Kuwait National Adaptation Plan 2019-2030

Enhanced Climate Resilience to Improve Community Livelihood and Achieve Sustainability

Environment Public Authority

Kuwait, 2019

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FOREWORD

Climate change is one of the main obstacles to human development at the present, and the fact that climate change is a global phenomenon, the risk of climate change is not confined to a specific place or who is responsible of emitting greenhouse gases, but beyond it to affect all mankind. where it affects different sectors in different ways and vary from place to another with its severity and the negative Impacts that cause it. The State of Kuwait is not an exception, as it is affected by climate change like other countries of the world, especially in the various vital and environmental sectors such as human health, coastal areas, water resources, marine environments and fisheries.

Climate change in arid areas is accompanied by a range of natural hazards associated with the sequential dynamics between humans, the environment and climate change, which has affected and still affecting the livelihoods of the populations throughout history. However, with the increasing Negative Impacts associated with climate change, it is necessary to increase our capacity to adapt to these changes by increasing resilience and flexibility these global challenges. Adapting to the challenges of climate change is the core of the challenge facing Kuwait and its people / inhabitants.

Kuwait is one of the countries that are most affected by the negative Impacts of climate change, especially those that climate change contributes in causing or increasing them, such as heatwaves, rainstorms and other rapid floods, as well as the increase in the number and intensity of dust storms and the rise of Sea level and the and consequent impacts on infrastructure projects and future long-term investment.

Climate change is the fundamental problem affecting natural resources, especially in arid, semi-arid and dry sub-humid areas. The key factor in the increase climate change negative Impacts is the interaction between natural and man-made factors, which is universally known as global warming. This reaffirms the need for international commitment to combat climate change and build national capacities to adapt to climate change. and concluded that this problem is not restrained to political boundaries but is rather mostly felt by countries that are the most vulnerable and are not equipped to face climate changes, even if they did not cause climate change .Therefore, the United Nations Framework Convention on Climate Change (UNFCCC) was created as a major international effort to halt climate change and increase the resistance to its negative impacts.

As a result of the State of Kuwait's commitment to preserve the local and regional environment, the Environment Public Authority (EPA) has developed The National Adaptation Plan. Which include medium and long-term strategies to increase strength and resilience in the face of climate challenges and to increase national capacity to adapt to climate change. It also includes a description of the environment's state and the most important sectors affected by climate change and a climate change risk assessment. In addition, an index of the vulnerability of sectors has been developed according to internationally approved scientific methodologies. On this basis, a sequential hierarchy approach was used to determine the socio-economic impacts of climate change risks. And the main material risks of the key sectors were also identified. Accordingly, stakeholders were identified according to each sector and the consequent risks.

The Government of Kuwait, represented by the Environment Public Authority (EPA), has committed itself to ensure the implementation of its National Adaptation Plan (NAP), in partnership with other governmental and non-governmental institutions, furthermore A national coordination mechanism has been identified to implement a range of national initiatives to protect the various vital sectors from the Negative impacts of climate change. Therefore, future programs have been developed to deal with the various risks face the sectors and across time periods.

Despite the difficulty of dealing with the risks of climate change due to its complexity and impacts on more than one sector, A sustainable program have been proposed to increase resilience and build national capacities to address the risks and negative impacts of climate change. The proposed programs are related to the four vital sectors focus on management practices, functional practices, technical practices, land use planning, water management, human health protection and identification of short, medium- and long-term initiatives to adapt to climate change.

One of the expected results is a comprehensive ongoing monitoring program through the necessary environmental data and information to monitor climate change and assess its impact on the State of Kuwait on an ongoing basis, In partnership with all stakeholders such as the academia, private sector and non-governmental actors in the areas of adaptation to climate change.

The implementation of the NAP is not the responsibility of EPA alone. Where Adaptation to climate change requires the work of all stakeholders and integration in the design and implementation of initiatives in several sectors, including water, coastal areas, the marine environment, human health and others. Therefore, EPA will seek technical assistance from international organizations, industrial community and other stakeholders to implement the proposed programs to adapt to climate change and reduce the side effects associated with socio-economic problems. This will be achieved in the manner of implementing the national plan which is based on participation, while maintaining the coordination and oversight role of the EPA in the various activities and initiatives that aim to reach the desired goal to reduce the Negative impacts of climate change and adopt with it.

I would like to take this opportunity to express my sincere gratitude and appreciation to all local and international experts and national institutions who have worked together in a participatory manner to develop an action plan that meets the actual needs of the local environment and the needs of the State of Kuwait. I hope that this plan will be a cornerstone in the policy framework of reducing the risks of climate change and increasing the resilience towards it, continuously, for the benefit of present and future generations.

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The contributors would like to take this opportunity to express appreciation to everyone who supported developing this National Adaptation Plan (NAP) in Kuwait. We are thankful to them for sharing information and knowledge which enriched and helped consolidate this document. This NAP will be a driving force that will lead the efforts in addressing Climate Change in Kuwait and furthermore implementing initiatives in several sectors. This NAP was prepared under the Kuwait Environmental Governance Initiative (KEGI) funded by the General Secretariat of the Supreme Council for Planning and Development in Kuwait (GSSCPD) and coordinated by United Nations Development Programme (UNDP), implemented by UN Environment in close collaboration with Kuwait Environment Public Authority (KEPA).

ABBREVIATIONS AND ACRONYMS

ASA	Annual Statistical Abstract
AQMIS	Air Quality Management Information System
BOT	Build-Operate-Transfer
BUR	Biennial Update Report
CIS	Coastal Information System
CMP	Coastal Management Program
CVA	Climate Vulnerability Assessment
CVI	Climate Vulnerability Index
eMISK	Electronic Environmental Monitoring Information System of Kuwait
EPA	Environmental Protection Authority
EPC	Environmental Pollution and Climate Program
FAO	Food and Agricultural Organization
GCC	Gulf Cooperation Council
GDI	Gender Development Index
GEF	Global Environmental Facility
GHG	Greenhouse Gases
GII	Gender Inequality Index
GIS	Geographical Information System
GNI	Gross National Income
GPD	Gross Domestic Product
HDI	Human Development Index

HFC	Hydrofluorocarbon
ICZM	Integrated Coastal Zone Management
IPCC	Intergovernmental Panel on Climate Change
IWPP	Independent Water and Power Project
KEPA	Kuwait Environment Public Authority
KEPS	Kuwait Environmental Protection Society
KFAS	Kuwait Foundation for Advancement and Science
KIA	Kuwait International Airport
KIEMS	Kuwait Integrated Environmental Management System
KISR	Kuwait Institution for Scientific Research
KUNA	Kuwait News Agency
KWD	Kuwait Dinar
MCM	Million Cubic Meters
MDGs	Millennial Development Goals
MEED	Middle East Economic Digest
MEW	Ministry of Electricity and Water
MGD	Millions of Gallons per Day
MIT	Massachusetts Institute of Technology
MODIS	Moderate Resolution Imaging Spectroradiometer
MPW	Ministry of Public Works
MSF	Multi-Stage Flash Desalination Unit
MSW	Municipal Solid Waste
NAP	National Adaptation Plan

NBK	National Bank of Kuwait
OPEC	Organization of Petroleum Exporting Countries
PA	Protected Agriculture
PAAFR	Public Authority for Agricultural Affairs and Fish Resources
PACI	Public Authority of Civil Information
PFC	Perfluorocarbon
PIC	Prior Informed Consent
PRB	Population Reference Bureau
RCP	Representative Concentration Pathway
RO	Reverse Osmosis
ROPME	Cooperation on the Protection of the Marine Environment
SDGs	Sustainable Development Goals
SDSS	Spatial Decision Support System
SEA	South East Asia
SLR	Sea Level Rise
SNC	Second National Communication
SST	Sea Surface Temperature
TDS	Total Dissolved Solids
TSE	Treated Sewage Effluent
TSE	Total Sewage Effluent
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme

UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
WEAP	Water Evaluation and Planning
WHO	World Health Organization
WRDM	Water Resources Development and Management Program
WWI	World War I
WWTP	Waste Water Treatment Plant

EXECUTIVE SUMMARY

Background

Climate change has become the most common threat to human development and adapting to climate change is becoming an essential component of any planning processes, at any time and at all levels. The Kuwait Environment Public Authority together with the UN Environment and United Nations Development programme launched a national initiative in 2017 aimed at designing a National Adaptation Plan (NAP) to enhance national adaptive capacity and resilience to reduce vulnerability to the impacts of climate change. In Kuwait, coastal zones and marine life and fisheries are the most sensitive sectors to climate change and its induced disasters.

This report forms part of the country's activities to comply with international environmental agreements. It includes analysis of baseline scenarios and analysis of projected scenarios and their impact on specific sectors in the country. The report represents guidelines of the national actions needed to adapt to climate change in Kuwait. The objectives of establishing the NAP process in Kuwait are to build an adaptive plan with capacity and resilience that can reduce vulnerability to the climate change impacts and facilitate and integrate the adaptation of climate change into policies, programs, and activities, within all national relevant sectors.

Methodology

The methodology included the analysis of existing data, literature review, and GIS modeling to define the impact of climate change on the selected sectors. Following the United Nations Framework Convention on Climate Change (UNFCCC) guidelines, Different decision support tools were proposed to evaluate the future climate change impact on Kuwait. The NAP process comprises four main elements that can be summarized as follows 1. laying the groundwork and identifying gaps; 2. making preparatory elements; 3. implementation strategies and; 4. reporting, monitoring and reviewing. The methodology used in this Action Plan focuses on the real planning activities, which are comprised of elements A and B of the NAP process.

National circumstances

To understand how climate change will affect Kuwait, a holistic view of the state's national circumstances is needed. Kuwait is a dry tropical and sub-tropical desert with a hyperarid climate and summers and winters in Kuwait have significant temperature differences. Due to the arid climate, it is nearly impossible for the soil to form, and strong wind erosion also limits soil formation. Due to its climate, Kuwait suffers from a scarcity of conventional fresh water, groundwater replenishing is even scarcer due to how dry the soil is and the infamous evaporation rate. The Gulf is however rich in vibrantly colonies of coral reefs with fish, sea turtles, sharks, dolphins, and whales swimming in its waters and Kuwait is also the home of many plants and animal species.

Climate hazards and vulnerability analysis

Kuwait NAP was set based on a Climate Vulnerability Assessment (CVA) and a Climate Vulnerability Index (CVI) at strategy level targeting the main four sectors identified in Kuwait Second National Communication Report to the United Nations Framework Convention on Climate Change (SNC). Those sectors are **marine life and fisheries, water resources, coastal zones,** and **human health.** Kuwait CVA's objectives are to identify and understand historical and projected climate risks at the country level, to evaluate sectoral climate risks to inform sector planning, and to identify gaps for conducting climate vulnerability index.

Climate projections such as increased temperatures will put pressure on Kuwait's **water resources** with increased demand for drinking water, which will put more pressure on the groundwater. Extreme weather, such as drought or flood, will affect **human health**, with an increased rate of respiratory diseases and injuries due to weather conditions. **Coastal areas** in Kuwait will face the destruction of infrastructure, due

to risen sea levels, along with corrosion of beaches and negative affected marine resources. Raising temperatures and sea levels will also impact the **marine life and fisheries** through coral bleaching, fish migration and disturbance in microplankton.

Results showed that increased sea-surface temperature risk has the greatest impact on marine life and fisheries sector with 5 points out of 5 in the ranking of climate change risks and vulnerability analysis. This is followed by the increased salinity and inundation of low-lying areas and their impacts on the marine life and fisheries and the coastal zones with 4.35 point each, followed by the risks of increased air temperature and its impact on water resources sector with 4.25 point.

Coordination of Adaptation Actions

As part of the NAP process, a stocktaking of the past and on-going climate change adaptation projects and initiatives that have been implemented in the State of Kuwait was prepared. Kuwait has implemented several projects to adapt to climate change in the water resources sector. The adaptation to climate change in the public health sector is one of the most critical sectors for Kuwait and the nation has undertaken some adaptation projects within this sector. Many projects investing in the agriculture sector are also taking place in Kuwait in addition to introducing new varieties of crops that can adapt to high temperatures and have high resistance to salinity and drought.

Adaptation action plan

Kuwait has implemented key adaptation measures to cope with climate change impacts, however, there are still major gaps and still more to do in all sectors. Within the **fisheries and the marine sector,** there is a lack of integration into adaptation and development plans and projects in Kuwait to help in meeting the local food security requirements as well as the absence of a strategic adaptive framework capable to respond to the emergency situations and hazardous crises. The major gaps in the **water sector** are poor water resources management and the lack of modern technologies, along with absence in information, studies, and knowledge. Within the **coastal zone sector,** the major gaps have been identified as the lack of restrictions, legislation, and policies in addition to inadequate communication. Finally, the major gaps within the **health sector** are insufficient climatic information which results in lack of awareness along with a lack of financial and physical capacities in Kuwait.

A set of adaptation measures are proposed in the NAP. These were divided into three categories; short-term initiatives to be implemented in less than a year; medium term-initiatives to be implemented in three years, and long-term initiatives those need three to five years to be accomplished. In total, 56 initiatives were proposed as follows; 21 short-term initiatives, 18 medium-term initiatives, and 17 long-term initiatives. The marine life and fishers' sector required the highest number of initiatives; 16, followed by the water resources sector with 15 initiatives, then the coastal areas sector with 13 initiatives and finally the human health sector needed 12 initiatives.

The important conclusions that can be drawn from the analysis are the high level of interest at the national level to enhance national and sectoral capacities to adapt to climate change and its induced disasters. The climate change and the variations among years, the high vulnerability of four main sectors and the adverse impacts of the different climate change scenario are of high concerns to decision-makers in the country. Therefore, the report had included many recommendations for adaptation at sectoral and national levels. In summary, the Action Plan recommends the preparation of sectoral action plan for adaptation with emphasis on the four main sectors. Mobilization of financial resources, therefore, is urgently needed for technology transfer and for implementing the proposed adaptation measures.

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CHAPTER 1: INTRODUCTION

1.1. Background

Climate change has become the most common threat to human development. Global climate change-induced disasters, such as increases in global temperatures, drought, flash floods, and sea levels rise, became sensible threats to human settlements and natural environments in recent decades. The Fifth Assessment Report of Inter-governmental Panel on Climate Change (IPCC) revealed that these global climate change aspects would have multi-directional impacts on anthropogenic and natural features at global, regional and local scales (IPCC, 2014). These impacts are expected to be severe in developing countries, especially those that extend in arid and semi-arid environments where the ecosystems are highly vulnerable (Lioubimtseva & Henebry, 2009).

Climate change has occupied a front seat and a major challenge to our planet. This necessitated adaptation plans for climate change to become a top of the list essential component of planning at all levels. The Kuwait Environment Public Authority together with UN Environment and UNDP aim at designing a National Adaptation Plan (NAP) with adaptive capacity and resilience to reduce vulnerability to the impacts of climate change. Also, this NAP will strengthen the national capacity of the country to assess climate change policy options and development planning strategies across different sectors and economic activities.

Adaptation can be classified as preventive and reactive adaptation, autonomous and planned adaptation, and private and public adaptation (IPCC, 2007a). The establishment of NAP requires adequate information on risks and vulnerabilities to identify the needs and appropriate adaptation options that can reduce risks and build resilient capacity. It is important to engage stakeholders with different knowledge, experience, and backgrounds

in order to reach a shared approach to addressing the challenges and needs (Preston and Smith, 2009; Tompkins et al., 2010; Fünfgeld and McEnvoy, 2011).

1.2. Purpose and objectives of the UNFCCC

Adaptation is defined as a human-driven change in social, ecological or economic systems or policy processes, in response to a climate stimulus and their potential impacts (IPCC, 2007a). The Intergovernmental Panel on Climate Change (IPCC) has defined adaptation with regards to the ecosystems, human societies and the possible exploitation of the climate change benefits: "Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC, 2007b).

The main objective of the UNFCCC is to "*stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system*."[1] through genuine and collaborative action at all levels, supported by international cooperation and partnership arrangements, in the framework of an integrated approach consistent with Sustainable Development Goals (SDGs), with a view to contributing to the achievement of sustainable development in affected areas.

1.3. The need for National Adaptation Plan (NAP)

Adapting to climate change is becoming an essential component of any planning processes, at any time and at all levels. At the 17th Conference of Parties (COP), of the United Nations Framework Convention on Climate Change, the Convention acknowledged that national adaptation planning enables affected countries, mainly developing and least developed countries, to assess their vulnerabilities, to mainstream climate change risks, and to address adaptation. It also acknowledged the need to address adaptation planning in the broader context of sustainable development planning to enable countries to achieve their millennium development goals (MDGs) and more recently the sustainable development goals (SDGs). Hence, the COP established the national adaption plan (NAP) process to facilitate effective adaptation planning. Accordingly, the planning for adaptation at the national level should be a continuous,

[1] UNFCCC. Article Number 2. Retrieved 5 January 2019.

progressive and iterative process. It should be based on national priorities with a focus on vulnerable communities and sectors and should be mainstreamed in national strategies, action plans and policies to ensure effective implementation. According to the UNFCCC, COP 17th, the main objectives of these action plan are[2]:

a) *To reduce vulnerability to the impacts of climate change, by building adaptive capacity and resilience;*
b) *To facilitate the integration of climate change adaptation, in a coherent manner, into relevant new and existing policies, programmes and activities, in particular, development planning processes and strategies, within all relevant sectors and at different levels, as appropriate.*

Accordingly, the NAP shall incorporate long-term strategies, within the national policies for sustainable development, to adapt to climate change. It is also expected that NAP should enhance national climatological, meteorological and hydrological capabilities and the means to contribute to climate change-induced disasters early warning. It should promote policies and strengthen institutional frameworks which develop cooperation and coordination, in a spirit of partnership between the government, local populations, and community groups and facilitate access by local populations to appropriate information and technology. As a participatory approach, NAP is expected to provide effective participation at the local, national and regional levels of non-governmental organizations and local populations, both women and men, particularly resource users in policy planning, decision-making, and implementation and review of the NAP; and require regular review of, and progress of implementation.

1.4. Climate Change

Despite the different debates in definition and causes of climate change, the term "*Climate Change*" was used to indicate any change in the climate over time, whether due to natural variability or as a result of human activities. The most widely accepted definition of climate change, climate variability, adaptation, resilience, and vulnerability come from the IPCC Fourth Assessment Report (2007) as:

[2] Decision 5/CP.17, paragraph 1.

Climate change Refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC AR4, 2007).

Climate variability Variations in the climate (as measured by comparison with the mean state and other statistics such as standard deviations and statistics of extremes) at all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability) or to variations in natural or anthropogenic external forcing (external variability) (IPCC AR4, 2007).

Adaptation human-driven adjustments in ecological, social or economic systems or policy processes, in response to actual or expected climate stimuli and their effects or impacts (LEG, 2011). Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC Fourth Assessment Report (AR4), 2007).

Resilience The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change (IPCC AR4, 2007).

Vulnerability The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity. Therefore, adaptation would also include any efforts to address these components (IPCC AR4, 2007).

These definitions are widely used in all development, humanitarian and research work related to climate change adaptation and mitigation. As included in the UNFCCC work and IPCC reports, the problems of climate change are mainly affecting developing and least developed countries.

1.5. National Adaptation Plan in Kuwait

This document represents guidelines of the national actions needed to adapt to climate change in Kuwait. The overall objective of the National Adaptation Plan (NAP) is to *provide an integrated development plan and subsequent programmes targeting local communities and environmental components in areas under the threat of climate change*. The NAP is prepared in accordance with the UNFCCC directives and articles and includes a detailed survey of the environment and the most affected areas and sectors in climate change, detailed analysis pertaining to climate change vulnerability, and gaps in each sector to adapt to climate change. Subsequently, programmes and projects are to be initiated in the short term and in the long term to adapt to climate change in the country. The programmes form integrated strategies and plans for sustainable development under the threat of climate change.

1.6. Process and methodology of establishing the NAP

The key frameworks for implementing adaptation actions are Action Programmes. The convention calls upon affected countries to develop National Adaptation Action Plan (NAP) with the full participation in the process of all parties with a stake in the issue of climate change. The proposed projects and programmes need to reflect the factors that contribute to climate change as well as generate practical solutions to adapt to its consequences. The convention also calls for the building of partnership at national, regional and global levels as well as for the development of innovative resource mobilization strategies and well-structured effective implementation plans.

The United Nations Framework Convention on Climate Change (UNFCCC) has produced technical guidelines to support the NAP process in the Least Developed Countries. The process aims to assist in reducing the vulnerability to the impacts of climate change and to address adaptation options (UNFCCC, 2012).

The UNFCCC technical guidelines for the national adaptation plan process is proposed to be followed in the preparation of the NAP process framework and roadmap. The main objectives of establishing the NAP process in Kuwait are to:

a) build an adaptive plan with capacity and resilience that can reduce vulnerability to the climate change impacts; and

b) facilitate and integrate the adaptation of climate change into policies, programs, and activities, in specific development planning strategies and processes, within all national relevant sector.

The process of NAP preparation in Kuwait was based on the following principles:

- The NAP preparation was based on the "Second National Communication Report to the UNFCCC", in which the country's vision is clearly reflected and the main sectors affected by climate change are identified,
- The NAP was processed in a well-designed time frame following the UNFCCC NAP preparation guidelines which were also tailored whenever and wherever needed. Moreover, the innovative projects have been formulated based on priorities determined throughout the SNC process in order to maintain credibility with affected sectors,
- The international knowledge and know-how in climate change adaptation were utilized by involving key international experts in NAP development and finalization. National experience in climate change adaptation was also integrated by involving a few national experts in the NAP development,
- National consultations at different levels were undertaken to identify main stakeholders, build long-term commitment, mobilize support and to create a consensus for action.
- Several national consultation meetings and workshops were held as part of the consultative mechanism to enable various interest groups to reach consensus on how to proceed with the NAP, which priorities to address, and in what order. The stakeholders' involvement workshops included extensive consultation with all key stakeholders

at all levels and from different sectors to ensure the involvement of all sectors' representatives.

The NAP process defined by the UNFCCC comprises four main elements that can be summarized as follows:

(A) laying the groundwork and identifying gaps;
(B) making preparatory elements;
(C) implementation strategies and;
(D) reporting, monitoring and reviewing.

Elements A and B are the main skeletons of the NAP, while elements C and D are implementation post plan stages (UNFCCC, 2012). This UNFCCC framework can be customized according to the specific situation and requirements of the State of Kuwait as shown in Figure 1 highlights the detailed steps of each element.

FIGURE 1: PROPOSED NAP PROCESS ACCORDING TO UNFCCC

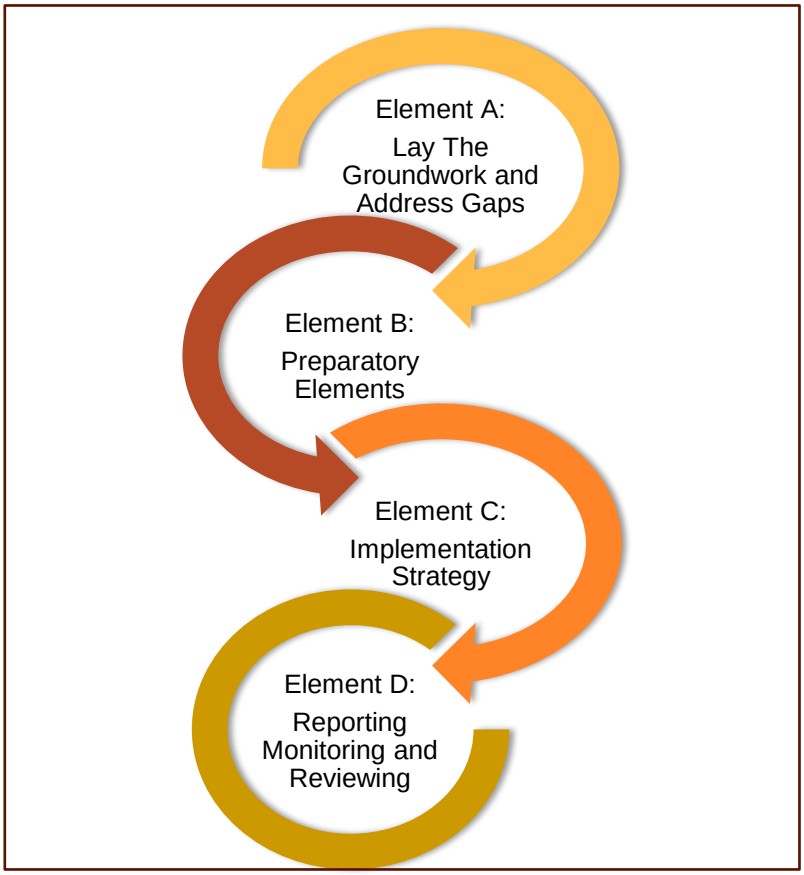


TABLE 1: NAP PROCESS ACCORDING TO UNFCCC[3]

Item	Description
Element A: Lay the groundwork and address gaps	
A.1	Initiating and launching the NAP process
A.2	Stocktaking: identifying available information on climate change impacts, vulnerability and adaptation and assessing gaps and needs of the enabling environment
A.3	Addressing capacity gaps and weaknesses in undertaking the NAP process
A.4	Comprehensively and iteratively assessing development needs and climate vulnerabilities
Element B: Preparatory elements	
B.1	Analyzing current climate and future climate change scenarios
B.2	Assessing climate vulnerabilities and identifying adaptation options at sector, subnational, national and other appropriate levels
B.3	Reviewing and appraising adaptation options
B.4	Compiling and communicating national adaptation plans
B.5	Integrating climate change adaptation into national and subnational development and sectoral planning
Element C: Implementation strategy	
C.1	Prioritizing climate change adaptation in national planning
C.2	Developing a (long-term) national adaptation implementation strategy
C.3	Enhancing capacity for planning and implementing adaptation
C.4	Promoting coordination and synergy at the regional level and with other multilateral environmental agreements

[3] Source: UNFCCC, 2012

Element D: Reporting, monitoring and reviewing	
D.1	Monitoring the NAP process
D.2	Reviewing the NAP process to assess progress, effectiveness, and gaps
D.3	Iteratively updating the national adaptation plans
D.4	Outreach on the NAP process and reporting on progress and effectiveness

These four elements can be summarized as follows:

- **Laying the groundwork and identifying gaps:** A pre-planning stage of NAP process. It covers three major areas: (1) initiating and launching NAP process; (2) stocktaking and synthesizing the available information and data on climate change impacts, vulnerability, adaptation in addition to assessing gaps and needs of the enabling environment (3) addressing capacity gaps and weaknesses in undertaking the NAP process.
- **Making preparatory elements:** This is the planning stage of the NAP process. Planners must identify the suitable methodological framework for respective countries considering the ground realities in respective countries. However, UNFCCC emphasizes the necessity of extensive consultation of relevant stakeholders in the planning stage.
- **Implementation strategies:** This is a post-planning stage that deals with implementing the selected interventions of the action plan. However, essential aspects of implementation strategy should be laid down in the plan itself with necessary flexibility for adjusting unforeseen changes that may come up in the future.
- **Reporting, monitoring and reviewing:** The final post-planning stage of NAP process deals with the monitoring of the implemented activities of the plan. However, mechanisms for reporting, monitoring and reviewing the progress of the plan shall be set. These mechanisms aim at reviewing the progress and iteratively updating the plan according to the unforeseen changes.

