.

The updated Climate Change Policy (2020-2050) highlighted that Jordan possesses certain national capabilities to implement the CC Policy 2022-2050, but it is recognized that these will not be sufficient to achieve the long-term policy objective and the policy vision. The climate change policy suggested the following policies and actions to avail of the provisions made under Article 9 (financing) of Paris Agreement (PA):

1) Develop budget tags and codes for tracking the allocation of climate finance in national budgetary process (including funds related to CC such as the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF), Environment Fund, disaster funds etc.) at all levels;
2) Establish a National Implementing Entity (NIE) for direct access to multilateral climate funds;
3) Develop a Climate Finance Policy and Strategy Framework;
4) Enhance human capacity (public, private, CSO/NGOs, academia) to develop bankable proposals to attract international climate finance from multilateral (e.g., Green Climate Fund) and bilateral sources;
5) Develop a pipeline of concept notes and proposals to increase preparedness to attract climate finance based on country priorities;
6) Strengthen donor / development partner coordination to match concept notes and proposals with potential sources of climate finance; and
7) Leverage private sector participation and investments through public-private engagements.

5.10 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 Cancun 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 (2013) were:

- 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.

The Ministry of Environment, with GEF-UNDP support, has earlier published a technology needs assessment (TNA) and technology transfer report for 2004-2005. More recently, the Ministry has completed a Climate Change Technology Needs Assessment for Jordan for the period 2015-2017.

The project was implemented through a partnership between the United Nations Environment Program (UNEP) and the Technical University of Denmark (DTU), and is known as UNEP-DTU Partnership. Three reports have been published by this project. The first report is for the selection of priority mitigation and adaptation sectors for TNA activities in Jordan. The second report presented a list of the main barriers and an enabling framework, while the third report, which was published in August 2017, offered a technology action plan for two priority mitigation sectors (energy and transport) and two priority adaptation sectors (water and agriculture). The following TNA analysis was extracted from the three published reports.

Results revealed the following top three technologies, prioritized, out of a long initial roster of assessed technologies in each targeted sector.

The top three mitigation technologies for the energy sector were:

(1) Solar thermal,
(2) PV for electrification, and
(3) PV for water pumping.

The three top-ranked priority mitigation technologies for the transportation sector were:

(1) Bus Rapid Transit,
(2) Improving pedestrian infrastructure, and
(3) Ticketing systems to improve the quality and the attractiveness of public transport services.

The final results for the water sector's top three priority adaptation technologies were:

(1) Roof-top rainwater harvesting,
(2) Augmentation and expansion of Water Users Association (WUAs), and
(3) Desalination and brackish water treatment and re-use.

The results for the agricultural sector's top three priority adaptation technologies were:

(1) Water saving technologies, such as drip or subsurface irrigation,
(2) Farm-level water harvesting, and
(3) Plant varieties resistant to climate change.

The report has also provided a combined technology action plan (TAP) for the three priority technologies for each sector and key projects have been suggested to turn ideas into action.

The main actions proposed for the energy sector are:

- Removal of financial and economic barriers;
- Enforcement of standards;
- Focused training programs; and
- Effective awareness programs.

The following three main project ideas have been suggested:

- Designing financial support mechanisms and subsidies for solar powered systems;
- Developing a complete PV process industry from silicon to module;
- Developing a high-tech comprehensive solar thermal industry; flat, evacuated tube, and parabolic trough technologies.

The main actions proposed for the transportation sector are:

- Introducing regulations that incentivize users and potential users of public transportation;
- Planning strategic rehabilitation of the main streets that will contain BRT lanes;
- Institutionalizing the roles of stakeholders;
- Organizing capacity building programs for drivers and operators; and
- Organizing a broad awareness campaign to incentivize users and potential users of public transportation.

The following three main project ideas have been suggested:

- Establishing a new sustainable transportation graduate course of study (Master degree program) at Jordanian universities to train practitioners in this understaffed field;
- Planning a public transportation project between Amman and Irbid;
- Modernizing public transportation vehicles.

The three technologies prioritized in the water sector have distinctive characteristics and independent applied aspects in terms of resources, management modalities, beneficiary groups, and stakeholders involved as well as unique technical and governance barriers. Thus, the three technologies were addressed and assessed separately. Moreover, each technology has its unique scale and context of deployment as follows:

1) Roof-top Rainwater Harvesting (RWH) technology:

Among the actions proposed for this technology are:

- Conducting a technical assessment and screening study to identify the most appropriate modality of RWH technology for different types of building characteristics in Jordan;
- Revising or developing a new water efficiency code/by-law for buildings to regulate water efficiency measures including RWH. The proposed code would address regulatory incentives such as tax cuts and fees deduction to encourage compliance by housing construction companies with RWH directives (building codes) and enhance feasibility and payback period;
- Developing awareness and information dissemination programs targeting relevant bodies (Ministry of Water and Irrigation, Jordan Engineers Association, Contractors Association).

Some actions inspired new project ideas. For example, the TAP for RWH inspired a proposal to establish a Regional Green Building Engineering Training Center in Jordan, which will be a fully-fledged demonstration of green buildings with installed RWH technology, among other sustainable building-oriented technologies (such as greywater, insulation, RE&EE technologies).

2) Empowerment and Expansion of WUAs Technology

Among the actions proposed for this technology are:

- Having a suitable law governing WUAs to empower its operations in Jordan;
- Strengthening WUAs to enable them to perform the mandated tasks (irrigation management transfer);
- Attaining effective means of financial sustainability for WUAs and building their capacity to develop income-generating activities and projects;
- Establishing a program for continuous training and capacity building and developing effective coordination and communication platforms for WUAs in the Jordan Valley;
- Developing capacity building programs to empower WUAs in marketing the concept of WUA as an innovation in participatory irrigation management, and improving the skills of WUAs in marketing their products;

It is expected that the above actions will become components of one mega program seeking to accelerate full irrigation management transfer to the WUAs throughout the Jordan Valley. This will contribute to removing the barriers for WUAs and facilitate its expansion in other parts of the country, such as southern Jordan.

3) Desalination and Brackish Water Treatment and Re-use

Because investment in these technologies requires a high capital cost, the scale for potential diffusion of this technology will be confined to a pilot site of promising readiness and preference for the authorities in charge (Water Authority of Jordan).

Among the actions proposed for this technology are:

- Promoting reasonable system prices for capital and operating costs through cost-effective desalination units integrated with energy solutions (such as solar energy);
- Promoting and providing incentives to locally produced and assembled desalination units; and
- Promoting technologies of less environmental impact.

A well identified project idea for this technology is the installation of a PV-powered desalination plant with a capacity 3-3.5 MCM/year to be utilized for drinking water supply to Amman and the local area. A suggested site is the Al Husban Well Field (a set of 4 groundwater wells on the Dead Sea Groundwater Basin).

The three technologies prioritized in the agricultural sector have distinctive characteristics and independent applied aspects in terms of resources, management modalities, beneficiary groups, and stakeholders involved, as well as unique technical and governance barriers. Thus, the three technologies were addressed and assessed separately as well.

1) Application of Water Saving Technologies, such as Drip or Subsurface Irrigation Technology

The ambition for said technologies was set as a target: "Increase the irrigated areas in the Jordan Valley and Highlands using water saving technologies to 60,000 hectares by 2030". The ambition also extends to expanding water harvesting activities to the catchments of dry areas and the Badia region to deliver socio-economic and environmental benefits in the arable areas. To that end, the following actions are proposed for this technology:

- Improving agricultural extension services significantly to provide necessary advisory services and capacity building activities on the advantages of the technology;
- Developing capacity building campaigns targeting farmers;
- Providing economic incentives and subsidized tariffs for water saving irrigation practices in order to increase efficient use by land-owners and farmers;

2) Farm-level Water Harvesting

The scale and ambition for this technology is centered in local catchments in dry areas and the Badia region. Thus, among the actions proposed for this technology are:

- Implementation of pilot projects to demonstrate the advantages of the technology;

- Enabling provision of long-term and low interest loans or grants through state funds, private sources (different banks), and international funds (WB, IFAD, GEF, GCF, Adaptation Fund); and supporting the creation of a stakeholder network for the development and transfer of the technology through a network of technical experts.

3) Introduction (or Promotion) of Plant Varieties Resistant (Adaptive) to Climate Change

The scale of application for this technology will be restricted to rain-fed agricultural areas, where cereal-legume cropping systems are predominant. Therefore, the following actions are proposed for this technology:

- Establishing modern breeding programs to produce climate change resilient varieties in collaboration with multinational and international organizations;
- Developing specific subsidy mechanisms and incentives to the farmers to promote the utilization and dissemination of the climate change resilient crop varieties;
- Strengthening institutional capacity; and
- Promoting knowledge transfer and increasing public awareness regarding the benefits of improved varieties.

The updated Climate Change Policy (2020-2050) highlighted that Jordan possesses certain national capabilities to implement the CC Policy 2022-2050, but it is recognized that these will not be sufficient to achieve the long-term policy objective and the policy vision. The climate change policy suggested the following policies and actions to avail of the provisions made under Article 10 (technology development and transfer) of Paris Agreement (PA).

1) Identify and prioritize (adaptation and mitigation) technologies for all adaptation and mitigation sectors using a participatory, inclusive multi-stakeholder process;
2) Carry out barriers analysis and detail the enabling environment for prioritized technologies;
3) Develop Technology Action Plans (TAPs) and use to formulate bankable proposals to attract international climate finance and financing from development partners and to update sectoral strategies and action plans;
4) Update TAPs on a regular basis to inform the formulation of higher-level ambition NDCs and the continuing effort to attract climate finance;
5) Capacity building on the TNA-TAP methodology and tools; and
6) Institutionalization of TNA methodology and tools to develop TAPs through appropriate institutional arrangements.

5.11 Roadmap for Climate Change Action: (2022-2025)

Prior to the preparation of Jordan's Fifth National Communication Report, the following roadmap for implementation of fourth NC 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 5th NC and development of Climate Change portfolio in Jordan

Item	*Action*
1. Technical gaps in National Communications 1.1 GHG Inventory	1.1.1 Create a single dedicated entity at the climate change directorate in the Ministry of Environment and capacitate its staff members to act as a hub to collect, process, archive and report GHG inventories; 1.1.2 Develop a legal mechanism that "adheres" activity data producers to submit information to the MoEnv; 1.1.3 Identify all sources of data, their measurement units and sources that are required by an GHG inventory using 2006 IPCC guidelines and Software, and arrange for a sustainable flow of information from source to MoEnv; 1.1.4 Conduct an intensive training programme on the development of a GHG inventory system, including detailed use of IPCC guidelines; 1.1.5 Conduct research orientated towards estimating real emission factors based on actual measurements and monitoring actions; 1.1.6 Build the technical capacity that is required to estimate the emissions of Short-Lived Climate Forcers (SLCFs) and the assessment of their climate impacts.
1.2 Mitigation Assessment	1.2.1 Establish a dedicated entity is suggested to be created to oversee collection and processing of data for GHG estimation by setting up institutional arrangements and clear responsibilities and mandates; 1.2.2 Expand the expertise base and the knowledge capacity for conducting mitigation analysis through an extensive training programme on LEAP and other tools; 1.2.3 Adopt the Jordanian case built in BURs and Fourth NC using the LEAP model for further developed in upcoming national communications and BURs; 1.2.4 Raise awareness on international mitigation mechanisms and initiatives among all decision makers and stakeholders.
1.3 Vulnerability & Adaptation	1.3.1 Enhancing the capacity of all related agencies in expanding the scope of climate indices recorded and the distribution of monitoring stations and improvement of equipment performance. 1.3.2 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. 1.3.3 Expand 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; 1.3.5 Invest in building the capacities of the focal points acting in the technical groups and researchers to support the NCCC; 1.3.6 Integrate nexus approach in future vulnerability assessments to design future, inherently interlinked systems planning in a holistic manner;

	1.3.7 Promote the use of GIS and remote sensing for supporting climate information systems in all sectors; 1.3.8 Conduct studies and observations of climate impacts on health, also covering short-lived climate pollutants (SLCP).
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; 2.3 Strengthen laws & regulations such as creating legal code for defining the responsibilities of main emitters, introduction of extended producer responsibility, etc.; 2.4 Develop a Code of Corporate Governance for public interest entities to mandate sustainability reporting, including climate change (adaptation and mitigation); 2.5 Regulatory change to enshrine climate change; 2.6 Improving stakeholder coordination for climate inclusiveness; 2.7 Institutional strengthening of public institutions to integrate the function of climate change; 2.8 Institutional strengthening for enhanced regional and international climate dialogues
3. Policy Mainstreaming	3.1 Develop a coordinated policy approach for mitigation that integrates CDM, NAMA, PMR, MRV, LEDS and NDCs; 3.2 Activate the national policy of climate change through stakeholders' coordination and mainstreaming of CC concepts in sectoral policies; 3.3 Develop detailed Operational Guidelines for supporting institutions to carry out their obligations and responsibilities; 3.4 Provide technical capacity building of stakeholders to fulfil their respective roles and responsibilities in relation to Operational Guidelines; 3.5 Develop Stakeholder Engagement Plan (SEP) for engaging all key stakeholders; 3.6 Establish a formal advisory body to the NCCC to enhance the science-policy interface; 3.7 Establish a work programme under the aegis of the NCCC that will culminate in the setting up of a formal institutional mechanism for taking the views of all groups in public decision-making related to climate change; 3.8 Establish a work programme under the aegis of the NCCC that will enhance the capacity of Jordan to contribute to regional and international climate dialogues for enhanced climate governance.
4. Public Awareness	4.1 Develop a communication strategy based on the Stakeholder Engagement Plan (SEP) and Women and Youth Action Plan; 4.2 Carry out outreach activities to cover communication and awareness raising on all climate-related issues with stakeholders at all geographical levels of governance; 4.3 Build partnerships between public, private, NGOs and CSOs to deliver the most effective and efficiency sensitization campaigns at all levels; 4.4 Awareness raising among parliamentarians and legislators to enhance cross-sectoral integration of climate in public policies; 4.5 Capacity building of journalists and influencer; 4.6 Establish focal points in traditional media outlets and engage them on a regular basis to communicate on all climate-related initiatives.
5. Education and Capacity Building	5.1 Strengthen the integration of the science of climate change, climate change adaptation and mitigation in primary and secondary school curricula, including adequate pedagogical tools for learning-by-doing and interactive approaches; 5.2- Strengthen outreach of climate change (science, impacts, adaptation, and mitigation) in non-formal education to ensure that vulnerable children and young people (and any other individual) are not left behind; 5.3- Support the development of undergraduate and postgraduate courses in areas of climate change;

	5.4 Review and update / develop vocational training courses for supporting climate change adaptation and mitigation based on needs gaps analyses, in conjunction with the private sector; 5.5 Support the establishment of environmental clubs within schools at all levels to incentivize students to participate in climate action
6. Knowledge Management	6.1 Develop a data bank and interface hub for GHG inventory, mitigation, vulnerability and adaptation data.
7. Scientific research and innovation	7.1 Create or update existing research hub for collaboration between policy institutions and research institutions for climate change related issues; 7.2 Update the Oriented Research Guidelines, Procedures and Tools to Support Rio Conventions to ensure all new obligations and mandates are covered with latest technical tools and guidelines; 7.3 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; 7.4 Support provided to tertiary institutions for the development of poles of excellence in different areas of climate science; 7.5 Establish collaborations between local research institutions and regional and international counterparts; 7.6 Establish a dedicated funding scheme for prioritizing research on climate change in support of the science-policy interface; 7.7 Encourage tertiary institutions to network with overseas research partners to access international research funding and to bridge gaps in climate research capabilities to enhance the national science-policy interface.
8. Financial resources	8.1 Develop budget tags and codes for tracking the allocation of climate finance in national budgetary process. 8.2 Establish a National Implementing Entity (NIE) for direct access to multilateral climate funds. 8.3 Develop a Climate Finance Policy and Strategy Framework; 8.4 Enhance human capacity (public, private, CSO/NGOs, academia) to develop bankable proposals to attract international climate finance from multilateral (e.g., Green Climate Fund) and bilateral sources; 8.5 Develop a pipeline of concept notes and proposals to increase preparedness to attract climate finance based on country priorities; 8.6 Strengthen donor / development partner coordination to match concept notes and proposals with potential sources of climate finance; 8.7 Leverage private sector participation and investments through public-private engagements.
9. Technology Transfer	9.1 Identify and prioritize technologies for all adaptation and mitigation sectors using a participatory, inclusive multi-stakeholder process. 9.2 Carry out barriers analysis and detail the enabling environment for prioritized technologies; 9.3 Develop Technology Action Plans (TAPs) and use to formulate bankable proposals to attract international climate finance; 9.4 Update TAPs on a regular basis to inform the formulation of higher-level ambition NDCs and the continuing effort to attract climate finance; 9.5 Capacity building on the TNA-TAP methodology and tool; 9.6 Institutionalization of TNA methodology and tools to develop TAPs through appropriate institutional arrangements.

ANNEX A

Table A.1: Primary Energy Requirements 2018-2065

Primary Supply
Selected Fuels (19/22), All Primary Supply Categories
Branch: Resources
Units: Thousand Tonnes of Oil Equivalents

2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
10,535.	10,358.	10,670.	10,701.	11,128.	11,247.	11,537.	11,835.	12,116.	12,364.	12,691.	13,020.	13,132.	13,151.	13,437.	13,644.	13,946.

2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051
14,090.	14,380.	14,609.	14,853.	15,154.	15,456.	15,771.	15,831.	16,229.	16,597.	16,908.	17,289.	17,666.	18,045.	18,459.	18,762.	19,198.

2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065
19,599.	20,019.	20,483.	20,914.	21,363.	21,834.	22,320.	22,793.	23,276.	23,795.	24,228.	24,751.	25,376.	25,843.

Table A.2: Energy Balance for Area "Jordan ver 2022 (Recovered 01-17-22)"

Scenario: Baseline, Year: **2022**, Units: Thousand Tonnes of Oil Equivalent									
	Solid Fuels	Natural Gas	Crude Oil	Hydropower	Renewables	Biomass	Electricity	Oil Products	Total
Production	-	-	-	-	-	-	-	-	-
Imports	225.	4,225.	3,037.	3.	667.	74.	106.	3,337.	11,674.
Exports	-	-	-	-	-	-	-543.	-	-543.
Total Primary Supply	225.	4,225.	3,037.	3.	667.	74.	-437.	3,337.	11,131.
Oil Production	-	-	-	-	-	-	-	-	-
Oil Refining	-	-	-3,037.	-	-	-	-	2,911.	-126.
Gas Production	-	-0.	-	-	-	-	-	-	-0.
Gas Transmission	-	-	-	-	-	-	-	-	-
Electricity Generation	-	-4,225.	-	-3.	-393.	-	2,484.	-1,069.	-3,205.
Own Use	-	-	-	-	-	-	-64.	-	-64.
Transmission and Distribution	-	-	-	-	-	-	-301.	-	-301.
Distributed Generation	-	-	-	-	-33.	-	33.	-	-
Total Transformation	-	-4,225.	-3,037.	-3.	-426.	-	2,153.	1,842.	-3,695.
Industrial	225.	-	-	-	-	-	396.	430.	1,051.
Residential	-	-	-	-	180.	55.	774.	558.	1,568.
Services	-	-	-	-	61.	19.	246.	169.	494.
Transport	-	-	-	-	-	-	5.	3,591.	3,596.
Other	-	-	-	-	-	-	295.	292.	587.
Non-Energy Sector	-	-	-	-	-	-	-	139.	139.
Total Demand	225.	-	-	-	241.	74.	1,716.	5,179.	7,435.
Unmet Requirements	-	0.	-	-	0.	-	-0.	0.	0.

Scenario: Baseline, Year: **2025**, Units: Thousand Tonnes of Oil Equivalent									
	Solid Fuels	Natural Gas	Crude Oil	Hydropower	Renewables	Biomass	Electricity	Oil Products	Total
Production	-	-	-	-	-	-	-	-	-
Imports	241.	4,493.	3,302.	3.	792.	77.	106.	3,368.	12,382.
Exports	-	-	-	-	-	-	-544.	-	-544.
Total Primary Supply	241.	4,493.	3,302.	3.	792.	77.	-438.	3,368.	11,838.
Oil Production	-	-	-	-	-	-	-	-	-
Oil Refining	-	-	-3,302.	-	-	-	-	3,165.	-137.
Gas Production	-	-	-	-	-	-	-	-	-
Gas Transmission	-	-	-	-	-	-	-	-	-
Electricity Generation	-	-4,493.	-	-3.	-489.	-	2,699.	-1,110.	-3,396.
Own Use	-	-	-	-	-	-	-70.	-	-70.
Transmission and Distribution	-	-	-	-	-	-	-332.	-	-332.
Distributed Generation	-	-	-	-	-38.	-	38.	-	-
Total Transformation	-	-4,493.	-3,302.	-3.	-527.	-	2,335.	2,055.	-3,935.
Industrial	241.	-	-	-	-	-	449.	441.	1,131.
Residential	-	-	-	-	198.	57.	852.	564.	1,671.
Services	-	-	-	-	67.	20.	270.	175.	531.
Transport	-	-	-	-	-	-	8.	3,781.	3,789.
Other	-	-	-	-	-	-	318.	313.	631.
Non Energy Sector	-	-	-	-	-	-	-	150.	150.
Total Demand	241.	-	-	-	265.	77.	1,897.	5,423.	7,903.
Unmet Requirements	-	-	-	-	-0.	-	-0.	0.	-0.

Scenario: Baseline, Year: **2030**, Units: Thousand Tonnes of Oil Equivalent									
	Solid Fuels	Natural Gas	Crude Oil	Hydropower	Renewables	Biomass	Electricity	Oil Products	Total
Production	-	-	-	-	-	-	-	-	-
Imports	1,590.	4,380.	3,577.	3.	904.	81.	106.	3,040.	13,680.
Exports	-	-	-	-	-	-	-546.	-	-546.
Total Primary Supply	1,590.	4,380.	3,577.	3.	904.	81.	-440.	3,040.	13,134.
Oil Production	-	-	-	-	-	-	-	-	-
Oil Refining	-	-	-3,577.	-	-	-	-	3,429.	-148.
Gas Production	-	-	-	-	-	-	-	-	-
Gas Transmission	-	-	-	-	-	-	-	-	-
Electricity Generation	-1,323.	-4,380.	-	-3.	-558.	-	3,099.	-546.	-3,710.
Own Use	-	-	-	-	-	-	-83.	-	-83.
Transmission and Distribution	-	-	-	-	-	-	-391.	-	-391.
Distributed Generation	-	-	-	-	-38.	-	38.	-	-
Total Transformation	-1,323.	-4,380.	-3,577.	-3.	-595.	-	2,663.	2,883.	-4,332.
Industrial	267.	-	-	-	-	-	550.	456.	1,273.
Residential	-	-	-	-	231.	61.	992.	571.	1,854.
Services	-	-	-	-	78.	21.	314.	186.	598.
Transport	-	-	-	-	-	-	9.	4,188.	4,197.
Other	-	-	-	-	-	-	358.	353.	711.
Non Energy Sector	-	-	-	-	-	-	-	169.	169.
Total Demand	267.	-	-	-	308.	81.	2,224.	5,922.	8,802.
Unmet Requirements	-	-	-	-	-	-	-0.	-0.	-0.

Scenario: Baseline, Year: **2035**, Units: Thousand Tonnes of Oil Equivalent									
	Solid Fuels	Natural Gas	Crude Oil	Hydropower	Renewables	Biomass	Electricity	Oil Products	Total
Production	-	-	-	-	-	-	-	-	-
Imports	1,614.	4,728.	3,577.	3.	1,120.	85.	106.	3,407.	14,640.
Exports	-	-	-	-	-	-	-548.	-	-548.
Total Primary Supply	1,614.	4,728.	3,577.	3.	1,120.	85.	-442.	3,407.	14,092.
Oil Production	-	-	-	-	-	-	-	-	-
Oil Refining	-	-	-3,577.	-	-	-	-	3,429.	-148.
Gas Production	-	-	-	-	-	-	-	-	-
Gas Transmission	-	-	-	-	-	-	-	-	-
Electricity Generation	-1,323.	-4,728.	-	-3.	-729.	-	3,527.	-426.	-3,681.
Own Use	-	-	-	-	-	-	-96.	-	-96.
Transmission and Distribution	-	-	-	-	-	-	-453.	-	-453.
Distributed Generation	-	-	-	-	-38.	-	38.	-	-
Total Transformation	-1,323.	-4,728.	-3,577.	-3.	-766.	-	3,016.	3,002.	-4,379.
Industrial	292.	-	-	-	-	-	663.	467.	1,422.
Residential	-	-	-	-	265.	63.	1,139.	570.	2,037.
Services	-	-	-	-	89.	22.	361.	197.	668.
Transport	-	-	-	-	-	-	11.	4,593.	4,604.
Other	-	-	-	-	-	-	400.	394.	794.
Non Energy Sector	-	-	-	-	-	-	-	189.	189.
Total Demand	292.	-	-	-	354.	85.	2,574.	6,410.	9,714.
Unmet Requirements	-	-	-	-	-	-	-0.	0.	0.

Scenario: Baseline, Year: **2040**, Units: Thousand Tonnes of Oil Equivalent									
	Solid Fuels	Natural Gas	Crude Oil	Hydropower	Renewables	Biomass	Electricity	Oil Products	Total
Production	-	-	-	-	-	-	-	-	-
Imports	1,638.7	4,598.7	3,577.0	2.5	1,236.4	86.9	106.4	3,567.9	14,814.4
Exports	-	-	-	-	-	-	-12.5	-	-12.5
Total Primary Supply	1,638.7	4,598.7	3,577.0	2.5	1,236.4	86.9	93.9	3,567.9	14,801.9
Oil Production	-	-	-	-	-	-	-	-	-
Oil Refining	-	-	-3,577.0	-	-	-	-	3,428.7	-148.3
Gas Production	-	-	-	-	-	-	-	-	-
Gas Transmission	-	-	-	-	-	-	-	-	-
Electricity Generation	-1,322.7	-4,598.7	-	-2.5	-797.2	-	3,453.0	-112.6	-3,380.7
Own Use	-	-	-	-	-	-	-110.3	-	-110.3
Transmission and Distribution	-	-	-	-	-	-	-520.9	-	-520.9
Distributed Generation	-	-	-	-	-37.7	-	37.7	-	-
Total Transformation	-1,322.7	-4,598.7	-3,577.0	-2.5	-834.8	-	2,859.4	3,316.0	-4,160.3
Industrial	315.9	-	-	-	-	-	793.5	476.1	1,585.6
Residential	-	-	-	-	299.9	64.7	1,289.1	562.9	2,216.5
Services	-	-	-	-	101.7	22.3	412.0	208.9	744.8
Transport	-	-	-	-	-	-	12.1	4,987.0	4,999.1
Other	-	-	-	-	-	-	446.7	438.7	885.3
Non Energy Sector	-	-	-	-	-	-	-	210.4	210.4
Total Demand	315.9	-	-	-	401.5	86.9	2,953.4	6,883.9	10,641.6
Unmet Requirements	-	-0.0	-	-	-	-	0.0	-0.0	-

Scenario: Baseline, Year: **2045**, Units: Thousand Tonnes of Oil Equivalent									
	Solid Fuels	Natural Gas	Crude Oil	Hydropower	Renewables	Biomass	Electricity	Oil Products	Total
Production	-	-	-	-	-	-	-	-	-
Imports	1,567.0	5,488.9	3,577.0	2.5	1,493.7	88.9	106.4	3,979.6	16,304.1
Exports	-	-	-	-	-	-	-12.5	-	-12.5
Total Primary Supply	1,567.0	5,488.9	3,577.0	2.5	1,493.7	88.9	93.9	3,979.6	16,291.6
Oil Production	-	-	-	-	-	-	-	-	-
Oil Refining	-	-	-3,577.0	-	-	-	-	3,428.7	-148.3
Gas Production	-	-	-	-	-	-	-	-	-
Gas Transmission	-	-	-	-	-	-	-	-	-
Electricity Generation	-1,226.7	-5,488.9	-	-2.5	-1,002.3	-	3,969.0	-9.5	-3,761.0
Own Use	-	-	-	-	-	-	-126.4	-	-126.4
Transmission and Distribution	-	-	-	-	-	-	-596.7	-	-596.7
Distributed Generation	-	-	-	-	-37.7	-	37.7	-	-
Total Transformation	-1,226.7	-5,488.9	-3,577.0	-2.5	-1,040.0	-	3,283.6	3,419.2	-4,632.3
Industrial	340.2	-	-	-	-	-	943.6	484.0	1,767.8
Residential	-	-	-	-	338.1	66.0	1,453.3	553.9	2,411.4
Services	-	-	-	-	115.7	22.9	468.7	223.2	830.4
Transport	-	-	-	-	-	-	13.8	5,414.2	5,428.0
Other	-	-	-	-	-	-	498.1	489.0	987.1
Non Energy Sector	-	-	-	-	-	-	-	234.5	234.5
Total Demand	340.2	-	-	-	453.7	88.9	3,377.5	7,398.8	11,659.3
Unmet Requirements	-	-	-	-	0.0	-	-0.0	-0.0	-0.0

Scenario: Baseline, Year: **2050**, Units: Thousand Tonnes of Oil Equivalent									
	Solid Fuels	Natural Gas	Crude Oil	Hydropower	Renewables	Biomass	Electricity	Oil Products	Total
Production	-	-	-	-	-	-	-	-	-
Imports	1,638.7	4,598.7	3,577.0	2.5	1,236.4	86.9	106.4	3,567.9	14,814.4
Exports	-	-	-	-	-	-	-12.5	-	-12.5
Total Primary Supply	1,638.7	4,598.7	3,577.0	2.5	1,236.4	86.9	93.9	3,567.9	14,801.9
Oil Production	-	-	-	-	-	-	-	-	-
Oil Refining	-	-	-3,577.0	-	-	-	-	3,428.7	-148.3
Gas Production	-	-	-	-	-	-	-	-	-
Gas Transmission	-	-	-	-	-	-	-	-	-
Electricity Generation	-1,322.7	-4,598.7	-	-2.5	-797.2	-	3,453.0	-112.6	-3,380.7
Own Use	-	-	-	-	-	-	-110.3	-	-110.3
Transmission and Distribution	-	-	-	-	-	-	-520.9	-	-520.9
Distributed Generation	-	-	-	-	-37.7	-	37.7	-	-
Total Transformation	-1,322.7	-4,598.7	-3,577.0	-2.5	-834.8	-	2,859.4	3,316.0	-4,160.3
Industrial	315.9	-	-	-	-	-	793.5	476.1	1,585.6
Residential	-	-	-	-	299.9	64.7	1,289.1	562.9	2,216.5
Services	-	-	-	-	101.7	22.3	412.0	208.9	744.8
Transport	-	-	-	-	-	-	12.1	4,987.0	4,999.1
Other	-	-	-	-	-	-	446.7	438.7	885.3
Non Energy Sector	-	-	-	-	-	-	-	210.4	210.4
Total Demand	315.9	-	-	-	401.5	86.9	2,953.4	6,883.9	10,641.6
Unmet Requirements	-	-0.0	-	-	-	-	0.0	-0.0	-

Table A.3: Electricity Requirements 2018-2066. GWH

Year	Electricity Generation	Total	Year	Electricity Generation	Total	Year	Electricity Generation	Total
2018	19,882.	19,882.	2039	39,036.	39,036.	2060	69,616.	69,616.
2019	20,589.	20,589.	2040	40,158.	40,158.	2061	71,474.	71,474.
2020	21,275.	21,275.	2041	41,306.	41,306.	2062	73,374.	73,374.
2021	21,988.	21,988.	2042	42,479.	42,479.	2063	75,315.	75,315.
2022	22,723.	22,723.	2043	43,679.	43,679.	2064	77,299.	77,299.
2023	23,482.	23,482.	2044	44,905.	44,905.	2065	79,327.	79,327.
2024	24,334.	24,334.	2045	46,159.	46,159.	2066	81,399.	81,399.
2025	25,210.	25,210.	2046	47,489.	47,489.			
2026	26,085.	26,085.	2047	48,849.	48,849.			
2027	26,984.	26,984.	2048	50,241.	50,241.			
2028	27,908.	27,908.	2049	51,664.	51,664.			
2029	28,858.	28,858.	2050	53,121.	53,121.			
2030	29,833.	29,833.	2051	54,610.	54,610.			
2031	30,777.	30,777.	2052	56,133.	56,133.			
2032	31,744.	31,744.	2053	57,690.	57,690.			
2033	32,736.	32,736.	2054	59,283.	59,283.			
2034	33,752.	33,752.	2055	60,912.	60,912.			
2035	34,792.	34,792.	2056	62,577.	62,577.			
2036	35,818.	35,818.	2057	64,279.	64,279.			
2037	36,866.	36,866.	2058	66,019.	66,019.			
2038	37,939.	37,939.	2059	67,798.	67,798.			

Table A.4: Total GHG from Energy Sector in Gg CO_2eq for 2018-2066

Year	Demand	Transformation	Total	Year	Demand	Transformation	Total	Year	Demand	Transformation	Total
2018	11,470.	15,335.	26,805.	2038	10,357.	21,110.	31,467.	2059	21,575.	29,253.	50,827.
2019	9,671.	15,591.	25,262.	2039	10,795.	21,412.	32,206.	2060	22,224.	29,735.	51,958.
2020	9,803.	15,836.	25,639.	2040	11,165.	21,718.	32,883.	2061	22,851.	30,225.	53,076.
2021	9,302.	16,085.	25,387.	2041	11,627.	22,030.	33,657.	2062	23,612.	30,725.	54,337.
2022	10,019.	16,338.	26,357.	2042	11,404.	22,346.	33,750.	2063	24,408.	31,233.	55,641.
2023	9,502.	16,594.	26,096.	2043	11,931.	22,666.	34,597.	2064	25,129.	31,750.	56,879.
2024	9,954.	16,853.	26,807.	2044	12,512.	22,992.	35,505.	2065	27,087.	32,277.	59,364.
2025	10,419.	17,117.	27,535.	2045	12,935.	23,323.	36,258.	2066	32,814.	26,624.	59,437.
2026	10,883.	17,422.	28,304.	2046	13,487.	23,700.	37,187.				
2027	11,359.	17,732.	29,091.	2047	13,955.	24,084.	38,039.				
2028	11,849.	18,048.	29,897.	2048	14,442.	24,475.	38,917.				
2029	12,352.	18,369.	30,721.	2049	15,026.	24,873.	39,899.				
2030	10,407.	18,696.	29,103.	2050	16,014.	25,277.	41,291.				
2031	10,152.	18,993.	29,145.	2051	16,697.	25,688.	42,386.				
2032	10,526.	19,295.	29,820.	2052	17,225.	26,107.	43,332.				
2033	9,332.	19,602.	28,934.	2053	17,717.	26,533.	44,250.				
2034	9,843.	19,913.	29,756.	2054	18,442.	26,967.	45,409.				
2035	9,691.	20,230.	29,921.	2055	19,013.	27,408.	46,421.				
2036	9,922.	20,519.	30,440.	2056	19,552.	27,857.	47,409.				
2037	10,110.	20,812.	30,922.	2057	20,231.	28,314.	48,545.				
2038	10,357.	21,110.	31,467.	2058	20,942.	28,779.	49,721.				

Table A.5: GHGs emission from Final Energy Demand by Sector 2018-2066. Gg CO_2eq

year	Industrial	Residential	Services	Transport	Other	year	Industrial	Residential	Services	Transport	Other
2018	2,237.	1,545.	474.	10,262.	816.	2045	3,053.	1,546.	629.	16,581.	1,514.
2019	2,274.	1,554.	479.	10,446.	837.	2046	3,079.	1,543.	637.	16,894.	1,547.
2020	2,306.	1,560.	483.	10,629.	857.	2047	3,105.	1,540.	645.	17,213.	1,582.
2021	2,340.	1,566.	488.	10,813.	878.	2048	3,130.	1,538.	653.	17,537.	1,617.
2022	2,374.	1,571.	493.	11,000.	900.	2049	3,156.	1,535.	662.	17,868.	1,652.
2023	2,408.	1,576.	498.	11,190.	922.	2050	3,181.	1,532.	670.	18,204.	1,689.
2024	2,442.	1,581.	503.	11,383.	944.	2051	3,206.	1,529.	680.	18,547.	1,727.
2025	2,476.	1,585.	508.	11,579.	967.	2052	3,231.	1,526.	689.	18,896.	1,765.
2026	2,510.	1,589.	513.	11,819.	990.	2053	3,256.	1,522.	699.	19,252.	1,804.
2027	2,543.	1,593.	519.	12,064.	1,014.	2054	3,281.	1,519.	709.	19,615.	1,844.
2028	2,576.	1,596.	524.	12,313.	1,039.	2055	3,305.	1,515.	719.	19,984.	1,885.
2029	2,609.	1,599.	530.	12,568.	1,063.	2056	3,329.	1,512.	729.	20,360.	1,927.
2030	2,642.	1,602.	536.	12,828.	1,089.	2057	3,354.	1,508.	740.	20,743.	1,970.
2031	2,671.	1,602.	541.	13,067.	1,113.	2058	3,378.	1,504.	751.	21,133.	2,013.
2032	2,700.	1,601.	546.	13,310.	1,138.	2059	3,402.	1,500.	763.	21,530.	2,058.
2033	2,729.	1,600.	551.	13,558.	1,164.	2060	3,425.	1,496.	775.	21,934.	2,104.
2034	2,757.	1,599.	557.	13,810.	1,190.	2061	3,449.	1,492.	787.	22,347.	2,150.
2035	2,786.	1,598.	563.	14,067.	1,217.	2062	3,473.	1,488.	799.	22,766.	2,198.
2036	2,813.	1,593.	568.	14,300.	1,244.	2063	3,496.	1,484.	812.	23,194.	2,247.
2037	2,841.	1,588.	574.	14,538.	1,271.	2064	3,519.	1,480.	825.	23,629.	2,297.
2038	2,868.	1,584.	580.	14,779.	1,299.	2065	3,542.	1,476.	839.	24,072.	2,348.
2039	2,895.	1,579.	587.	15,024.	1,328.	2066	3,566.	1,471.	852.	24,524.	2,400.

Table A.6: GHGs emission by Gas from Energy Sector 2018-2066. Gg CO_2eq

year	Carbon Dioxide	Methane	Nitrous Oxide	Total	year	Carbon Dioxide	Methane	Nitrous Oxide	Total	year	Carbon Dioxide	Methane	Nitrous Oxide	Total
2018	26,555.	87.	164.	26,805.	2034	29,447.	105.	204.	29,756.	2051	41,983.	133.	269.	42,386.
2019	25,015.	86.	161.	25,262.	2035	29,607.	106.	207.	29,921.	2052	42,923.	135.	274.	43,332.
2020	25,389.	87.	163.	25,639.	2036	30,123.	108.	210.	30,440.	2053	43,833.	137.	279.	44,250.
2021	25,134.	88.	165.	25,387.	2037	30,601.	109.	213.	30,922.	2054	44,985.	139.	285.	45,409.
2022	26,098.	89.	170.	26,357.	2038	31,140.	110.	216.	31,467.	2055	45,990.	142.	290.	46,421.
2023	25,835.	90.	171.	26,096.	2039	31,875.	112.	220.	32,206.	2056	46,970.	144.	295.	47,409.
2024	26,542.	91.	174.	26,807.	2040	32,546.	114.	224.	32,883.	2057	48,098.	146.	301.	48,545.
2025	27,266.	93.	177.	27,535.	2041	33,315.	115.	227.	33,657.	2058	49,266.	148.	306.	49,721.
2026	28,029.	94.	181.	28,304.	2042	33,404.	116.	230.	33,750.	2059	50,365.	151.	312.	50,827.
2027	28,811.	96.	184.	29,091.	2043	34,246.	118.	233.	34,597.	2060	51,488.	153.	318.	51,958.
2028	29,611.	98.	188.	29,897.	2044	35,148.	119.	237.	35,505.	2061	52,597.	156.	324.	53,076.
2029	30,430.	100.	192.	30,721.	2045	35,897.	121.	241.	36,258.	2062	53,849.	158.	330.	54,337.
2030	28,812.	100.	191.	29,103.	2046	36,819.	123.	245.	37,187.	2063	55,145.	161.	336.	55,641.
2031	28,850.	101.	194.	29,145.	2047	37,665.	125.	250.	38,039.	2064	56,374.	163.	342.	56,879.
2032	29,520.	102.	198.	29,820.	2048	38,536.	127.	255.	38,917.	2065	58,849.	166.	349.	59,364.
2033	28,631.	103.	200.	28,934.	2049	39,511.	129.	259.	39,899.	2066	58,914.	168.	355.	59,437.
2034	29,447.	105.	204.	29,756.	2050	40,896.	131.	264.	41,291.					