1.7. Kuwait Methodology

The methodology used in this report focuses on the real planning activities, which are comprised of Elements A and B of the NAP process, they include (a) initiating and launching NAP process; (b) stocktaking and synthesizing the available information and data on climate change impacts, vulnerability, adaptation in addition to assessing gaps and needs of the enabling environment, (c) addressing capacity gaps and weaknesses in undertaking the NAP process, (d) analyzing current climate and future climate scenarios; (e) assessing vulnerabilities; (f) identifying, reviewing and appraising adaptation options and (g) compiling and communicating national adaptation plan.

This methodology aims at covering the main elements of the NAP as summarized in Table 2.

TABLE 2: METHODOLOGY FOR THE NAP PROCESS IN KUWAIT.

Steps	Description
1.	Analyze the major climatic changes in the atmospheric and coastal systems for the State of Kuwait.
2.	Determine the physical impacts and dimensions of these changes accompanied by the major projections.
3.	Assess the main vulnerabilities and risks caused by the determined physical impacts of the projected changes on major sectors of the country.
4.	Estimate the socio-economic outcomes of the changes in the concerned stakeholders and sectors.
5.	Recognize the concerned stakeholder and relevant sectors adaptation needs such as: - Social Needs - Biophysical and Environmental Needs - Institutional Needs - Need for Engagement of the Private Sector - Information, Capacity, and Resource Needs
6.	Promote appropriate adaptation options to fulfill the needs and select the most suitable alternative.

7.	Prioritize the actions required for the implementation of the selected options for fulfilling the national adaptation needs.
8.	Producing a draft of NAP and have the NAP process endorsed by KEPA, then communicate it with the relevant stakeholders at the national level.
9.	Identifying the opportunities and constraints for integrating climate change into the planning process.

Consultations' outputs:

- An agreed upon and clearly-outlined mechanism for coordination among the existing concerned institutions, i.e. all relevant activities and consultations have been overseen by the Government lead agency responsible for climate change,
- Participation of all concerned stakeholders ensured,
- Agreed on and identification of priority areas in which projects are to be formulated and implemented.

Sectors identified in the SNC:

- Water Resources;
- Human Health;
- Coastal Areas; and
- Fisheries and Marine life.

1.8. Road Map Checklist for NAP Process

A proposed checklist for the road map of the NAP Process is prepared to highlight the detailed activities and the expected outputs for each of the four elements of the NAP process. Figure 2 includes the proposed framework for the road map of the NAP Process.

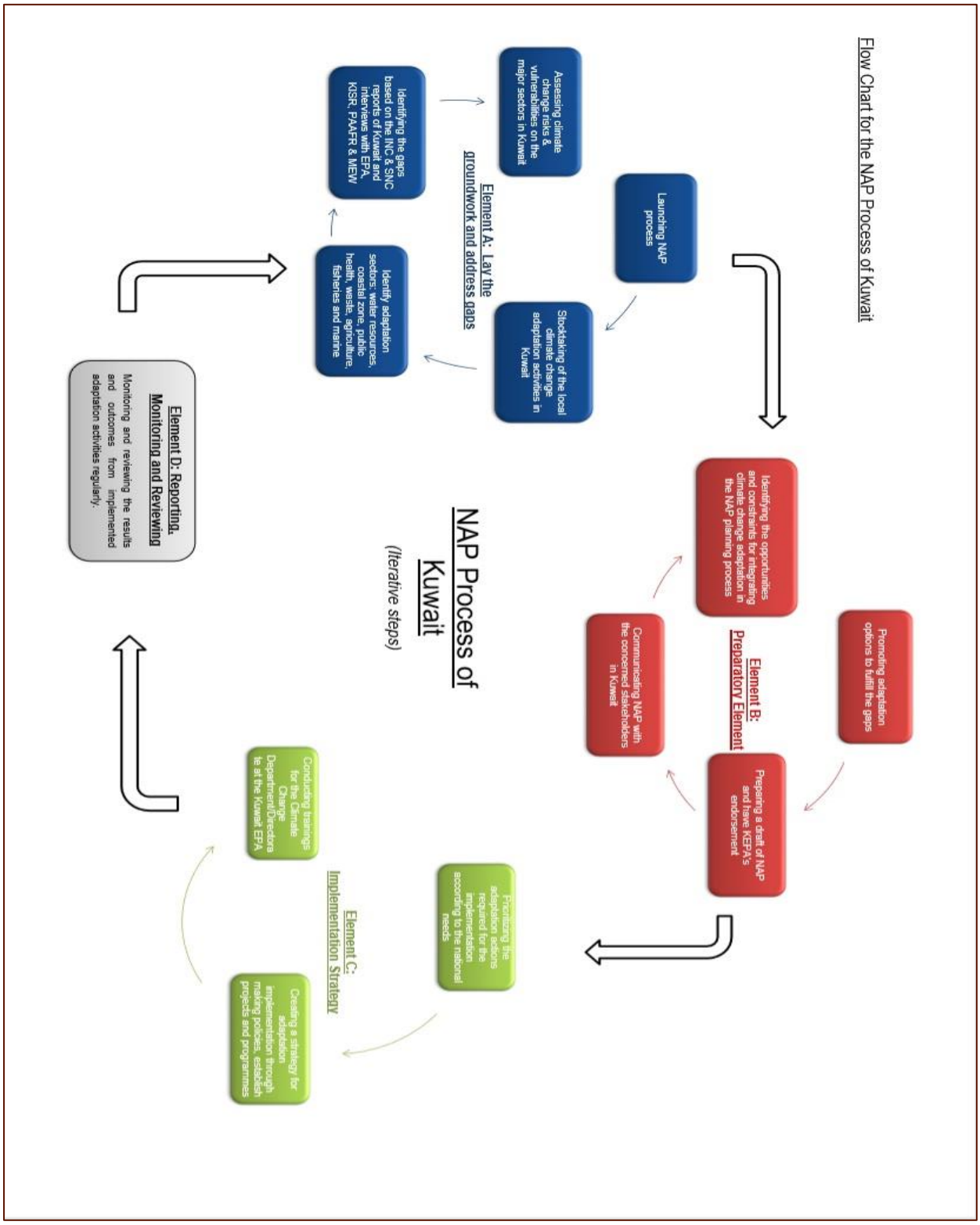


FIGURE 2: THE PROPOSED ROAD MAP OF THE NAP PROCESS IN KUWAIT, MODIFIED AFTER THE PROPOSED UNFCCC METHODOLOGY.

1.9. Structure of the NAP document

The document of the NAP is divided into the following parts:

1. ***Introduction***: The introductory part includes a definition of Climate Change and the need for NAP within the context of the UNFCCC,
2. ***National Circumstances***: This includes a description and brief analysis of the country's climate and natural resources, socio-economic characterization of the country including the demography, economy as well as sectors analysis,
3. ***Climate Hazard and Vulnerability Analysis:*** The main sectors affected by climate change, causes, indicators, and aspects of climate change in the main affected areas have discussed this part of the document,
4. ***Coordination of Adaptation Action:*** This part of NAP summarizes the main environmental laws and by-laws related to climate change. It includes a comprehensive review of all ongoing initiatives in relation to climate change adaptation. Deficiencies and gaps in current legislation are also briefed in this part. A proposed coordination mechanism for the implementation of the NAP is presented based on the comprehensive review and listing of concerned stakeholders, and
5. ***Adaptation Action Plan:*** This part utilizes the previous information in the synthesis of action plan divided into programmes. Listing and justification of programmes and projects are also included in this part.

1.10. Outlook and future objectives

The NAP has benefited and made use of the results and recommendations of previously conducted research and studies related to climate change, mainly the second national communication to the UNFCCC. Monitoring and evaluation of the plan and subsequent impacts of interventions from the different programmes are future objectives and tasks of

the Kuwait Environment Public Authority. This is a very important task as it provides a feedback mechanism for modification of programmes, setting priorities and implementation of activities based on the needs and requirements of local communities in most affected areas.

CHAPTER 2: NATIONAL CIRCUMSTANCES

2.1 Introduction

The abundant marine life has always been prosperous in the shorelines of the Kuwait bay due to the rich silt content in the river systems of southern Iraq, and so humans chose Ras Subiyah; the northern shores of Kuwait Bay, as a place to settle back from the Ubaid period in 6500 BC. It provided a place of interaction between the people of Mesopotamia and Neolithic. Ras Subiyah proved to have the earliest evidence of urbanization in the Arabian Gulf area. Debris of stone walls, tools and the remains of boats link the Ubaids with the Mesopotamians. Early evidence of a large town built and lived in on the Failaka Island by the Dilmun people was also found, and what said to be one of best structures in the Bronze Age, which resembled buildings typical to those found in Iraq at the time.

The discovery of oil in 1937 in Kuwait proved the beginning of another era of prosperity for Kuwait. The large oil reserve was uncovered by the US-British Kuwait Oil Company; however, further investigation was not until after World War II in 1951. Only a year after, Kuwait became the largest oil exporter in the region. Foreign workers started coming into the country for a better standard of living from Palestine, India, and Egypt. Upon its newly acquired independence in mid-1961, Kuwait constructed a new Constitution and became the first state in the Gulf to initiate parliament and constitution.

The state of Kuwait extends in a semi-arid region in the northeastern part of Arabian Peninsula facing the Arabian Gulf with a 495 km border with Saudi Arabia (KEPA, SNC, 2019) (Figure 3) The coastal zone of Kuwait is enriched with biodiversity. For instance, Subkhas[4] extending along the northern coast of Kuwait and considered an ecotone between the terrestrial and marine environments are productive ecosystems that support a number of plant species and other organisms (El-Sheikh, El-Ghareeb, & Testi, 2006). Coral reefs in the southern offshore islands of Kuwait are unique environments that

[4] Subkha is an Arabic word widely used in the scientific documents written in English to refer to coastal salt marshes of inland salt flat. The subakha is one of distinct coastal features in Arabic lands

support various trophic levels. Kuwait islands are indeed fabulous environments where marine and terrestrial organisms interact. The coastal region of Kuwait can be divided based on urbanization into two regions. The northern coastal area that extends from the Kuwait-Iraq border in the north to the northern coast of Kuwait Bay is non-urbanized, but some mega developing projects on this area have already started, such as Mubarak Al-Kabeer Port on Boubyan Island (Al-Gabandi, 2011; Baby, 2014). The middle and southern coastal area of Kuwait that extends from the western and southern coast of Kuwait Bay to the Kuwait-Saudi border in the south is extensively urbanized.

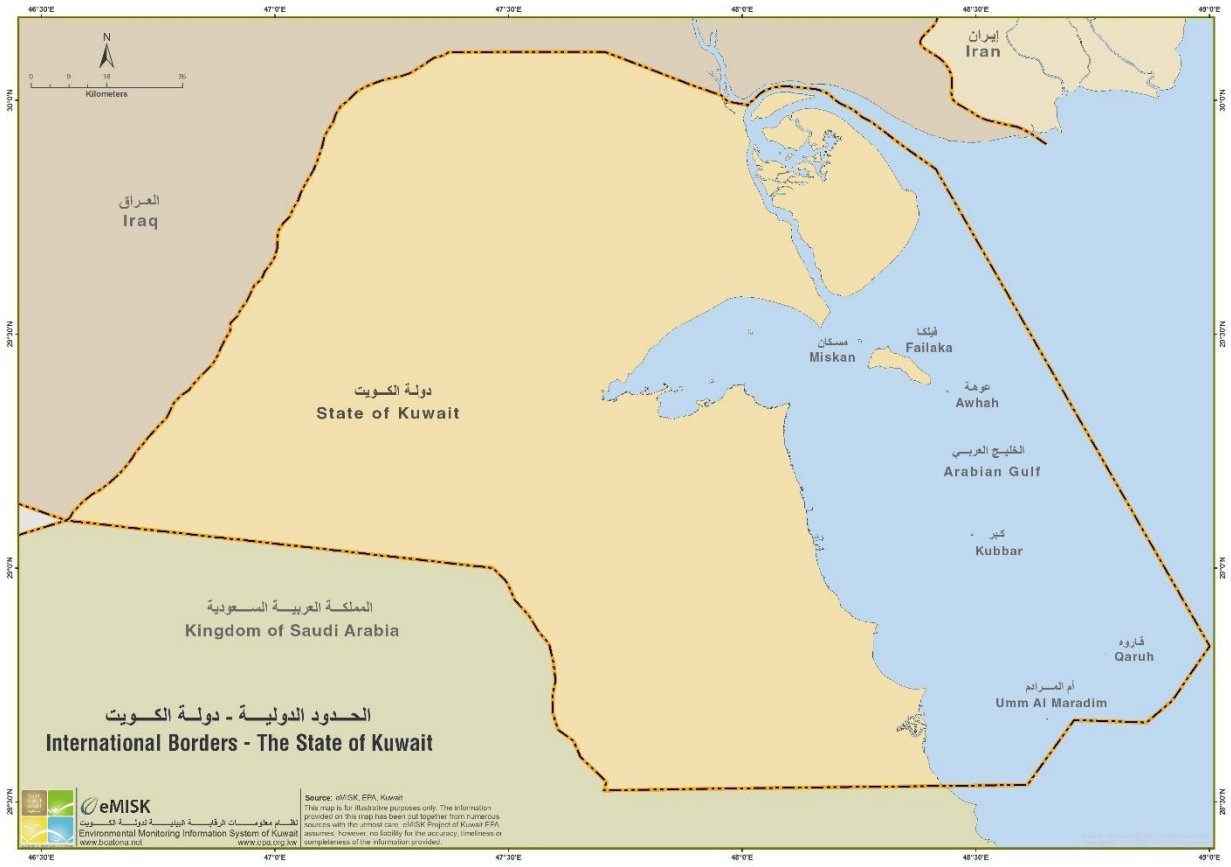


FIGURE 3: THE GEOGRAPHIC LOCATION AND INTERNATIONAL BORDERS OF THE STATE OF KUWAIT

The middle and southern coastal is a very vital area in Kuwait where most of urban, commercial, industrial, and recreational activities are concentrated. The coastal area of Kuwait Bay hosts Kuwait City, the capital, and the main commercial port in Kuwait,

Shuwaikh Port. The southern coast includes residential, commercial and recreational areas, power plants, and desalination stations (Bakri & Kittaneh, 1998).

This urbanized area that lies within only 20 km of coast is settled by most of Kuwait population that reached 3.5 million in 2011 (Annual Statistical Abstract (ASA), 2011). The urban districts of Kuwait have been divided administratively into six governorates (i.e., the capital, Al-Jahara, Hawalli, Al-Farwaniyah, Mubarak Al-Kabeer, and Al-Ahmadi). Most urban districts extend along the coastal zone, from western and southern Kuwait Bay to the southern area of Kuwait, and are home to most of the Kuwaiti population, which in 2011 reached three million people, about two-thirds of them non-citizens (FIGURE 4).

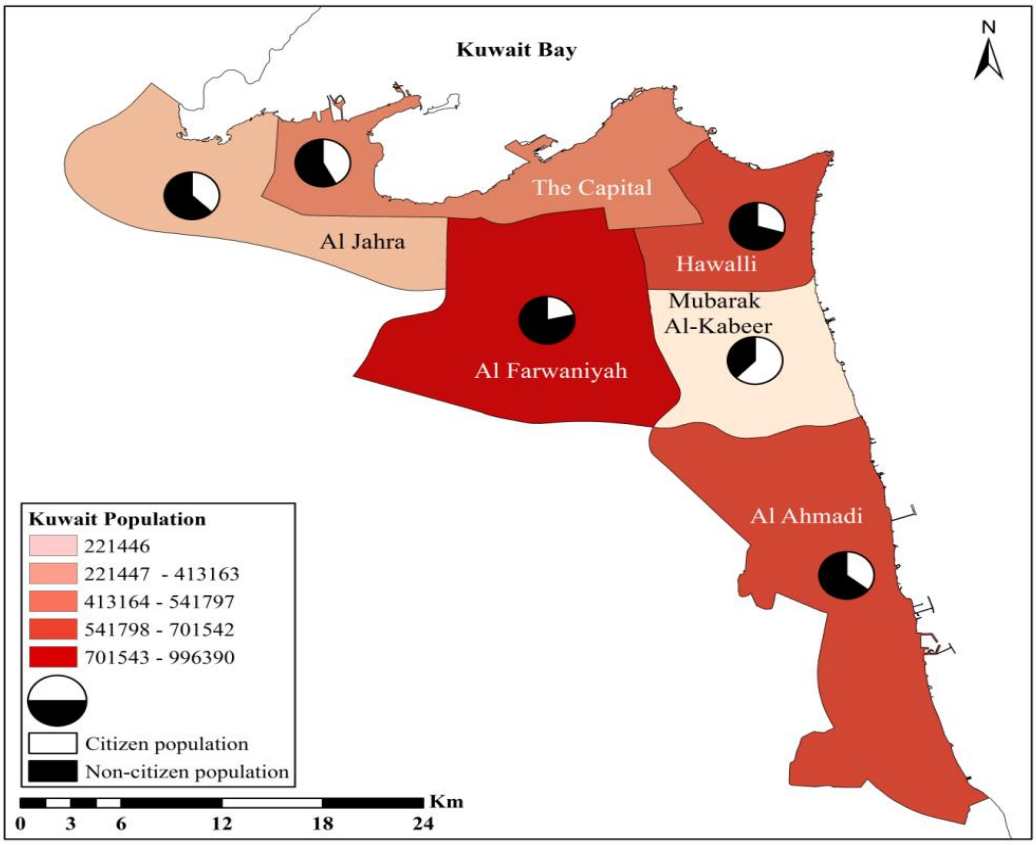


FIGURE 4: THE POPULATION DISTRIBUTION IN KUWAIT'S GOVERNORATES. THE PIE SYMBOLS ILLUSTRATE THE POPULATION PROPORTION OF CITIZENS AND NON-CITIZENS IN EACH GOVERNORATE[5]

[5] Source: KEPA, INC, 2012

2.2 Geography

Kuwait, officially known as The State of Kuwait is a country in West Asia, located in the Arabian Peninsula in the northeastern head of the Arabian Gulf. It lies between latitudes 28° 30° N and 30º 50º, and longitudes 46° 30º and 48° 30º E (e-Misk, KEPA). At 17,818 km^2 (6,880 sq mi), zero of which is water, Kuwait is one of the smallest countries in the world, ranking 158 in the world. Kuwait is 170 km in length from West to East and 200 km from North to the South (FIGURE 5). Kuwait's land boundaries are shared with both Iraq taking up to 195 km from the north-west and Saudi Arabia, 495 km, from the south. (KEPA, SNC, 2019).

FIGURE 5: SATELLITE IMAGE OF KUWAIT

Accounting for a significant length of Kuwait's shore is Kuwait Bay, which provides natural protection for the port. And within the coastline lies nine islands, some of which are Bubiyan, Warbah, Failaka, and Kubbar.

The territorial sea of the State of Kuwait extends seawards for twelve nautical miles from the baselines of the mainland and of Kuwaiti islands as mentioned in Article 1 of the Decree regarding the Delimitation of the Breadth of the Territorial Sea of the State of Kuwait of 17 December 1967 (National Legislation, 1969). Kuwait shares maritime boundaries, Territorial sea, with Iraq, Saudi Arabia, and Iran.

The Arabian Gulf has the lowest elevation in Kuwait coming at 0 m, and the highest point is at 306 m above sea level by the Al-Salmi Border in the west. The elevation gradually rises from the coast (east) to the west (FIGURE 6). The landscape provides elevations and depressions throughout. Most depressions found in Kuwait are in the north (e-MISK, KEPA).

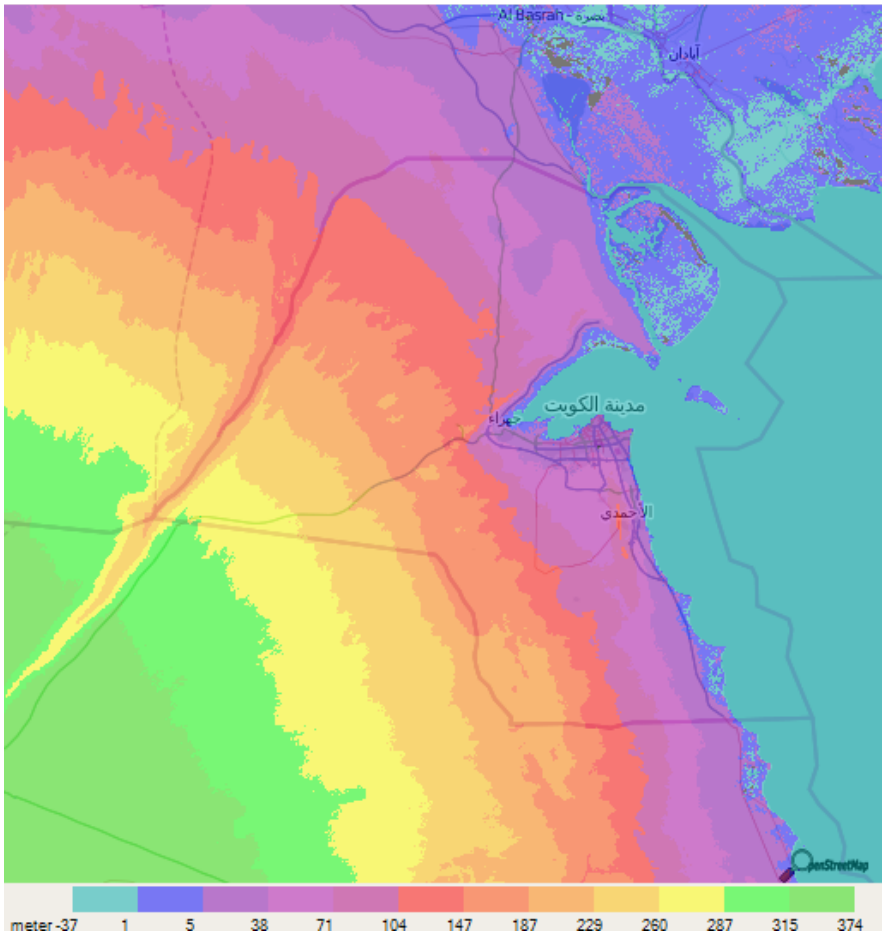


FIGURE 6: KUWAIT ELEVATION MAP[6]

[6] Source: OpenStreetMap Contributors, www.FloodMap.net

Kuwait's northern landscape is mostly a gravely plain with pebbles. Along the west, courser gravel lines up the plain along Wadi Al Batin, continuing to the southern borders between Wadi Al Batin and Minagish[3]. Kuwait Bay has a decreasing topography from the south to the west. To the south and west of the AL Ahmadi, there is the Burgan fields, north of the Burgan lies the Wara hills, where the topography rises. Looking south of the Burgan, the elevation drops back.

2.3 Climate

Kuwait is a dry tropical and sub-tropical desert with a hyperarid climate. Annual rainfall has a range of 75 – 150 mm, but actual rainfall has reached as high as 600 mm one year. Summers and winters in Kuwait have significant temperature differences. In summer, the temperature can reach up to 48 ºC and an average of 44 ºC. On 21 July 2016, the temperature has reached its all-time high in all of Asia at 54 ºC.

Due to its location at relatively the furthest north in the Gulf region, the winters in Kuwait are colder than in Qatar, Bahrain or the United Arab Emirates. Northern winds blowing from Iran and Iraq ensure that Kuwait experiences lower temperature than other Arabian Gulf countries. Rainfall mostly happens from October till April.

During the summers, which are significantly longer than the winters, aggressive north-western dust storms dominate most of the weather happenings during the months March through April. In later months of the hot summer, between May and September, humidity is more likely. The south-eastern wind blows July through October from the Arabian Gulf, hence the humidity during these months (SNC, 2019). By the end of October, the winter-summer cycle starts again, with the temperature dropping as low as -6 ºC during the night. Daytime has a higher range of temperatures at 10 – 17 ºC. Thunderstorms usually occur during this time, with frost happening if temperatures drop below 5 ºC.

2.4 Natural Resources

2.4.1 Soil

Due to the arid climate of Kuwait, it is nearly impossible for the soil to form, as the evaporation rainfall ratio is very low, most parent material is formed from marine origin

sedimentary rocks. The soil is coarse and has high salinity content. Vegetation in these soils is not very effective on soil due to the ineffectiveness of biological weathering to provide organic matter. Strong wind erosion, which displaces the topsoil layer, also limits soil formation. Very small percentages of the land are being used for agriculture, about 5.7 km^2, and are in Jahra, Sulibiya, and Mangaf. The water used for the plants is saline water from the wells. This, along with other factors like wind erosion, low rain, high evaporation, temperature and the hardness of the soil, all limit the productivity of the soil (SNC, 2019).

The Soil in Kuwait falls under several classifications. The great soil group, which is a group of soils that have similar internal characteristics, and there are four kinds of great soils found in Kuwait; Desert, Desert-Regosol Intergrade, Lithosol, and Alluvial.

Desert Soils are generally pale brown with a sandy texture with cemented subsoil, which is very pale brown, consisting of lime pan, silica pan and/or lime-silica pan. Desert Soils extend largely on the Kuwait horizon. Highly drained desert soils could be found as well as imperfectly drained. This type of soil is very poorly developed in Kuwait; AC horizons could be found; however, B horizon is weakly developed if found at all. The soils in Kuwait deserts have not been well developed, in the west the soil is covered with a gravelly layer with different sizes and colors, with a more calcareous material than the layer below.