Table A.7: Cumulative Costs & Benefits 2018-2065 of Mitigation Scenario Relative to Baseline Scenario for energy measures.

	Natural Gas in Households & Industry	LED Lighting in Households & Commercial Buildings	RE &EE in Industry Program	High Pressure Sodium Street Lighting	Efficient Small & Medium Hotels	RE & EE in Public Buildings	Solar Water Heater 90000 system	Improved Loss of Transmission & Distribution	Energy Efficiency in Well Field Program	National Conveyer Wheeling	PV system for small farmers
Demand	0.13	0.01	0.00	0.01	0.01	0.00	-	-	-	-	0.07
Industrial	0.06	-	-	-	-	-	-	-	-	-	0.06
Residential	0.04	0.01	-	-	-	-	-	-	-	-	0.01
Services	0.03	-	0.00	0.01	0.01	0.00	-	-	-	-	-
Transport	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-
Non Energy Sector	-	-	-	-	-	-	-	-	-	-	-
Transformation	0.35	-0.01	-0.00	-0.00	- 0.00	-0.00	0.04	-0.15	0.01	0.34	-
Distributed Generation	0.41	-	-	-	-	-	-	-	-	0.41	-
Transmission & Distribution	0.03	-	-	-	-	-	-	0.03	-	-	-
Own Use	-	-	-	-	-	-	-	-	-	-	-
Electricity Generation	- 0.10	-0.01	-0.00	-0.00	-0.00	-0.00	0.04	-0.18	0.01	-0.07	-
Gas Transmission	-	-	-	-	-	-	-	-	-	-	-
Gas Production	-	-	-	-	-	-	-	-	-	-	-
Oil Refining	-	-	-	-	-	-	-	-	-	-	-
Oil Production	-	-	-	-	-	-	-	-	-	-	-
Resources	- 3.43	-0.06	-0.00	-0.03	-0.01	-0.00	-0.25	-0.76	-0.23	- 0.33	-1.78
Production	-	-	-	-	-	-	-	-	-	-	-
Imports	- 3.43	- 0.06	-0.00	-0.03	-0.01	-0.00	-0.25	-0.76	-0.23	-0.33	-1.78
Exports	-	-	-	-	-	-	-	-	-	-	-
Unmet Requirements	-	-	-	-	-	-	-	-	-	-	-
Environmental Externalities	-	-	-	-	-	-	-	-	-	-	-
Non Energy Sector Costs	-	-	-	-	-	-	-	-	-	-	-
Net Present Value	-35.20	-0.06	4.104	28.22	0.82	11.72	36.46	730	-23.6	-25.5	0.280
GHG Savings (Mill Tonnes CO_2e)	2.035	1.70	0. 36	2.940	0.028	0.426	1.080	18.33	-0.810	6.540	0.027
Cost of Avoiding GHGs (JD) /Tonnes CO_2e)	17.3	- 33.90	- 11.42	-9.66	-29.2	-27.6	-33.76	-40.1	21.8	3.9	-10.3

Table A.8: GHG emissions of the baseline scenario for Agriculture Sector - Animal waste in Jordan between (2019-2066), with historic data.

Year	CH_4 (Gg)			N_2O (Gg)		
	Enteric Fermentation	Manure Management	Total	Enteric Fermentation	Manure Management	Total
2007	24.36	1.04	25.40	0.00	0.03	0.03
2008	26.94	1.13	28.07	0.00	0.03	0.03
2009	28.97	1.19	30.16	0.00	0.03	0.03
2010	25.59	1.09	26.68	0.00	0.03	0.03
2011	25.95	1.10	27.05	0.00	0.03	0.03
2012	26.24	1.12	27.36	0.00	0.03	0.03
2013	26.01	1.11	27.12	0.00	0.03	0.03
2014	28.11	1.18	29.29	0.00	0.03	0.03
2015	31.54	1.28	32.82	0.00	0.03	0.03
2016	27.34	1.71	29.05	0.00	0.03	0.03
2017	31.40	1.53	32.93	0.00	0.03	0.03
2018	31.88	1.55	33.43	0.00	0.03	0.03
2019	32.37	1.57	33.94	0.00	0.03	0.03
2020	32.87	1.59	34.46	0.00	0.03	0.03
2021	33.38	1.61	34.99	0.00	0.03	0.03
2022	33.90	1.63	35.53	0.00	0.03	0.03
2023	34.43	1.65	36.08	0.00	0.03	0.03
2024	34.97	1.67	36.64	0.00	0.03	0.03
2025	35.52	1.69	37.21	0.00	0.03	0.03
2026	36.08	1.71	37.79	0.00	0.03	0.03
2027	36.65	1.73	38.38	0.00	0.03	0.03
2028	37.23	1.75	38.98	0.00	0.03	0.03
2029	37.82	1.77	39.59	0.00	0.03	0.03
2030	38.42	1.79	40.21	0.00	0.04	0.04
2031	39.03	1.81	40.84	0.00	0.04	0.04
2032	39.65	1.83	41.48	0.00	0.04	0.04
2033	40.28	1.85	42.13	0.00	0.04	0.04
2034	40.92	1.87	42.79	0.00	0.04	0.04
2035	41.57	1.89	43.46	0.00	0.04	0.04
2036	42.23	1.91	44.14	0.00	0.04	0.04
2037	42.90	1.93	44.83	0.00	0.04	0.04
2038	43.58	1.95	45.53	0.00	0.04	0.04
2039	44.27	1.97	46.24	0.00	0.04	0.04
2040	44.97	1.99	46.96	0.00	0.04	0.04
2041	45.68	2.01	47.69	0.00	0.04	0.04
2042	46.40	2.03	48.43	0.00	0.04	0.04
2043	47.13	2.05	49.18	0.00	0.04	0.04
2044	47.87	2.07	49.94	0.00	0.04	0.04
2045	48.62	2.09	50.71	0.00	0.05	0.05
2046	49.38	2.11	51.49	0.00	0.05	0.05

2047	50.15	2.13	52.28	0.00	0.05	0.05
2048	50.93	2.15	53.08	0.00	0.05	0.05
2049	51.72	2.17	53.89	0.00	0.05	0.05
2050	52.52	2.19	54.71	0.00	0.05	0.05
2051	53.33	2.21	55.54	0.00	0.05	0.05
2052	54.15	2.23	56.38	0.00	0.05	0.05
2053	54.98	2.25	57.23	0.00	0.05	0.05
2054	55.82	2.27	58.09	0.00	0.05	0.05
2055	56.67	2.29	58.96	0.00	0.05	0.05
2056	57.53	2.31	59.84	0.00	0.05	0.05
2057	58.40	2.33	60.73	0.00	0.05	0.05
2058	59.28	2.35	61.63	0.00	0.06	0.06
2059	60.17	2.37	62.54	0.00	0.06	0.06
2060	61.07	2.39	63.46	0.00	0.06	0.06
2061	61.98	2.41	64.39	0.00	0.06	0.06
2062	62.90	2.43	65.33	0.00	0.06	0.06
2063	63.83	2.45	66.28	0.00	0.06	0.06
2064	64.77	2.47	67.24	0.00	0.06	0.06
2065	65.72	2.49	68.21	0.00	0.06	0.06
2066	66.68	2.51	69.19	0.00	0.06	0.06

ANNEX B

Table B.1: Preliminary Statistical Analysis of the temporal historical changes in minimum daily air temperature per station

ID	Station Name	Mean	Median	Minimum	Maximum	Std Dev	CV	Skewness	Kurtosis
AGRO0001	Baqura	15.86	16	-3	31.2	6.29	39.66	-0.10	-1.09
AGRO0004	Deir Alla	17.81	18.3	0.5	36.3	5.59	31.36	-0.14	-1.10
AGRO0008	Irbid	12.67	13	-5	29.5	6.05	47.71	-0.16	-1.02
AGRO0018	Er Rabbah	10.74	11	-7.6	28.5	5.90	54.95	-0.05	-1.02
AGRO0020	Shoubak	6.13	6	-16	25.2	6.29	102.67	-0.04	-0.80
AGRO0025	Wadi Dhulil	10.19	10.5	-8.6	27.3	6.38	62.61	-0.10	-1.04
AGRO0055	Samma	15.14	15.6	-1.6	31.8	5.92	39.10	-0.21	-0.98
CLIM0003	Wadi El-Rayyan	15.29	15.2	-2.8	32.4	6.55	42.84	-0.07	-1.08
CLIM0015	Sweileh	11.41	12	-6.6	30.8	6.28	55.09	-0.06	-0.95
CLIM0032	Qatraneh	10.47	11	-6	28	6.24	59.59	-0.15	-1.07
CLIM0049	Tafileh	11.42	12	-6.5	29	6.14	53.75	-0.13	-0.96
CLIM0052	Zarqa	13.63	14.1	-4	30.4	6.34	46.49	-0.14	-1.11
PURP0009	Ramtha	11.18	11.4	-7	27.5	5.89	52.67	-0.11	-0.99
PURP0016	Madaba	9.77	10	-11	29.8	6.43	65.85	-0.03	-0.91
PURP0035	Wadi Mousa	11.77	12.4	-6.9	31	6.47	54.96	-0.15	-0.95
RAIN0037	Salt	12.96	13.5	-4.5	31	6.24	48.20	-0.10	-0.97
SYNP0006	King Hussein International Airport	18.22	19	1.4	33.4	6.47	35.51	-0.19	-1.15
SYNP0011	Ras Muneef	10.40	11	-8	28	6.14	59.06	-0.07	-0.88
SYNP0013	Amman Airport	11.81	12	-7.5	30.8	6.40	54.18	-0.02	-1.04
SYNP0022	Rwaished (H4)	11.88	12.5	-12	31.1	7.18	60.44	-0.18	-1.03
SYNP0023	Mafraq	9.71	10	-8.2	28.4	5.92	61.02	-0.13	-0.99
SYNP0024	Safawi (H5)	12.53	13	-6.8	32	7.38	58.86	-0.10	-1.06
SYNP0028	Azraq South	12.41	13	-7.5	32.2	7.10	57.20	-0.19	-1.07
SYNP0029	QAI Airport	8.25	8.5	-7.5	26.8	5.62	68.13	-0.04	-0.88
SYNP0030	Ma'an	10.41	11	-10	28.6	6.61	63.46	-0.13	-1.00
SYNP0031	Al Jafer	10.47	11	-10.5	28	6.90	65.89	-0.18	-1.02
SYNP0032	Ghabawi	12.16	12.8	-5.8	29.5	6.18	50.83	-0.17	-1.05
AGRO0005	Ghor Safi	20.07	20.5	1.7	34.2	6.65	33.13	-0.20	-1.18

Table B.2: Preliminary Statistical Analysis of the temporal historical changes in maximum daily air temperature per station

ID	Station Name	Mean	Median	Minimum	Maximum	Std Dev	CV	Skewness	Kurtosis
AGRO0001	Baqura	29.44	30.9	7.6	47.7	7.82	26.57	-0.29	-1.12
AGRO0004	Deir Alla	30.12	31.4	8.0	50.1	8.01	26.59	-0.26	-1.17
AGRO0008	Irbed	23.48	24.7	-1.2	45.5	7.78	33.12	-0.25	-1.04
AGRO0018	Er Rabbah	22.73	24.0	0.0	42.5	7.96	35.01	-0.32	-0.92
AGRO0020	Shoubak	20.10	21.4	-3.4	39.4	8.04	39.98	-0.36	-0.81
AGRO0025	Wadi Dhulil	25.87	27.2	1.6	46.5	8.75	33.81	-0.23	-1.14
AGRO0055	Samma	25.91	27.2	4.4	46.5	7.79	30.06	-0.28	-1.05
CLIM0003	Wadi El-Rayyan	30.11	31.5	8.4	49.5	7.93	26.33	-0.27	-1.15
CLIM0015	Sweileh	20.67	22.0	-1.4	40.0	8.31	40.19	-0.29	-1.01
CLIM0032	Qatraneh	24.79	26.0	1.4	44.8	7.95	32.09	-0.30	-0.97
CLIM0049	Tafileh	20.56	22.0	-2.4	39.2	7.60	36.96	-0.38	-0.77
CLIM0052	Zarqa	25.78	27.1	3.2	45.0	8.37	32.47	-0.26	-1.05
PURP0009	Ramtha	24.28	25.6	-1.0	44.4	8.12	33.45	-0.26	-1.06
PURP0016	Madaba	23.19	24.6	-0.2	42.3	8.20	35.35	-0.30	-0.95
PURP0035	Wadi Mousa	21.67	23.0	-1.0	40.7	7.80	36.00	-0.36	-0.88
RAIN0037	Salt	21.86	23.3	-0.5	41.6	7.94	36.30	-0.34	-0.91
SYNP0006	King Hussein International Airport	31.19	32.0	11.0	50.4	7.56	24.23	-0.21	-1.14
SYNP0011	Ras Muneef	18.95	20.4	-2.5	39.0	8.06	42.55	-0.29	-0.99
SYNP0013	Amman Airport	23.71	25.0	0.6	43.5	8.31	35.04	-0.26	-1.04
SYNP0022	Rwaished (H4)	26.87	28.0	2.2	47.8	9.32	34.67	-0.21	-1.14
SYNP0023	Mafraq	24.31	25.6	-0.2	44.8	8.33	34.28	-0.25	-1.09
SYNP0024	Safawi (H5)	26.50	27.5	1.8	46.4	9.26	34.96	-0.21	-1.17
SYNP0028	Azraq South	27.33	28.5	4.5	47.0	8.89	32.53	-0.21	-1.17
SYNP0029	QAI Airport	24.60	26.0	1.8	44.0	8.34	33.92	-0.27	-1.02
SYNP0030	Ma'an	25.09	26.4	0.0	43.5	8.48	33.79	-0.31	-1.04
SYNP0031	Al Jafer	26.60	28.0	2.6	46.0	8.50	31.94	-0.28	-1.10
SYNP0032	Ghabawi	25.14	26.5	2.5	43.5	8.35	33.21	-0.27	-1.05
AGRO0005	Ghor Safi	31.58	32.2	10.4	49.3	7.47	23.67	-0.15	-1.18

Table B.3: Preliminary Statistical Analysis of the temporal historical changes in seasonal precipitation per station

ID	Station Name	Mean	Median	Minimum	Maximum	Std Dev	CV	Skewness	Kurtosis
AGRO0001	Baqura	391.47	373.1	174.6	918.3	123.87	31.64	1.69	5.53
AGRO0004	Deir Alla	287.58	263.5	114.6	725.6	106.92	37.18	1.54	3.89
AGRO0008	Irbed	457.41	445.7	89.2	912.9	146.85	32.11	0.80	1.79
AGRO0018	Er Rabbah	346.63	332.0	138.3	1067.4	135.54	39.10	2.58	12.28
AGRO0020	Shoubak	269.25	247.5	95.2	821.5	122.52	45.51	1.82	5.89
AGRO0025	Wadi Dhulil	139.99	132.2	54.5	277.1	48.08	34.35	0.88	0.69
AGRO0055	Samma	431.18	446.2	79.2	601.6	131.55	30.51	-1.34	2.70
CLIM0003	Wadi El-Rayyan	299.01	276.8	66.4	708.4	101.27	33.87	1.29	3.93
CLIM0015	Sweileh	440.28	435.4	154.6	1034.9	167.72	38.09	1.00	3.53
CLIM0032	Qatraneh	101.25	102.3	24.7	156.3	32.19	31.80	-0.27	-0.46
CLIM0049	Tafileh	197.59	193.3	100.9	309.4	48.83	24.71	0.39	0.20
CLIM0052	Zarqa	128.53	122.4	90.0	206.7	30.64	23.84	1.13	1.12
PURP0009	Ramtha	232.19	214.0	62.4	477.3	89.21	38.42	0.89	0.81
PURP0016	Madaba	314.66	303.4	125.5	690.1	100.23	31.85	1.37	3.54
PURP0035	Wadi Mousa	165.53	152.4	34.0	308.5	64.21	38.79	0.08	-0.29
RAIN0037	Salt	517.41	512.1	246.1	829.5	136.30	26.34	0.45	0.17
SYNP0006	King Hussein International Airport	28.97	26.1	1.4	85.1	21.89	75.56	0.76	-0.17
SYNP0011	Ras Muneef	584.47	526.6	267.1	1168.0	175.80	30.08	1.04	1.90
SYNP0013	Amman Airport	258.60	247.7	110.5	547.7	87.68	33.90	1.04	1.45
SYNP0022	Rwaished (H4)	80.31	79.5	15.7	179.8	35.52	44.23	0.40	0.57
SYNP0023	Mafraq	151.06	145.6	58.2	300.9	53.84	35.65	0.77	0.63
SYNP0024	Safawi (H5)	71.04	68.0	16.0	175.7	33.18	46.71	0.78	1.13
SYNP0028	Azraq South	70.26	57.0	11.2	260.6	47.04	66.96	2.11	6.37
SYNP0029	QAI Airport	157.14	153.9	55.8	325.7	50.82	32.34	0.95	1.84
SYNP0030	Ma'an	41.47	39.3	12.2	107.7	22.09	53.26	1.02	1.26
SYNP0031	Al Jafer	39.12	27.7	0.5	251.8	39.63	101.31	3.37	15.28
SYNP0032	Ghabawi	92.55	92.6	59.6	150.2	24.05	25.99	0.77	0.58
AGRO0005	Ghor Safi	75.04	72.3	18.3	151.8	29.53	39.36	0.19	-0.19

Table B.4: Statistical analysis of the temporal air temperature variability on yearly basis per station

ID	Station Name	Daily Maximum Temperature °C				Daily Minimum Temperature °C			
		Rate of Change	R^2	RMSE	Prob > F	Rate of Change	R^2	RMSE	Prob > F
AGRO0001	Baqura	0.027	0.2644	0.728	<.0001*	0.003	0.0072	0.626	0.5422
AGRO0004	Deir Alla	0.018	0.1635	0.807	0.0007*	0.033	0.5563	0.596	<.0001*
AGRO0008	Irbed	0.024	0.1002	1.376	0.0102*	0.025	0.3920	0.597	<.0001*
AGRO0018	Er Rabbah	0.052	0.3055	1.483	<.0001*	0.016	0.0829	1.002	0.0221*
AGRO0020	Shoubak	0.050	0.2555	1.524	<.0001*	0.025	0.1428	1.081	0.0029*
AGRO0025	Wadi Dhulil	0.061	0.3505	1.330	<.0001*	0.056	0.4778	0.925	<.0001*
AGRO0055	Samma	-0.007	0.0016	0.828	0.8860	-0.049	0.0446	1.049	0.4497
CLIM0003	Wadi El-Rayyan	0.014	0.0603	1.023	0.0587	0.035	0.4697	0.675	<.0001*
CLIM0015	Sweileh	0.001	0.0000	2.010	0.9796	-0.020	0.0128	1.642	0.5452
CLIM0032	Qatraneh	0.051	0.4830	0.590	<.0001*	0.053	0.6502	0.438	<.0001*
CLIM0049	Tafileh	0.046	0.1903	0.628	0.0424*	0.074	0.4871	0.502	0.0003*
CLIM0052	Zarqa	-0.132	0.0726	2.736	0.2645	-0.077	0.0544	1.861	0.3364
PURP0009	Ramtha	0.002	0.0002	1.971	0.9261	-0.004	0.0008	1.792	0.8592
PURP0016	Madaba	-0.070	0.0665	3.007	0.1289	-0.014	0.0036	2.646	0.7268
PURP0035	Wadi Mousa	-0.011	0.0070	1.460	0.6287	0.029	0.0443	1.441	0.2180
RAIN0037	Salt	0.077	0.5100	0.656	<.0001*	0.022	0.0964	0.574	0.1012
SYNP0006	King Hussein International Airport	0.005	0.0131	0.876	0.3687	0.036	0.5710	0.590	<.0001*
SYNP0011	Ras Muneef	0.049	0.4655	0.704	<.0001*	0.027	0.2749	0.591	0.0002*
SYNP0013	Amman Airport	0.009	0.0473	0.881	0.0686	0.048	0.6462	0.731	<.0001*
SYNP0022	Rwaished (H4)	0.030	0.1504	1.219	0.0024*	0.038	0.3208	0.949	<.0001*
SYNP0023	Mafraq	0.023	0.2040	0.837	0.0002*	0.033	0.5391	0.549	<.0001*
SYNP0024	Safawi (H5)	0.032	0.2949	0.860	<.0001*	0.024	0.1899	0.850	0.0007*
SYNP0028	Azraq South	0.075	0.4082	1.091	<.0001*	0.058	0.4512	0.773	<.0001*
SYNP0029	QAI Airport	0.051	0.5346	0.720	<.0001*	0.054	0.6199	0.639	<.0001*
SYNP0030	Ma'an	0.020	0.1335	0.928	0.0035*	0.027	0.2552	0.841	<.0001*
SYNP0031	Al Jafer	0.037	0.2186	1.184	.0004*	0.059	0.5481	0.904	<.0001*
SYNP0032	Ghabawi	-0.005	0.0006	0.997	0.9258	0.044	0.0895	0.730	0.2433
AGRO0005	Ghor Safi	0.052	0.5837	0.510	<.0001*	0.031	0.3538	0.490	<.0001*

* significantly different at 95% confidence level.

Table B.5: Statistical analysis of the temporal precipitation variability on yearly basis per station

ID	Station Name	Spearman ρ	Prob>|ρ|	Kendall τ	Prob>|τ|	Yearly Rate of change	R^2	RMSE	Prob > F
AGRO0001	Baqura	0.0336	0.8133	0.0249	0.7945	0.1704	0.0004	125.0790	0.8834
AGRO0004	Deir Alla	-0.0223	0.8580	-0.0158	0.8498	-0.1519	0.0008	107.6961	0.8241
AGRO0008	Irbed	-0.0603	0.6334	-0.0433	0.6104	-0.1755	0.0005	147.9765	0.8582
AGRO0018	Er Rabbah	-0.1450	0.2607	-0.0999	0.2510	-1.4030	0.0355	134.2138	0.1423
AGRO0020	Shoubak	-0.2602	0.0447*	-0.1814	0.0406*	-1.7406	0.0616	119.7096	0.0560
AGRO0025	Wadi Dhulil	-0.0914	0.5195	-0.0649	0.4973	-0.4564	0.0207	48.0535	0.3090
AGRO0055	Samma	0.2464	0.3760	0.2190	0.2550	1.3464	0.0021	136.3736	0.8713
CLIM0003	Wadi El-Rayyan	0.0895	0.4966	0.0689	0.4365	0.4268	0.0054	101.8609	0.5762
CLIM0015	Sweileh	-0.3311	0.0520	-0.2168	0.0670	-6.3558	0.1508	156.8812	0.0212*
CLIM0032	Qatraneh	0.0799	0.6431	0.0461	0.6928	0.2483	0.0066	32.5561	0.6376
CLIM0049	Tafileh	-0.0519	0.8230	-0.0476	0.7627	0.2697	0.0012	50.0695	0.8827
CLIM0052	Zarqa	0.1352	0.5927	0.0719	0.6769	1.2035	0.0440	30.8798	0.4037
PURP0009	Ramtha	0.0796	0.6074	0.0613	0.5575	0.2456	0.0013	90.2059	0.8197
PURP0016	Madaba	-0.0506	0.7443	-0.0349	0.7385	-0.9542	0.0150	100.6578	0.4291
PURP0035	Wadi Mousa	-0.2564	0.1312	-0.1810	0.1205	-1.7873	0.0860	62.2804	0.0826
RAIN0037	Salt	0.1856	0.3445	0.1111	0.4067	3.5877	0.0469	135.5966	0.2684
SYNP0006	King Hussein International Airport	-0.1498	0.2376	-0.1067	0.2129	-0.2040	0.0301	21.7321	0.1703
SYNP0011	Ras Muneef	0.1231	0.4317	0.0875	0.4084	0.2693	0.0004	177.8941	0.9025
SYNP0013	Amman Airport	-0.1008	0.4066	-0.0717	0.3804	-0.3165	0.0054	88.0789	0.5455
SYNP0022	Rwaished (H4)	0.0662	0.6184	0.0456	0.6100	0.1261	0.0037	35.7611	0.6463
SYNP0023	Mafraq	-0.0781	0.5499	-0.0465	0.5968	-0.1963	0.0042	54.1844	0.6202
SYNP0024	Safawi (H5)	-0.1050	0.4369	-0.0771	0.3971	-0.2034	0.0104	33.3048	0.4513
SYNP0028	Azraq South	-0.3940	0.0051*	-0.2772	0.0050*	-1.3440	0.1667	43.3980	0.0036*
SYNP0029	QAI Airport	-0.1439	0.3188	-0.1120	0.2517	-0.6621	0.0361	50.4136	0.1865
SYNP0030	Ma'an	-0.0669	0.6118	-0.0294	0.7401	-0.0751	0.0035	22.2363	0.6522
SYNP0031	Al Jafer	-0.2379	0.0803	-0.1476	0.1119	-0.6094	0.0607	38.7733	0.0699
SYNP0032	Ghabawi	0.4088	0.1159	0.3000	0.1051	2.1392	0.1793	22.5536	0.1022
AGRO0005	Ghor Safi	-0.1062	0.5143	-0.0860	0.4350	-0.2202	0.0076	29.8052	0.5928

* significantly different at 95% confidence level.

Table B.6: Temporal trends of historical heatwaves from 1990 till 2020

Station	Linear Trend	R^2	RMSE	Prob > F
Al Jafer	0.18	0.3035	2.50	0.0013*
Amman Airport	0.17	0.3182	2.25	0.0009*
Azraq	0.14	0.2715	2.14	0.0027*
Baqura	0.11	0.1099	2.92	0.0685
Deir Alla	0.12	0.2093	2.07	0.0097*
Er Rabbah	0.13	0.1732	2.68	0.0199*
Ghor Safi	0.08	0.1758	1.66	0.0189*
Irbed	0.18	0.2704	2.81	0.0027*
King Hussein IA	0.07	0.1308	1.63	0.0456*
Maan	0.18	0.2553	2.89	0.0037*
Madaba	-0.08	0.0459	3.50	0.2473
Mafraq	0.19	0.3628	2.34	0.0003*
QAI Airport	0.13	0.1918	2.53	0.0137*
Qatraneh	0.16	0.3815	1.94	0.0002*
Ramtha	0.08	0.0988	2.21	0.0851
Ras Muneef	0.19	0.3507	2.45	0.0004*
Rwaished (H4)	0.26	0.3805	3.12	0.0002*
Safawi (H5)	0.15	0.2686	2.27	0.0028*
Salt	0.20	0.3520	2.50	0.0004*
Shoubak	0.24	0.4148	2.58	<.0001*
Sweileh	0.17	0.2751	2.57	0.0025*
Tafileh	0.08	0.0622	2.17	0.2630
Wadi Dhulil	0.11	0.1654	2.35	0.0232*
Wadi El-Rayyan	0.12	0.2037	2.11	0.0108*
Wadi Mousa	0.05	0.0646	1.93	0.1677
Zarqa	0.07	0.0250	2.47	0.5177

* means significantly different at 95% confidence level.

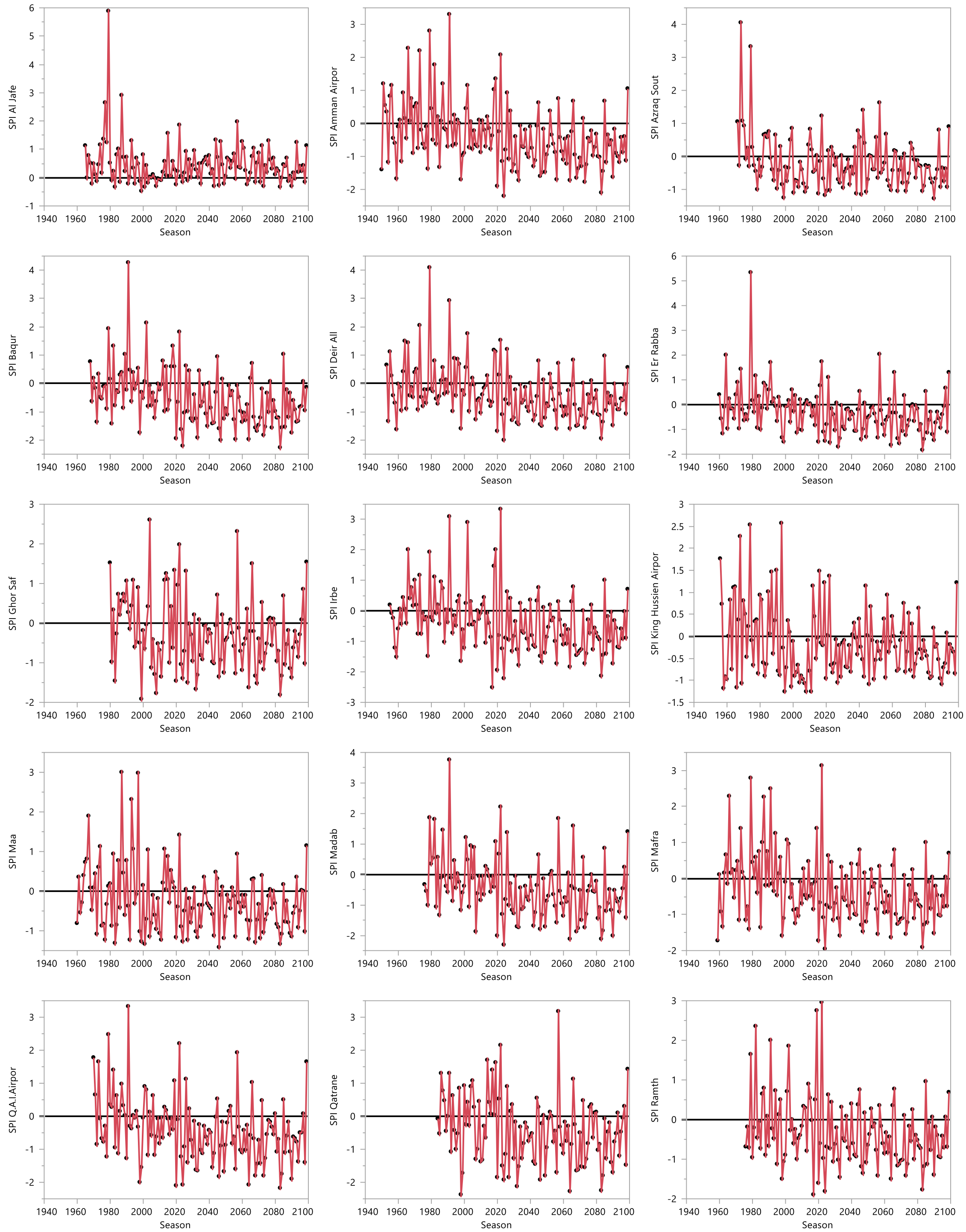
Table B.7: Suggested Health Vulnerability Matrix

Health Risk	Exposure	Sensitivity	Adaptive Capacity	Hazard
Water-borne and food-borne diseases	Increased temperature Decreased precipitation. Increase in Humidity	Pregnant women, infants, children, older people, infirm people, people with disabilities, people living in substandard housing along wadis. Urban, remote, rural areas Older adults and people with chronic medical conditions. Impoverished or low socio-economic status. Farmers using untreated organic fertilizers (manure) for cultivation of vegetables. Lack of personal hygiene. Economic constraints. Political instability. Increase of slum areas. Water-stressed zones.	Assess the current capacity of the health system. regulations to control water and foodborne diseases and contaminants, and water quality. programs to increase access to and use of safe water in sufficient quantities and improved sanitation. educational programs on food handling and safety. climate-resilient water safety plans and sanitation safety plans. Develop and review preparedness and response plans. Resourcing. preparing the health workforce developing and implementing health information systems (e.g., monitoring and surveillance systems, syndromic surveillance systems) to track illnesses, injuries, and deaths and to inform early warning systems. Community engagement. Early Warning System on Water and Food-borne diseases and climate change Increasing awareness among populations and preventable measures. Education programs on appropriate food handling Prevention of W&F borne diseases Establishment of a laboratory-based surveillance system Early detection and control of W&F borne diseases Undertake epidemiological studies to detect further risk factors and vulnerable populations Regular inspection by Jordan Food and Drug Administration. Prohibit using untreated wastewater for irrigation, as well as treated wastewater (reclaimed) for the cultivation of vegetables eaten raw by MOA. Introducing rotavirus vaccine to the current national program for vaccination, as recommended by the WHO and other vaccines, such as cholera, rotavirus, typhoid, and E. coli, Logistical support and adequate supplies (including antiviral, medications, vaccines, etc.) Improve access to medical care for vulnerable people who live in remote areas Strengthen regional collaboration and share experiences and information on adaptation among countries in the region	Flood risk zones. Drought risk zones Food-insecure zones

			Strengthen international collaboration with WHO, CEHA, and other organizations.	
Vector-borne diseases	Temperature rainfall. Humidity Wind	Infants and children Pregnant women and newborn infants Older adults and people with chronic medical conditions. Impoverished or low socio-economic status. Outdoor workers. Residents of Eastern Desert Certain population communities where Cutaneous Leishmaniasis caused by the shifts in the rainy season. Public at large due to disruption of water purification systems. Population growth and population movement, Changes in land use (due to development projects), Water, agricultural, housing and economic development projects and practices. Labor forces from endemic countries. International travel and imported vector-borne disease cases from abroad, Resistance of disease vectors and pathogens.	Elimination of breeding. Health evaluation of planned projects like housing, water, agriculture, touristic and industrial projects. Entomological surveys to determine vector capacity of disease transmission. Early warning systems. surveillance and monitoring programs for malaria and other vector-borne and zoonotic diseases. maternal and child health programs, including vaccination campaigns. integrated vector management and environmental hygiene programs. educational programs for individuals, communities, and health care workers on identifying and treating diseases. Prevent and control emerging and re-emerging vector-borne diseases. Strengthen existing emergency preparedness and disaster management. Formulate and implement disaster preparedness policies with adaptive strategies. Enhance capacity building and increase awareness through regular training workshops on hazard preparedness. Undertake research at the population and individual level to provide a solid basis for formulating adaptation strategies. Strengthen vector control programs by development, adoption, and implementation of integrated vector management strategy for vector control. Strengthening of national vector control capacities. Establishment of effective surveillance and sentinel sites for malaria vector. Use of effective and safe insecticide for the control of malaria vectors and the introduction of new biological vector control methods.	Floods and / or extreme Droughts
Air-borne and respiratory diseases (Asthma, Rhinosinusitis, Chronic Obstructive Pulmonary Disease (COPD), and	Decreasing precipitation Changes in allergen nature. Forest fires Dust and sandstorms. Increasing humidity	Adults with chronic respiratory disease, people with asthma, children, and outdoor workers. People living in areas of land-use change such as deforestation, coastal	Programs to alert the population and health workers on days with poor air quality or fires, and appropriate personal protection measures. Monitoring programs for air quality and its health consequences. educational programs for individuals, communities, and health care workers on the risks of poor air quality and appropriate protection measures to adopt.	Drought flooding Extreme temperature events

respiratory tract infections.)	Air quality.	development or urbanization. Pregnant women and newborn infants. Older adults and people with chronic medical conditions. Impoverished or low socio-economic status. Houses not well ventilated. Desert areas (sandstorms), Extended areas with olive trees (pollen). Areas with less well-developed and limited access to medical services. Badia area in the eastern part of the country. Hilly Regions where there is exposure to relatively low temperature. Jordan Valley where there is exposure high temperature	Strengthen surveillance and establish highly sensitive alert systems. Expand the vegetation cover to impede desertification. Equip hospitals with extra number of ambulances. Heat-related health information strategies and warning systems. Conduct education campaigns regarding heat-related illnesses. Mapping of vulnerable populations. Media and social media announcements. Improve infrastructure Raising awareness on climate change and its effect on respiratory diseases in Jordan. Establishing of air pollutants monitoring system focusing on ground level ozone. Set guideline to improve management of bronchial asthma and COPD. Develop public health preparedness and intervention plan for the health impacts due to climate change. Enhance vaccination programs for vaccine-prevented air borne and respiratory diseases	
Heatwaves / Heat stress	Increase in temperature Increasing humidity	Infants and children. Pregnant women and newborn infants. Older adults and people with chronic medical conditions. Impoverished or low socio-economic status. Patients with Ischemic heart diseases. Not well-ventilated houses causing dehydration, heart injury stroke Reduced access to health care Workers in the open air who will experience to increase in temperature sunburns and fatigue, heat rash, heat cramps and heat stroke	Developing Real-time Surveillance, Evaluation and Monitoring System: Preparation and printing of Surveillance Guideline and reporting forms for health effects of heat waves e.g., heat stroke, heat Building Capacity of Emergency Room Physicians and health care workers to detect symptoms of heat – related illness (heat stroke, heat stress, heat cramps) Preparation and printing of guidelines for management of health effects of heat waves early warning systems and emergency response plans. programs to monitor adverse health outcomes during and after extreme weather events. educational programs for individuals, communities, responders, and health care workers on the risks of and appropriate responses to extreme weather events. cross-sectoral management of disaster risk reduction activities. Establishment of collaborative mechanisms between relevant agencies, with a lead body to coordinate responses. Develop an accurate and timely alert system. Develop heat-related health information system. Develop strategies to reduce individual and community exposure to heat.	Heatwaves