The Desert-Regosol Integrates Soils have similar conditions in which they were developed to those of the desert soils, they differ slightly in color, being lighter, less developed than the latter, have better drainage and are younger. Where desert soils could be found in the west, these soils are indigenous to mostly the south to the southeast, they stretch over undulating relief and have good vegetation cover. Two categories of Desert-Regosol integrated soils were found in Kuwait; Sandy Desert Soils and Desert Dune Soils.

Another type of soil found in Kuwait was the Lithosole and mostly found on Az Zor escarpment, east of Kuwait Bay. This type of soil is usually found on rock fragments from consolidated rocks on sloping land. They are either A or C Horizons and while the A horizon is weakly developed it has considerable thickness due to the $CaCO_3$ and gypsum layers. Only one kind of soil form this category was found on Kuwaiti soil which is the Escarpment.

The Alluvial Soils are the fourth type of soils found in Kuwait. Unlike the previous soils, this type is formed by material carried by running water. They originate from the Kuwaiti marine, and so are mostly found by the shoreline on the level and concave relief. Due to their proximity to the water and thus the high-water table, they are almost always wet. They also have low water drainage. Two kinds of Alluvial soils were found; the Hydromorphic Saline Alluvial Soils and the Recent Alluvium Soils. The Kuwait group identifies recent and less recent sediments of multiple types including but not limited to gravel, clay, silts, and limestones covering all of Kuwait like the Dammam limestone formation.

The Kuwait group aquifer was divided in the north into three formations depending on the evaporate deposits, as follows; the Dibdibba Formation, Sand and Gravel; the Fars Formation, Evaporite Sequence; and the Ghar Formation, Sand and Gravel. The following table shows the aquitards and the aquifer sequence within the Kuwait Group, from top to bottom (Y. Villacampa, 2008).

Due to the environmental conditions, soil capacity, and weather conditions agriculture is very limited in Kuwait. Vegetation types cover Kuwait are presented in FIGURE 7.

TABLE 3: AQUITARD AND AQUIFER SEQUENCE WITH KUWAIT GROUP[7]

Dibdibba Aquifer (gravel sand).
Aquitard (silty sand).
Upper Kuwait Group Aquifer (sand and gravel).
Aquitard (clay and clay sand).
Lower Kuwait Group Aquifer (sand).
Aquitard (basal clay and cherty limestone at the top of Dammam formation)

[7] Source: Mukhopadhyay & A. Akber, 2018

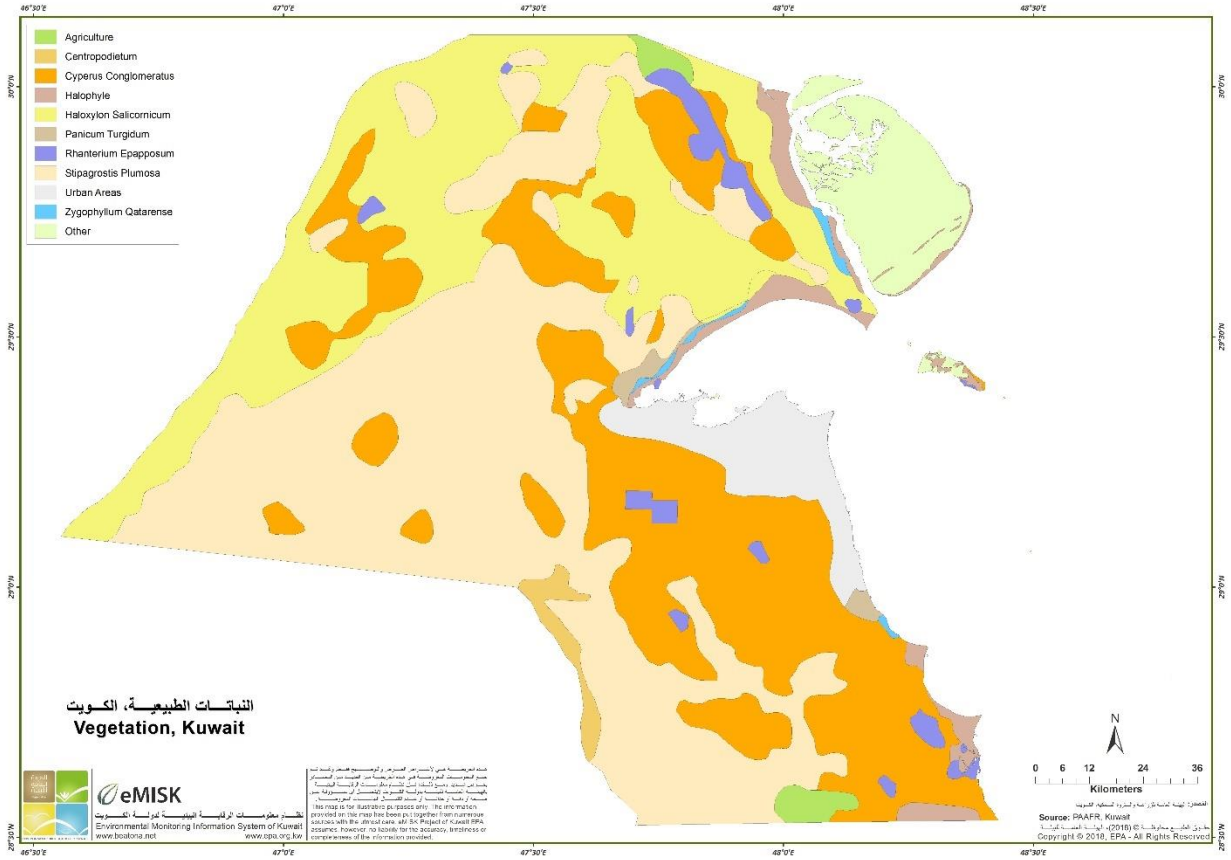


FIGURE 7: MAP OF KUWAIT DENOTING VEGETATION IN KUWAIT.

2.4.2 Water resources

As per its climate, Kuwait suffers from a scarcity of conventional fresh water. Endogenous precipitation is 121 mm/year (long-term average), which amounts to 2.156k 10^9 m^3/year in 2014, which is respectively low. It increases to 39.18 mm in December 2017 from 13.26 mm in November of 2015 as shown in FIGURE 8 (Y. Villacampa, 2008).

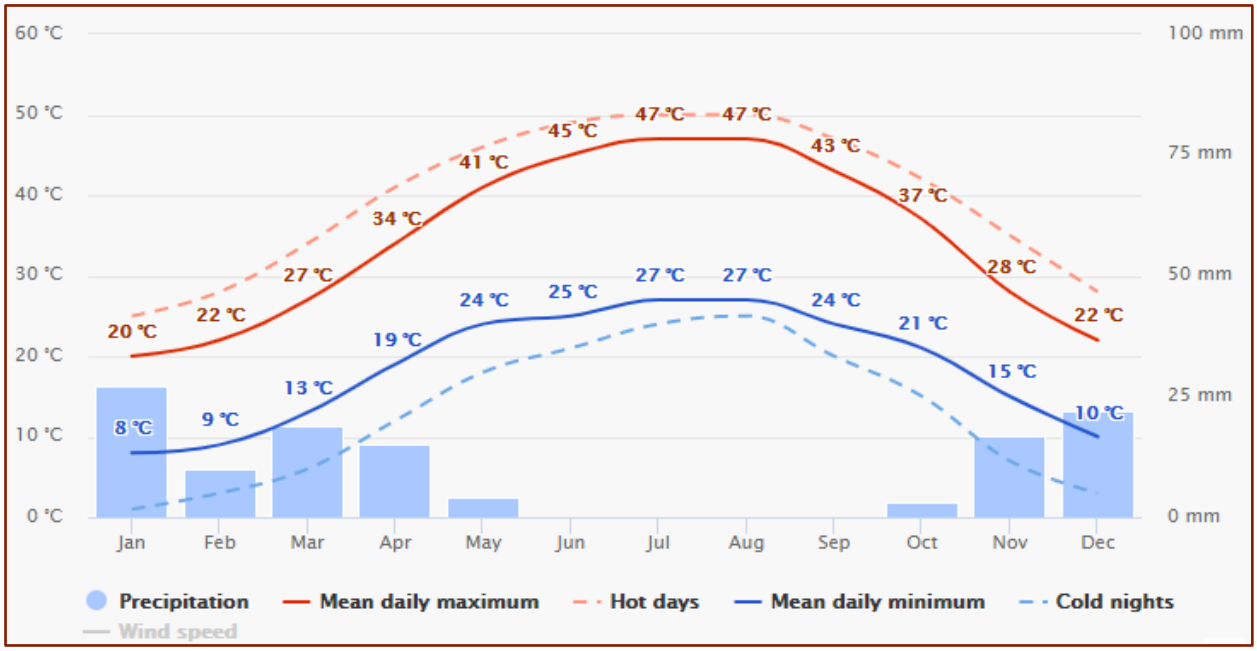


FIGURE 8: AVERAGE ANNUAL TEMPERATURES AND PRECIPITATION[8]

With the increasing growth of population, water from wells is no longer enough, and so the government built a desalination plant in Kuwait in 1953, followed by others, two in Doha with capacity reaching 138 M gallons per day. A third plant was built for desalination by reverse osmosis nearby. There are three main water sources for urban and agricultural uses in Kuwait, desalinated water groundwater and treated wastewater (Y. Villacampa, 2008).

There are no permanent rivers in the country and with how high the level of evaporation is streams and runoff water only last a few hours after rain. Groundwater replenishing is even scarcer due to how dry the soil is and the infamous evaporation rate. The groundwater produced internally amounts to nothing, as is the surface water, meaning that there is no overlap between the ground and surface water. The accounted groundwater inflow from Saudi Arabia through lateral underflow is estimated to be 20 MCM/year (Aquastat, 2016), and groundwater in Kuwait does not flow into neighboring countries groundwater basins. The total renewable water resources per capita are 5.139k m^3/year in 2014 (Aquastat, 2016).

[8] Source: meteoblue: https://www.meteoblue.com/en/weather/forecast/week/kuwait-city_kuwait_285787

Groundwater in Kuwait can be categorized into three classifications; the distinction is made according to the salinity level in the water. Fresh groundwater has less than 1 g/L of a soluble salt, and it is mainly considered a freshwater reservoir from drinking water rather than used for irrigation. Due to the precipitation patterns, which include intense rainfall in a short period of time, and the soil types that allow filtration, fresh groundwater can be found in the fields of Raudhatain and Umm Al Eish. Water extraction at these aquifers is 5,500 and 3,500 m^3/day respectively (Kwarteng et al, 2000).

Another type of groundwater is the Saline groundwater. The content of soluble salts in this type of groundwater is between 7 g/L to 20 g/L. It cannot be used for either agriculture or domestic use. The brackish groundwater is another type of groundwater present in Kuwait. It contains higher amounts of soluble salts than the fresh groundwater coming at an amount of 1 to 7 g/L. This type of water is used domestically, for agriculture and drinking water for animals, namely cattle. The source of this water is the Al Shaya, Al Qadeer, Al Solaybeia, Al Wafra, and the Al Abdali fields. The distribution of groundwater fields in Kuwait is shown in **FIGURE 9**. The outtake from these fields is estimably 545,000 m^3/day (Y. Villacampa, 2008), which is significantly higher than the fresh groundwater outtake.

In 1993 the water withdrawal was calculated to be 538 MCM; however, in 2002 it has increased to 913 MCM and that is due to the increasing water consumption by the Kuwaiti individual (**FIGURE 10**) and (**FIGURE 11**). 44% of the water withdrawn is being used for domestic uses, 2% for industrial purposes and the rest is for irrigation, which amounts to 492 MCM; 80% of it is for productive agriculture, 300 MCM is brackish water from the Al Abdali and Al Wafra private wells, 66 MCM is treated wastewater.

The quality of the groundwater is deteriorating due to the excessive withdrawal which reached its peak in 2006; 164.7 MCM. At which point the Ministry of Electricity and Water (MEW) realized that water preservation was necessary for future prosperity. Thus, the fresh and brackish water consumption started gradually decreasing as of 2007-2008 (Figure 11). The current groundwater withdrawal rate from each the Wafra and the Adbali wells is estimated to be 300,000 - 400,000 m^3/d.

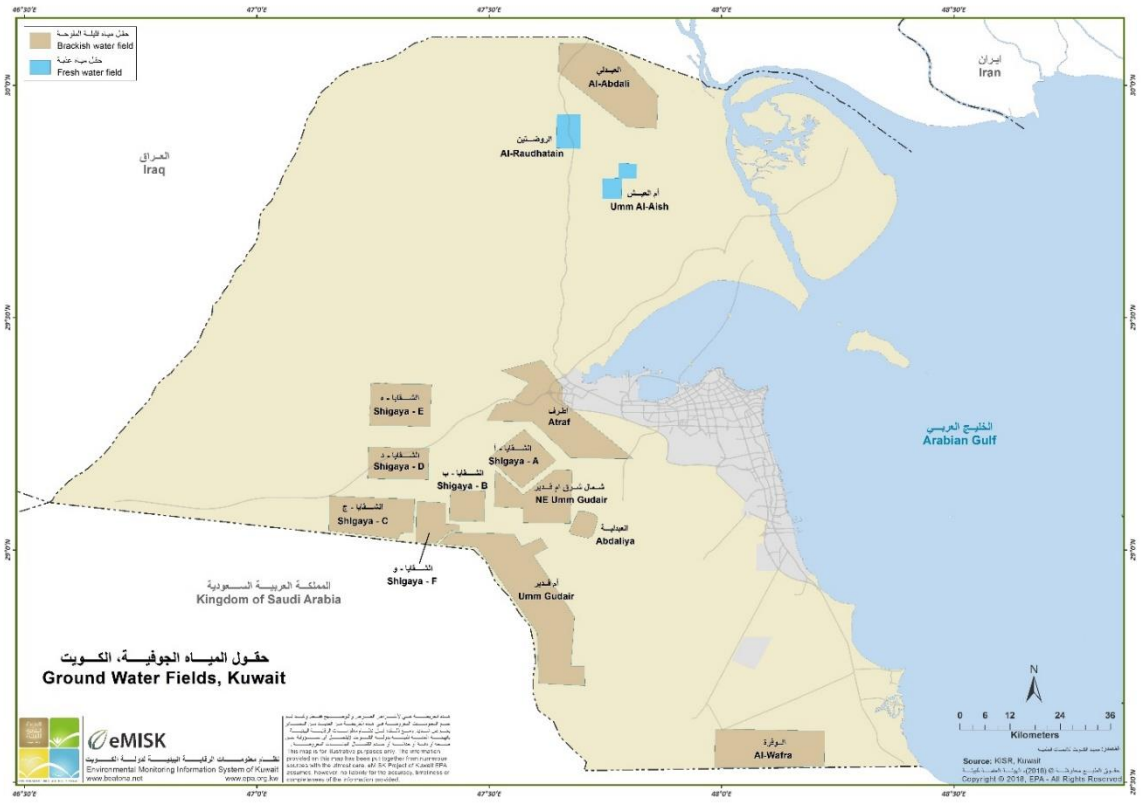


FIGURE 9: KUWAIT'S GROUNDWATER RESOURCES

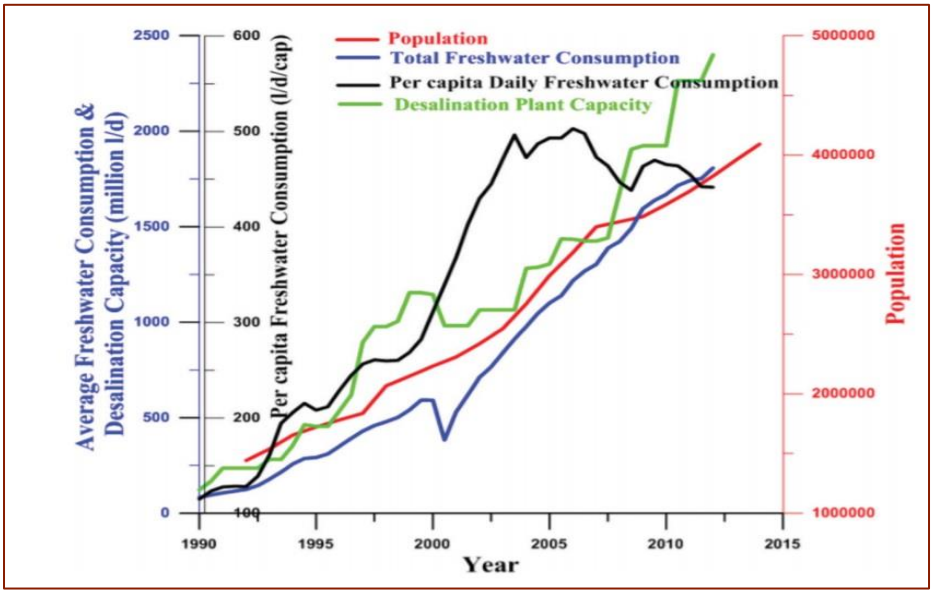


FIGURE 10: VARIATION OF FRESHWATER WATER CONSUMPTION, POPULATION GROWTH, AND DESALINATION PLANT CAPACITY IN KUWAIT 1990 -2015[9]

[9] Mukhopadhyay & A. Akber, 2018

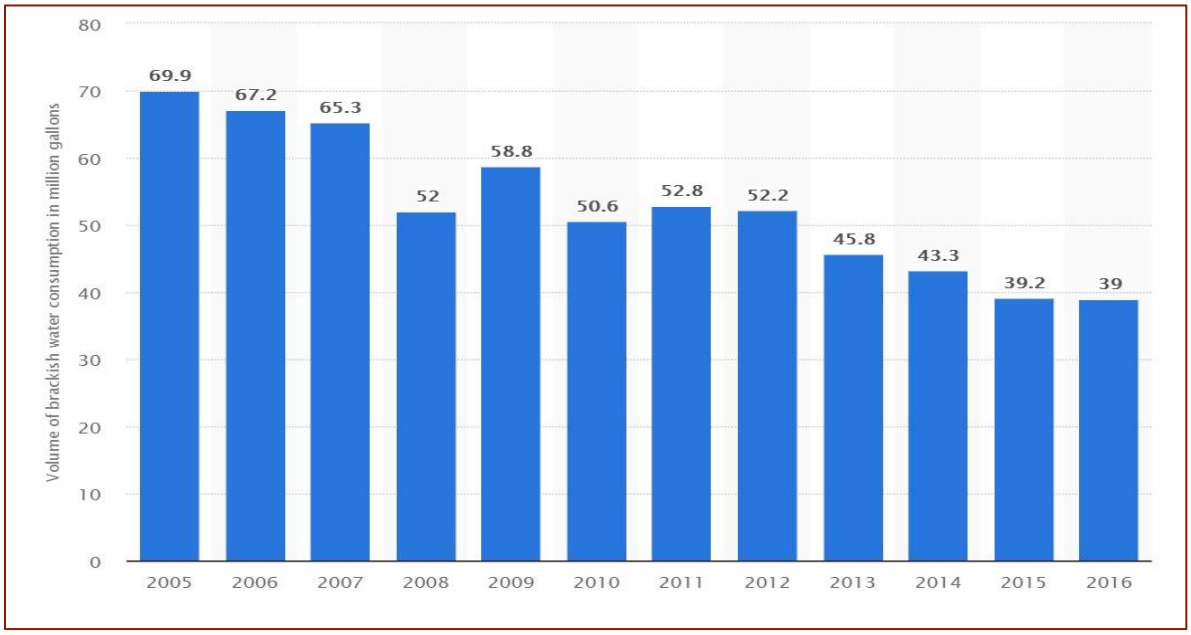


FIGURE 11: BRACKISH WATER CONSUMPTION IN KUWAIT[10]

Raudhatain, which is a freshwater field in the north, started with a production rate of above 9090 m^3/d in the years 1963-1967, now pumping about only 4545 m^3/d. The decrease of outtake is due to the increasing relativity of the total dissolved solids in the water acquired. By the year 1989, the water produced from the two water wells decreased to about 300 m^3/d (Mukhopadhyay & A. Akber, 2018).

Producing groundwater, be it fresh, brackish or saline water has the accompanying costs of pumping and desalination treatment, which includes the multi-stage flash evaporation process, Figure 13. The cost of the thermal process is largely dependent on the consumption of energy during the operation accounting to about 50% of the water unit cost. In 2014, desalination capacity was recorded to have reached 2.4 M m^3/d. Wastewater treatment has similar cost priorities; over 90% of the population of Kuwait has access to a central sewage system collecting both domestic and industrial wastewater. The total length of pipelines stretches over 650 km.

[10] @Statista 2019 https://www.statista.com/statistics/648858/kuwait-average-daily-consumption-of-brackish-water/

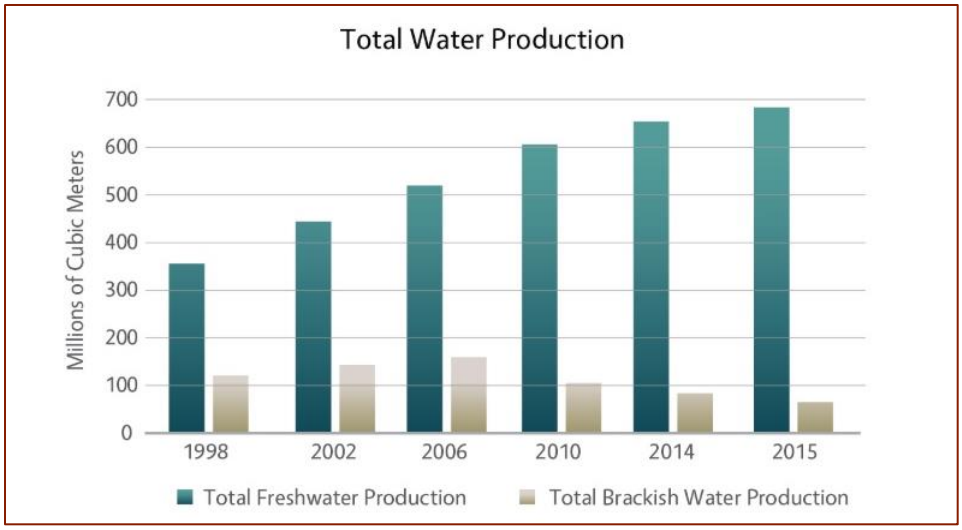


FIGURE 12: TOTAL FRESHWATER AND BRACKISH WATER PRODUCTION[11]

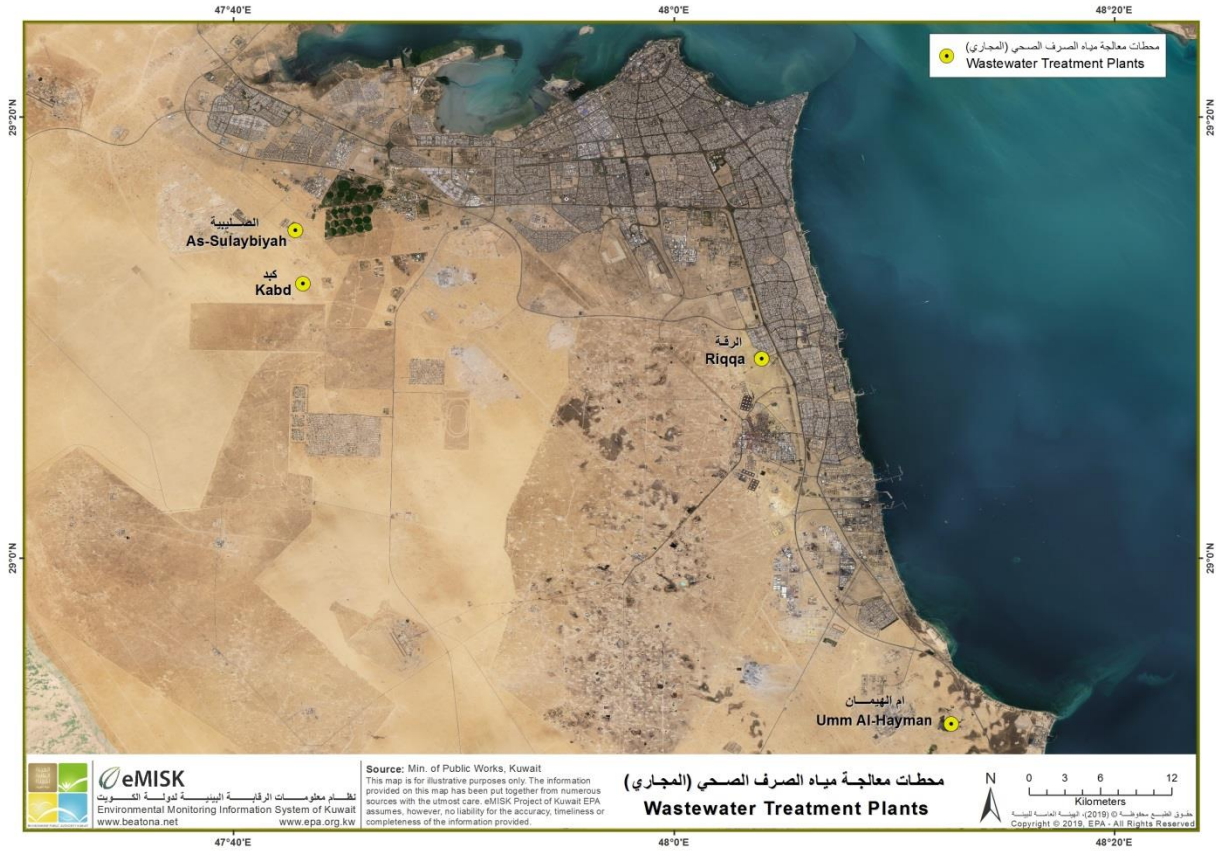


FIGURE 13: WASTEWATER TREATMENT PLANTS

[11] Source: KEPA, GIS portal, eMISK.

In 2004 a municipal wastewater treatment plant was constructed by a private consortium on Build – Operate – Transfer (BOT) formula in Sulaibiya, the plant uses Reverse Osmosis Process (RO) and has the capacity of 375,000 m^3/d. In 2006 the efficiency of the plant was at 94.7%, producing 355,102 m^3/d of treated wastewater from a 375,000 m^3/d influent (Abdel-Jawad et al.).