		Pregnant and breastfeeding women Immunocompromised populations Undernourished populations Populations with high infectious disease burden Populations with high chronic disease burden People with mental or physical disabilities	Provision of particular care for vulnerable population groups. Provision of health care, social services, and infrastructure to prevent heat related illnesses. Emergency departments of hospitals should be alerted to heat waves to manage an increase in admissions. Improve urban planning, transport policies, and building design to reduce energy consumption and ultimately reduce heat exposure.	
Malnutrition	Decrease in precipitation Shifting in the rainy season Land use change	Infants and children. Pregnant women and newborn infants. Poor communities Farmers and farm workers Older people. Urbanized dense areas. Community with low hygienic practices.	monitoring programs for malnutrition in vulnerable populations. programs to support local food production and sustainable food sources. emergency response plans to increase food and nutrition security. nutrition education for individuals and communities. Strengthen current preventive and curative programs. Prepare disaster management plans. Strengthen surveillance system. regulations and instruction for reuse of grey water and treated "reclaimed" wastewater.	Increasing Drought
Mental and psychosocial Stress	Conflicts Political instability.	Economic refugees. Forced migrants. COVID 19 infected people, their families, and the community at large. People experiencing civil war and conflicts. People coming from countries with political instability Discriminated minorities. People experiencing lack of freedom of speech and information Reduced civil rights and civil society movements	Surveillance and research studies. Training and empowering of people in psychosocial specialties.	Floods Extreme weather events.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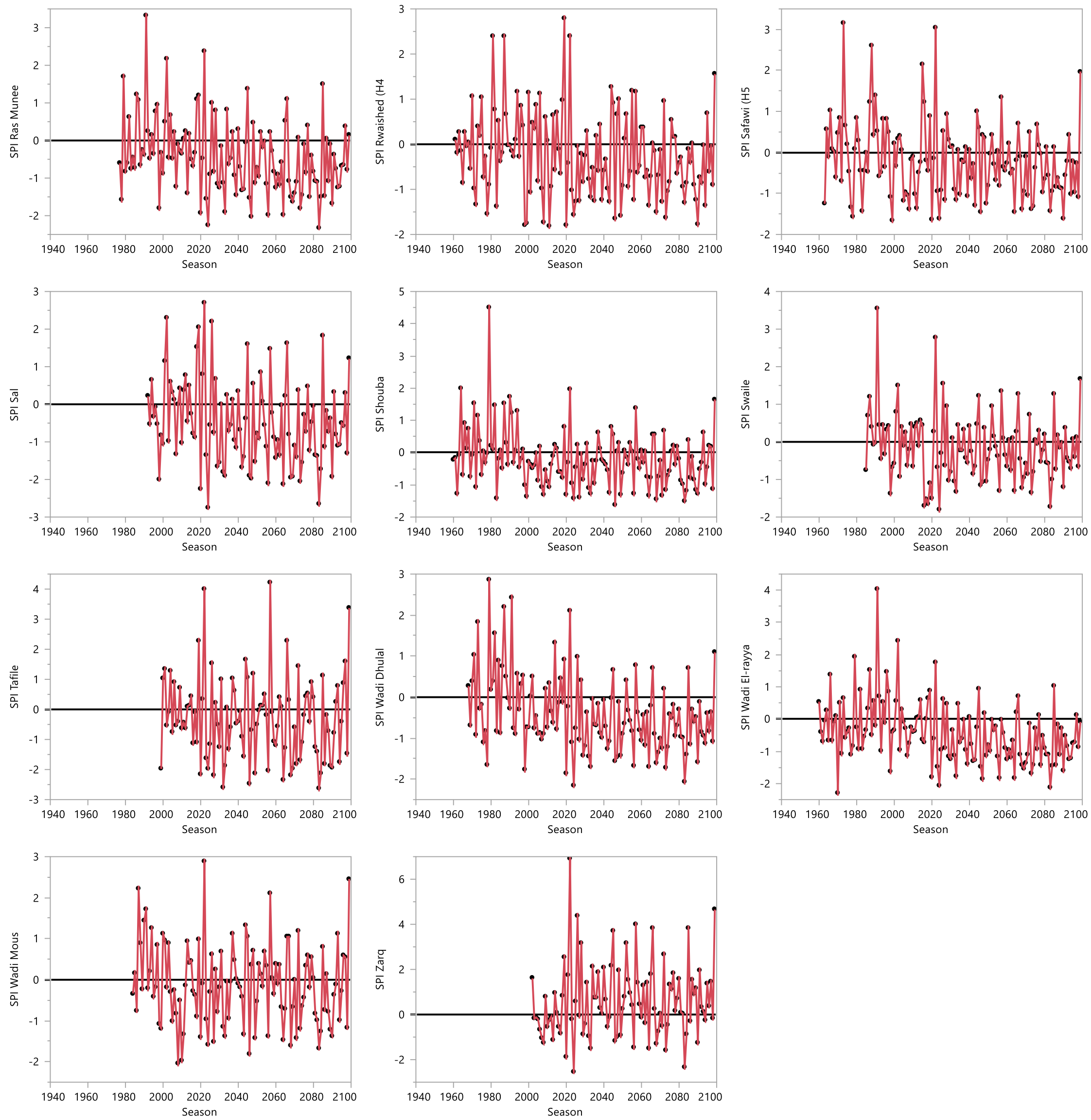
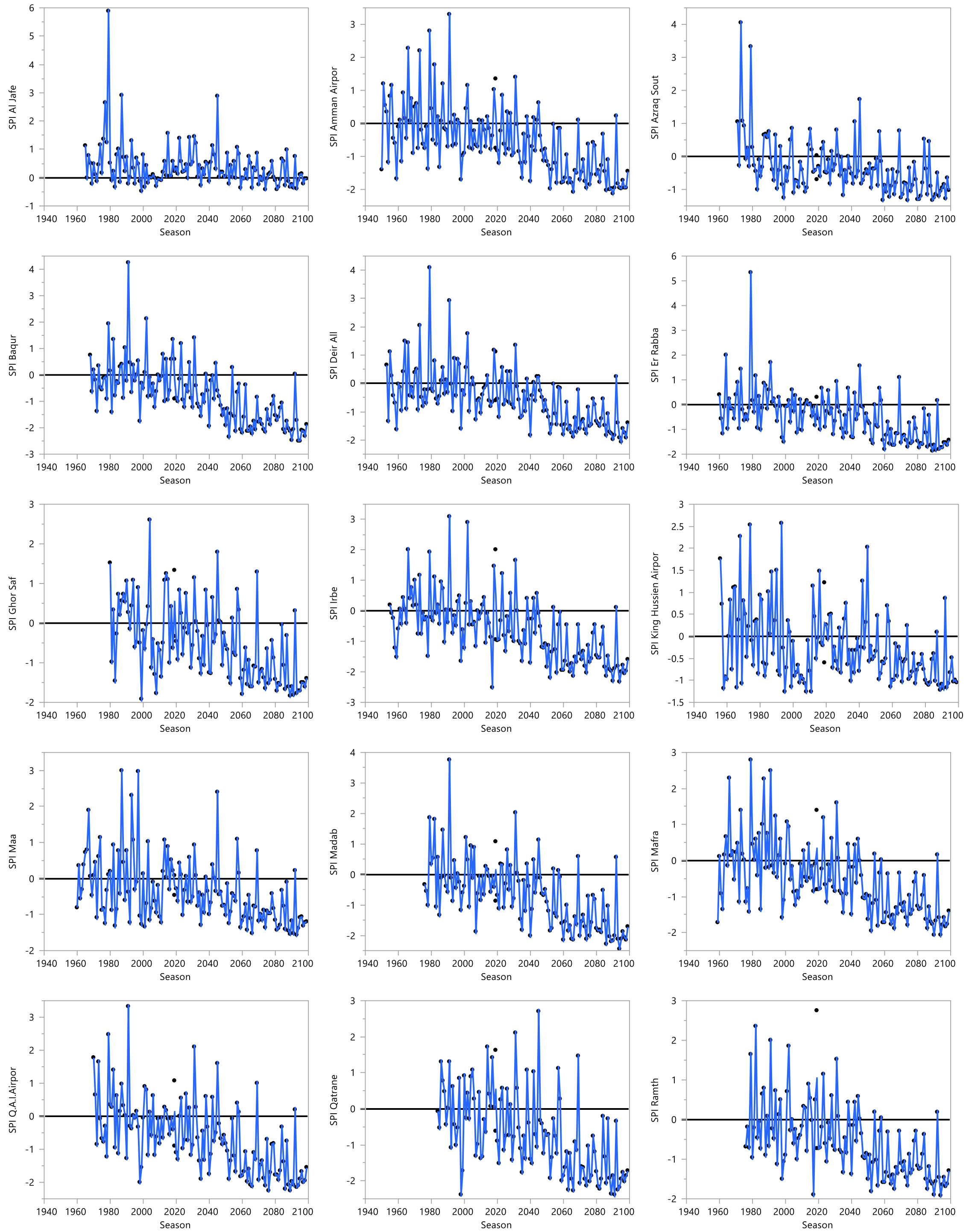


Figure B.1: Calculated SPI, by weather station, based on RCP 4.5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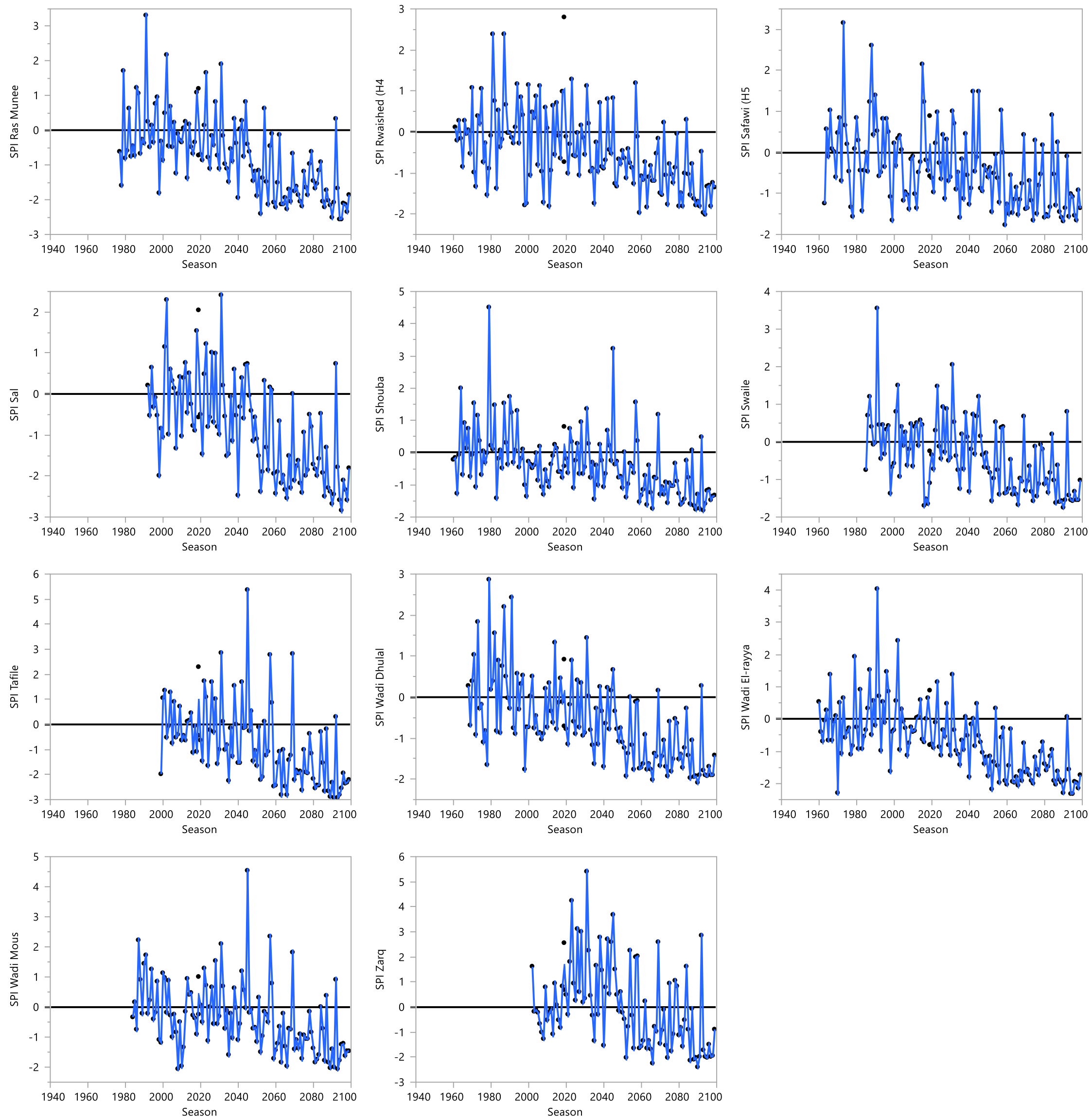

Figure B.2: Calculated SPI, by weather station based on RCP 8.5

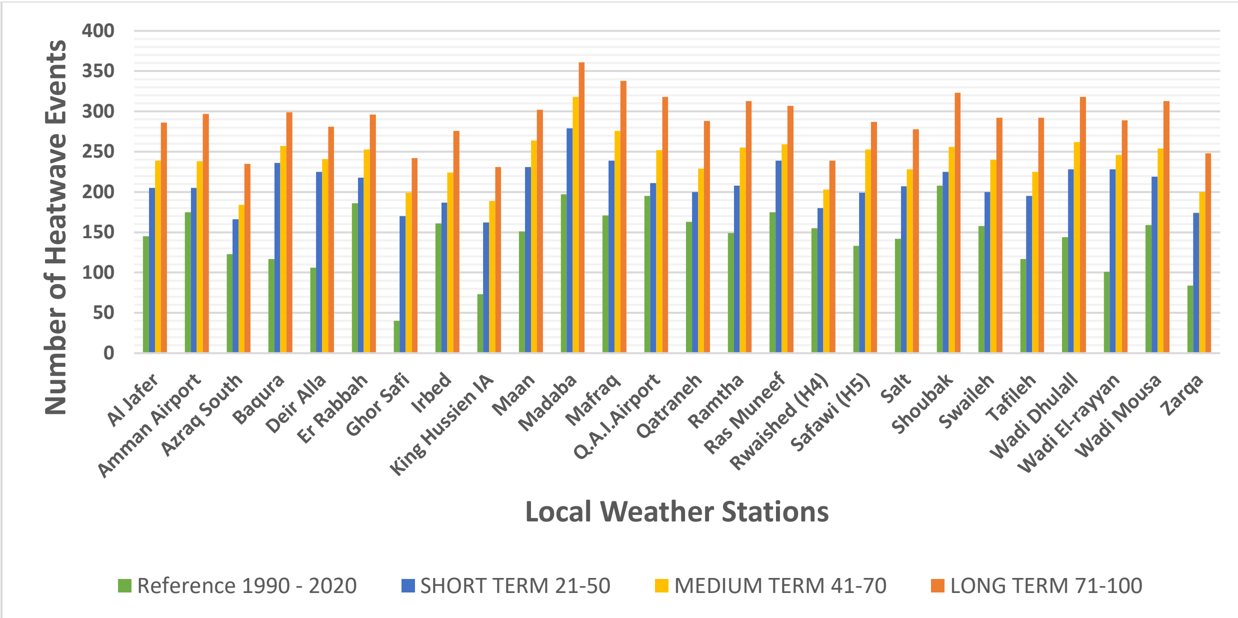

Figure B.3: Projected heatwave counts up to the end of the 21st century, by weather station, for RCP 4.5

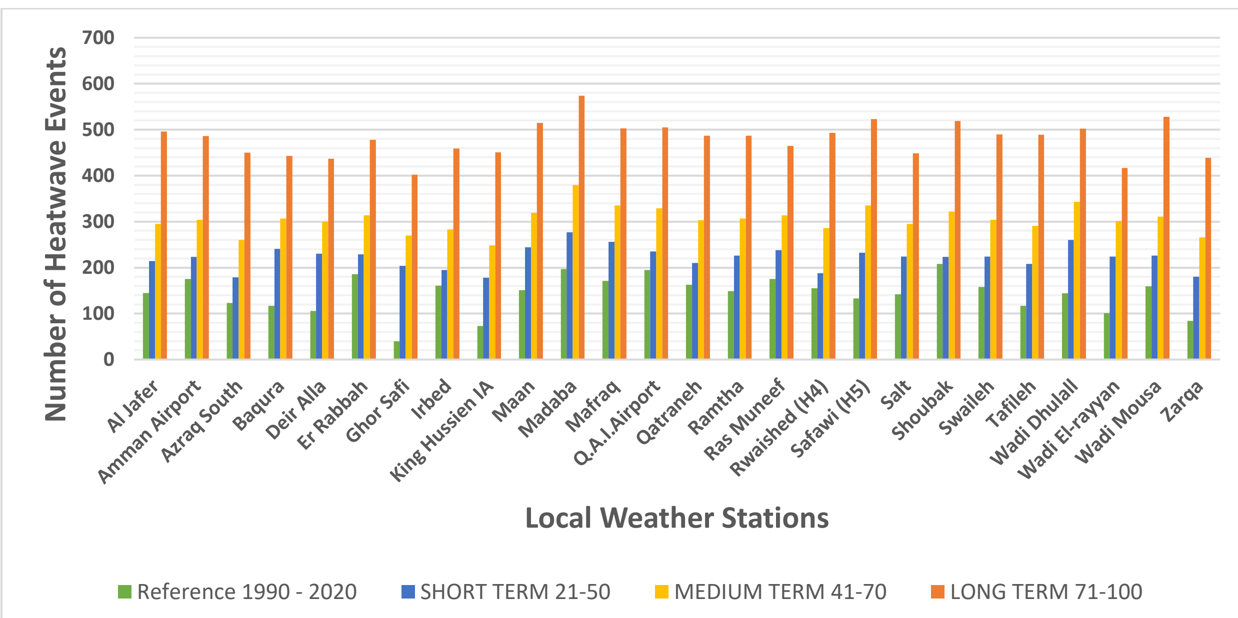

Figure B.4: Projected heatwave counts up to the end of the 21st century, by weather station, for RCP 8.5

ANNEX C

Table C.1: Updates on Climate Change Mainstreaming at Sectoral Policies, Strategies and Action Plans

Policy, Strategy or Action Plan	*Updates Description*
Amman Resilience Strategy	The "Amman Resilience Strategy"[216], was carried out with the support of 100 Resilient Cities network and the Rockefeller Foundation. The strategy assessed shocks, stresses, and potential scenarios affecting Amman city assets through engagement with the city's stakeholders, including Greater Amman Municipality departments, private-sector, NGOs, universities, youth organizations and more. The 2050 resilient vision was "A welcoming young and diverse city, balancing the old and new, the progressive and traditional. Amman promotes a culture of sharing and inclusivity and pioneering regional change". Through understanding the resilience challenges of the city, the plan provided sets of opportunities, set priorities and prioritized initiatives, using the Resilience Lens tool to improve the resilience of the city. The main strategic pillars are: 1. Integrated & Smart City by improving the mobility systems, promoting walkability, institutionalizing planning in the city, and connecting the city digitally. 2. Environmentally Proactive City through managing and fulfilling climate change commitments, improving energy efficiency and energy security, including by diversifying energy sources, applying green building codes and guidelines, and improving waste management systems. 3. Innovative & Prosperous City through leveraging existing human capital to create employment, supporting entrepreneurs, start-ups and incubators, and empowering women. 4. Young & Equal City through integrating and engaging young people equally and supporting youth through cultural campaigns. 5. United & Proud City through promoting a sense of belonging among citizens and promoting participation and engagement.
Amman Climate Plan	The Greater Amman Municipality developed "The Amman Climate Plan: A Vision for 2050" in 2019 [217]. The document was developed along with the Ministry of Environment, Partnership for Market Readiness of the World Bank Group and intensive consultation with GAM partners, with the aim to transform the city of Amman, to become a sustainable, green and livable city that works efficiently to preserve its resources for future generations. The Action Plan represents an ambitious first step on the long journey to creating a sustainable and vibrant future, through collaboration with government, private sector, development partners and residents of Amman. The plan lays out an approach to creating a carbon neutral Amman, while expanding services and meeting the needs of the rapidly growing city. This inaugural plan sets an interim target of a 40% reduction of greenhouse gas emissions by 2030, and carbon-neutrality by 2050. The main pillars for achieving 2050 Vision are: Decarbonizing electricity sources for the city; improving energy efficiency in buildings; Enabling sustainable transport mobility; Enhancing waste management and reducing waste; Reducing water use and improving efficiency; and improving integrated planning for denser, transit-oriented development and green infrastructure and behavior change towards increased public transport use.
Amman Green City Action Plan	In May 2021, the "Amman Green City Action Plan (GCAP)" was issued by the Greater Amman Municipality and European Bank for Reconstruction and Development (EBRD) that was prepared by AECOM Limited in association with Mostaqbal Engineering and Environmental Consultants, Leaders of Tomorrow, and the Jordan Green Building Council. The GCAP details the actions that will support Amman's green future through identification of six priorities including: (1) Efficient and resilient energy systems and buildings, (2) Accessible, diverse and low-carbon mobility systems, (3) Resource efficient and holistic waste management systems, (4) Integrated water resources management, (5) Comprehensive and reflective land-use planning, and (6) Responsive and forward-looking climate adaptation practices.

[216] Amman-Resilience-Strategy-English.pdf (resilientcitiesnetwork.org)

[217] https://documents1.worldbank.org/curated/en/816961617187012025/pdf/The-Amman-Climate-Plan-A-Vision-for-2050-Amman.pdf

	Setting 19 strategic goals, the Amman Green City Action Plan program proposes 37 short-term investments (5 years) and 27 (long-term enabling measures (as of 2025 or later), which fall within the following pillars of: • Efficient and resilient energy and building systems; • Diversified, easily accessible and low-carbon mobility systems; • Comprehensive resource-efficient waste management systems; • Integrated management of water resources; • Comprehensive and effective land use planning; • Responsive and future climate adaptation practices • Others
National Agricultural Research Center Strategy and Drought Atlas	The National Agriculture Research Center issued the National Agricultural Research Center Strategy (2019 – 2023)[218], which includes analysis of impacts of political, economic, social, technical, environmental and legal factors on the National Agricultural Research Center. It also defines strategic goals such as conducting agricultural research on plants and animals to improve productivity and efficiency, developing technology, conserving natural resources and biodiversity, building human capacities in the agricultural sector, increasing investment in agricultural research in order to disseminate knowledge and modern technologies, and Improving the added value of food industries. The main themes are Zero Hunger, Quality Education, Clean Water and Sanitation, Climate Action, Life on Land, and Establishing Partnerships to achieve Goals. Concerning climate action, the strategy aims to combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world. For each theme, outputs are defined with set Performance Indicators including Baseline 2017 and Means of Verification. In addition, the National Agriculture Research Center in corporation with the International Centre for Agricultural Research in the Dry Area published a Drought Atlas for Jordan for Agricultural Research in the Dry Area[219]. The atlas provides insights on the expected impact of climate change and drought on the length of the growing period, in addition to providing background information on the expected threats, which technologies can be built on to increase climate change adaptation measures.
Local Action Plans	The Ministry of Environment and Ministry of Local Administration in corporation the German Agency for International Cooperation (GIZ) issued a Guidebook for Local Action Plan Development by 2020, to incorporate climate risks, and opportunities with the development plans and initiatives of local municipal bodies[220]. The plans and programmes aimed at climate change proofing, supporting the resilience of local communities in Jordan, and enabling them to adapt to and mitigate the effects of climate change. In addition, to supporting many initiatives aimed at benefiting from the best practices to protect and manage resources on the national and local levels. The plans include the identification and prioritization of adaptation and mitigation options within the framework of national and local priorities, to apply adaptation and mitigation responses, and monitor results taking into consideration, gender balance and sensitivity. In order to mainstream the climate change actions in the subnational planning processes, two different pilot projects were implemented to support the local authorities in responding more actively to sustainable policy challenges including climate change, and to build their capacities to formulate and implement more sustainable local policies aligning with Jordan's NDC. The first project targeted the large municipalities, namely Greater Irbid Municipality, Municipality of Karak, and the Aqaba Special Economic Zone Authority (ASEZA). The training and technical assistance were provided for the municipalities' staff and local key stakeholders, which enabled them to develop their local Sustainable Energy and Climate Action Plans, that fit their local needs. The second project was implemented in 2019 in another three medium-sized municipalities namely, Municipality of Deir Alla (north of Jordan), Municipality of Aloyoon (middle), and Municipality of Basseera (south). The three municipalities had developed their Local Climate Action Plans (LCAPs) based on the local relevant climate actions, socio-economic analysis, capacities assessment, availability of plans, staff availability, institutional structure, and data availability to define key indicators to cover both the mitigation and adaptation objectives.
National Energy Strategy and Action Plan	Following the updated Master Strategy of Energy Sector in Jordan for the period (2007-2020), and the Strategic Plan (2019-2021), the Ministry of Energy & Mineral Resources developed the National Energy

218 www.ncare.gov.jo/DefaultEN.aspx
219 eAtlas of Climate Change in Iraq and Jordan (icarda.org)
220 Guidebook English-for web (mola.gov.jo)

	Strategy (2020-2030)[221], with the aim of achieving sustainable energy security and the optimal use of natural resources. The strategy provides five strategic objectives including: improving energy efficiency, diversification of energy sources, and increasing local energy sources contribution to the total energy mix. Based on 4 scenarios, the mix is suggested to reduce the crude oil and its derivative by 7% in 2030 compared to 2018, while increasing the use of natural gas by 4%, and increasing renewable energy by 3% in the total energy mix. The strategy plans to improve energy efficiency in various sectors by 9%, improve energy efficiency in the water sector by 25% for the year 2025, and reduce carbon emissions by 10% for the year 2030. The Ministry of Energy & Mineral Resources developed the first National Energy Efficiency Action Plan (NEEAP) in 2011 for the period 2012-2014 as a national document that summarizes all the national efforts that are taking place in Jordan and sets out the road map to be followed by the country towards reaching its objectives in energy efficiency and renewable energy. The Ministry also issued the Law No. (13) Of 2012 "Renewable Energy & Energy Efficiency Law" which sets the Ministry towards cooperation and coordination with the competent bodies for exploiting Renewable Energy Sources, for increasing the percentage of their contribution to the total energy mix, achieving safe supply therefrom and promoting investment thereto, contributing to environmental protection and achieving sustainable development, rationalizing the exploitation of energy and improving its efficiency in various sectors. The Second National Energy Efficiency Action Plan (NEEAP) [222] was issued in 2017 to set the energy efficiency midterm action plan as planned and ongoing energy efficiency measures at sector's level and to set the criteria to assess energy efficiency policy implementation progress. Along with the National Energy Strategy, a National Action Plan[223] was developed to guide the actions required for reaching the strategic goals. In terms of the electricity Sector, the National Action Plan suggested several actions within three programs including diversification of electric power generation sources; enhancing safety of the electricity system, enhancing system availability and reliability; and sustaining the financial situation of the electricity sector. In terms of the oil sector, the national action plan suggested several actions within two programs including diversification of crude oil sources; and improving the performance of the oil sector. For Natural gas, the NAP suggested two programs of diversification of natural gas supply sources, and use of natural gas in various sectors. Finally, the energy efficiency pillar included several actions with one program of improving the use of energy efficiency in various sectors to achieve a reduction (9%) by 2030 compared to the average energy consumption in 2018.
National Municipal Solid Waste Management Strategy	The National Municipal Solid Waste Management Strategy[224] and action plan was developed by the Ministry of Local Administration with the primary aim to mainstream the 3Rs approach (Reduce - Reuse - Recycle) into the management of solid waste and to align the sector's policies and infrastructure with Jordan's sustainable development and economic growth objectives. The document proposes solutions for the management of hazardous or special solid waste streams (such as waste tires and C&D waste) but recognizes that these are to be managed separately by the Ministry of Environment (MoEnv). The strategy divides implementation into three regions (north, central, and south), with phased approaches that introduce infrastructure upgrades, capacity building, and policy development over three time periods (short, medium, and long-term) between 2015 and 2034. The strategy is consistent with international best practice for waste sector development and lays a strong foundation to mainstream green growth into the sector. Specific objectives of the strategy include: • Mitigation of risks on environmental and human health by Municipal Solid Waste Management through integrated management (planning, design, and operation); • Extension of the Municipal Solid Waste collection coverage levels to ultimately reach 100% of the population; • Promotion of Municipal Solid Waste prevention and reuse practices; • Promotion of separate collection and management of special and hazardous waste; • Promotion of sorting-at-source with view to increase Municipal Solid Waste prevention, reuse, and recycling; • Maximization of the use of the energy content of Municipal Solid Waste, when viable, in order to produce energy as an alternative source;

[221] StrategyEN2020.pdf (memr.gov.jo)
[222] 2nd NEEAP (2018-2020) final clean November 2017.pdf
[223] Microsoft Word - Action Plan En VIV JULY 2020-Final.docx (memr.gov.jo)
[224] (3rd draft report) .pdf (mola.gov.jo)

	• Establishment of appropriate Municipal Solid Waste treatment facilities with respect to the Integrated Solid Waste Management (ISWM) hierarchy; • Establishment of the appropriate tools for recording, analyzing, monitoring, and facilitating efficient decision-making of Municipal Solid Waste Management related issues, at the national, regional, and local levels; • Strengthening of the Jordanian Municipal Solid Waste Management sector in order to correspond to potential emergency conditions that may occur in the future; • Integration of informal waste-pickers in the new Municipal Solid Waste Management facilities; • Promote an effective public awareness and education on Municipal Solid Waste Management issues in the long-term; • Promote effective capacity building activities to maintain and upgrade the Municipal Solid Waste Management system; • Increase of Municipal Solid Waste Management system efficiency through public administration initiatives and private sector involvement; • Increase the efficiency of infrastructure and equipment maintenance Recently, MoEnv has led the push to implement a Waste Management Framework Law No.16 of 2020[225], which would clarify governance responsibilities in the sector and identify a broad range of waste management activities required for the Kingdom. This law covers municipal solid waste, agricultural waste, hazardous waste, industrial sector waste, medical waste, and special waste such as e-waste.
National Strategy for Agricultural Development	The Ministry of Agriculture updated its 2010 strategy to a National Strategy for Agricultural Development (2020-2025)[226] through incorporating and analyzing the internal and external factors and the weaknesses and threats affecting the agricultural sector. The strategy identified the priorities for the next phase and set the main partners in implementing the strategy, priorities, strategic objectives, outputs, enablers, indicators and strategic interventions. The strategy aims to improve the living conditions of farmers, increase the productivity of the agricultural sector, and improve the efficiency of irrigation water use and saving water. Along with the strategy, National Plan for Sustainable Agriculture (2025-2022) [227] was issued to guide the measures' implementation towards achieving the strategic goals. The plan included identifying challenges specific to the agriculture sector, which include: (1) Climate change and limited water resources, (2) Challenges arising from regional instability, (3) Unavailability of funding sources for capital projects, (4) Weak agricultural marketing infrastructure, and (5) Weakness of farmers' organizations and multiple references. The plan also defined the hypotheses of the national plan for sustainable agriculture, and then set the priorities of the national plan for sustainable agriculture through Developing the business environment in the agricultural sector, Enhancing the efficiency of irrigation water use, Encouraging the use of modern technology in agriculture, Enhancing the competitiveness of Jordanian agricultural products, Promote agricultural exports, and Development and sustainability of the forest sector and ecosystem. Finally, the plan provided the foundations of the national plan for sustainable agriculture, which was represented by: Job creation in the agricultural sector, increasing value-added growth rate, Increasing the productivity of the cubic meter of irrigation water, Increasing the value of agricultural exports, and increasing the area of sustainable forests. The Ministry of Agriculture also issued the Executive Program for Agricultural Development (2018-2020) and the Economic Growth Stimulation Plan (2018-2022) that defines initiatives and policies for programs, projects development needs. On the other hand, the institutional strategy of the Ministry of Agriculture (2016-2025), which defines the national goals and strategic axes related to the Ministry, the private sector, the rural community and farmers, and defines the programs, projects, and administrative and legislative procedures for the institutional strategy. A Strategy of the Ministry of Agriculture in Managing National and Agricultural Crises and Disasters was issued in 2018, which define the axis of climate change and drought disasters as one of the most important axes. The strategy sets the general objectives to increase efficiency and readiness in dealing with the phenomenon of climate change and drought, and define projects and procedures, and the body responsible for issuing the procedure.

[225] http://moenv.gov.jo/ebv4.0/root_storage/ar/eb_list_page/waste_management_framework_law_no_16_of_2020.pdf
[226] الاستراتيجية_الوطنية_للتنمية_الزراعية_2020_2025-0.pdf (moa.gov.jo)
[227] ملخص_الخطة_9_1_2022_نهائي.pdf (moa.gov.jo)

National Water Strategy and Water Sector Policies	The Ministry of Water and Irrigation issued Jordan's Water Strategy: “Water for Life” (2016-2022) [228] and its amendments which set goals and actions for water vision, goals, management and actions for different uses (e.g., irrigation, wastewater, and alternative water resources). The strategy addressed the preparedness and adaptation towards upcoming, mostly unknown challenges triggered by Climate Change. The strategy set the rationale and national priorities including the Water Sector Investment Plan, implementation tools, Sustainable Development Goals 2016-2030, IWRM plan and the monitoring and evaluation tools. The Ministry of Water and Irrigation developed the “Climate Change Policy for Resilient Water Sector” in 2016[229], which provides the background, concept, solutions, and implementation mechanisms for building resilience. The policy aims to provide a framework and methodology for strengthening the resilience of the Jordanian water sector, based on existing IWRM approaches through i) Prioritizing solutions according to a combination of climate specific and other (already established) criteria, ii) Applying climate-proofing steps to solutions or investments, and iii) Monitoring and evaluating the results based on indicators derived. This policy explicitly assures the importance of conformity between the sectoral national policies as well as the international policies particularly the Paris Agreement for developing robust solutions and building resilience for sustainable development. The policy set the guiding principles, rational objectives, implementation: prioritization, climate-proofing and monitoring, and action plan to ensure cc resilience in the water sector. The Ministry of Water and Irrigation also developed the Water Sector Policy for Drought Management in 2018[230]. The policy aimed to promote an integrated management approach to minimize the negative impacts on society, economy, social values, environment and natural resources, especially water. The policy focuses on mainstreaming climate change mitigation and adaptation and integrating water resource management solutions with SDGs to build resilience for sustainable development. The main objectives are: (1) Ensure an adequate supply of water to meet the basic needs of the population, to ensure good health and preserve lives during all phases of drought;(2) Minimize the negative impacts of drought on water resources and bodies, especially freshwater resources, dams and surface and groundwater; (3) Reducing the negative impacts of drought on agriculture and other economic activities, in accordance with the priority given in the National Water Strategy and other drought-related plans and strategies; (4) Strengthening national capacities through the establishment of a national drought forecasting and early warning system; (5) Develop and implement national drought management plans based on proactive risk management rather than crisis management in order to address various types of drought in coordination with the public and private sectors; and (6) Ensure effective coordination of institutional response to drought mitigation measures. The Ministry of Water and Irrigation also developed the Energy Efficiency and Renewable Energy Policy for the Water Sector (2020 – 2030)[231], which aims at providing a solid basis for promoting the desired change of achieving actual measurable improvement in energy efficiency and in increasing the use of renewable energy in the water sector. The policy presents 4 goals, 9 targets and 12 indicators. The targets aim to (1) Increase energy efficiency by 15% in water supply and wastewater treatment activities by the year 2025 based on 2019 MWI energy consumption baseline, (2) Increase the use of renewable energy in all water sector activities to cover 20% of the 2019 MWI energy consumption baseline (10% by the year 2025 and 20% by the year 2030), (3) Perform feasibility studies and implement renewable energy powered desalination plants for seawater by 2025 on 25% of the total water supply based on 2019 baseline, (4) Implement energy management systems to gradually cover the entire water sector activities (cover 60% of the water sector in Jordan by the year 2025 and 100% by the year 2030), (5) Develop and implement a Water and Energy Data Management System (DMS) for the water sector by 2022 and implemented in 80% of water sector by 2025 measured by water assets capacity in MCM that are covered by the DMS divided by the total water sector capacity in MCM, and (6) Develop an energy and GHG emissions balance annual report for the water sector activities starting from 2025 onwards.
Climate –Smart Agriculture Action Plan	The agriculture sector, which is impacted by the climatic changes that affect agriculture production in Jordan recently developed the “Climate–Smart Agriculture Action Plan”[232], in 2021 to strengthen farmers’ adaptation and resilience to climate change and also support mitigation efforts. The CSA

[228] الخطة_الاستراتيجية_لوزارة_المياه_والري.pdf (mwi.gov.jo)
[229] سياسة بناء المنعة لمواجهة أثر التغير المناخي على قطاع المياه Xrox (mwi.gov.jo)
[230] سياسة_قطاع_المياه_لإدارة_الجفاف__2018.pdf (mwi.gov.jo)
[231] energy_efficiency_and_renewable_-_energy_policy_for_the_water_sector.pdf (mwi.gov.jo)
[232] World Bank Document

	Action Plan provided prioritized investment packages for each of Jordan's agroecological zones including expansion of date palms and protected vegetables in irrigated parts of the Jordan Valley and highlands, olive production and processing and barley production in rain-fed regions, and small ruminant value chains and Badia restoration in agropastoral areas. At both the farm and aggregated levels, the cost-benefit analysis was determined and provided a generally good return on investment for all CSA packages. All the packages also promised to increase water productivity, create jobs in high-value export chains, and benefit farmers and vulnerable populations both directly and indirectly. The aggregated economic profitability of the six packages was estimated based on a combination of the net incremental benefit at the farm level, the annual adoption rate and, the large-scale investment costs beyond the farm level, such as for trainings and equipment for post-harvest storage and processing: and the number of targeted beneficiaries.
Private Sector Engagement	Jordan acknowledges the fundamental role of the private sector in achieving economic, social and environmental development. In this regard, the government developed the Jordan Economic Growth Plan (2018-2022)[233] to recapture the growth momentum and realize the development potential over the coming five years. The plan addresses 19 areas of enabling environment including 23 private sector investments, among others. The identified investment opportunities are distributed over ICT, infrastructure and economic sectors. Although Jordan's experience in Public-Private Partnership started in the last decade, the government is still committed to moving forward with reforms and enabling the Jordanian economy to be more resilient to macroeconomic challenges. For this objective, the government has recently adopted the new Public-Private Partnership Projects Law No. 17 of 2020, to be the legal reference and institutional framework for private sector investments and to enable future PPP projects in the country. At sectoral level, the government cooperate with the local banks by designing a financing mechanism comprising a financial contribution from the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) to promote the use of renewable energy and energy efficiency in residential and industrial sectors to contribute to reducing the final energy consumption. There is a need to streamline the process of creating and sustaining high skill green jobs. Establishment of a green jobs council or similar body, with a strong representation of private sector and key public sector stakeholders could be explored. This could lead demand-side and supply-side assessments to identify gaps in Jordanian ecosystem in terms of green technology and green entrepreneurship skills; supporting and coordinating private sector-led green technology skills' development and national awareness activities.
National Climate Change Health Adaptation Strategy and Action Plans	The Ministry of Health issued a National Climate Change Health Adaptation Strategy and Action Plan of Jordan (2012), which provides detailed plan for adaptation measures to Reduce Vulnerability and Enhance Preparedness against the Potential Negative Impacts of Climate Change, including creation of an Early Warning System for air-borne and respiratory diseases. The plan deals with climate change and air-borne and respiratory diseases, climate change and water and food-borne diseases, vector-borne diseases, nutrition and food safety, and occupational health. The strategy and action plan detail Jordan's climate change adaptation strategy and plan of action to protect health including approach, scope, goals, objectives, proposed strategy implementation arrangements, plan of action, and adaptation project proposals for the six climate-sensitive health issues. The Ministry of Health issued the Strategic Plan 2018-2022[234], which sets coordination, responsibilities and actions to provide equitable and high quality healthcare services, increase rate of universal health coverage for the population, improve the effectiveness of human resource management, improve effectiveness and efficiency of infrastructure management, improve effectiveness and efficiency of knowledge-management based on digital transformation and technology, improve effectiveness and efficiency of financial management, maximize governance and supervisory role of the ministry and implement decentralization. The plan focused on environmental risks resulting from climate change, shortage in water supplies, lack of sanitation networks in many areas of Jordan, air pollution, and poor household solid waste management. The Ministry of Health issued the Health Information System Strategic Plan 2019-2023[235], which provides an assessment of Jordan's Health Information System and Health Information Strategic Plan. The plan supports building an electronic knowledge=management system infrastructure that

[233] JEGProgramEnglish.pdf (ssif.gov.jo)
[234] the_ministry_of_health_strategic_plan_2018-2022.pdf (moh.gov.jo)
[235] Document 3 - HIS .indd (moh.gov.jo)

	promotes the creation, dissemination and sharing of knowledge. The plan is to survey, count, optimize, review, and enable data use for policy and action.
Road Safety Strategic Plan	The Ministry of Transport issued the Strategic Plan for Road Safety 2019-2023[236], which aims to reduce the use of private cars and raise the technical level of vehicles, so that reducing the negative environmental impacts of the transport sector from pollutant emissions, greenhouse gases and fuel consumption is done through three major action plans (1) Establishing the railway network (2) Establishing a number of procedures to renew the private fleet (cars and trucks) and public (buses), through financial, regulatory and mandatory incentives and controls, and reducing the average life of used cars, which means relying on modern technologies with better performance and fuel savings, (3) Sector partners' commitment to implement the strategy.
Jordan National Building Codes	Buildings consume 21% of the primary energy and 43% of the electricity generated in Jordan. In order to save energy and material resources which are consumed by buildings, and reduce harmful greenhouse gas emissions, LEED and BREEAM display the responsible use of resources and promotes integrated design practices. The development process of Jordan's national building codes goes back to 1980 when the Jordanian National Building Council (JNBC) was formed by the Prime Minister under the directives of His Majesty late King Al-Hussein, to look at preparing Building Codes and National Building Laws to ensure the safety of buildings. Efforts started in 2009 to develop a rating system for buildings that will reduce the energy and water demand and provide an efficient and healthier environment. Subsequently the attention to the energy consumption in building increased, and the building officials started implementing the local building codes related to energy. The Ministry of Public Works and Housing (MoPWH) has the Jordan National Building Council (JNBC) division which is responsible for the development of the Building Codes in Jordan. The Jordan Green Building Guide (JGBG) technical committee was established in 2009 to develop the Green Building Rating System in Jordan with the help of specialist in the public and private sectors under the leadership of the technical arm at the Construction and Sustainable Building Center (CSBC) at the Royal Scientific Society. International references from leading sustainability rating systems were used as references such as Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Method (BREEAM), with emphasis on the local conditions in Jordan pertaining to energy and water scarcity. The JGBG was issued in 2013, and it became available to everyone to use. An incentive program for the adoption of green buildings in Jordan based on the JGBG rating system was approved in 2015 and it was launched on the 3rd of September 2015[237]. Several codes were already developed including Thermal Insulation Code, Green Building Guide, Natural Lighting Code, Natural Ventilation Code, Interior Illumination Code, Energy Efficient Buildings Code, Solar Energy Code, Central Heating Code, Mechanical Ventilation and Air Conditioning Code, and Code for Gas Piping in Buildings[238].
Aqaba Special Economic Zone Authority	The Aqaba Special Economic Zone is a global hub, for investors and tourists alike. It forms a strategic outlet for regional and international markets, maximizing business opportunities in all sectors and providing an advanced standard of living. The Aqaba Special Economic Zone Authority adopted, in 2002, a comprehensive regulatory plan, covering development activities in the region at the level of the tourism, commercial, industrial and logistics sectors, as well as other investment sectors. The broad planning currently covers five areas: Aqaba City, Aqaba Port Area, Southern Coastal Zone, Southern Heavy Industries Area and Northern Airport Area. The ASEZA has set several laws and regulations to guide the development within the area along with the Aqaba Development Corporation (ADC) that was established in 2004 to attract investments and maximize the private sector participation in the various development projects through the adoption of public and private partnerships. The ASEZA has adopted a number of policies related to management oversight and protection of the natural environment. Environmental policy requires the conservation, protection and sustainable development of the natural resources of the region. The environmental policy requires preservation and protection of the environment and the sustained development of the Zone's natural resources. This includes a water policy for protecting and managing the groundwater resources, water conservation by managing both supply and demand and efficiency of use, an energy conservation