Future demand for water is increasing and does not show any signs of stabilizing. The availability of desalinization capacity will depend on the economic growth in the country. Burney et al. carried out a study projecting the water demand in Kuwait by 2025, and results show that it will rise to 2 M m^3/d to 8.3 M m^3/d. There seem to be several available options for rationalizing water demand, one of many is to reduce the gap between the increase of income and the government-fixed price of water, another is the used of reclaimed municipal wastewater. In 2007, 76% of the treated wastewater was used for landscaping and agriculture (Mukhopadhyay & A. Akber, 2018).

2.4.3 Ecosystems and biodiversity

While oil and gas are two of the major natural resources in Kuwait, history and culture have been tied to water for far longer than oil has been a dominant resource. Shipping pearls, diving, and fishing have provided a livelihood in the region for centuries. Underwater ecosystems contain around 600 kinds of coral in the world, 35 of them grow in Kuwait's waters. The Gulf is home to vibrantly colored colonies of coral reefs with fish, sea turtles, sharks, dolphins, and even whales swimming in its waters. Kuwait has three major coral islands; Umm Al Maradem Island, Garo Island and Kimber Island. Tragically, many of the reefs were severely damaged during the years 1990-1991; the Gulf War and continue to be harmed by pollution.

There are 15 marine protected areas and 15 terrestrial protected areas in Kuwait and their percentage out of the total surface area accounted in Kuwait is 1.48%. The terrestrial and the marine protected areas out of the total territorial area amounts to about 11% (Trading Economics, 2018). Figure 14 presents total fisheries production in Kuwait over the last 10 years in Marine Cages.

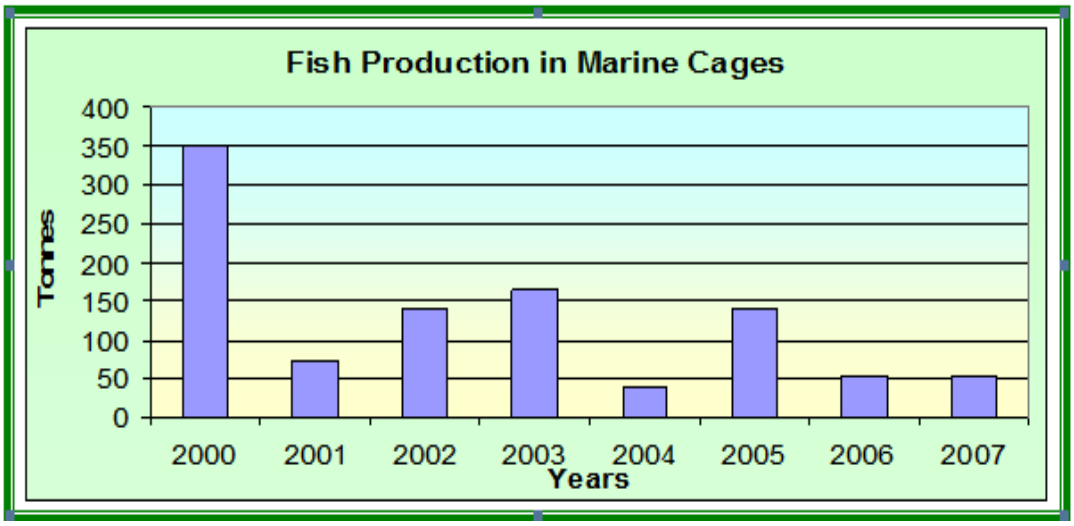


FIGURE 14: FISH PRODUCTION IN MARINE CAGES[12]

Land ecosystems are also significantly important as Kuwait's coastlines are home to threatened Mangrove trees. The groves provide homes for a variety of Fauna and Flora, including big flocks of flamingos. Regular beach cleanups helped to ensure these animals and plants can live in a suitable environment clear of waste and hazardous materials. Kuwait is at a crossroad of three continents, where migrating birds flying through the skies of Kuwait every year to reach their destinations. There are two major routes for migration passing through the skies of Kuwait, one is from north-eastern Europe to the southern half of Africa and the other is from western Europe to southern Asia. Bird lakes and sanctuaries are being created for these animals by teams working to protect marine and other habitats in the Gulf.

There are many plants and animals species in Kuwait, about 354 species of birds, 11 of which are being threatened, 32 species of mammals, 7 threatened (Trading Economic, 2018), 42 species of amphibians and reptiles and 806 species of arthropods (Al-Oula Shamal Azzour, 2017), including but not limited to, Barrel Catus, Armadillo Lizard, Bobcat, Cactus Wren, Jumping Cholla, Ocotillo, Thorny Devil, Mound Cactus, Desert Locust, two types of scorpion; the Yellow Scorpion and the black scorpion[9]. There are also 26 subspecies if grasshoppers in Kuwait, numerous species of beetles, wasps, bees,

[12] Source: Hyder A. Murad, Deputy Director General, Public Authority for Agriculture Affairs and Fish Resources, State of Kuwait: National review on marine cage aquaculture

butterflies, ants, and ladybirds. Birds, namely Eagles, fall under two categories in Kuwait, the residential birds and the migratory one. Twice a year, once during the winter and the other during the spring, birds of all species travel through the Kuwaiti skies in the routes mentioned earlier (Al-Oula Shamal Azzour, 2017).

As mentioned earlier, Kuwait hosts routes of migration for birds from all over the world. There are two routes passing through Kuwait's skies. Some of the many species of birds that fly through Kuwait's skies, whether as migrating or indigenous, are Spotter Eagle, Steppe Eagle, Imperial Eagle, Golden eagle, Booted Eagle, Common Kingfisher, Mallard, Night Heron, Squacco Heron, Indian Pond Heron, Cattle Erget, Reef Heron, Purple Heron, Crab Plover, Collard Dove Saker Falcon, Yellow-Throated Sparrow, Chaffinch, Hoopoe, European Roller, Bee-Eater (Al-Oula Shamal Azzour, 2017).

Unfortunately, Kuwait has lived through the extinction of many species due to extensive and unregulated hunting, habitat loss and fragmentation, genetic pooling, species isolation and loss of proper habitat for their specific species. All these reasons lead to the endangerment and extinction of animals like the Arabian wolf, Arabian Oryx, striped hyena, jackal, honey badger, Gazelle subgutturosa and G Gazelle, sand cat, Ruppell's fox, and Cape hare, and unless immediate and drastic changes and actions are being taken in order to protect and preserve these species, Kuwait will continue to suffer a drop in its biodiversity.

The number of mammals in Kuwait is no less intensive, and just as is the case with birds, mammals have suffered a plummet in their numbers and species over the centuries. The selected species of mammals in Kuwait include the Red Fox, Wanger's Gerbil, Cheesman's Gerbil, Libyan Jird, Sundevall's Jird, Lesser Jerboa, Naked-Bellied Tomb Bat, Long-Eared Hedgehog, Wild Cat, House or Black Cat, Kuhl's Pipistrelle Bat. The Reptiles and amphibians are restricted to remote areas in the deserts with limited human interaction, these species include; the Spiney-Tailed Lizard, Jayakar's Sand Boa, Green Toad, Loggerhead Turtle, Green Turtle, Arabian Rear-Fanged Snake, Hissing Sand Snake, Rat Snake, Leaf-Nosed Snake, Black Desert Corbra, Arabian Cobra, Pallied Agama, Blue-Throated Agama, Sand Gecko, Stone Gecko, Rock Gecko, Fringe-Toed Sand Lizard, Lacertid Lizard, and many other.

At 863 km^2, Bubiyan Island is the largest island in Kuwait; it is near the border with Iraq, third Island to the north. Now the island is a nature reserve with very limit access to the marshland and creeks manly due to military reasons (Al-Oula Shamal Azzour, 2017). Figure 15 illustrates the distribution of protected areas in Kuwait.

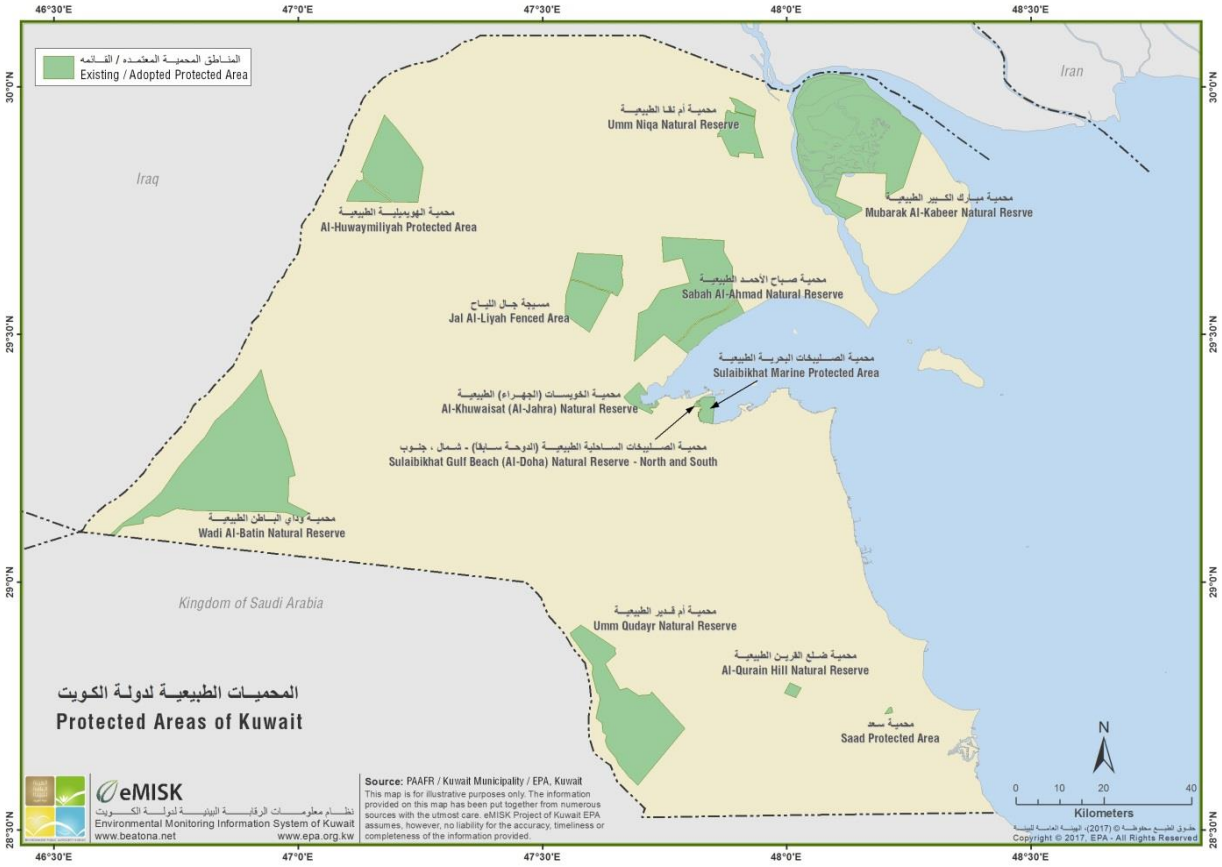


FIGURE 15: PROTECTED AREAS OF KUWAIT

2.4.4 Environment

As the contributor to over 90% of the oil consumption in Kuwait, vehicle causing pollution is strictly regulated by the authorities responsible. The Kuwait Institute for Scientific Research (KISR) has conducted a study on vehicle exhaust. The results of the study showed that the rate of HC, CO and NOx emissions in Kuwait is higher than the emission in the US. Owing to this study and others following, legislative and regulation on the limit of exhaust a car can emit were put in place, and thus vehicles were adjusted during maintenance (E. Al Bassam and A. Khan, 2004).

Since signing into the United Nations Framework Convention on Climate Change, Kuwait has introduced new policies and rules concerning the emission of gases into the atmosphere. Kuwait also encouraged the consumption of unleaded fuel by decreasing its price compared to the leaded fuel; also, the number of gas stations offering the leaded option is very few.

Greenhouse gas emission is a serious pollution issue that all countries around the world suffer from, in varying degrees, and Kuwait is no different. **Table 4** provides an overview of some of the emissions taking place in Kuwait.

To define the air quality and illustrate changes in four specific parameters of air quality during the period of 2010-2015, KEPA has aggregated the daily observations from different air quality monitoring stations as presented in **Table 4**.

Solid waste has increased substantially in the last decade in Kuwait due to several reasons like the industrial growth, population increase, and slow development of solid waste management in the country. Solid waste management includes the collection, sorting, processing, and disposal of MSW (municipal solid waste). As of 2011, there were 15 sites of solid waste management under the authority of the Municipality, only 5 of which are operational. Kuwait has one of the highest waste generations in the world, coming at 2 million tons per annum, largely owed to a high standard of living and lack of awareness about sustainable solid waste management (Salman Zafar, 2018).

Table 4: Data on Gases Emission in Kuwait[13]

Indicator		Value (Gg)
Total GHG emissions of CO_2 equivalent		**86336.469**
Emissions by Gas	**CO_2 emission**	**83910.932**
	CH_4 emission	**2002.077**
	N_2O emission (Gg)	**423.46**
Emissions by Sector	**GHG emissions from electricity and water**	**47665**
	GHG emissions from oil and gas	**16464.208**
	GHG emissions from Transportation	**15000.175**
	GHG emissions from industry (Energy + Process)	**4788.445**
	GHG emissions from Agriculture	**141.181**
	GHG emissions from Waste sector	**1706.539**

Figure 17 shows some of the pollution sources in Kuwait. Naturally, there are other factors, these are the major causes.

[13] Source: KEPA, 2019.

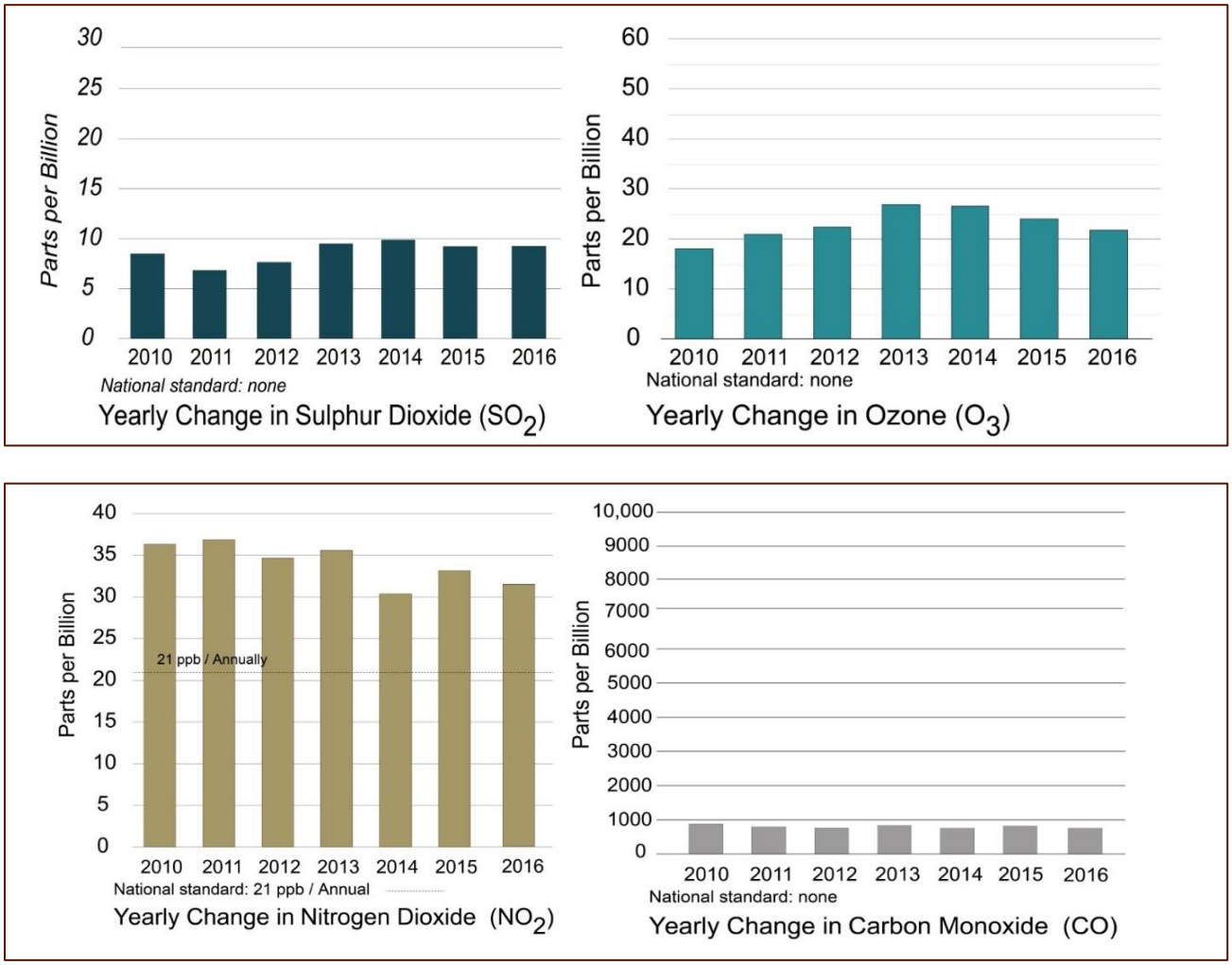


FIGURE 16: YEARLY CHANGES IN AIR QUALITY (2010-2015)[14]

Table 5 shows the readings of air pollution in Kuwait collected in the span of a year. The investigation showed that Kuwait has a low level of air pollution; below the required standards by EPA. Traffic vehicles are the main contributors to Benzene and other gases. The wind direction and speed, on the other hand, have great effects on SO_2 concentrations. Temperature affects the relationship between gases and the accumulation of gases in the air (Jasem Al-Awadhi, 2014). The $PM_{2.5}$ concentration over time is presented in **FIGURE 17**.

[14] Source: KEPA, Emisk, 2019.

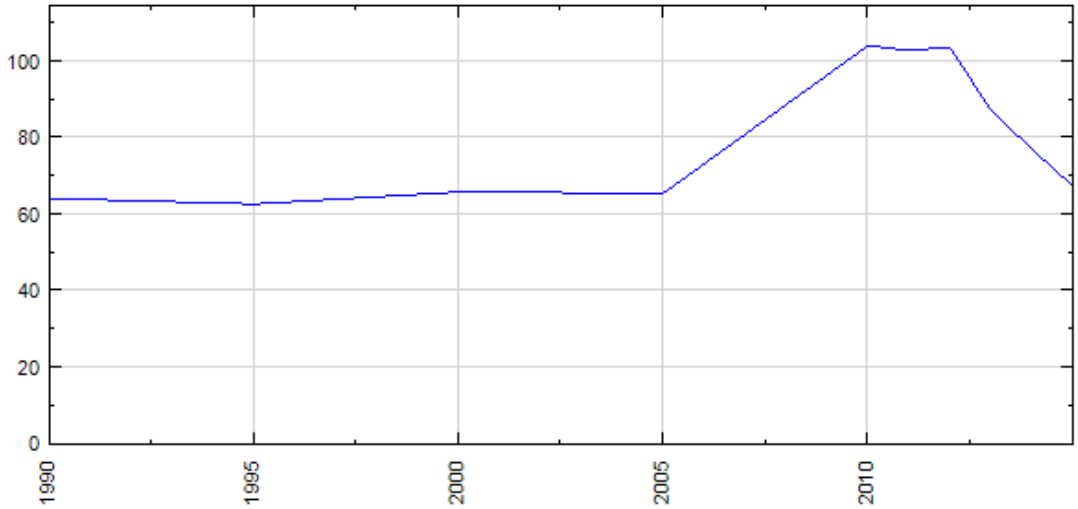


FIGURE 17: PM2.5 AIR POLLUTION, MEAN ANNUAL EXPOSURE (µ/M^3)[15]

	Mean	95% Confidence Interval for Mean		5% Trimmed Mean	Median	Variance	Std. Deviation	Minimum	Maximum	Max/Min	Range	Interquartile Range	Skewness	Kurtosis	25th percentile	75th percentile
		Lower Bound	Upper Bound													
H_2S	5.5	2.2	5.6	3.8	3.8	8.0	2.4	3.9	7.5	2.0	6.3	4.0	0.3	−0.6	4.6	6.3
SO_2	13.4	6.5	15.4	10.8	11.4	62.5	6.3	8.8	20.2	14.4	16.0	9.4	0.3	0.1	10.7	15.4
O_3	42.8	21.7	46.8	34.2	36.0	339.9	16.3	27.1	65.0	8.7	41.2	28.2	0.1	−0.3	32.4	51.0
NH_3	4.8	2.1	5.0	3.5	3.7	4.3	1.9	3.0	8.0	3.8	4.9	3.2	0.0	−0.6	3.7	5.8
NO_2	28.9	12.8	29.0	20.8	20.6	163.7	11.4	21.1	35.6	2.3	28.3	20.0	0.1	−0.7	24.3	33.5
NO	42.4	16.0	42.6	28.5	24.3	409.1	18.6	25.7	62.8	4.3	52.9	29.3	0.8	0.7	32.1	53.0
Benzene	2.5	1.4	2.8	2.0	1.9	1.2	1.0	1.8	3.7	2.2	2.7	1.6	0.4	−0.6	2.0	3.1
Toluene	15.7	7.5	18.3	12.6	11.8	64.1	7.5	9.1	26.9	3.2	22.2	11.4	0.6	0.1	10.7	20.4
N-Octane	1.3	0.7	1.4	1.0	1.0	0.3	0.5	0.8	1.8	3.6	1.3	0.8	0.2	−0.8	1.0	1.5
Ethyle-Benzene	4.6	2.2	5.2	3.7	3.5	5.4	2.1	2.4	7.4	10.9	6.0	3.5	0.4	−0.6	3.2	6.0
m&p Xylene	18.1	9.0	20.7	14.6	13.8	79.7	8.2	10.5	29.1	2.9	23.6	12.8	0.4	−0.4	12.4	23.6
O-Xylene	7.3	3.7	8.2	5.9	5.6	12.1	3.2	4.3	11.4	2.8	9.2	5.1	0.3	−0.5	5.1	9.4
Nonane	1.1	0.3	1.3	0.8	0.7	0.6	0.7	0.6	2.6	4.3	2.3	0.6	2.0	4.7	0.7	1.2

TABLE 5: DESCRIPTIVE STATISTICS OF AVERAGE MEASURED POLLUTANT CONCENTRATION (µg/m^3) AT 10 SITES FROM MARCH 2011 TO FEBRUARY 2012[16]

[15] Source: indexMundi, 2015
[16] Source: Jasem Al-Awadhi, 2014.

The two percentile points define the upper and lower tails of data. The range indicates the difference between the maximum and minimum measured values. Interquartile represents the difference between the 75th and 25th percentile. Skewness number measures to what extent the distribution of values deviates from symmetry around the mean. Kurtosis number measures the “peakedness” or the “flatness” of a distribution. Positive kurtosis indicates a shape flatter than normal.

2.5 Agriculture

The total area that could be potentially used for agriculture is marginal, less than 1% of the total land and the area that is used for cultivation is less so. There are several areas in Kuwait equipped for agriculture; the Ahmadi occupies about 3,935.3 ha, the Jhara district is 6,206.9 ha. The water used for irrigation is either groundwater or from non-conventional sources, amounting to 7,742.1 ha and 2,400.1 ha, respectively (FAO, 2013).

Due to the country’s harsh climate and the huge negative impact the Gulf war had on the land and agriculture, farmers had to replay on Protected Agriculture (PA). Protected Agriculture ranges from “simple uncooled and unheated plastic tunnels to very sophisticated computer-controlled, cooled and heated, metal-frame glasshouses. Approximately 85% of the PA is carried out in uncooled (57%) and cooled (28%) plastic tunnels, with the remaining 15% in cooled greenhouses covered with fiberglass, glass or acrylic material. Cucumber and tomato are the two main crops grown in PA, accounting for approximately 90% of the total area” (Afaf Y. Al-Nassar and N.R. Bhat, 1998). However, Kuwait has yet to develop a proper monitoring system to keep track of the changes in the environment. The number of greenhouses with cooling systems is also not as high as it should be. Figure 18 illustrates agricultural and animal farming in Kuwait.

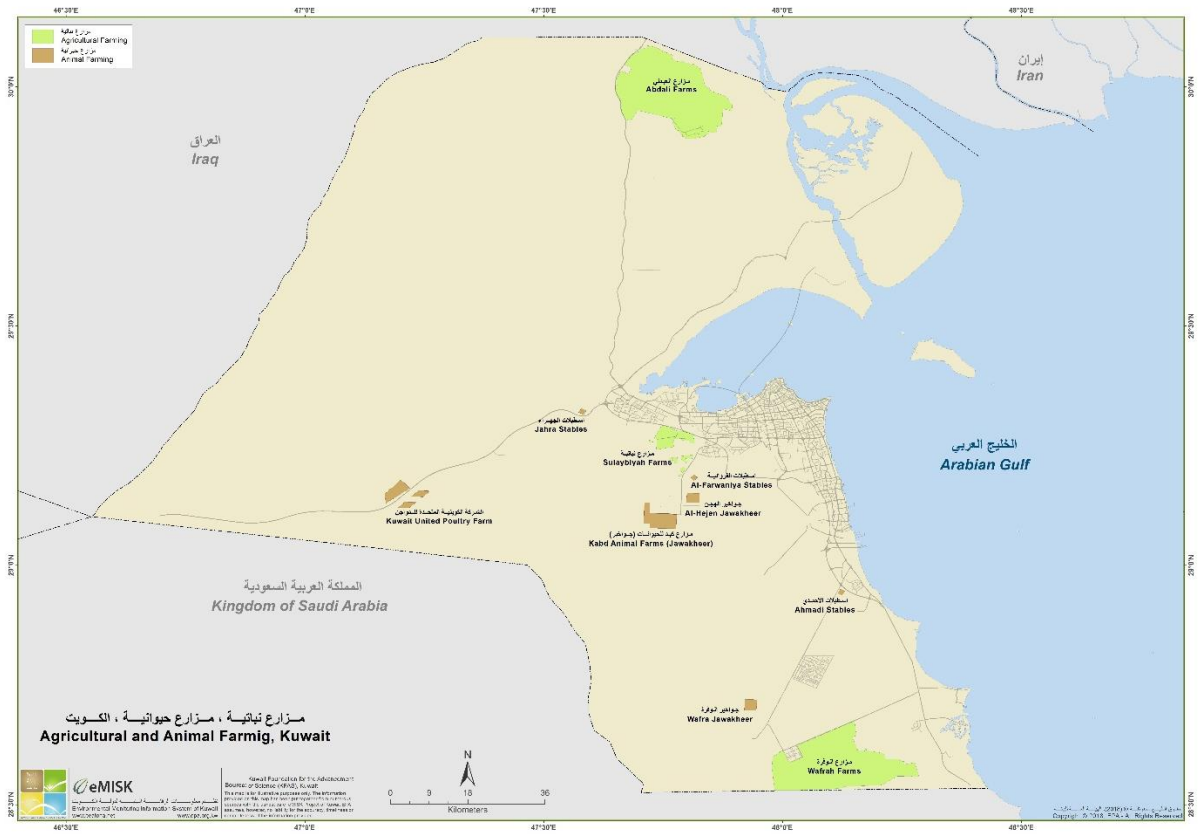


FIGURE 18: AGRICULTURE AND ANIMAL FARMING, KUWAIT

2.6 Economy

Kuwait's economy is highly dependent on oil exports and thus vulnerable to drops and changes in the global oil market prices. The GPD in 2018 was estimated to be at $303 billion and the GDP per capita at $69,669. Since 2014, Kuwait's GPD has decreased substantially going from 174.16 and 162.63 billion US dollars in 2013 and 2014 respectively to a sudden drop to $114.57 billion dollars in 2015 (Trading Economics, 2018). Although the GPD has increased marginally in 2017 to $120.13 billion dollars, it has a long way of reaching its previous values. The currency is Kuwaiti Dinar (KWD). And the highest valued currency in the world. Kuwait offers help to other developing countries through the Kuwait Fund for Arab Economic Development. Although the oil and petroleum shares contributed to over 50% of Kuwait's economy in the previous decade, in 2018 Kuwait's economic dependency on oil has decreased to 46.5% (Niall McCarthy, 2016).

There are other activities that contribute to the non-oil GPD fraction, such as the social and financial services, transport and manufacturing.

Due to higher OPEC quotas set in June 2018, the economy is expected to increase by 3.5% in 2019, according to the private bank NBK. The output would be increasing by 1m barrels per day (bpd), which translates to an increase in production from 80,000 bpd to 2.8 bpd. Figure 19 presents the oil and gas production as a percent of real GDP growth.

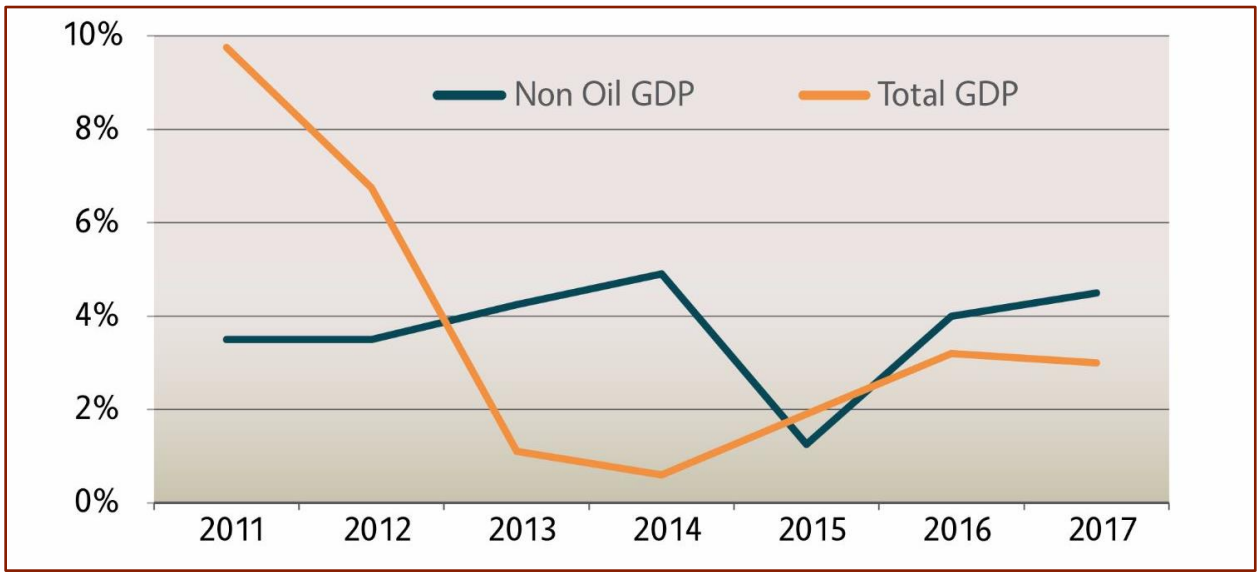


FIGURE 19: OIL AND GAS PRODUCTION AS A PERCENT OF REAL GDP GROWTH[17]

2.7 Socio-Economy

2.7.1 Development Indicators

The Human development indicators (HDI) assess the progress a country is making in the long run in areas where the life of an individual is making by measuring the standard of living, how healthy their life is and their accessibility to knowledge. The assessment of knowledge is done by accounting the number of years an adult receives of education in a lifetime.

[17] Source: Central Statistical Bureau, NBK, 2016.

In 2017, the HDI in Kuwait was 0.803, which is relatively high at a rank of 56 out of 159 countries worldwide. The increase from the year 1990 until the latest date comes at 12.6%. Life expectancy at birth increased from 72.1% in 1990 to 74.8% in 2017, and the expected years of schooling increased by 3 years, whereas the average schooling years increased from 5.5 years to 7.3 years. The GNI, gross national income increased by 32% in that time period. FIGURE 20 shows the trend of increase in the HDI. However, compared to the average HDI of other Gulf countries, Kuwait's falls behind. Qatar's values are the highest in the region (UNDP, 2018).

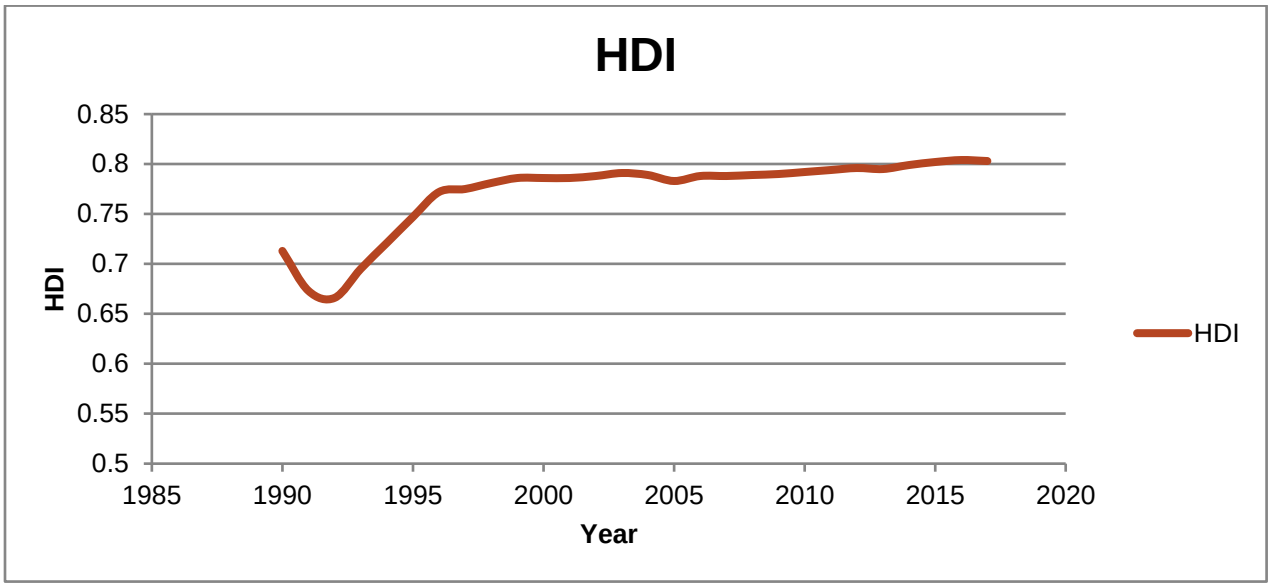


FIGURE 20: TRENDS IN KUWAIT'S HDI [18]

2.7.2 Health

After the ministries of education and interior, the Ministry of Health is the largest in the country. Assisting the Minister of health are the Undersecretary and twelve secretary undersecretaries, the latter is responsible for "public health affairs, dental health, health services, blood transfusion and laboratories, nutrition and drug control, drugs and medical supplies, financial affairs, administrative affairs, legal affairs, quality control affairs, and

[18] Source: countryeconomy.com - https://countryeconomy.com/hdi/kuwait

newly established health regions and private health services & licensing department" (WHO, 2006).

Kuwait was split up in 6 different health regions; in the Capital, Ahmadi, Jahra, Farwania, Hawali and Al Suabah. Each health region has different and assigned responsibilities as a separate unit, in charge of its area. The prime tasks of the area include:

1. Carrying out the ministry's plans in order to confirm and protect health services for the people of the area;
2. Providing training of all kinds for the body of professionals employed;
3. Offering every health care possible;
4. Introducing and perfecting a digital and computerized system of health data for residents in the area.

There are different kinds of care in the health system in Kuwait, the primary, secondary, tertiary and specialized health cares, each with their separate centers. The primary health care includes the general clinics, maternal and child clinics, dental and diabetes. It also includes the school health centers, police and paramedics are also in this sector of health care, all provided in 72 centers in the country. The secondary and tertiary health care is provided at six hospitals, and these include general hospitals and health centers. The specialized health care centers- according to the World Health Organization- are the following: Obstetrics (delivery) hospital: for maternity, Chest hospital: for pulmonary ailments, Psychiatric hospital: for mental disorders, Ibn Sina hospital: for neurosurgery, Razi hospital: for burns, Kuwait Center for Allergies: for allergies, Kuwait Cancer Control Center: for cancer diagnosis and treatment, Hearing Impairments Center: for disorders connected with hearing, Hamed Al-Essa Transplant Center: for organ transplants, and Sulaibikhat hospital: for physiotherapy and rehabilitation.[19]

While the public health sector is heavily involved in preventing disease, like vaccinations and such, the private sectors offer little services in that regard. The number of staff and patients in the private sector compared to the public sector is not negligible; 798,985 to 1.75 million patients, respectively. Some of these Hospitals are Ahmadi Hospital, Texaco Hospital, and Kuwait National Petroleum Company Hospital. In 2014, the health

[19] Source: The World Health Organization, Health System Profile – Kuwait, 2006.

workforce was counted to be 25 doctors and 59 nurses and midwives per 10,000 people (WHO, 2006).

2.7.3 Demography

The population of Kuwait has increased sharply since the 1960s owing to the income from oil: from about 0.5 million in 1965 to about 1.5 million in 1995, mostly attributed to migration (Kuwait Central Statistical Bureau, 2013). This population growth has been accompanied by rapid urban extension: Many public hospitals, health centers, and clinics were established during this time to fulfill the increasing demand for public health services. The population also increased greatly during the last two decades. During this period, however, urban development was relatively slow, and thus the country's infrastructure faced increasing pressure, including public health services.

As of July 2017, Kuwait's population was at 2,875,422. However, with immigration amounting to more than 69.5%, the population, it has increased to 4,437,590 according to Kuwait's Public Authority for Civil Information. The growth rate at which the population is increasing is 1.46%. Immigration to Kuwait has been taking a slow descent at a rate of -0.24%. In 2018, almost 100% of Kuwait's population lives in its Capital city; Kuwait and on Failaka Island, as opposed to just the year before that where 96.4% of the population lived in Kuwait.

TABLE 6: POPULATION DATA[20]

Indicators	Value
Population (million) mid-2018	4.2
Births per 1,000 People	14
Deaths per 1,000 People	2
The Rate of Natural Increase (%)	1.3
Population (million) mid-2030	4.9
Population (million) mid-2050	5.6
Infant Fertility Rate	8
Pop. per km^2 of Arable Land	54,508

[20] Source: 2018 Population Reference Bureau

The total dependent ratio, meaning those who are unable to depend on themselves to earn their living and be a part of the labor force, is 29.8, the youth dependency ratio is 27.1 and the elderly is 2.7, as of 2015. Kuwait has a densely urban population and is gradually increasing. In 2017, the urban population was consistent with 98.4% of the total population of Kuwait (PUBLIC Authority of Civil Information, 2018). However, in 2018, that percentage has increased to nearly 100%. Studies in 2017 show a rate of urbanization at 2.29% annual rate of change (2015-20) est, while the ratio of population as a whole has increased from 62.8% to 69.6% over the past three decades. (PACI, 2018).

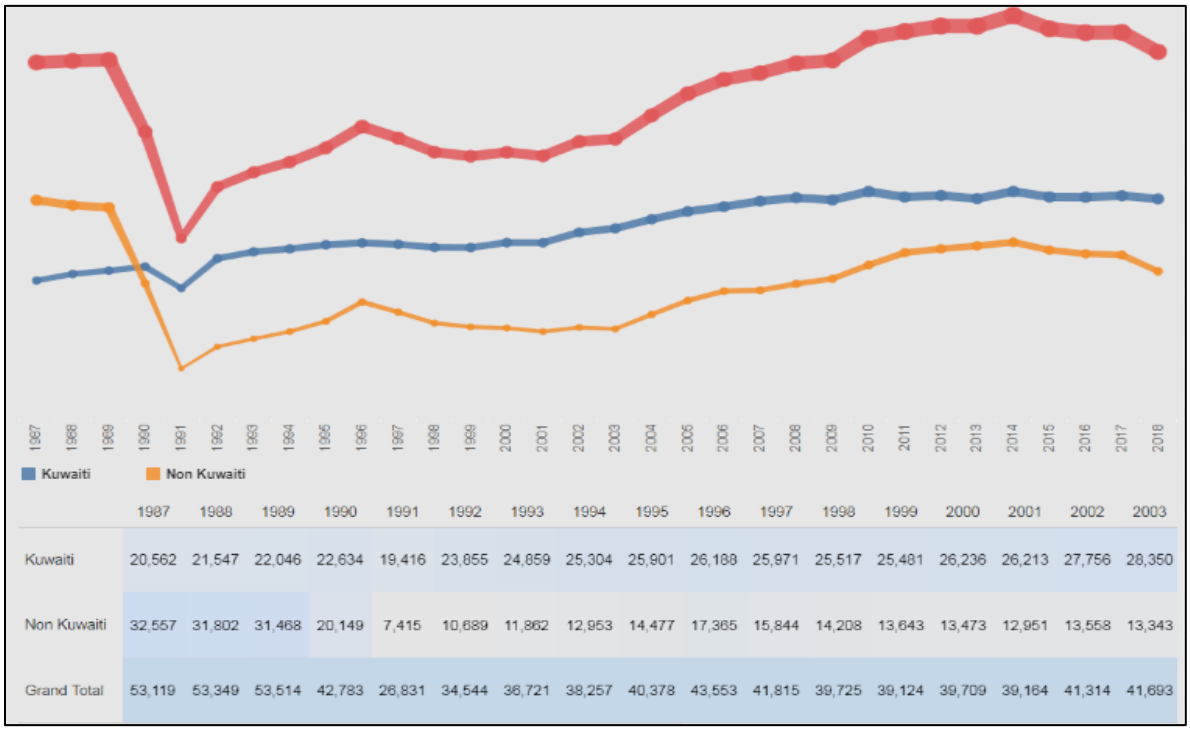
> The urban expansion along the coast and the rapid population growth due to the uncontrolled migration rate are significant non-climate stressors that are expected to play a great role in increase the country's susceptibility to climate change.

Islam is the official religion in Kuwait with most of the Kuwaiti population being Muslims. In 2015, Christianity made up 26.4% of the population of non-citizen, and 0.02% of a citizen in Kuwait. The percentage of non-citizens that are Muslim is 64.1%, 26.4% Christian and the rest of other religion; Hindu, Buddhist, mostly due to the large Indian population in Kuwait. 65% of Kuwaiti citizens are Sunni while the rest are Shi'as. Official Arabic or otherwise known as Modern Standard Arabic is the official language in Kuwait, however people speak the Kuwaiti dialect, standard Arabic is used in school books, newspapers. Most private schools and Universities teach in English rather than Arabic. French is taught as a third language.

As the case is in all the countries in the world, not only natives reside in it, however, the ratios may vary. For example, America has the biggest ethnicity diversity in the world. Kuwait, on the other hand, due to its small size and another factor like the weather and its geographical location, has lower ethnicity percentages than most. The Kuwaiti citizens make 30.36% of the population, other Arab 27.29%, Asian 40.42%, African 1.02%, other 0.9% (includes European, North American, South American, and Australian) (2018 est.). (PACI, 2018).

2.7.4 Gender and Age Structure

Depending on the culture, eating habits, jobs and other variables, a society's mortality vary in gender and age simultaneously, making for varying sex ratios for different ages in the communities. In Kuwait, at birth, the sex ratio is 1.05 males to females, 1.08 from ages 0-14, 1.22 from ages 15-24, 1.72 from ages 25-54, 1.31 from ages 55-64, 0.89 from ages 65 and over. The total population seems to settle at a ratio of 1.41 male/female. FIGURE 21 illustrates the birth rate in Kuwait for the last 30 years.



	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Kuwaiti	20,562	21,547	22,046	22,634	19,416	23,655	24,659	25,304	25,901	26,188	25,971	25,517	25,481	26,236	26,213	27,756	28,350
Non Kuwaiti	32,557	31,802	31,468	20,149	7,415	10,689	11,862	12,953	14,477	17,365	15,844	14,208	13,643	13,473	12,951	13,558	13,343
Grand Total	53,119	53,349	53,514	42,783	26,831	34,544	36,721	38,257	40,378	43,553	41,815	39,725	39,124	39,709	39,164	41,314	41,693

FIGURE 21: BIRTH RATE, CRUDE[21]

The median age lies at 29 years, 30.4 for males and 27.4 for females. Age group ratios male to female from 0-14 years make 51.11% to 48.89%, 15-29 years make 61.51% to 38.49%, 30-44 years are at 68.66% to 31.34%, 45-59 years: 67.47% to 32.53% and 60-74 years 57.2% to 42.79% on average in 2018. (PACI, 2018).

The Gender Development Index is a relatively new indicator, introduced in 2014 in the Human Development Report. The GDI is a ratio of comparison of the female to the male

[21] Source: PACI, 2018.

population. In 2017, the GDI was 0.990 because the HDI value for females in Kuwait was 0.791 as opposed to 0.799 for males. The life expectancy at birth for females sits at 76.1, 73.9 for males, the expected years of education is 14.3 and 12.9, the GNI per capita is 39,570 and 93,476, respectively. The Gender Inequality Index (GII), which studies the gender-based inequalities in society by measuring the "reproductive, empowering and economic activity". Maternal mortality and birth rates are indicators of Reproductive Health; empowerment is measured by the amount of higher education a woman gets and the number of seats in the parliament dedicated for females, and lastly, the economic activity is measured by the amount of female involvement in the workforces. The higher the GII, the lower the country's HDI is. The percentage of women in the Kuwaiti parliament is 3.1%; the number of women that have reached at least secondary education comes up to 54.8%, as opposed to men where the percentage is 49.3%. The GII index in Kuwait is 0.270 (UNDP, 2018).

TABLE 7: KUWAIT'S GII FOR 2017[22]

	GII value	GII Rank	Maternal mortality ratio	Adolescent birth rate	Female seats in parliament (%)	Population with at least some secondary education (%)		Labour force participation rate (%)	
						Female	Male	Female	Male
Kuwait	0.270	57	4	9.0	3.1	54.8	49.3	47.4	84.1

2.7.5 Education

Kuwait offers education to all its citizens with the goal of improving lives and the community. Although receiving an education is seen as a right for all in Kuwait, it is not free, especially higher education. The municipality of education has long-term goals concerning the educational and schooling systems. A successful educational system offers a balance between keeping the county's identity while preparing the student for all kinds of changes the country might undergo. Education also prepares for any technological, industrial or mechanical advancements. The 2005-2025 Education Strategy includes;

[22] Source: UNDP, 2018

1. Contributing to the achievement of interaction with the current age requirement of freedom of thought and response to the dynamics of change without conflict with the cultural identity of the society;
2. Contributing to enhancing the values of faith in the importance of dialogue and respect for human rights among the educated and providing the basis for a sound democratic life;
3. Enhancing the concept of wealth production, the preservation of the environment and the resources of the country;
4. Enhancing the basic requirements for school curricula in the general education system to ensure the achievement of the objectives and principles of the state[23].

There are numerous laws, regulations, and legislation concerning education in the Constitution of Kuwait;

- **Article 13;** "Education is a fundamental requisite for the progress of society, assured and promoted by the State".
- **Article 14;** "The State shall promote science, letters, and the arts and encourage scientific research therein".
- **Article 40;**
    1) "Education is a right for Kuwaitis, guaranteed by the State in accordance with law and within the limits of public policy and morals. Education in its preliminary stages is compulsory and free in accordance with the law.
    2) The law lays down the necessary plan to eliminate illiteracy.
    3) The State devotes particular care to the physical, moral, and mental development of the youth" (Kuwait Constitution, 1962).
- **Article 1 of the Compulsory Education Law:** "Education shall be compulsory and free for all male and female Kuwaiti children from the beginning of the primary stage until the end of the intermediate stage. The State undertakes to provide school premises, books, teachers and any other human or material resources, which guarantee the success of education". However, this law only applies to Kuwaiti citizens, rather than all the children living in Kuwait, which would mean that

[23] Points directly quoted from "World Data on Education VII Ed. 2010/11" by UNESCA-IBE.

not all children receive the same opportunities or level of education. Non-citizens could enroll in private schools (Kuwait National Assembly, 2017).

- **Legislative Decree of 1979 regarding the Ministry of Education;** defines the Ministry's role "as the development of Kuwaiti society and the upbringing of its young within an integrated scientific, spiritual, moral, intellectual, social and physical framework. They were tasked with meeting this objective in light of the principles of Islam, Arab heritage, defines the Ministry's role as the development of Kuwaiti society" (Kuwait National Assembly, 2017).
- **Legislative Decree No. 4, 1981 concerning the Eradication of Illiteracy;** it states that all males between the ages of 14-40 and females 14-35 to enroll in literacy programmes (United Nations Economic and Social Sector, 2015).
- **Legislative Decree No. 4 of 1987 concerning Public Education;** the first legislative giving legal framework for public education. This legislation focused on the constitutional laws in the State of Kuwait Kuwait National Assembly, 2017).

Despite the dedication and the amount of money spent on the educational sector (**FIGURE 22)**, Kuwait is said to deliver a relatively poor level of education. According to the Global Competitiveness Report 2015-2016, Kuwait is ranking 66th of 140 countries and that the level of education has receded in 14 categories in the past decades, and places 47th out of 53 countries in the Gulf Cooperation Council assessment.

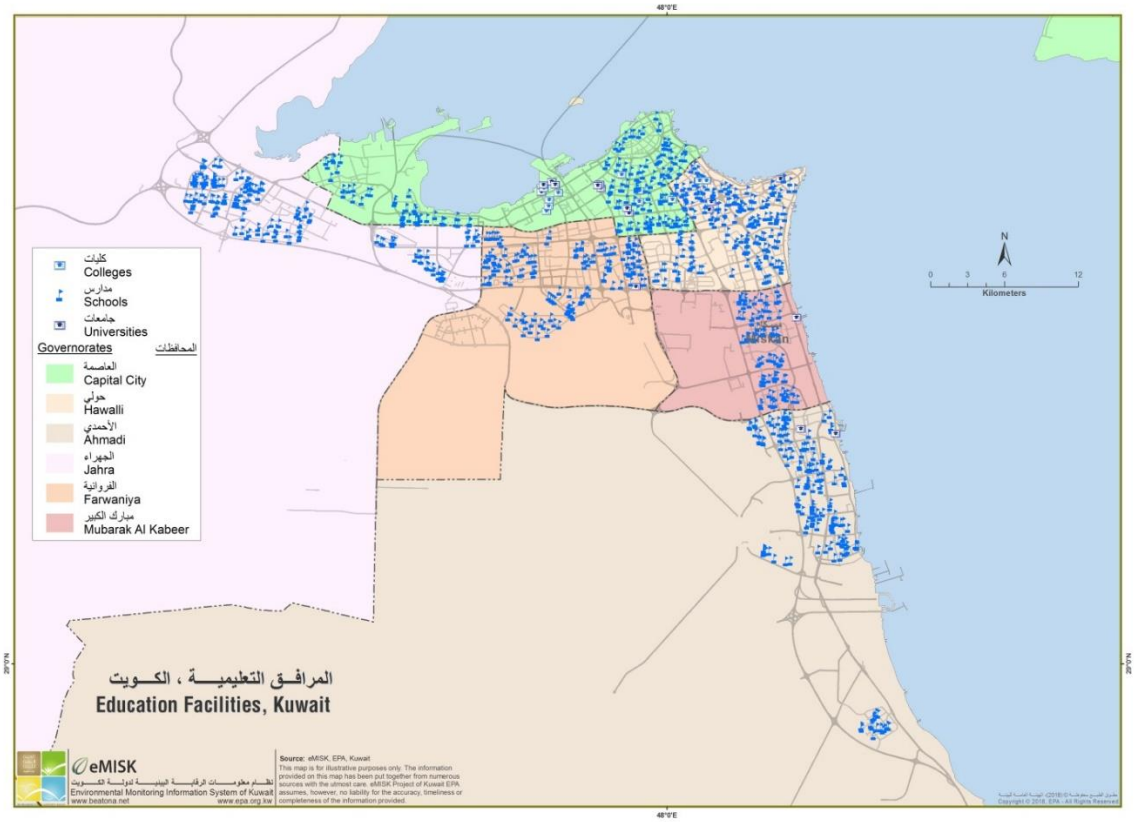


FIGURE 22: EDUCATION FACILITIES, KUWAIT

2.7.6 Unemployment

According to the 2015 United Nations Economic and Social Council the second developmental plan of (2015/2016-2019/2020) included many policies to achieve the increasing productivity and cooperation between international labor standards, environmental safeguards, productivity, competitiveness, and economic growth as follows:

7 "Expat workers in Kuwait enjoy health, education and social services for them and their dependents, according to laws and regulations, which assures Kuwait respect to international labor standards.