236 Strategic_Plan-_Road_Saftey__7-03-2019.pdf (mot.gov.jo)
237 Green Building Rating System in Jordan | EcoMENA
238 Jordan National Building Codes (buildings-mena.com)

	policy, and a stringent discharge policy of "Zero Discharge" to the sea, in order to preserve the marine environment Aqaba International Laboratories - Bin Hayyan was established within the framework of the institutional support program for the Aqaba Special Economic Zone Authority, with technical and financial support from the European Union Commission, with the aim of developing the Aqaba Special Economic Zone and qualifying it to become a tourist attraction, attracting investment for economic activities in the region, as well as facilitating the flow of trade and goods across the city of Aqaba, the Kingdom and the region in general, taking into account the need to maintain and improve public health. The Environmental Planning Directorate (EPD) is responsible for assessing any environmental impact assessment[239], within the zone. The strategic plan (2018-2020)[240] includes the preservation of the environment, safety and public health, which includes planning, monitoring and implementation of many measures that ensure environmental safety. There are many economic activities granted by the Environmental Planning Department of the Aqaba Special Economic Zone Authority for all environmental requirements, as well as stipulating standards regarding water quality and preservation, air quality, noise, the seacoast, environment and biodiversity, solid waste management, and hazardous materials and waste management. Therefore, all economic activities within the zone are subject to environmental inspections to ensure their compliance with environmental rules, regulations and requirements. Environmental policies include preventing environmental pollution, sound management of resources, rationalizing energy consumption, supporting the use of renewable energy, reducing CO_2 emissions whenever possible, preventing discharges to the sea, and developing a sustainable local community, encouraging education and awareness, enhancing the local environment, improving its environmental performance, providing environmentally friendly services, implementing environmental legislation, and fulfilling national / international environmental obligations.
National Social Protection Strategy	Ministry of Social Development issued its National Social Protection Strategy (2019 – 2025)[241] with a vision of "All Jordanians enjoy a dignified living, decent work environment, and empowering social services." The strategy aims to eradicate poverty in all its forms everywhere, completely eliminate hunger, provide food security and improved nutrition, and promote sustainable agriculture. The strategy suggested three pillars: (1) opportunities for families to be economically self-sufficient through the labor market; (2) empowerment of the population through education, health care and social services that support those with special needs to remain integrated within their families and communities; and (3) targeted social assistance that allows the poor to maintain a basic level of consumption with dignity.
Jordan Tourism Strategy	Ministry of Tourism & Antiquities updated its strategy in Jordan Tourism Strategy (2021-2025)[242] entitled: "A Tourism Strategy That Is Fit for Purpose and Circumstances". The Strategy addresses the challenges and gaps Jordan faces, and aligns them with the strengths and opportunities the country can build on, to bolster national economic growth and job creation. The strategy reflects the implications of COVID-19 and the perceived way forward for the period 2021-2025. Three phases were identified, the response, recovery and resilience. The Recovery phase aimed to limit damage to the economy, including those in the tourism sector by focusing on financial liquidity and employment protection. The Government of Jordan (GoJ), The Central Bank of Jordan (CBJ), The Social Security Corporation (SSC), The Ministry of Tourism and Antiquities (MoTA) and Jordan Tourism Board (JTB) took several monetary and fiscal actions to support the tourism sectors, such as reduction of interest rates, sales tax and service fees as well as pumping significant amounts of liquidity into the economy, the provision of soft loans and waiving fees. The Resilience phase was designed to, wherever possible, get back to pre-COVID-19 levels and build abilities to deal with the 'new normal'. It included the launch of several niche tourism products such as medical tourism and film tourism and boosted the domestic tourism segment, which proved to be very successful in the absence of international travelers. This phase also included the gradual reopening of tourism activities, the reopening of airports and quarantine cancellation for international visitors. Additionally, the launch of the Tourism Resilience Fund provided a protective layer to the tourism sector to shield it from the pandemic's impacts. The strategy also included spreading environmentally friendly practices within the tourism sector, such as reducing carbon emissions, increasing the efficient use of energy in transportation within and to

[239] Environmental Protection 2 (aseza.jo)
[240] الخطة الاستراتيجية (2018 – 2020) (aseza.jo)
[241] NSPS.pdf (unicef.org)
[242] view_file.cfm (undp.org)

	Jordan, promoting the efficient use of energy, energy conservation, and use of renewable energy where possible, achieving efficiency in water use, and rationalizing consumption by reducing and reusing, reducing waste and improving its management - the sector will work alongside the government to adopt environmentally friendly practices to manage solid waste landfills, recycling facilities and waste-use solutions for energy generation.
National Center for Security and Crises Management	In 2015, Jordan endorsed the *Sendai Framework for Disaster Risk Reduction (2015-2030)*[243]. This international agreement sets several priorities for action, including strengthening government capacity to manage disaster risk, enhance disaster preparedness, and invest in disaster risk reduction for resilience. The Jordanian National Center for Security and Crisis Management (NCSCM) was established in 2015 to coordinate and unify all efforts made by national institutions to enable them to face national crises in various forms, to help achieve more strategic adjustment processes and secure a stable and secure national environment. The NCSCM aims to achieve its mission by harnessing the national potential and unifying the efforts of relevant national institutions in order to achieve professionalism in both preparation for and response to national crises, both natural and man-made, reducing effort, time, costs, and possible losses. In 2017, the GoJ thus delegated the responsibility for establishing and institutionalizing the national disaster risk reduction (DRR) platform to the NCSCM. Recently, drought was included as a national crisis by NCSCM. The Natural Disaster Risk Reduction Strategy (2019-2022)[244] developed a road map to have a common understanding of the Disaster Risk Reduction (DRR) sector. It is guided by Jordan's development priorities and aims specifically at achieving a set of objectives, including setting basic disaster risk reduction, increasing awareness and knowledge of disaster risk reduction approaches and opportunities, establishing legal and institutional bases for effective planning and implementation of disaster risk reduction, and contributing to the inclusion of disaster risk reduction in development policies, programs and projects.
Environmental Information Systems	The Department of Statistics (DoS) was established in late 1949 to assist all ministries in producing, analyzing and disseminating data by using the best improved techniques and applying best practices and statistical methods internationally recommended to meet the needs of stakeholders, and improving the performance of Jordanian statistical system components. In addition to population, national accounts, industry, economics, census, and labor forces, the Directorate of Agriculture and Environmental Statistics was developed to tackle the environmental issues in many international indicators related to achieving the goals of sustainable development. It described the state and trends of the environment, covering the media of the natural environment (air/climate, water, land /soil), the biota within the media, and human settlements. Environment statistics are integrative in nature, measuring human activities and natural events that affect the environment, the impacts of these activities and events, social responses to environmental impacts, and the quality and availability of natural assets in addition to including environmental indicators, indices and accounting. Recently DOS issued the National Strategy for Agricultural Development Surveys 2020 that covers the results of the National Strategy Surveys for Agricultural Development 2019[245]. This bulletin includes the results of the Olive Oil Presses Survey, the Agricultural Nurseries Survey, and the Aquaculture, Fishing and Beehives Survey. In addition, DOS issued the Electronic and Electrical Wastes discarded by Households Survey, 2018[246] in parallel to reports on other issues including Hazardous Solid and Liquid Wastes Survey for both Medical Services Activity, and industrial activity (chemical, plastic, rubber and other activities), Municipal Solid Waste Survey, an Environment Survey for the services sector (hotels and education activities), an Electronic Waste Survey in the Financial and Insurance sector and for Software Maintenance Activities. DOS created an active interphase web through Environmental Management Information System (EMIS) to provide statistics for all environmental indicators[247].
Airport International Group Carbon Neutrality	The Airport International Group (AIG) adopted an Environment, Social, Health and Safety Management (ESHSM) Plan and an ESHS Monitoring System was developed to monitor the environment, social, health and safety, which includes water quality monitoring, wastewater - reclaimed, organic sludge quality control, industrial water monitoring, soil quality monitoring, ambient air quality monitoring, stack emissions monitoring, fuel consumption monitoring, including monitoring of CO_2 emissions. In addition, the AIG issued an Environment & Safety Handbook to assist and provide rules and guidance for environment & safety work practices.

[243] http://www.unisdr.org/we/inform/publications/43291
[244] https://www.jo.undp.org/content/dam/jordan/docs/DRR/National%20Natrual%20Disaster%20Risk%20Reduciotn%20Strategy.pdf
[245] http://dosweb.dos.gov.jo/wp-content/uploads/2021/08/agr_strat2019.pdf
[246] http://dosweb.dos.gov.jo/databank/publication/Electronic_and_Electrical_Waste_at_Households_2018.pdf
[247] PxWeb - Select table (dos.gov.jo)

	Several actions have been taken to reduce energy consumption over the past years. The reduction in overall CO_2 emissions between 2012 and 2019 reached 20%. In 2021, the AIG announced its commitment to achieving net-zero emissions by 2050 and, accordingly, devised a road map for attaining this target through clearly defined actions. During 2021, the carbon dioxide emissions generated directly by AIG due to its fuel and electricity consumption amounted to 20,267 tCO_2 marking an 82% decline from the emissions in 2020. In 2021, emissions resulting from aircraft movement (including cruise emissions) and service providers reached 542,282.15 tCO2 – noting a decline of 40% compared to 2019 (2020 was excluded due to the COVID-19 pandemic). In terms of carbon neutrality (i.e., zero net carbon dioxide emissions over an entire year), the QAIA achieved the highest level of Neutrality in 2018, making it the first airport in the Middle East to achieve this distinguished accomplishment, which was successfully renewed in 2020 until 2022. In 2021, AIG has chosen to adopt a Paris-based target to achieve net zero emissions by 2050 and a 59% emissions reduction by 2035, compared to AIG's first published Scope 1 & 2 emissions inventory in 2012. This reflects an ambitious net zero pathway limiting global temperatures to 1.5°C, based on the Paris Agreement. Based on this projection, emissions in 2021 at QAIA should be in the region of 24,673 tCO_2. Actual Emissions in 2021 were 20,267 tCO_2 and are therefore 17.9% lower than the 2021 target projection. Recently, the Queen Alia International received Airports Council International (ACI) Asia-Pacific Green Airports recognition[248] under the theme of Carbon Management - in line with global industry goals to reduce carbon emissions and attain net-zero status by 2050. The recognition aims to promote environmental best practices to curb the impact of the aviation industry on the environment and champion airports that bring forth outstanding carbon management projects.
Aqaba Marine Reserve Management Plan	Due to the importance of the Gulf of Aqaba, His Majesty King Abdullah II gave his directive on June 3rd, 2020 to declare that the existing area of the Aqaba Marine Park be re-designated as the Aqaba Marine Reserve. Accordingly, the reserve was declared by the cabinet of Jordan as the first Marine reserve in Jordan in December 2020, to be part of Jordan's network of protected areas. It occupies an area of 2.8km^2 out of 96 km^2 which represents 3% of the total Jordanian territorial water area, and its shorelines extends over 7km out of 27km thus taking up 26% of the total coastline length. The reserve is managed by the Aqaba Special Economic Zone Authority (ASEZA) after a Memorandum of Understanding signed with the Ministry of Environment. As a result, a bespoke Management Plan was developed to support policy implementation as well as to draw the road-map management activities to drive the conservation efforts in line with green sustainable development as well as achieving international recognition and accreditation including, but not limited to, the UNESCO world heritage landscape area, UNESCO Man and Biosphere Reserve (MAB), IUCN Green List of protected areas, Key Biodiversity Area and as a Ramsar site. The Management Plan (2022-2026)[249] is presented as an innovative management tool that solidifies the recognition of Aqaba as a socio-ecosystem, where successful conservation requires integrated management of the protected areas with the populated zones of Aqaba. This includes acknowledging the capacity of relevant ecosystems and their biodiversity to generate services, and contributing to the recovery of those components that have been altered primarily by anthropogenic causes (invasive species, habitat degradation and fragmentation, among others), in ways that guarantee a sustainable human presence and quality of life or good living. In addition, the reserve was categorized according to the international Union for the Conservation of Nature in Category VI aiming to protect natural ecosystems and use natural resources sustainably, when conservation and sustainable use can be mutually beneficial. This category allows the reserve management to use the natural resources sustainably as a means to achieve nature conservation together with associated cultural values and natural resource management systems. The plan is based on a shared vision: "Aqaba Marine Reserve is a model of effective planning and management that ensures that the unique ecological values and associated social and economic benefits are used sustainably for future generations through active stakeholder stewardship". The

[248] Queen Alia International receives ACI Asia-Pacific Green Airports recognition | Times Aerospace
[249] https://www.undp.org/sites/g/files/zskgke326/files/migration/jo/Aqaba-marine-park-management-plan-AMP.pdf

	main areas of intervention of the AMRMP (Aqaba Marine Reserve Management Plan) (2022-2026) are determined by six objectives and a series of outputs, which correspond to the objectives of ASEZA. The objectives include: (1) Maintain and improve healthy, resilient, bio-diverse reefs and seagrass habitats within the AMR up to and beyond 2026 (2) Create and implement the necessary mechanisms to promote the AMR as a model for ecologically sustainable tourism which complies with international principles and standards (3) Effective surveillance and patrolling are being implemented to cover the entire AMR area (4) Improve and strengthen institutional/legal framework and associated management capacities (5) Marine Conservation awareness and Education is improved at the International and National Level (6) Sustainable financial mechanisms are established and implemented to finance future AMR related management operations and activities
Aligned National Action Plan to Combat Desertification	Since signing the agreement of the United Nations Convention to Combat Desertification (UNCCD) in 1994 and ratification by 1996, the GoJ is totally committed to combat desertification through all means. As a result of Jordan's commitment towards conservation of the local and regional environment, the Ministry of Environment developed the National Strategy and Action Plan (NAP)[250] in 2006 to Combat Desertification within the context of the UNCCD. The overall objective is to provide an integrated development plan and subsequent programs targeting local communities and environmental components in areas under threat of desertification. The NAP includes six programs with specific objectives and focal themes of activities. Under each program several projects with justification, objectives, activities, expected outputs, duration, implementing agencies, and estimated budget were proposed. The programs include (i) Desertification Information System, (ii) Drought Prediction and Desertification Control, (iii) Capacity Building and Institutional Development, (iv) Restoration of Degraded Ecosystems of Rangelands and Forests, (v) Watershed Management, and (vi) Human, Social and Economic Development. According to UNCCD Articles 9 to 11, Action Programs (National, Sub Regional or Regional) should be central to the strategy to combat Desertification, Land Degradation and Drought (DLDD). In 2007, Parties to the Convention adopted a 10 Year Strategic Plan and Framework to enhance the implementation of the Convention for 2008-2018 ("The Strategy"). As a result, the MoEnv developed the Aligned National Action Plan to Combat Desertification in Jordan[251] 2015 – 2020 with a vision of "Productive and sustainable use and management of land resources to support poverty reduction, environmental sustainability and national economy". This vision focuses on sustainability of land resources, enhancement of population livelihood, and contribution to the national economy. A logical framework has been prepared for expected outcomes under each of the Operational Objectives outlining the indicators, responsible parties and assumptions. The outcomes include communication and outreach strategy, policy coherence regarding addressing DLDD issues, DLDD platform for knowledge sharing, a national monitoring program on DLDD and Sustainable Land Management Practices (SLM), and updating and fulfilling capacity needs for proper implementation of DLDD activities. Sustainable programs for combating desertification and its negative implications were suggested based on best management practices and guidance, local communities' involvement, planning of land use and water management and identifying multisectoral and multi-environmental indicators for long-term and short-term monitoring of desertification. Sustainable management of land resources and combating desertification require integrated interventions in various sectors, including water, agriculture, energy, urban development among others.

[250] Microsoft Word - NAP Final.doc (iucn.org)
[251] Jordan%20-%20eng%202015-2020.pdf (unccd.int)

Table C.2: Support received to fulfil the national climate change commitments (2015-2020)

Timeframe	Project	Donor/Implementing Entity	Total budget	Type of Support	Project objective
2015-2021	Policy dialogue and knowledge management on low emissions development strategies in the MENA region "DIAPOL-CE"	BMU- GIZ/MoEnv	Grant: Euros 460,000	CB, TS	To support strategies that reduce greenhouse gas emissions in countries of the MENA region. The project provides policy dialogue and supports the implementation of low-emission development in Jordan.
2015-2019	CCAC SNAP- Supporting National Action and Planning on Short-Lived Climate Pollutants (SLCPs)	CCAC/MoEnv	Grant: USD 125,550	CB, TS	Strengthening the institutional capacity dedicated to promoting SLCP mitigation and integrating SLCPs into relevant national planning processes in Jordan.
2015-2016	Partnership for Market Readiness (PMR)	PMR/ MoEnv	Grant: USD 350,000	TS	Preparing the Jordanian Proposal for Market Readiness.
2016-2020	Implementing the activities included in Market Readiness Proposal of Jordan	PMR/ MoEnv	Grant: USD 3,000,000	CB, TS, TT	To enhance the capacity of public agencies and private sector towards the design of future market-based instruments. The readiness activities include: 1. Fully Implemented Multi level MRV 2. Identification of market-based instruments through private sector engagement
2016-2017	Development of Jordan`s first Biennial Update Report to the UNFCCC	GEF-UNDP/MoEnv	Grant: USD 352,000	CB, TS	To prepare and submit of Jordan's FBUR to the Conference of the Parties to the UNFCCC.
2017	Developing a concept note to seek support on solar water pumping	Clima-South initiative EU Commission/MoEnv	Grant	TS	The concept note aims to introduce 10,000 solar water pumps for farmers in Jordan
2017-2019	Mainstreaming Rio Convention Provisions into	GEF-UNDP/MoEnv	Grant: GEF: USD 950,000	CB, TS	Mainstreaming Rio convention provisions into key national