8 Improving the business environment, facilitating the procedures, and providing major investment opportunities are the most important aims of the second development plan. Establishment of joint-stock companies, engagement in partnership projects with the

private sector, improving public projects management, review and amend legislation, support the establishment of small businesses, and improve investment rates; are the most important policies to create opportunities at the private sector and to improve the economy in general.

9 The second development plan aims at increasing the productivity and efficiency of the economy by reducing the role of the public sector, increasing competition in the private sector, fighting monopolies, and rationalizing subsidies".

Kuwait has attempted to tackle the issue of graduates and job mismatch by undertaking several steps; analyze and investigate the marketplace and the needs and shortages in it, which indicates the shortages of specialized graduates, and then directing the higher education towards those need and demands. In the second development plan, the importance of integrating the product of the education to the labor market was put in highlight. The second development plan also included a few policies concerning training; one being the need for formulating and implementing a clear training methodology in Kuwait, also adopting strategies and standards from the National Institutes of Training to elevate the level of training programs (UN Economic and Social Council, 2015). The Kuwait unemployment rates over the last decade are presented in **FIGURE 23**.

FIGURE 23: KUWAIT UNEMPLOYMENT RATE[24]

[24] www.tradingeconomics.com, SESRIC

2.8 Industry

The Construction Industry, one of the industry sectors in Kuwait is massive with about $12.6 billion of infrastructure investment. With oil generation and a somewhat steady economy, Kuwait is more than capable of funding large projects. Coupled with the infrastructure and construction expertise, and the leading development in this field between the Gulf States in the GCC, opportunities will be readily available for Kuwaiti firms. The opportunity to expand the energy infrastructure and construction projects come with the success of the Al Zour projects. According to the Building and Construction Sector in Kuwait; "Kuwait's construction industry value is forecast at approximately USD 3.2bn in FY13, representing a real value annual growth of 3.6%. MEED estimates the total value of projects planned or underway in Kuwait at USD 188bn". The distribution of industrial areas is presented in Figure 24.

Transport Construction takes up to 76% of the budget of the total construction in Kuwait:

- "Kuwait City's USD 7bn metro project has been subject to delays, although there are signs of progress. The project is expected to be completed by 2020. However, according to Khaled Mahdi, the secretary general of the supreme council for planning and development, the AL Zour oil refinery project is to be completed in December of 2019.
- USD 3.3bn Kuwait International Airport (KIA) terminal will open in September 2016".

The Energy and Resources construction sector in Kuwait accounts for 20% of the total:

- "Kuwait National Petroleum Company is set to construct the largest oil refinery in the Middle East.
- The USD 14.5bn facility will have a daily processing capacity of 615,000 barrels from 2018.
- USD 1.8bn water and power project is being developed at Al Zour North".

Social Construction accounts for 4%:

- "Kuwait has at least USD 5bn of university building projects either in the planning stage or under construction" (Mounif Kilwani, 2014).

The first phase of the project is said to take a 1.7 M bpd in 2025 and 2 M bpd by 2035 in the second phase. And that includes building a new refinery, amongst other things. (Ian Simm, Newsbase Ltd. 2019).

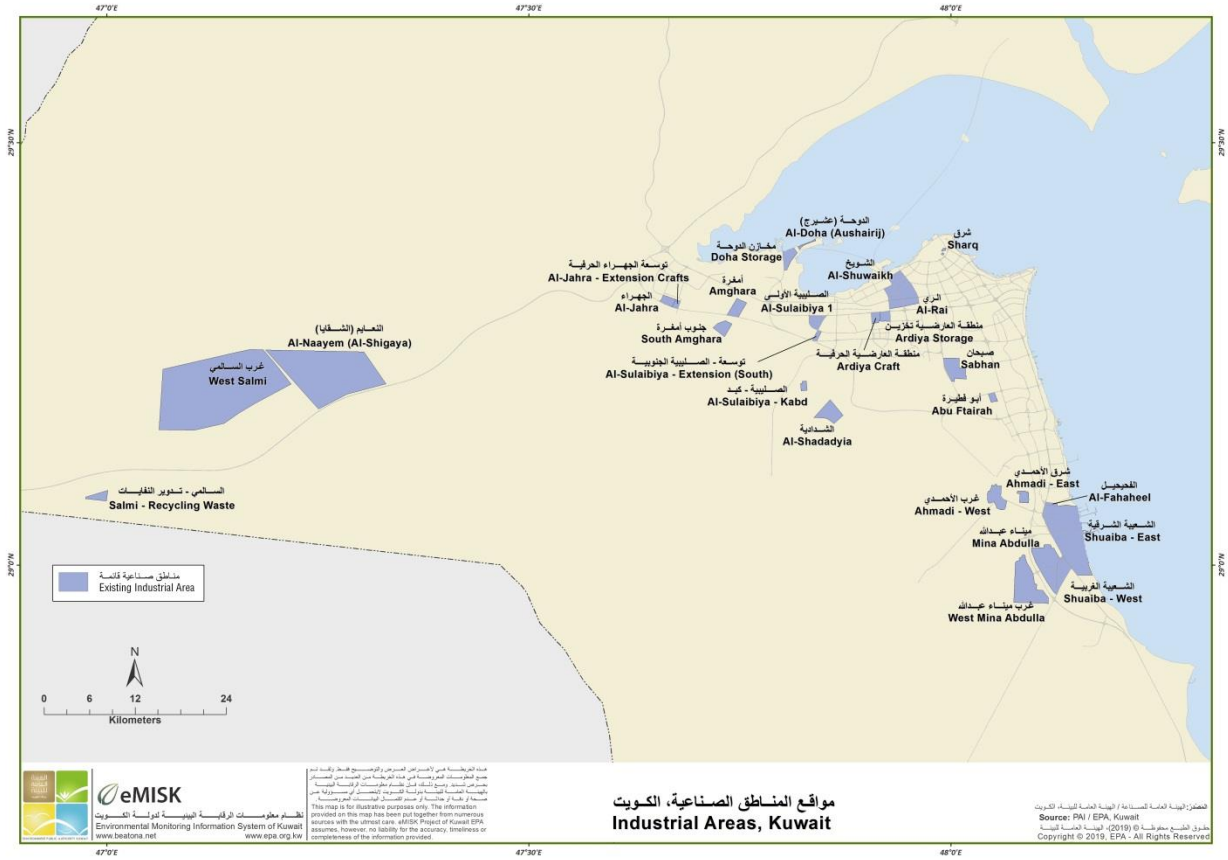
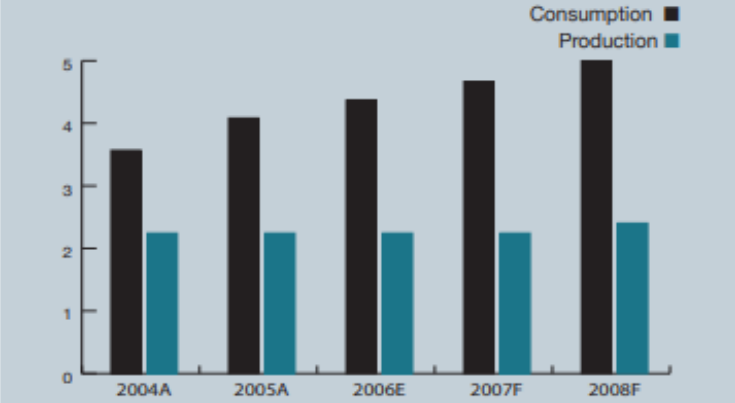


FIGURE 24: INDUSTRIAL AREAS, KUWAIT

There is only one cement company in Kuwait as of 2018, with the capacity of 2.24Mta. There is no indigenous raw material in Kuwait, rather all imported from UAE and Iran. In 2005, the Kuwaiti government gave license to a one-time export of 20,000t of cement to Iran. In 2006, The Kuwait-Jordan Holding Company launched that another cement factory ($230 M, 1.8Mta) was to be built in Kuwait. The cement prices are government controlled and sold in bulk coming at US$55/t export works, locally US$65/t. In practice, the government sells to Kuwaiti nationals at US$50/t by covering the cost between this price and the local free market price of more near to US$75/t (The Global Cement Report, 2018). Figure 25 illustrates cement industry growth in Kuwait, as an example.



m tonnes	2004	2005	2006E	2007F	2008F
Consumption	3.57	4.08	4.37	4.67	5.00
Change (%)	*0*	*+14.5*	*+7.0*	*+7.0*	*+7.0*
Production	2.24	2.24	2.24	2.24	2.24
Exports*	0	0.02	0	0	0
Imports*	1.40	1.84	2.13	2.43	2.80

** cement only*

FIGURE 25: CEMENT GROWTH IN KUWAIT[25]

2.9 Current climate trends

2.9.1 Temperature

Kuwait extends in a desert region characterizing with very high air temperatures during summer seasons that ranged from 43.0 to 48.6 ^{o}C, and relatively low air temperatures in winter seasons ranging from 6.4 to 10.6 ^{o}C: These ranges were absorbed based on the climatic data recorded at Kuwait international airport station during the last decade (2007 – 2016). Temperatures occasionally exceed this range. For instance, the highest maximum temperature ever recorded (51.7 ^{o}C) was observed in Kuwait international airport station in July 2017, while an air temperature of 54 ^{o}C was recorded in Mitibah station during July 2016. Also, lower temperatures below the range during winter seasons were occurred in 47 days from 1962 to 2017. This wide yearly range of temperatures is one of the significant harsh environmental conditions that Kuwait experiences. The overall temperature trend during the study period exhibited an observable rise in the temperature estimated to be 1.6 ˚C.

[25] Source: ICR Research

2.9.2 Rainfall

The average annual precipitation over Kuwait for the period of 1962-2017 was 112 mm: Most of the precipitation occurred during winter and spring seasons. Some years clearly deviated from this annual average: For instance, the annual precipitation of 1979 was 244.8 mm, while it was only 32.2 mm in 1964. The precipitation trend, however, was not clearly stated in the second national communication report. The statement that can be concluded from these precipitation values is that the lower and fluctuating precipitation values are expected to be one of the significant factors disturbing Kuwait ecosystems.

A study, by Jaber Almedeij in 2012 was conducted using a model to form and understand the precipitation (mainly rainfall) patterns in the urban areas in Kuwait. Rainfall data, whether spatial or temporal, are collected from different stations in Kuwait and Kuwait International Airport, respectively and then analyzed accordingly. One of the objectives of this study is to connect the rainfall intensity and frequency in Kuwait and how that correlates to the amount of water that goes to agriculture and helps with the supply of water that is dedicated to Agriculture in Kuwait. The mentioned weather stations in Kuwait for the Spatial Rainfall data collections in the urban areas in Kuwait are Jahra, Shwaikh, Ahmadi, Salmiyeh and a few more. The data was collected from the mid of 1990 decade till 2005. The average annual total rainfall data for 20 years is presented in Figure 26.

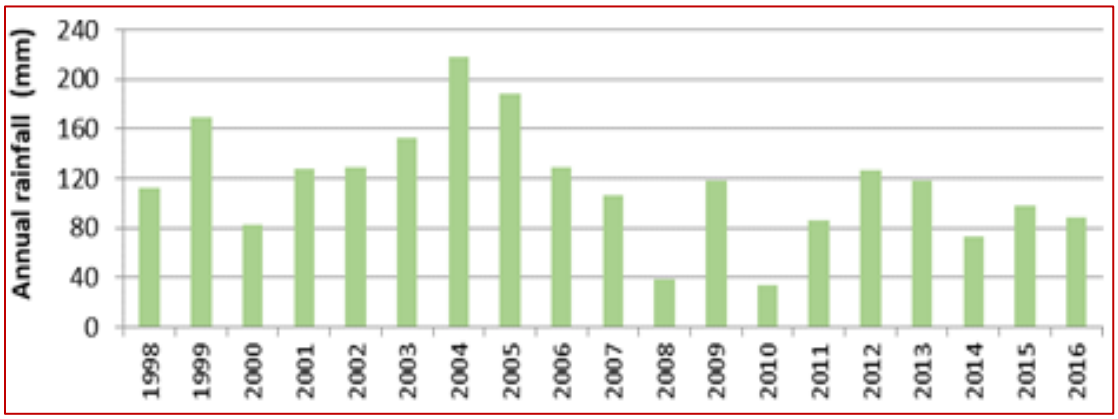


FIGURE 26: AVERAGE ANNUAL TOTAL RAINFALL DATA 1998-2016[26]

[26] Source: Kuwait Civil Aviation – Metrology Department

The precipitation diagram for Kuwait City shows on how many days per month, certain precipitation amounts are reached. In tropical and monsoon climates, the amounts may be underestimated (Figure 27).

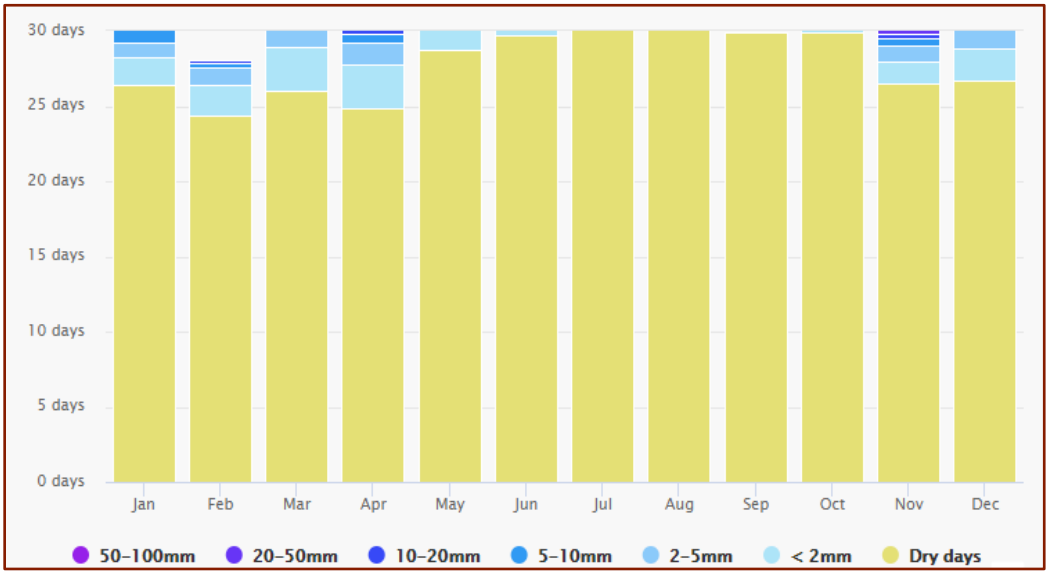


FIGURE 27: PRECIPITATION AMOUNTS[27]

2.9.3 Relative Humidity

Other climatic aspects that are disturbing Kuwait urban ecosystems are dust storms and rising dust that occur frequently in Kuwait during the last three decades. For instance, the yearly average durst storm events and rising durst events from 1987 to 2016 were 8.3 and 97.4 days, respectively. These frequent dust events were highly associated with air quality degradation by increasing the concentration of particulate matter ($PM_{2.5}$ and PM_{10}) in the atmosphere leading to serious health-related issues. The annual median of $PM_{2.5}$ levels was 75 of $\mu g/m^3$ (about seven times higher than the safe limit recommended by the World Health Organization, 10 $\mu g/m^3$) (KEPA, SNC, 2019). These high levels of $PM_{2.5}$ would increase the vulnerability of Kuwait urban areas to climate change.

[27] The precipitation diagram for Kuwait City shows on how many days per month, certain precipitation amounts are reached. In tropical and monsoon climates, the amounts may be underestimated. Source: meteoblue- Kuwait.

Samples were taken in ten locations over the period of a year. The data collected were the humidity concentration, Temperatures, wind information, and air pressures, as shown in the following table;

TABLE 8: DESCRIPTION OF THE SAMPLING PROTOCOL[28]

Month	Sampling duration		Temp °C	Humidity %	WD °N	WS m/s	Pressure m Bars
	Start	End					
March	03/03/2011	26/3/2011	19.75	46.17	213.14	3.81	1013.60
April	04/08/2011	23/4/2011	25.49	43.19	155.69	3.77	1007.25
May	05/07/2011	22/5/2012	32.31	37.58	134.14	3.47	996.13
June	06/11/2011	30/6/2011	36.81	30.80	234.38	3.82	994.43
July	16/7/2011	31/7/2011	38.04	32.68	204.67	3.38	994.89
August	08/01/2011	16/8/2011	38.08	33.61	195.70	3.34	1000.00
September	09/05/2011	20/9/2011	35.06	38.10	130.77	3.42	1008.62
October	14/10/2011	31/10/2011	28.55	43.37	171.01	3.51	1014.27
November	16/11/2011	30/11/2011	20.35	51.12	211.51	4.26	1019.65
December	12/02/2011	21/12/2011	15.07	55.16	253.84	3.96	1019.65
January	01/01/2012	28/1/2012	15.83	51.12	187.43	4.07	1016.74
February	02/10/2012	03/02/2012	15.76	55.96	195.84	3.66	1012.89

2.10 Future climate trends

2.10.1 Temperature and Rainfall Projections

Two scenarios of temperature rise drawn in the second national communication of Kuwait were considered: The first scenario, called RCP 4.5, was estimated considering low to medium emission increases; the other called RCP 8.5 was estimated considering intensive uses of fossil fuel in this century. The table below illustrates the expected temperatures based on the two scenarios. These temperatures were divided based on time intervals to draw detailed information of the future temperature trend for the next decades. Such detailed information would be a valuable mean in setting an adaption plan that imitates climate changes during each time interval. Overall, temperatures are expected to increase from 2.4 to 4.8 ^{o}C at the end of this century.

[28] Source: Jasem Al-Awadhi, 2014

THE SAME SCENARIOS WERE USED TO PREDICT PRECIPITATION CHANGES OVER KUWAIT. BOTH SCENARIOS SHOWED THAT PRECIPITATION VALUES ARE EXPECTED TO DECREASE DUE TO CLIMATE CHANGE IN THIS CENTURY.

Table 10 illustrates the expected decreases in precipitation based on the two scenarios. The precipitation values are expected to fall from 25% to 30% comparing to the baseline data recorded from 1986 to 2005. The expected temperature and precipitation values for the surrounding regions were also provided in the report. In conclusion, severe temperature increases and decreases in precipitation values would fundamentally change the02 ecosystem functions and socioeconomic aspects. Some recommended efforts to minimize the effect of these changes are tree plantings to decrease the albedo, educating citizens and raising public awareness about climate changes consequences.

TABLE 9: AN ILLUSTRATION OF TEMPERATURE CHANGES DIFFERENT TIME INTERVALS[29]

Scenario	Increase in Temperature (ºC)	Projected period
RCP 4.5	0.6-1.2	2031-2050
	1.2-1.8	2051-2070
	1.8-2.4	2071-2100
RCP 8.5	0.2-1.4	2031-2050
	2.4-3.0	2051-2070
	3.0-4.8	2071-2100

TABLE 10: ILLUSTRATES PRECIPITATION CHANGES IN DIFFERENT TIME INTERVALS[30]

Scenario	The decrease in annual mean precipitation (%)	Projected period
RCP 4.5	5 - 15 to 20 - 25	2031-2050
	5 - 20 to 5 - 25	2051-2070

[29] Source: KEPA, SNC, 2019.
[30] Source: KEPA, SNC, 2019.

	5 - 25 to 5 - 15	2071-2100
RCP 8.5	0 - 5 to 5 – 15	2031-2050
	5 - 25 to 5 - 15	2051-2070
	5 - 15 to 25 - 30	2071-2100

CHAPTER 3: CLIMATE HAZARD AND VULNERABILITY ANALYSIS

3.1 Introduction

Climate change is expected to have a profound effect on developing countries in different important sectors including water resources, food security, human health, terrestrial ecosystems, and coastal zones. For instance, variations in the temporal and spatial distributions of precipitation due to climate change would add a significant pressure on developing countries, especially those extending in arid and semi-arid environments, such as the State of Kuwait, where freshwater resources are scarce and desalinated water is the main source of freshwater (AL-Yamani, Bishop, Ramadhan, AL-Husaini, & Al-Ghadban, 2004). In Kuwait, the agriculture is highly vulnerable sector relying on domestic water supply from desalination: Groundwater is a minor source for the agriculture in the country (Al-Rashed, Al-Senafy, Viswanathan, & Al-Sumait, 1998). Thus, experiencing frequent drought events would increase the water demand for irrigations and other domestic needs (Pereira, Oweis, Zairi, & Santos, 2002). This demand requires more energy consumption to fulfill: According to the statistical year-book of 2017 published by the ministry of electricity and water, Kuwait consumed more than 710,000 BTUs of energy to fulfill it demands of electricity and desalinated water costing the country more than 1 billion KD (Ministry Of Electricity & Water, 2017). Such disturbance would also have other consequences, including increases in dust storm events that degrade the urban air quality and consequently put people with chronic epidemiological disease in danger (e.g., Barnett, Fraser, & Munck, 2012; Geravandi et al., 2017; Yang, Tsai, Chang, & Ho, 2005).

Drought events, dust storms, and heat waves play a significant role in degrading Kuwait terrestrial ecosystems. These harsh environmental conditions increase the susceptibility

of biodiversity reduction and threaten Kuwait food security. For instance, Asem and Roy (2010) stated that some indigenous plants and animals are less tolerance to drought conditions and are expected to be significantly disturbed due to climate change. Also, increasing temperatures would have multiple impacts not only on Kuwait terrestrial ecosystems but also on its coastal and marine ecosystems. Al-Husaini et al., (2015), for instance, discussed that the observed decline in shrimp production from 1985 to 2013 might be linked to increased coastal water temperatures due to climate change.

The coastal zone of Kuwait is also expected to be affected by sea level rise (SLR), one of the major consequences of global climate change. (KEPA, INC, 2012) revealed that about 65 thousand people would be exposed to SLR risk and more than 240 km^2 of land (1.35% of Kuwait's land) would be inundated when sea level increases only 0.5 m: These lands include vital services and infrastructures, such as hospitals, educational institutions, and major ports. Thus, designing an adaptation plan to face climate change, which has already observed, is a mandatory task to ensure the sustainability of human settlements and natural environments of Kuwait.

3.2 Designing Climate Vulnerability Assessment (CVA) for Kuwait

3.2.1 Climate Vulnerability Assessment

Climate Vulnerability Assessments (CVAs) are derived mostly from qualitative analyses to identify the susceptibility of people as individuals, their societies and ecological systems to climate change. CVAs are also set to draw strategies of facing climate change impacts so that stakeholders can use those strategies as a tool to mitigate climate change and maintain human settlements and natural resources. Successful assessments would help individuals, communities and societies to understand which sectors and natural resources more vulnerable and which activities should be taken to reduce their vulnerability. CVAs also illustrate links between climate change factors (e.g., elevated temperature and sea level rise) and non-climate factors (e.g., population growth and corruption): Understanding these links would assist societies to improve their capacity building for climate change (Kim, Calzada, Scott, & Zermoglio, 2018). Such efficient CVAs require systematic methods to be delivered.

Methods used to conduct CVAs depends on several factors including the complexity of CVA framework, spatial and temporal extents, objectives, and level of expertise required for conducting the assessment (Kim et al., 2018). The amount of detail and depth of analysis presented in the CVA depend on its scope: An overall CVA covering the most important sectors might involve gathering and synthesizing results of previous studies, whereas targeting a specific sector might require data collection and extensive analyses including modeling exercises. Also, CVA spatial and temporal extents might vary from a local to global scale and from short-term to long-term periods including projection exercises (Hansen, Hoffman, Drews, & Mielbrecht, 2010; Warren et al., 2018): The spatial and temporal extents would determine which method is most appropriate for conducting the CVA. The objectives are also an important factor in determining the adequate CVA method. CVAs involving identification of climate change impacts require methods differ from those aimed to monitor the progress of climate change impacts. Finally, the level of expertise that requires establishing a CVA is very important in determining the CVA method. Some assessments require, for instance, the Geographic Information System (GIS) skills to analyze geospatial data and illustrate informative maps of Climate Vulnerability Index (CVI, (Kim et al., 2018)).

CVAs can be classified into three levels in terms of the scope and depth of analysis: These levels are strategy, project, and activity. The objectives of CVAs at strategy level are addressed at the country level and set to understand and identify climate risks, allocate climate risk hotspot and evaluate climate risks on the most vulnerable sectors. Achieving these objectives would assess in prioritizing the most vulnerable regions and sectors to climate change. The output of CVAs at strategy level might include identifying adaptation measures and highlighting areas for further analysis. CAVs at project and activity levels are conducted to answer more specific and detailed questions focusing on the smaller spatial extent and specific groups: CVAs at activity level address the most specific questions comparing to the other two levels (Kim et al., 2018). CAVs at project and activity levels are beyond the scope of Kuwait NAP.

3.2.2 Kuwait CVA Objectives[31]

Kuwait CVA's objectives are:

1. Identify and understand historical and projected climate risks at the country level,
2. Evaluating sectoral climate risks to inform sector planning, and
3. Identifying gaps for conducting climate vulnerability index.

Questions raised from these objectives were:

1. What are the historical trends of climate change?
2. What are the projected changes in climate to 2010?
3. What are the potential impacts on coastal zones?
4. How is climate change expected to affect fisheries and other marine resources?
5. How is climate change expected to affect human populations?
6. What are the gaps for conducting CVI?

3.2.3 Methodology to develop a CVA

Kuwait NAP was set based on a CVA at strategy level targeting four sectors (i.e., marine and fisheries, water resources, coastal zones, and health) identified by the stakeholders and the SNC. Data and information used to conduct the CVA were derived the SNC, national reports, peer-reviewed studies, and technical reports published by local and international agencies. The overview of methods, data, and information used to conduct the CVA of Kuwait are illustrated in the following table:

TABLE 11: OVERALL METHODOLOGY

Objectives	Methods	Sources	Output
Identify and understand historical and	A desktop review of	• Kuwait SNC	• Description of Kuwait's general climate.

[31] Kuwait CVA objectives were set following the suggestion of Kim et al., (2018).

projected climate risks at the country level	secondary sources		• Climate trends and modeled climate change: - Temperature projections. - Precipitation projections. - Sea level projections.
Evaluating sectoral climate risks to inform sector planning	A desktop review of secondary sources and basic GIS analysis	• Kuwait SNC • Peer-reviewed studies and technical report on relevant sectors, non-climate stressors, and climate impacts on Kuwait. • Geospatial data produced for Kuwait SNC.	• Description of: - Kuwait's marine and fisheries, water resources, coastal zones, and health sectors, - Climate impacts, and - Non-climate stressors (population growth, negative anthropogenic activities and SST). • Maps of climate risk hotspot (SLR). • A table describing SLR scenarios on Kuwait. • Distribution maps of total population, population density, and asthma patients. • Profile summarizing climate risks, vulnerability, and impacts on marine and fisheries, water resources, coastal zones, and health sectors. • Adaptation options

3.3 Assessing and Ranking climate change vulnerability

Assessing the climate change vulnerability of sectors is usually carried out by conducting CVI in which climate change vulnerabilities are spatially analyzed and indexed using geographic information system (GIS): This requires each sector to be spatially ranked

based on its vulnerabilities to climate change. In the SNC, the only sector that its vulnerability to climate change was spatially ranked was the coastal zone. The other sectors were analyzed using non-spatial approaches. Thus, this section presents the methodology and data required for conducting the CVI of Kuwait as a guideline for Kuwait national communication teams.

3.3.1 An Overview of the CVI method

CVI is calculated using spatial analysis tools available in GIS (mainly raster recalculation, reclassification, and GIS overlay function) through five main steps:

i) Selection of evaluation criteria,
ii) Determine and prepare the input layer (convert input data into spatial layers),
iii) Define criteria weight,
iv) Assessing the weights (constructing hierarchy, standardization of criteria, and assigning weights) and produce maps, and
v) Evaluate and assess output (matrix consistency check).

Determining criteria of climate change vulnerabilities is based on the previous studies that investigated climate change impacts and consequences on each sector such as those used to assess the vulnerability of the coastal zone. The required input GIS layers for the climate change vulnerability analysis are specified based on the selected criteria. These layers must share the same spatial extent, or at least they have a spatial overlap.

The CVI map is carried out using a raster-based GIS analysis. Thus, any input vector layer must be converted to raster as an initial step in the spatial computation. The processed raster layers are ranked and then weighted based on their priorities (Aldababseh, et al., 2018). Although the priority of layers is subjective, the decision can be made based on the monetary values or exposure to climate change risks.

The ranked weighted layers are then spatially overlaid to compute the sum of weighted scores. This process produced a CVI layer for each sector. These layers are weighted with the same manner to calculate the overall CVI map illustrating the vulnerable places to climate change: The highest pixel values in the CVI map revealed the most vulnerable

places to climate change. Figure 28 provides an overview of the processes involved in hypothetical vulnerability analysis.

3.3.2 Identifying and analyzing data

Proposed Kuwait NAP covers four sectors: Marine and fisheries, water resources, coastal zone, and health. These sectors must be spatially analyzed as an initial step to calculate CVI for Kuwait. In the SNC, the marine and fisheries sector focused on the impact of three water quality variables (i.e., SST, pH, and salinity) on coral reefs and other marine communities. The spatial distribution of SST and salinity can be significantly mapped by integrating into situ measurements with remotely sensed data, whereas understanding the spatial and temporal distribution of pH requires monthly well spatially distributed in situ measurements ($n \geq 30$). Another variable that can be mapped by integrating into situ measurements with remotely sensed data is water transparency measured using Secchi disk depth (SDD). Water transparency is one of the most important water quality variables that indicates light availability in aquatic ecosystems. It influences by various important factors, such as colored dissolved organic matter (CDOM), chlorophyll concentrations and suspended sediments (Attivissimo, Carducci, Lanzolla, Massaro, & Vadrucci, 2015; Cui, Zhang, Ma, & Li, 2007). SST, pH, salinity, and SDD layers can be used to allocate the vulnerable places within Kuwait coastal and marine environments. The susceptible areas, such as coral reefs, should gain more weight when calculating CVI for the marine and fisheries sector.

The CVI map of marine and fisheries must be analyzed impudently: It cannot be incorporated with CVI layers for the other sectors since the spatial overlap between them does not exist (INC, 2012; SNC, 2019). The water resource and health sectors share the same spatial extent, whereas the coastal zone sector spatially overlaps with them. These sectors can be analyzed together to calculate the overall terrestrial CVI for Kuwait.

Kuwait relies on three water resources: desalinated water, brackish groundwater and treated wastewater to fulfill its water demand in domestic, agriculture, and industrial sectors: The water desalination source is the main source of water in Kuwait. In the SNC, future water demands were analyzed using different scenarios based on three main inputs: water supply, water demand, and water transmission. The scenarios were drawn

considering a normal population growth (3.2%). These scenarios can be spatially analyzed to index the vulnerability of Kuwait to climate change in the water resource sector by considering the spatial distributions of water supply, water demand, water transmission, and population within Kuwait districts. Also, the cost of water supply for each district can be considered since this factor is expected to be varied from district to district.

The health sector in the SNC described the effects of harsh environmental conditions in degrading the quality of human environments and consequently exposing people lives to danger. The susceptibility of asthma patients to dust events and effects of heat waves discussed in the SNC can be investigated from a spatial perspective. The association of asthma patients with suspended dust and other air quality variables (e.g., ozone, sulfur dioxide, and nitrogen dioxide) can be spatially detected by observing them in each district. The in-suite measurements can then be spatially interpolated and represented as GIS layers, whereas asthma patients can be spatially mapped by the number of patients' visits to emergency departments from each census block (Gorai et al., 2014). The spatial association between the asthma layer and air quality layers can be evaluated using spatial relationship tools available in GIS (Gorai et al., 2014; T.J., P., J.M., S., & S., 2017). Understanding the role of climate stressors and non-climate stressors will assess in predicting the unhealthiest places for asthma patients (i.e., the most vulnerable places).

Events of heat waves, on the other hand, can be incorporated in this analysis if they exhibited spatial variability within the study area.

The coastal zone resource was spatially analyzed in the SNC: The CVI map of this sector was produced based on four physical parameters (i.e., elevation, coastal slope, geomorphology, and distance to 20 m isobath) and four socioeconomic parameters (i.e., population, land-use, cultural heritage, and transportation) (KEPA, SNC, 2019). The CVI map of this sector can be used as an input layer to calculate the terrestrial CVI of Kuwait.

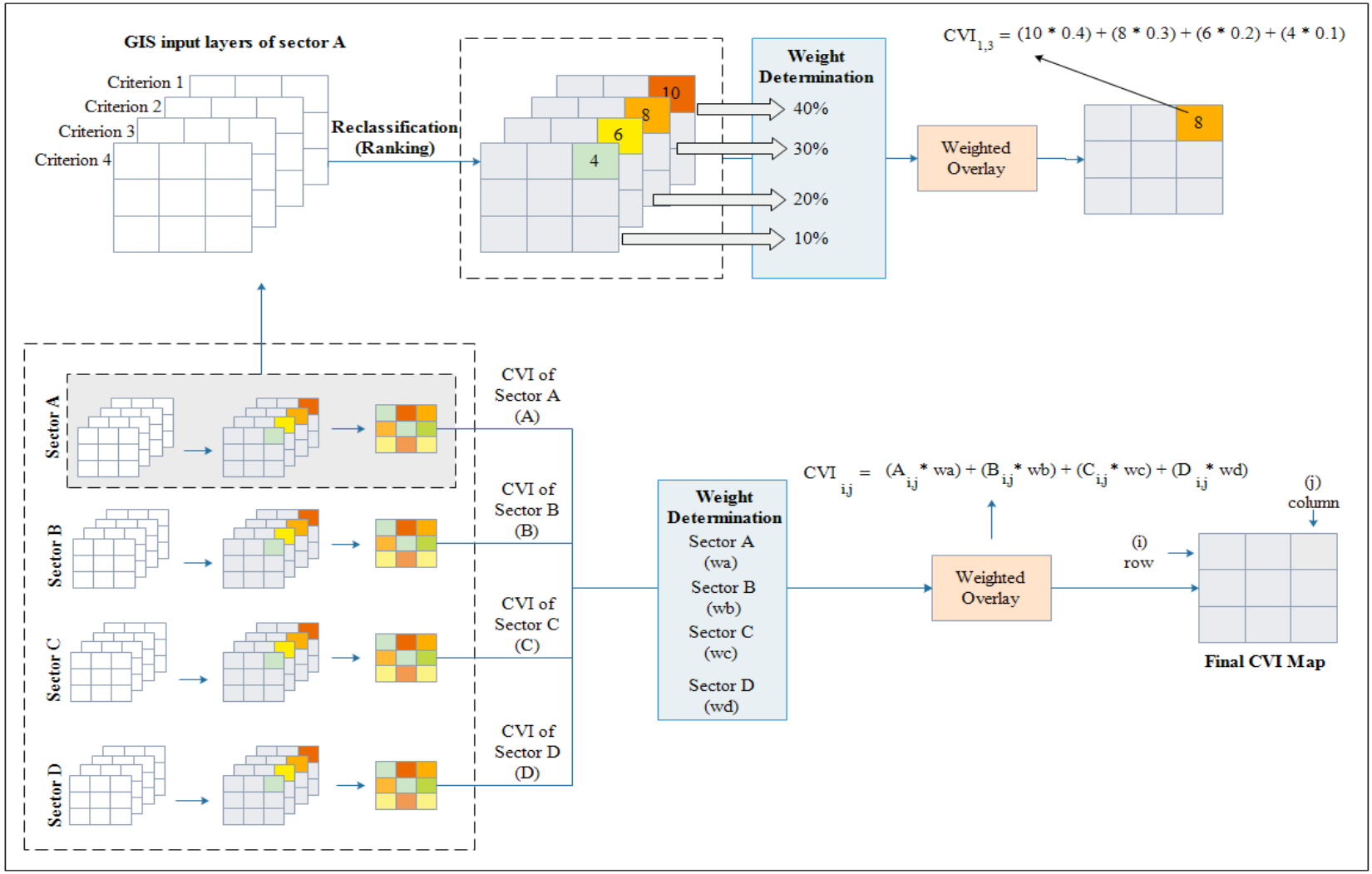


FIGURE 28: ILLUSTRATES THE OVERALL STEPS FOR CALCULATING CVI. THIS HYPOTHETICAL EXAMPLE REVEALED THE CALCULATION OF CVI FOR A CASE WITH FOUR SECTORS AND FOUR CRITERIA IN EACH SECTOR.

3.3.3 Ranking Climate Risks and Vulnerabilities

Assessing ranks of climate risks and vulnerabilities is a critical step in conducting CVI. It is also a fundamental component in prioritizing adaptation options and illustrating vulnerabilities of sectors to climate change in a comprehensive context. The ranking process is complex and subjective relying on qualitative analysis and experts' opinions (Aldababseh, et al., 2018). For instance, the climate risks and adaptation options were addressed in NAP of Sri Lanka with a context of prioritizing actions based on discussions of experts and working groups (Seneviratne et al., 2016). De Bruin et al. (2009) provided a systematic methodology for ranking and weights adaptation options for the Netherlands considering climate change risks on different sectors: The weights were based on experts' judgments. They stated that their methodology of ranking is interactive and can be used for another country with adjustments to that country conditions.

Following De Bruin et al. (2009), climate change risks and vulnerabilities of Kuwait have been ranked with adjustments in the context of ranking, criteria, and weights. The framework of ranking focused on climate change risks and vulnerabilities of Kuwait, whereas ranking adaptation options were not assessed: Such in-depth analysis is beyond the scope of this initial NAP. Also, the criteria and weights were adjusted based on data availability and differences in climate change risks. The proposed ranking method is fixable and should be reviewed and adjusted for future analyses based on data availability and input criteria.

The ranking of climate change risks and vulnerabilities consisted of five criteria:

(i) the level of damage that a climate change risk is expected to leave;
(ii) the level of a hazard on human health and food and water security,
(iii) the urgency of adaptation illustrating the necessity of immediate action,
(iv) the mitigation difficulty reflecting the incapability of controlling a climate change risk, and
(v) the level of impact across the sectors.

These criteria had weights of 30%, 20%, 20%, 15%, and 15%, respectively. The score of each criterion ranged from 1 (very low) to 5 (very high). The weights and scores were

chosen based on a subjective judgment drawn from the understanding and analyzing of multiple sources including De Bruin et al. (2009), Mwangi & Mutua (2015), UNFCC (2007), and Kunreuther et al. (2013). The weighted sum of climate change risk score (S) was calculated using the following equation:

$$S_j = \sum_{i=1}^{n} C_i * w_i,$$

where C_i is the criterion (i), and

$w_i$is its corresponding weight.

3.3.4 Scoring Assessment and Results

Marine fisheries sector has great importance to the country in providing about 50% of the seafood demand (AL-Yamani et al., 2004). The country extends in semi-arid environments where food and natural freshwater resources are very limited: The coastal and marine environments are the ultimate natural resources of food and fresh water for Kuwait (Al-Abdulrazzak et al., 2015). Thus, Kuwait is considered in a good position to tolerate the expected degradation of coastal and marine environments due to climate change risks (i.e., increased SST, increased salinity and ocean acidification). These risks can leave a severe impact on socio-economic components under limited mitigation options (e.g., the development of aquaculture). For these reasons, increased SST increased salinity and ocean acidification were given the highest score among the climate change risks. Increased SST was given the highest score (5) in all criteria because it is the most threating risks on coastal and marine environments as it has already reached intolerant levels (Table 12) (F. Al-Yamani et al., 2004; Glibert et al., 2002). Increased salinity was given a score of four in damage, risks and impact since organisms living near estuarine systems such as those living in coastal and marine environments of Kuwait exhibit a degree of tolerance to the salinity fluctuating (George & John, 1999). Ocean acidification was given a score of four in mitigation since it is caused by very complex factors including anthropogenic activities that can be controlled. Levels of pH within Kuwait seawater did not exhibit a significantly elevated trend. Thus, risks of ocean acidification were given a score of three.

Water resources sector mainly relies on desalinated water for freshwater demands. Thus, increased temperatures may have indirect effects on the water desalination, such as increasing seawater salinity and water irrigation demands. This climate change risk received a score of four in risks and impact, whereas its score in the mitigation difficulty was three since some mitigation options are feasible, such as controlling the population growth through restricted migration rules to decrease freshwater demands (Table 12) (Amery, 2015; Gulseven, 2016). The saltwater intrusion risk has a limited effect on the water resources sector since it mainly impacts groundwater, a minor source of freshwater in Kuwait. Controlling groundwater withdraw and restricting negative anthropogenic practices are some mitigation options to these risks (Al-Rashed et al., 1998; Kløve et al., 2011; Taylor et al., 2012). The saltwater intrusion risk was given these scores for these reasons.

The risk of inundation of low-lying areas due to SLR is expected to leave a significant impact on the coastal zone: Important infrastructure and facilities including power and desalination plants, ports, hospitals, and educational institutions are expected to be exposed to SLR risks. The monetary value of recovering damages on this infrastructure and facilities would be very high. One of the feasible mitigation options to this risk is to apply an adaptive coastal land use policy that restricts establishing major projects on vulnerable coasts. This risk received a weighted sum score of 4.35 due to the severe impact that can cause (Table 12).

The risks of increased dust events and heat waves on health sector were given a score of three in most of the criteria (Table 12). Although these risks are very serious and spatial comprehensive, they threaten certain susceptible population categories: Dust events affect children and elderly people; whereas heat waves affect outdoor workers. These risks can be minimized with mitigation options including adjusting the official working hours to avoid working during maximum temperatures in the day and establishing national health alerts for dust events and heat waves.

TABLE 12: RANKING OF CLIMATE CHANGE RISKS AND VULNERABILITIES

Climate Change Risks and Vulnerabilities	Sector	Damage (30%)	Risks (20%)	Urgency (20%)	Mitigation (15%)	Impact (15%)	Weighted Sum
Increased SST	Marine and Fisheries	5	5	5	5	5	**5**
Increased salinity	Marine and Fisheries	4	4	5	5	4	**4.35**
Ocean acidification	Marine and Fisheries	4	3	5	4	4	**4**
Increasing air temperature	Water resources	4	5	5	3	4	**4.25**
Salt water intrusion	Water resources	4	4	5	2	4	**3.9**
Inundation of low laying areas (SLR)	Coastal Zone	5	4	5	3	4	**4.35**
Increased dust events	Health	3	3	5	3	3	**3.4**
heat waves	Health	3	3	5	3	3	**3.4**

3.4 Climate Risks and Vulnerable Sectors

Kuwait's second national communication (SNC) consisted of three main sections: national circumstances; gas inventory and mitigation; and vulnerability and adaptation. The Kuwait National Plan (NAP) is mainly based on the vulnerability and adaptation work under the SNC. The vulnerability and adaptation section assesses the vulnerability of four sectors believed to be the most important sectors for the country and suggests immediate adaptation solutions (KEPA, SNC, 2019). The four main sectors identified by the stakeholders and the SNC are presented in detail in the following sections. Figure 29 illustrates climate projections and climate change impacts in Kuwait.

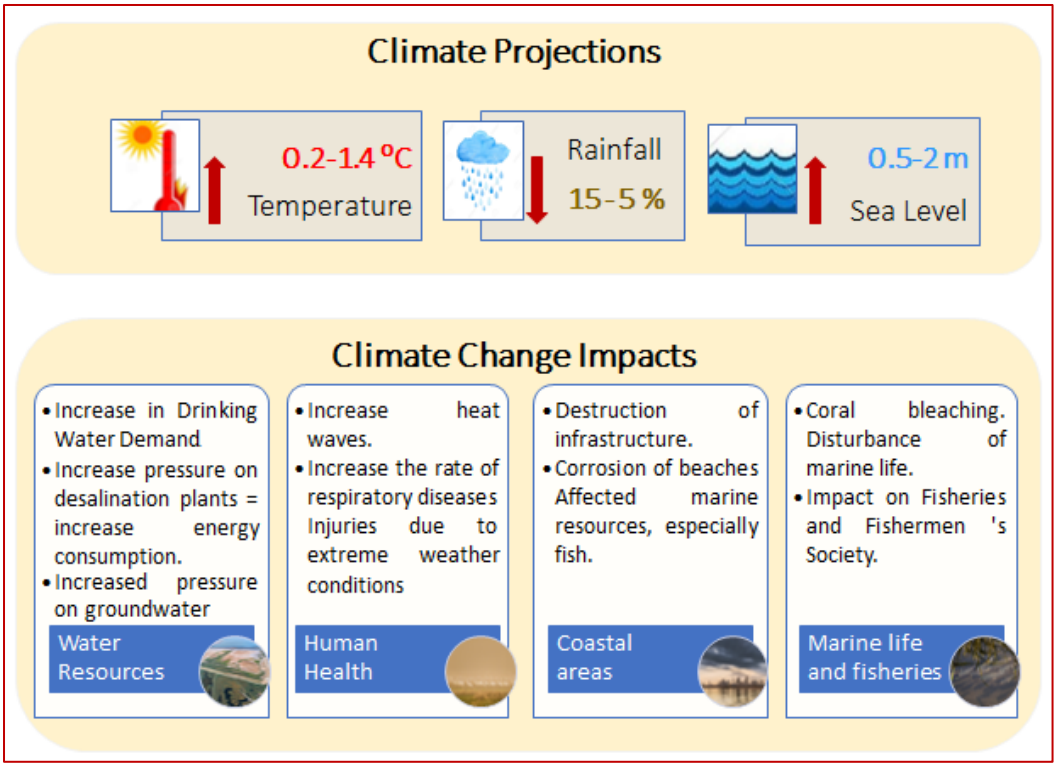


FIGURE 29; CLIMATE PROJECTIONS AND CLIMATE CHANGE IMPACTS- KUWAIT

3.4.1 Fisheries and Marine Life

Kuwait is in the northwestern bank of Arabian Gulf. It has a coastline of 495 km including its islands. Coastal and marine ecosystems of Kuwait are very productive that enrich with biodiversity: About 345 fish and shrimp species have been observed in Kuwait waters (Al-Husaini et al., 2015). These invaluable ecosystems provide the country with about 50% of the country seafood demand (AL-Yamani et al., 2004). Thus, fisheries are the second important sector after oil sector for Arabian Gulf countries, including Kuwait (Al-Abdulrazzak, Zeller, Belhabib, Tesfamichael, & Pauly, 2015). Kuwait marine and coastal environments have various habitats supporting a diversity of species: These habitats include intertidal mudflats, seagrass, algal beds, mangroves, and coral reefs. Among these habitats, coral reefs in the southern Kuwait waters that provide optimum habitats for many organisms and can serve as an indicator for the aquatic ecosystem status are the most stressful habitat because of complicated physical and anthropogenic factors.

One of these stresses is sea surface temperature (SST), one of the climate change consequences, Table 13.

Climate stressors and climate risks –Fisheries and Marine	
Stressors	**Risks**
Increased SST	Coral Reef Disturbance (Bleaching)
	Fish migration
	Effecting aquatic organisms' production
Ocean Acidification	Reducing the growth of many aquatic organisms
Increased Salinity	Negatively affects biotic and abiotic processes, disturbing microplankton, such as foraminifera.

TABLE 13: CLIMATE STRESSORS AND CLIMATE RISKS – FISHERIES AND MARINE

In Figure 30, the solid black line and the solid gray line represent SST derived from MODIS images, international airport station and in situ SST, respectively. Air temperatures clearly drive SST with a temporal lag of one month due to the thermal capacity of seawater: The highest SST occurs in August, while the highest air temperature occurs in July.

SST within Kuwait waters exhibited distinct spatial and temporal distributions. Overall, SST of north Kuwait waters including Kuwait Bay is lower than SST of southern waters: This spatial pattern persists in the winter, middle and later summer, and fall, whereas in spring, especially in March and April, this spatial pattern is totally reversed. May and June are a transition period between the two patterns. SST Kuwait waters increase from January (15.4 ^{o}C) and February (15.7 ^{o}C) to August (32.4 ^{o}C) and then decreased to December (18.1 ^{o}C) (KEPA, INC, 2012), Appendix A. This wide temporal range of SST significantly disturbs coral reef ecosystems (Carpenter et al., 1997) that relatively extend in warmer waters most of the year. The high SSTs in summer seasons and overall

increasing SSTs due to climate changes (Al-Rashidi, El-Gamily, Amos, & Rakha, 2009) would be a serious threat to these valuable ecosystems.

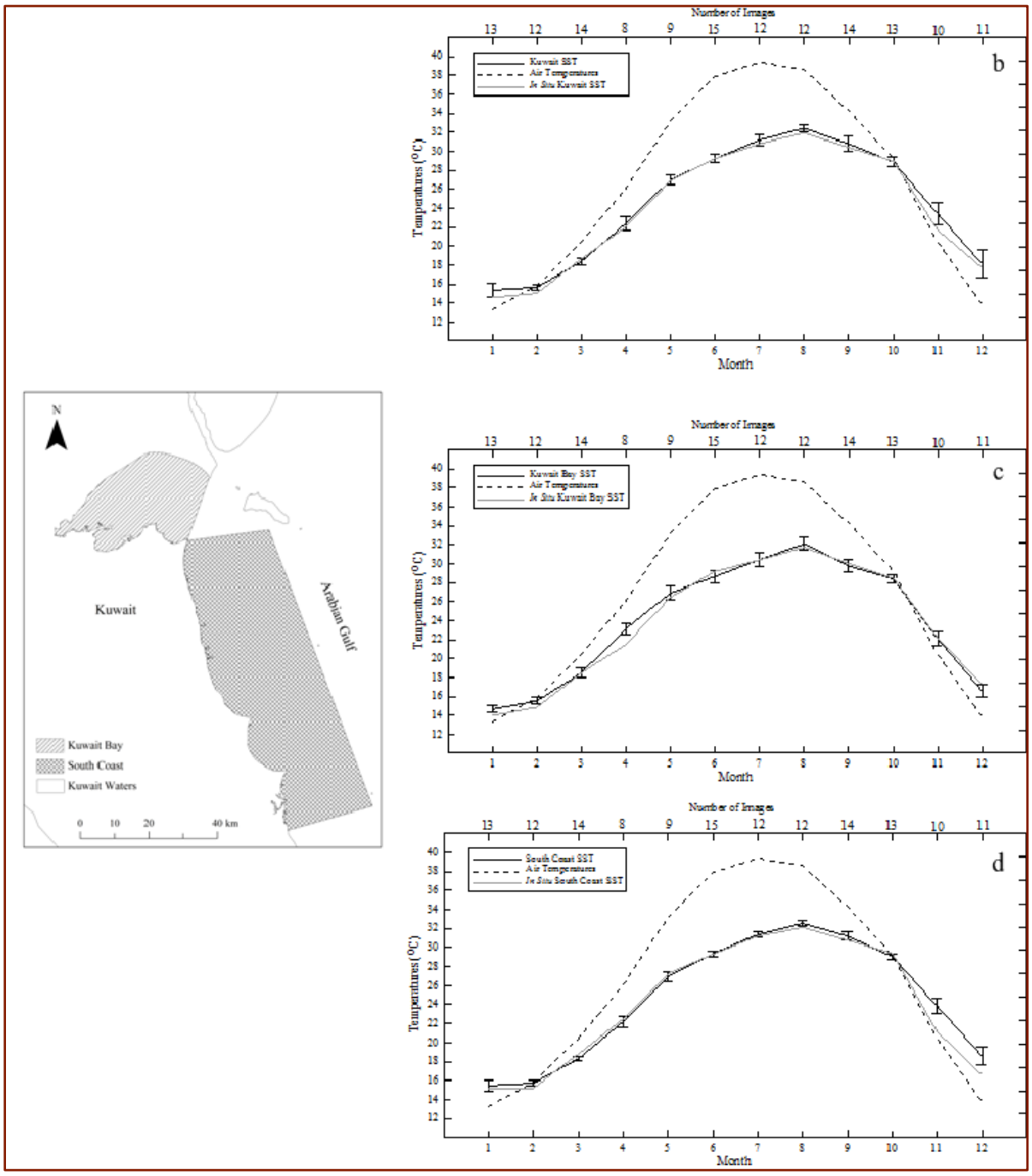


FIGURE 30: THE RELATIONSHIP BETWEEN AIR TEMPERATURES AND SSTS WITHIN KUWAIT SEAWATERS[32]

[32] Source: KEPA, INC, 2012

Average SST in January and August 2017 derived from Aqua MODIS level 2 images: SSTs were calibrated using KEPA, INC, 2012 model within an error of ± 0.7 oC (Appendix B). Coral reefs experience thermal stress during winter and summer seasons as the SSTs are off the optimism SST range for coral reefs.