	National Sectoral Policies		UNDP: USD 25,000		sectoral policies and/or legislation in Jordan.
2017-2019	Development of the National Adaptation Plan process in Jordan to support the implementation of the Paris Agreement and Jordan's NDC	BMU- GIZ/ MoEnv	Grant: Euros 400,000	CB, TS	To develop first NAP in 2020 through a national consultation process based on international guidelines and best practices related to UNFCCC and Paris Agreement.
2018-2020	Supporting effective governance for NDC review and implementation in Jordan (IKI - NDCs)	BMU- GIZ/ MoEnv	Grant: Euros 2,000,000	TS, CB	To advise MoEnv and national partners on the key elements of: 1. Reviewing and updating the first NDC document and development of a new NDC document by 2020 2. Developing a framework for enhanced transparency in Jordan. 3. Localization of NDC through developing three local climate action plans.
2018-2020	Development of Fourth National Communication and Second Biennial Update Report under the UNFCCC	GEF-UNDP/MoEnv	Grant: USD 852,000	TS, CB	To prepare and submit Jordan's 4thNC and Second BUR to the Conference of the Parties to UNFCCC.
2018-2020	Strengthening National Designated Authority (NDA) of Jordan to deliver on Green Climate Fund (GCF) Investment Framework	GCF/ MoEnv	Grant: USD 220,000	CB, TS	To strengthen and enable Jordan NDA to effectively engage with the GCF.
2018-2020	GCF Readiness for Accreditation	GCF/ MoEnv	Grant: USD 660,000	CB, TS	To support a national entity to get accreditation for DAE (Direct Access Entity). Pipeline development. Private sector engagement
2018-2021	CLIMA-MED project	EU Commission/ MoEnv	Grant	CB, TS	Technical assistance task for the Southern Neighborhood region, including Jordan, to enhance municipalities to develop sustainable

					energy and climate action plans, to support climate action
2019-2023	NDC Action Program (IKI), Regional program.	BMU /UN Environment/MoEnv	Grant: Euros 1,000,000	CB, TS	This program is being implemented in selected countries. The project outcome is to apply a systematic approach to using policies and economic instruments that accelerate public and private investment in NDC implementation
2020	Green Growth Action Plan Implementation	GGGI/ MoEnv	Grant: USD 183,000	CB, TS	Complete the implementation arrangements for the Green Growth National Action Plan (GG-NAP). Support MoEnv to establish an internal climate and green growth Project Management Unit.
2020-2021	GCF Readiness	GCF/ MoEnv	Grant: USD 1,000,000	CB, TS	- National Climate Finance Needs Assessment & Strategy - Pipeline Development. - Private Sector Mobilization
2020	Preparing Jordan's NDA and DAE for Partnership in Climate Action through GCF Direct Access	GCF / MoEnv, GGGI		CB, TS	To provide comprehensive training on the tools created under the previous readiness projects (e.g., country program, online bilingual platform etc.) and in the area of project development (e.g., SAP, concept notes etc.) as well as increase dialogue and collaboration between all (especially the private sector) in order to ensure effective, coordinated engagement with the GCF and access climate finance

CB= Capacity Building, TS= Technical Support, TT= Technology Transfer, F= Finance

Table C.3: Support Received for Energy Sector (2015-2020)

Timeframe	Project	Donor/Implementing Entity	Total budget	Type of Support	Project objective
2015	Wind Energy- Tafilah, 117 MW	IFC/Private company: Jordan Wind Project Company (JWPC)	Commercial Loan: USD 290,000,000	F, CB, TT	Generating clean energy, and diversification of energy sources.
2015	Solar energy- Azraq, 2.17 MW	Bilateral Spanish Jordan Debt Swap mechanism/ MEMR	Grant: USD 5,000,000	TT	Generating clean energy, and diversification of energy sources.
2015	Solar energy- Azraq, 3 MW	Spanish Loan/ MEMR	Grant: USD 6,000,000	TT	Generating clean energy, and diversification of energy sources.
2016-2017	Solar Energy Round I, 200 MW	Private lenders/ Private companies	Commercial Loan: USD 400,000,000	TT	Generating clean energy, and diversification of energy sources.
2016-2019	Renewable Energy and Energy Efficiency Program REEE II.	EU Commission/ Private company	Grant (General Budget Support): Grant: Euro 90,000,000	CB, TS, TT	To support government of Jordan in enhancing the clean energy and energy efficiency practices.
2017	Wind energy- Ma’an, 80 MW	Gulf Grant/ MEMR	Grant: USD 150,000,000	TT	Generating clean energy, and diversification of energy sources.
2017	Solar energy - Zaatari	KFW/ MEMR	Grant: Euros 15,000,000	TT	Generating clean energy, and diversification of energy sources.
2017	Solar energy (round II) Mafraq, 50 MW	EBRD/ Private company	Loan: USD 86,000,000	TT	Generating clean energy, and diversification of energy sources.
2017	Solar energy- Mafraq, 50MW	EBRD/ Private company	Loan: USD 80,000,000	TT	Generating clean energy, and diversification of energy sources.
2017	Solar energy- Alsafawi, 50MW	EBRD/ Private company	Loan: USD 80,000,000	TT	Generating clean energy, and diversification of energy sources.
2018	Solar energy- Quwera, 103MW	Abu Dhabi Fund/ MEMR	Grant: USD 150,000,000	TT	Generating clean energy, and diversification of energy sources.

2019	Wind energy- Rajef/ Ma'an, 86 MW	EBRD/ Private company	Loan: USD 183,000,000	TT	Generating clean energy, and diversification of energy sources.
2019	Wind energy- Fujij/ Shobak, 90MW	Private sector/ Private company	Loan: USD 182,000,000	TT	Generating clean energy, and diversification of energy sources.
2019	Wind energy- Tafila, 50MW	Private sector/ Private company	Loan: USD 113,000,000	TT	Generating clean energy, and diversification of energy sources.
2019	Wind energy- Tafila, 100MW	Private sector/ Private company	Loan: USD 201,000,000	TT	Generating clean energy, and diversification of energy sources.
2019	Wind energy- Irbid, 45MW	Private sector/ Private company	Loan: USD 100,000,000	TT	Generating clean energy, and diversification of energy sources.
2019	Wind energy- AlShobak ,45MW	EBRD and Islamic Cooperation for the Development of Private Sector/ Private company	Loan: USD 100,000,000	TT	Generating clean energy, and diversification of energy sources.
2019	Solar energy, Azraq, 5MW	EU commission/ MEMR	Grant: USD 5,000,000	TT	Generating clean energy, and diversification of energy sources.
2019	Solar energy- East of Amman, 40MW	- Overseas Private Investment Corporation/ Private company - Sumitomo Mitsui Banking Corporation (SMBC)/ Private company	Loan: USD 50,000,000	TT	Generating clean energy, and diversification of energy sources.
2019	Solar Energy – Risha, 50MW	- EBRD - DEG (Deutsche Investitions Und entwicklungs gesellschaft) - Arab Bank Implementing/ Private company	Loan: USD 75,000,000	TT	Generating clean energy, and diversification of energy source.
2019	Solar Energy in South Amman, 46.33 MW	- KFW/ MEMR	Grant: USD 51,000,000	TT	Generating clean energy, and diversification of energy sources.
2019	Wind energy- Fujij/ Shobak, 90MW	- The Export-Import Bank of Korea (KEXIM)	Loan: USD 182,000,000	TT	Generating clean energy, and

		- SMBC -MIZOHO Bank/ Private company			diversification of energy sources.
2019	Wind energy - Tafila, 50MW	-IFC -Standard Chartered Bank -Shinhan Bank/ Private company	Loan: USD 113,000,000	TT	Generating clean energy, and diversification of energy sources.
2018	Solar energy-Muwaqer, 200MW	-Japan International Cooperation Agency -DEG, -Open Fund for International Development/ Private company	Loan: USD 200,000,000	TT	Generating clean energy, and diversification of energy sources.
2020	Solar energy- Round III, 150MW	Private sector/ Private company	Loan: USD 250,000,000	TT	Generating clean energy, and diversification of energy sources.

CB= Capacity Building, TS= Technical Support, TT= Technology Transfer, F= Finance

Table C.4: Support Received for Waste Sector (2015-2020)

Timeframe	Project	Donor/Implementing Entity	Total budget	Type of Support	Project objective
2015-2018	Comprehensive Landfill Gas Recovery program at Ghabawi landfill	EBRD/GAM	Loan: USD 18,000,000	CB, TS, TT	Design, build and operate Landfill Gas to Energy in Ghabawi Landfill
2016-2020	Solid Waste Crisis Response Program to Syrian Refugees Influx / GAM	EBRD/GAM	Grant: GBP 4,900,000	TS, TT	To mitigate the effects of the increasing number of refugees by providing more sustainable and long term solutions in the solid waste sector.
2017-2019	Solid Waste Crisis Response Program to Syrian Refugees Influx / GAM	EBRD/GAM	Loan: JOD 3,250,000 Grant: GBP 4,165,000	TS, TT	Construction of new cell in Ghabawi Landfill
2017-2021	Solid Waste Crisis Response Program to Syrian Refugees Influx / GAM	EBRD/GAM	Grant: USD 396,412.	CB, TS	Supervision on the implementation of Biogas project
2017-2023	Support the implementation of the National Solid Waste Strategy in Jordan	EU/GAM	Grant: Euro 120,000,000	CB, TS, TT	General support to Government of Jordan to enhance the implementation of the NSWMS with focus on northern area.
2018-2020	Solid Waste Crisis Response Program to Syrian Refugees Influx / GAM	EBRD/GAM	Loan: JOD 11,100,000 Grant: GBP 5,630,000 Grant: USD 7,400,000	TS, TT	Improving the machinery and infrastructure at Ghabawi landfill.
2018-2020	Solid Waste Crisis Response Program to Syrian Refugees Influx / GAM	EBRD/GAM	Loan: USD 3,100,000 Grant: Euro 3,700,000	CB, TS, TT	Installations of LFG recovery for power generation
2018-2020	Solid Waste Crisis Response Program to Syrian Refugees Influx / GAM	EBRD//GAM	Grant: USD 689,784	CB	Developing the Environmental and Social Action Plan (ESAP) for GAM, and ESIA for Ghabawi Landfill

2018-2020	Solid Waste Crisis Response Program to Syrian Refugees Influx / GAM	EBRD/GAM	Grant: Euro 578,450	CB	Support GAM to complete a mapping exercise on mapping all current waste related activities
2018-2020	Climate and Response Protection through Circular Economy (CIRCLE)	BMZ- GIZ/GAM	Grant: Euro 4,000,000	CB, TS	Improving the solid waste management system in the city of Amman
2019	The rehabilitation and expansion of Al-Shaer Waste Transfer Station (WTS)	EBRD/GAM	Loan: JOD 2,500,000 Grant: Euro 3,000,000	TS, TT	To rehabilitate and expand Al-Shaer Waste Transfer Station
2019	The purchase of 25 sweepers to be used in the City of Amman for solid waste services	EBRD/GAM	Loan: JOD 2,400,000 Grant: Euro 3,000,000	TS, TT	To improve the solid waste services in the City of Amman
2020	Awareness raising on solid waste management practices	EBRD/GAM	Grant: Euro 500,000	CB	Capacity building and awareness raising on solid waste management practices

CB= Capacity Building, TS= Technical Support, TT= Technology Transfer, F= Finance

Table C.5: Support Received for Transport Sector (2015-2020)

Timeframe	Project	Donor/Implementing Entity	Total budget	Type of Support	Project objective
2010/2015-2021	Amman Bus Rapid Transit	AFD/GAM	Loan: USD 166,000,000	CB, TS, TT	To provide high-quality public transport by encouraging mode shift from private cars to public transport.

CB= Capacity Building, TS= Technical Support, TT= Technology Transfer, F= Finance

Table C.6: Support Received for Industrial Sector (2015-2020)

Timeframe	Project	Donor/Implementing Entity	Total budget	Type of Support	Project objective
2015-2020	Mediterranean Transfer of Environmentally Sound Technology III (MED TEST)	EU Commission/ MIT & MoEnv	Grant: Euro 1,500,000	CB, TS, TT	The project is part of the EU Switch-MED program on enhancing sustainable consumption and production /circular economy themes with coordination of the Jordanian industries.

CB= Capacity Building, TS= Technical Support, TT= Technology Transfer, F= Finance

Table C.7: Support Received for Water and Wastewater Sector (2015-2020)

Timeframe	Project	Donor/Implementing Entity	Total budget	Type of Support	Project objective
2012-2018	Climate Adaptation: Hydrological Monitoring System	KFW/MWI	Loan: Euro 6,400,000	TS, TT	Strengthening of the hydrological and meteorological monitoring system
2013-2019	Climate Change Mitigation in the Wastewater Sector	KFW/ MWI	Loan: Euro 20,000,000	TT	Mono landfill at Samra WWTPs and sludge management in part of the WWTP in the north: biogas digester in two WWTPs
2014-2020	Adaptation to Climate Change in the Water Sector	KFW/ MWI	Loan: Euro 20,000,000	TT	
2014-2020	Consulting measures for Adaptation to Climate Change in the Water Sector	KFW/ MWI	Grant: Euro 1,500,000	TS	

2014-2017	ACCBAT- Adaptation to climate change through improved water demand management in irrigated agriculture by introduction of new technologies and best agricultural practices.	ENPI CBC Med Program/MWI	Grant: Euro 829,000	TS, CB	The project aimed to promote balance between supply and demand by stabilizing water demand through the reduction of water losses and promoting development and sustainable use of non-conventional water resources mainly in agriculture.
2014-2019	Improved Water Resources Security for Low Income Rural and Urban Communities	EU Commission / MWI	Grant: Euro 6,500,000	CB, TS, TT	Enhance re-use of treated wastewater for farmers.
2015-2020	Reduce vulnerability in Jordan in the context of water scarcity and increasing food energy demand	Swiss Agency for Development and Cooperation (SDC)/ MWI	Grant: Euro 2,216,267	CB, TS, TT	Reduce vulnerability of the rural Jordanian in the context of water scarcity for agriculture, increased demand for food and livelihood provision from growing population and increasing energy demand.
2016-2020	Improved access to water, water distribution performance and related sewerage disposal in Irbid Governorate for host communities and Syrian refugees	EU Commission / MWI	Grant: Euro 40,000,000	CB, TS, TT	Develop water and wastewater services in host communities.
2017-2019	Resilience and Water Optimization in Communities Hosting Syrian Refugees and Vulnerable Jordanians	SDC/ MWI	Grant: Euro 1,300,000	CB, TS	This project aimed to increase water use efficiency as a response to scarce water resources through rehabilitation and upgrade of water networks in two villages and of water and sanitation facilities in households.
2017-2020	Climate Protection in the wastewater sector - ACCBAT measures	KFW/ MWI	Loan: Euro 3,000,000	TS	Support to Yarmouk Water Company (YWC) in operation of WWTP

2018-2019	Aqaba Flash Flood Mitigation Measures and Early Warning System	SDC/ MWI	Grant: Euro 420,000	CB, TS	To support ASEZA and their operational arm Aqaba Development Corporation (ADC) in mitigating the threat of flash floods.
2019-2022	Water Companies for Climate Mitigation, WaCCliM	BMU-GIZ/ MWI	Grant: Euro 400,000	CB, TS, TT	Working with water utilities to reduce their carbon emissions throughout the whole cycle (abstraction, distribution, collection and wastewater treatment).
2019	Climate Resilient Water Safety Plan in Wadi Heidan	UNICEF/ MWI	Grant: Euro 200,000	CB, TS	To support Miyahuna Company on implementing the Climate Resilient Water Safety Plan in Wadi Heidan
2019-2024	Adaptation to climate change in the water sector II	KFW/ MWI	Loan: Euro 25,000,000	TT	Irrigation infrastructure rehabilitation i.e., irrigation networks, reservoirs and water conveyors.
2019-2024	Consulting measures for Adaptation to Climate Change in the Water Sector II	KFW/ MWI	Grant: Euro 1,500,000	TS	Consulting measures for the Adaptation to Climate Change in the Water Sector Project II.

CB= Capacity Building, TS= Technical Support, TT= Technology Transfer, F= Finance

Table C. 8: Support Received for Vulnerable Communities (2015-2020)

Timeframe	Project	Donor/Implementing Entity	Total budget	Type of Support	Project objective
2015-2025	Special Fund for Emergency and Rehabilitation Activities (SFERA). Revolving Fund Component Needs Assessment and Program Development Window	Multilateral/FAO	300,000 USD	CB, TS, TT	Building the resilience and livelihood of Syrian refugees and Jordanian host community in climate smart agricultural practices to achieve food security
2017	Improving household food security and access to livelihoods. Food production and processing by Syrian refugees and vulnerable host community households.	FAO	270,000 USD	CB, TS, TT	Building resilience of Syrian Refugees and Jordanian host community in climate smart agricultural practices to achieve food security.

CB= Capacity Building, TS= Technical Support, TT= Technology Transfer, F= Finance

Table C. 9: Support Received for Urban Planning (2015-2020)

Timeframe	Project	Donor/Implementing Entity	Total budget	Type of Support	Project objective
2018-2022	A Systematic Approach to Sustainable Urbanization and Resource Efficiency in Greater Amman Municipality (SURE)	GEF-UNDP/GAM	Grant: USD 2,640,000 UNDP: USD 100,000	CB, TS, TT	To assist GAM to improve the quality of life for its citizens and comply with the National Energy Efficiency Action Plan (NEEAP) by targeting low-carbon interventions related to municipal buildings and street lighting.
2018-2021	Sustainable Inclusive, Evidence Based National Urban Policies in Selected Arab Countries.	United Nations Department of Economic and Social Affairs (UNDESA)/ UN-Habitat	Grant: USD 451,000	CB, TS	To strengthen capacities of policy-makers for more informed, sustainable and inclusive National Urban Policies (NUP) leading to mainstreaming of climate change.

2020-2021	Strengthening the social stability and resilience of vulnerable Jordanian communities and Syrian refugees in Amman against flash flood	Government of Japan/ UN-Habitat	Grant USD 978,709	CB, TS, TT	To strengthen the government and the community resilience to better manage flash flood, including implementation of infrastructure.
2021-2025	Increasing the Resilience of both Displaced Persons and Host Communities to Climate Change-Related Water Challenges in Jordan and Lebanon	Adaptation Fund / Ministry of Environment, Ministry of Water and Irrigation; Line departments in municipalities; UNICEF and NGO partners	Grant USD 13,973,509	TS, TT, F	To better respond to climate change impacts and vulnerabilities in the context of the Syrian crisis in Jordan and Lebanon. This is done by demonstrating what concrete adaptation measures respond to the needs of both DPs and host communities, and especially women and youth, while avoiding any tension over resources and employment opportunities.

CB= Capacity Building, TS= Technical Support, TT= Technology Transfer, F= Finance

Table C.10: Support Received for Multi-sector Projects (2015-2020)

Timeframe	Project	Donor/Implementing Entity	Total budget	Type of Support	Project objective
2016-2020	Increasing the resilience of poor and vulnerable communities to climate change	Adaptation Fund / Ministry of Planning and International Cooperation	Grant: USD 9,226,000	TS, TT, F	To develop the sustainability of wastewater reuse activities and on-farm integrated agriculture in Wadi Mousa as a mean of climate change adaptation.

CB= Capacity Building, TS= Technical Support, TT= Technology Transfer, F= Finance

Table C.11: Support Received for Agriculture-sector (2015-2020)

Timeframe	Project	Donor/Implementing Entity	Total budget	Type of Support	Project objective
2021-2028	Building resilience to cope with climate change in Jordan through improving water use efficiency in the agriculture sector (BRCCJ)	Adaptation Fund / FAO	Grant: USD 25,000,000	TS, TT, F	The project will have three interrelated components: Climate Resilient Water Systems for enhanced water security; Climate Change resilience for Enhanced Livelihoods and Food Security; and Scaling-up climate adaptation into policy and across actors (institutions, private sector, civil society).
2022	Increase the resilience of the Jordanian vulnerable communities through the "*Sustainable Production and Utilization of Agro-natural Resources (SPUAR*)	The Government of Italy, FAO and the Ministry of Agriculture	Italian Agency for Development Cooperation (AICS) Grant not defined yet	TS, TT, F	To support the agriculture sector and sustainable management of natural resources. It targets vulnerable communities and their access to socio-economic infrastructures in the governorate of Ma'an
2018	Building Resilience to Cope with Climate Change in Jordan Using the Water-Agriculture-Energy Nexus Approach	GCF / UNDP, FAO, and Ministry of Environment	Grant: USD 50,000,000	TS, TT, F	1) To strengthen social resilience to climate change through investments in social development programs; 2) To strengthen ecological resilience of agricultural systems through ecosystem-based management, adoption of agro-ecology and sustainable land management; and 3) To enhance the enabling environment of policy, regulatory and institutional setup in support of mitigation and

					adaptation to climate change.
2021	Integrated Low Emission Approach for Efficient Use of Reclaimed Wastewater in the Agricultural Sector in Jordan	GCF / Ministry of Environment, Ministry of Water and Irrigation and The International Union for the Conservation of Nature	Grant: USD 9,460,000	TS, TT, F	To use the treated water for agriculture purposes. A key issue is to see how water needs can be met by balancing demands for agriculture without drying up river flows. This project will develop an integrated low-emission water management approach for the efficient use of reclaimed wastewater.

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