Another factor expected to have an increasing impact on coral reefs and other marine and coastal ecosystems are increases of seawater acidity as pH decline. Seawater is a great atmospheric CO_2 absorber: As the concentrations of anthropogenic CO_2 are elevated in the atmosphere, oceans and other water bodies will absorb more CO_2. This process leads to ocean acidification, unhealthy status for aquatic organisms. Marine organisms are intolerant to a long-term ocean acidification that could substantially slow the growth of many organisms including reef-building corals, plankton and invertebrates and disturb the other trophic levels (Doney, Fabry, Feely, & Kleypas, 2009; Fabry, Seibel, Feely, & Orr, 2008; Hoegh-Guldberg et al., 2007). Normal pH values of seawater range from 7.8 to 8.3: pH values off this range for a long-term condition would be a stressful factor on aquatic ecosystems. Values of pH observed from 2009 to 2015 in the southern waters of Kuwait ranged from about 7.5 to 9.5 with a mean value of 8.4 (F. Al-Yamani, Bishop, Ramadhan, AL-Husaini, & Al-Ghadban, 2004).

The ocean acidification with other stressful factors, such as increasing seawater salinity, are expected to have serious negative effects on biotic and abiotic processes within Kuwait marine and coastal ecosystems. Kuwait seawater salinity ranges from 38.6 to 42.4 psu: This range is relatively high compared to the southern Arabian Gulf waters near the Strait of Hurmoz that has an average salinity of 36.5–37 psu (Carpenter et al., 1997). Increasing Kuwait salinity can be related to various factors including the decrease of Shatt Al-Arab discharge because of upstream water regulations (Lapshin, 2000; Rahi & Halihan, 2010) and high evaporation rates associated with weather temperatures and water shallowness. Coral species and other marine organisms exhibited difference salinity tolerance. Although some coral communities are salinity tolerance that can successfully live in some areas in the Arabian Gulf where water salinity exceeds 40 psu (George & John, 1999), Bauman et al., (2013) revealed that salinity ranges and other

physical parameters significantly explain the spatial distribution of coral reef communities in the Arabian Gulf. Thus, salinity fluctuations due to multiple factors including climate change are expected to disturb coral reef communities and other marine species leading to a general degradation in marine and coastal ecosystems.

Some microplankton species, such as foraminifera, are sensitive to changes in salinity and other factors, including pH and temperature (Fabry, Seibel, Feely, & Orr, 2008; Kurbjeweit et al., 2000; Segar, 2018). Al-Yamani et al. (2004) reported that the average salinity of Kuwait's sweaters is 41.6 psu: This range is relatively high compared to the southern Arabian Gulf waters near the Strait of Hurmoz that has an average salinity of 36.5–37 psu (Carpenter et al., 1997). Increasing Kuwait salinity can be related to various factors including the decrease of Shatt Al-Arab discharge because of upstream water regulations (Lapshin, 2000; Rahi & Halihan, 2010) and high evaporation rates associated with weather temperatures and water shallowness. Coral species and other marine organisms exhibited difference salinity tolerance). Although some coral communities are salinity tolerance that can successfully live in some areas in the Arabian Gulf where water salinity exceeds 40 psu (George & John, 1999), Bauman et al., (2013) revealed that salinity ranges and other physical parameters significantly explain the spatial distribution of coral reef communities in the Arabian Gulf. Thus, salinity fluctuations due to multiple factors including climate change are expected to disturb coral reef communities and other marine species leading to a general degradation in marine and coastal ecosystems.

3.4.2 Water Resources

Many developing countries experience an increasing demand for freshwater resources because of the exponential growth in population, urbanization, industry, and agriculture. Developing countries extending in arid and semi-arid regions, such as Kuwait, experience limited freshwater resources increasing the vulnerability of this important sector to climate change. Kuwait has a high daily per capita water use levels comparing to other countries. Kuwait relies on three water resources: desalinated water, brackish groundwater and treated wastewater to fulfill its water demand in domestic, agriculture, and industrial sectors. In the second national communication of Kuwait, the status and consumption of

these three water resources in Kuwait were reported based on the current and future demands (KEPA, SNC, 2019).

Kuwait relies on seven seawater desalination plants: Shuwaikh, Shuaiba North, Shuaiba South, Doha East, Doha West, Al-Zour South, and Sabiya (Figure 32). Ministry of Electricity and Water has increased the total desalination capacity for all units from 1.3 MM^3 to 2.4 MM^3 per day between 2000 and 2015 to fulfill the increasing demands on fresh waters (KEPA, SNC, 2019). Another freshwater resource is the groundwater, the only natural water resource in Kuwait. Most of the groundwater resources in Kuwait are brackish with total dissolved solids (TDS) ranges from 3,000–10,000 mg/liter. The other source of water is the treated sewage effluent (TSE) that becomes a valuable source of water with the high cost of water desalination. Ministry of Public Work collects wastewaters coming from all Kuwait areas and treats them in six wastewater treatment plants (Riqqa, Um Alhaiman, Kabd, Al-wafra, Kheran, and Sulaibiya). The TSE is mainly used for irrigation of highway landscapes, households' greening, public parks, and artificial wetlands (KEPA, SNC, 2019).

SST, pH, and salinity were recorded by KEPA from 2009 to 2015 at six nearshore sites in southern waters (KEPA, 2015). SSTs were off the optimum ranges for coral reefs in the winter and summer seasons. pH values varied from sites to another with an overall mean of 8.4. Monthly mean salinity ranged from about 40 to 43 psu. This high range of salinity is expected to increase in the future due to climate change **FIGURE 31**.

The water resources team in the second national communication projected the future demand of freshwater using Water Evaluation and Planning (WEAP) model based on the three scenarios: normal growth of demand, and the two climate scenarios (RCP 4.5 and RCP 8.5) (Box.1/ **FIGURE 33**). The model had three main inputs: water supply, water demand, and water transmission. The normal population growth (3.2%) was also considered in constructing the model. In the normal growth of the demand scenario, the total domestic sector water consumption would be 6,124 MCM in 2035 (2.24 times of the water consumption in 2017). In the RCP 4.5 and RCP 8.5 scenarios, the total domestic sector water consumption would reach 6,221 MCM and 6,233 MCM in 2035, respectively.

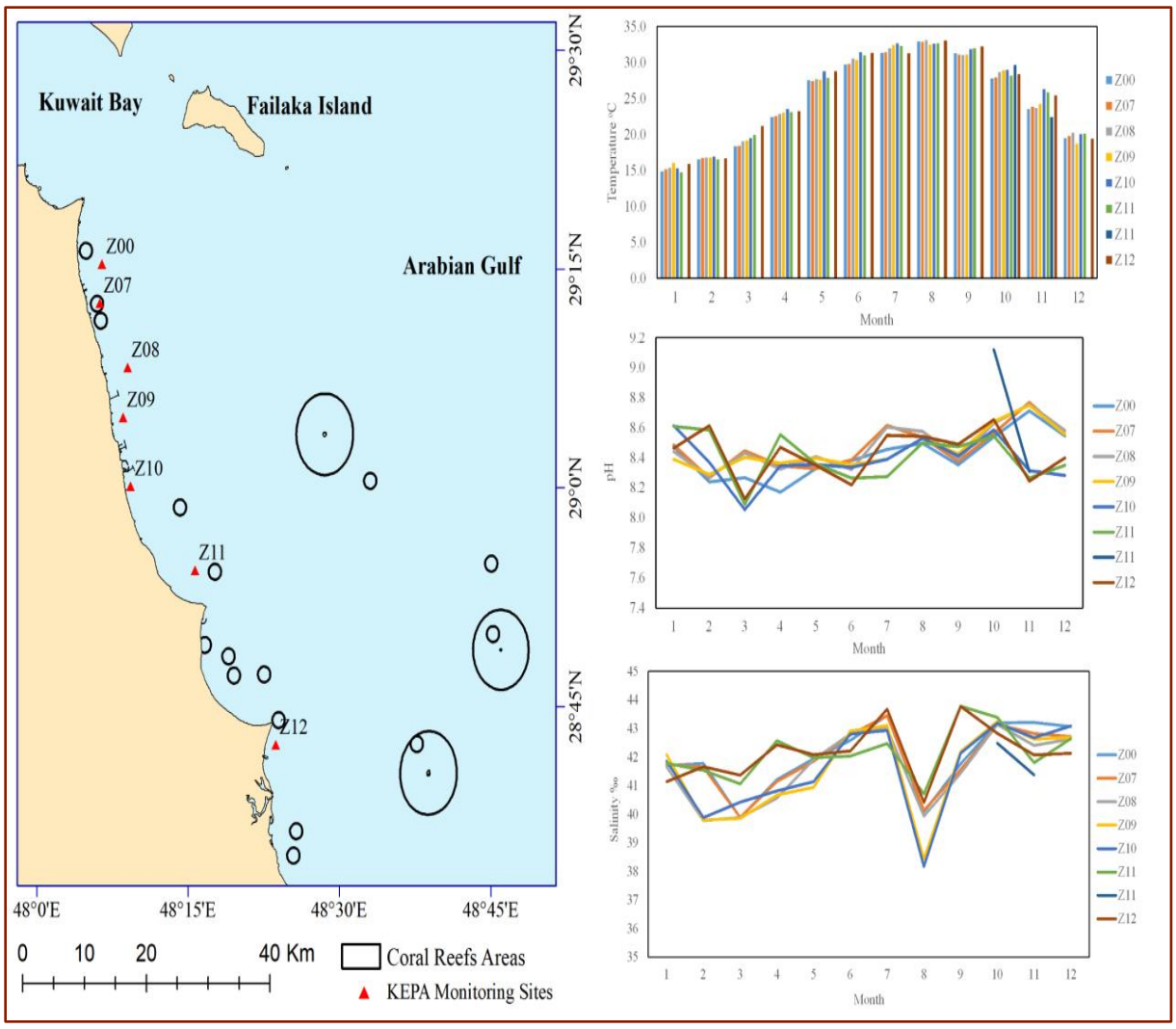


FIGURE 31: SST, PH, AND SALINITY 2009-2015[33]

[33]Source: KEPA, 2015

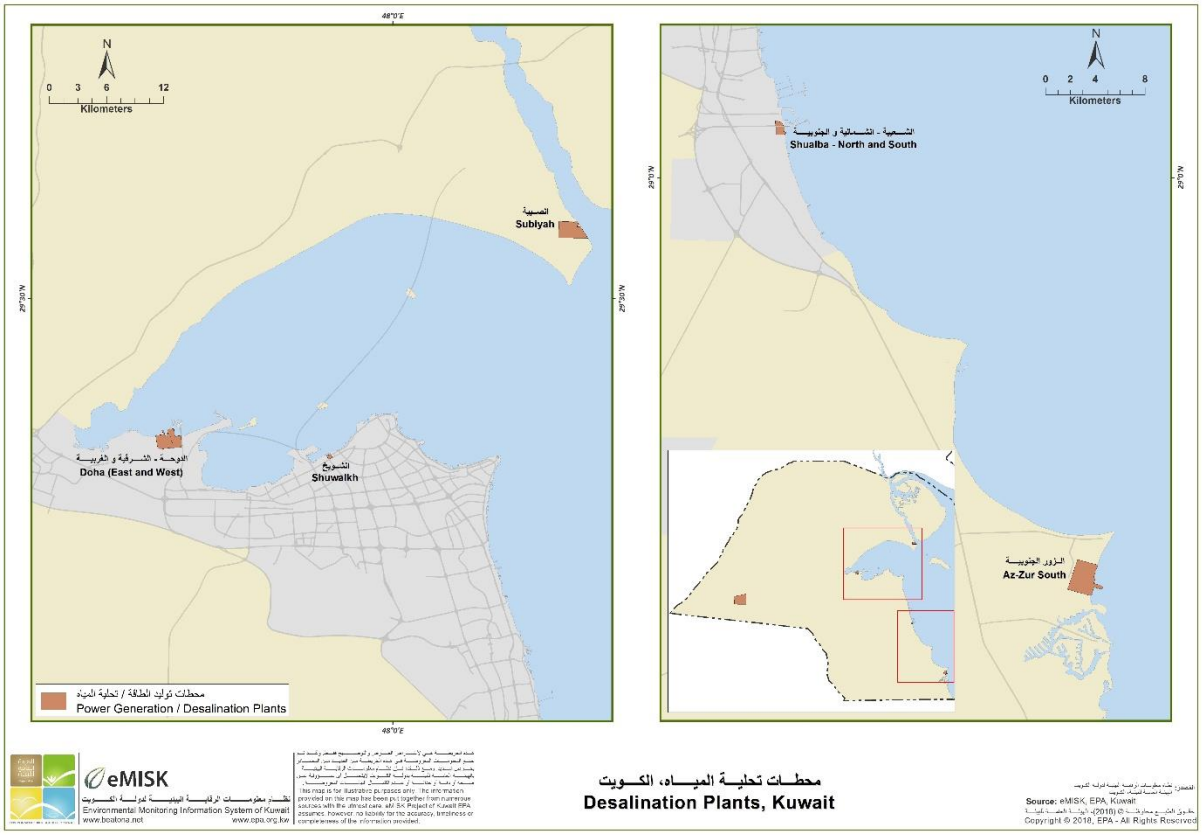


FIGURE 32: LOCATIONS OF KUWAIT DESALINATION PLANTS

The SNC highlighted some recommendations to reduce water consumption, including employing new water a block-tariff, and reducing physical leakages. Applying these recommendations was estimated based on the three scenarios as well as the cost in US dollars of the increasing demand for water resources under the three scenarios. Also, some important steps to mitigate the issue include capacity building, raising awareness, designing effective policies and supporting research and development were addressed.

Temperature and Precipitation Projections

Two scenarios of temperature rise were considered in the second national communication: The first scenario, called RCP 4.5, was estimated considering low to medium emission increases; the other, called RCP 8.5, was estimated considering intensive uses of fossil fuel in this century. The table below illustrates the expected temperatures based on the two scenarios. These temperatures were divided based on time intervals to draw detailed information of the future temperature trend for the next decades. Such detailed information would be a valuable mean in setting an adaption plan that imitates climate changes during each time interval. Overall, temperatures are expected to increase from 2.4 to 4.8 °C at the end of this century.

An illustration of temperature changes in different time intervals (KEPA, SNC, 2019).

Scenario	Changes in Temperature (°C)	Projected period
RCP 4.5	0.6-1.2	2031-2050
	1.2-1.8	2051-2070
	1.8-2.4	2071-2100
RCP 8.5	0.2-1.4	2031-2050
	2.4-3.0	2051-2070
	3.0-4.8	2071-2100

The same scenarios were used to predict precipitation changes over Kuwait. Both scenarios showed that precipitation values are expected to decrease due to climate change in this century. The table below illustrates the expected decreases in precipitation based on the two scenarios. The precipitation values are expected to fall from 25% to 30% comparing to the base line data recorded from 1986 to 2005. The expected temperature and precipitation values for the surrounding regions were also provided in the report. In conclusion, severe temperature increases and decreases in precipitation values would fundamentally change the ecosystem functions and socioeconomic aspects. Some recommended efforts to minimize the effect of these changes are tree plantings to decrease the albedo, educating citizens and raising public awareness about climate changes consequences.

An illustrates precipitation changes in different time intervals (KEPA, SNC, 2019).

Scenario	Changes in annual mean precipitation (%)	Projected period
RCP 4.5	5 - 15 to 20 - 25	2031-2050
	5 - 20 to 5 - 25	2051-2070
	5 - 25 to 5 - 15	2071-2100
RCP 8.5	0 - 5 to 5 - 15	2031-2050
	5 - 25 to 5 - 15	2051-2070
	5 - 15 to 25 - 30	2071-2100

FIGURE 33: TEMPERATURE AND PRECIPITATION PROJECTIONS

3.4.3 Coastal Zones

The coastal zone of Kuwait is enriched with biodiversity. For instance, Subkhas[34] extending along the northern coast of Kuwait and considered an ecotone between the terrestrial and marine environments are productive ecosystems that support a number of plant species and other organisms (El-Sheikh, El-Ghareeb, & Testi, 2006). Coral reefs in the southern offshore islands of Kuwait are unique environments that support various trophic levels. Kuwait islands are indeed fabulous environments where marine and terrestrial organisms interact. The coastal region of Kuwait can be divided based on urbanization into two regions. The northern coastal area that extends from the Kuwait-Iraq border in the north to the northern coast of Kuwait Bay is non-urbanized, but some mega developing projects on this area have already started, such as Mubarak Al-Kabeer Port on Boubyan Island (Al-Gabandi, 2011; Baby, 2014). The middle and southern coastal area of Kuwait that extends from the western and southern coast of Kuwait Bay to the Kuwait-Saudi border in the south is extensively urbanized.

THE MIDDLE AND SOUTHERN COASTAL AREA IS A VERY VITAL AREA IN KUWAIT WHERE MOST OF URBAN, COMMERCIAL, INDUSTRIAL, AND RECREATIONAL ACTIVITIES ARE CONCENTRATED: THIS URBANIZED AREA THAT LIES WITHIN ONLY 20 KM OF COAST IS SETTLED BY MOST OF KUWAIT POPULATION THAT REACHED 3.5 MILLION IN 2011 (ANNUAL STATISTICAL ABSTRACT (ASA), 2011). THE COASTAL AREA OF KUWAIT BAY HOSTS KUWAIT CITY, THE CAPITAL, AND THE MAIN COMMERCIAL PORT IN KUWAIT, SHUWAIKH PORT (

Figure 34). The southern coast includes residential, commercial and recreational areas, power plants, and desalination stations (Bakri & Kittaneh, 1998).

- Vulnerability assessment of Kuwait coastal zones to Sea Level Rise (SLR)

[34] Subkha is an Arabic word widely used in the scientific documents written in English to refer to coastal salt marshes of inland salt flat. The subakha is one of distinct coastal features in Arabic lands.

The estimation of IPCC-5 report to SLR reveals that sea level would rise from 0.26 to 0.82 m by the end of the 21st century (Intergovernmental Panel on Climate Change, 2014). As a baseline, the mid-range of this estimation, the 0.5 m SLR scenario, was adapted to assess the vulnerability of Kuwait coasts to SLR. The Coastal Vulnerability Index (CVI) of Kuwait coasts based on the other three scenarios (i.e., 1 m, 1.5 m and 2 m of SLR) were also calculated. The inundated areas at the four SLR scenarios were estimated by comparing the shoreline (high water tide) with elevations of the area adjacent to the coast. Areas with elevations below the projected SLR and connected with seawater were considered as inundated areas. The number of people at risk was estimated by multiplying the inundation area by its population density.

A CVI for Kuwait coasts was then computed using four physical parameters (i.e., elevation, coastal slope, geomorphology, and distance to 20 m isobath) and four socioeconomic parameters (i.e., population, land-use, cultural heritage, and transportation).

The total inundated area varied from about 214 km^2 at SLR of 0.5 m to 498 km^2 at SLR of 2 m. The geographic distribution of inundated areas at SLR of 0.5 m revealed that the northern islands of Kuwait, especially Boubyan Island, would be highly impacted: About 18.6% of the island would be inundated. Climate stressors and associated risk are presented in Table 14. The island would encounter a massive inundation when sea level rises 2 m: About half of the island would be inundated (Figure 35).

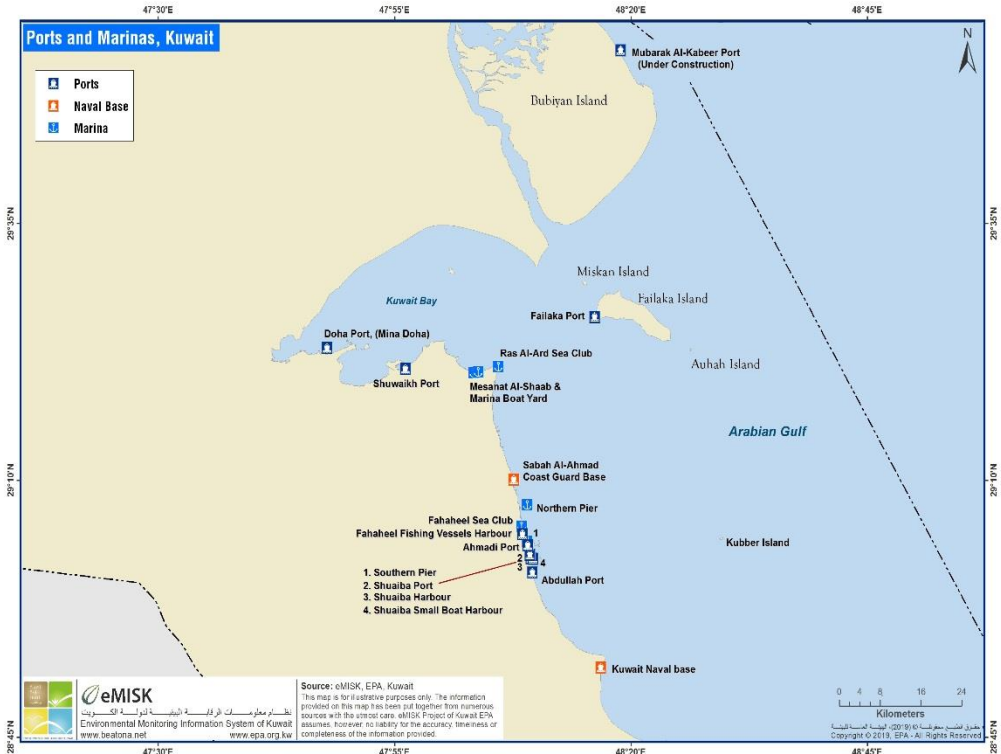


FIGURE 34: MAJOR PORTS IN KUWAIT

Climate stressors and climate risks – Coastal Zones	
Stressors	**Risks**
SLR	Damage to essential infrastructure
	Damage to private properties
	Disturbance of coastal ecosystems

TABLE 14: CLIMATE STRESSORS AND CLIMATE RISKS – COASTAL ZONE

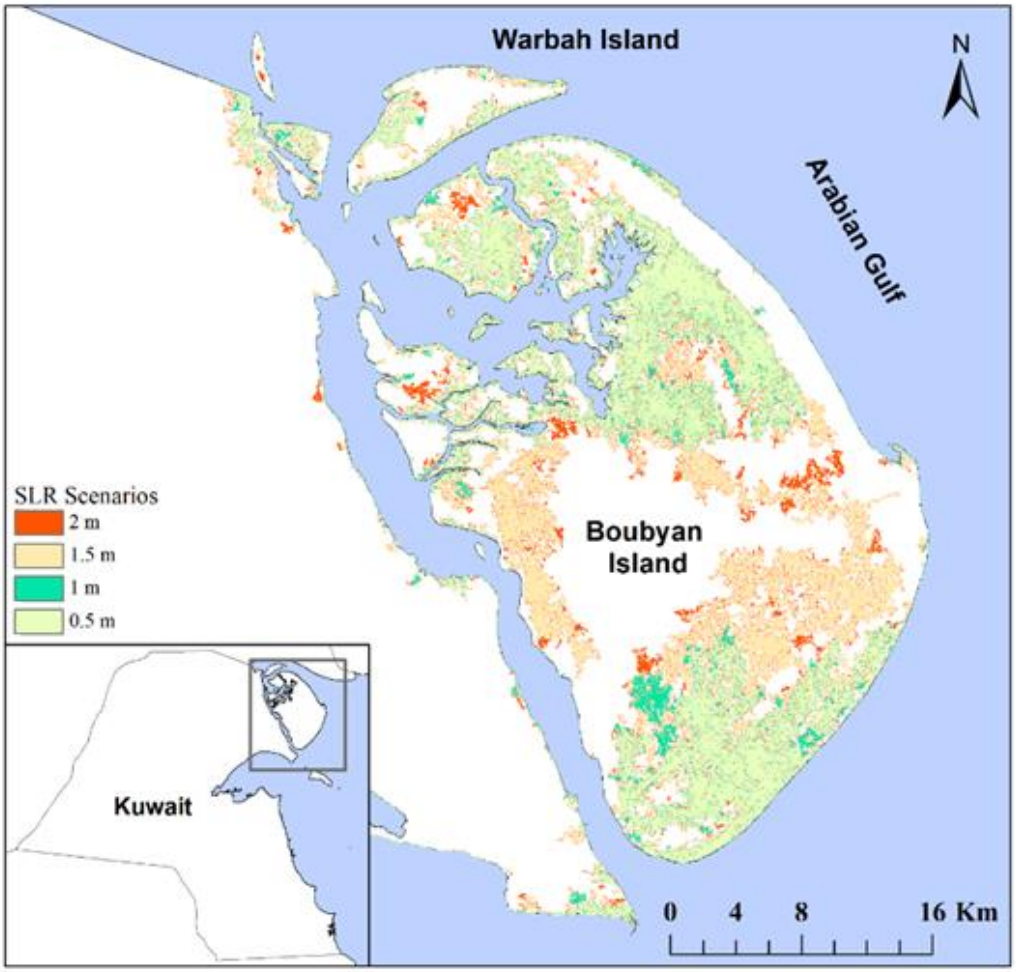


FIGURE 35: BOUBYAN ISLAND[35]

Boubyan Island is highly vulnerable to SLR at the four SLR scenarios. The island would encounter a massive inundation at the extreme SLR scenarios. Also, the coastal area along Kuwait Bay would be influenced by SLR, especially the western coast near Doha Port and populated areas (Figure 36). In the southern coast, the area near Shuaibah Port was the most influenced coast. In addition, the number of people at risk due to SLR is 30453 (about 0.8% of Kuwait population), whereas this number sharply increased to 527462 at SLR of 2 m (about 13.1% of Kuwait population). People exposed to the SLR impact are in the middle and southern coasts Kuwait Bay in the north to the Al-Khairan area in the south.

[35] Source: Draft SNC, 2018

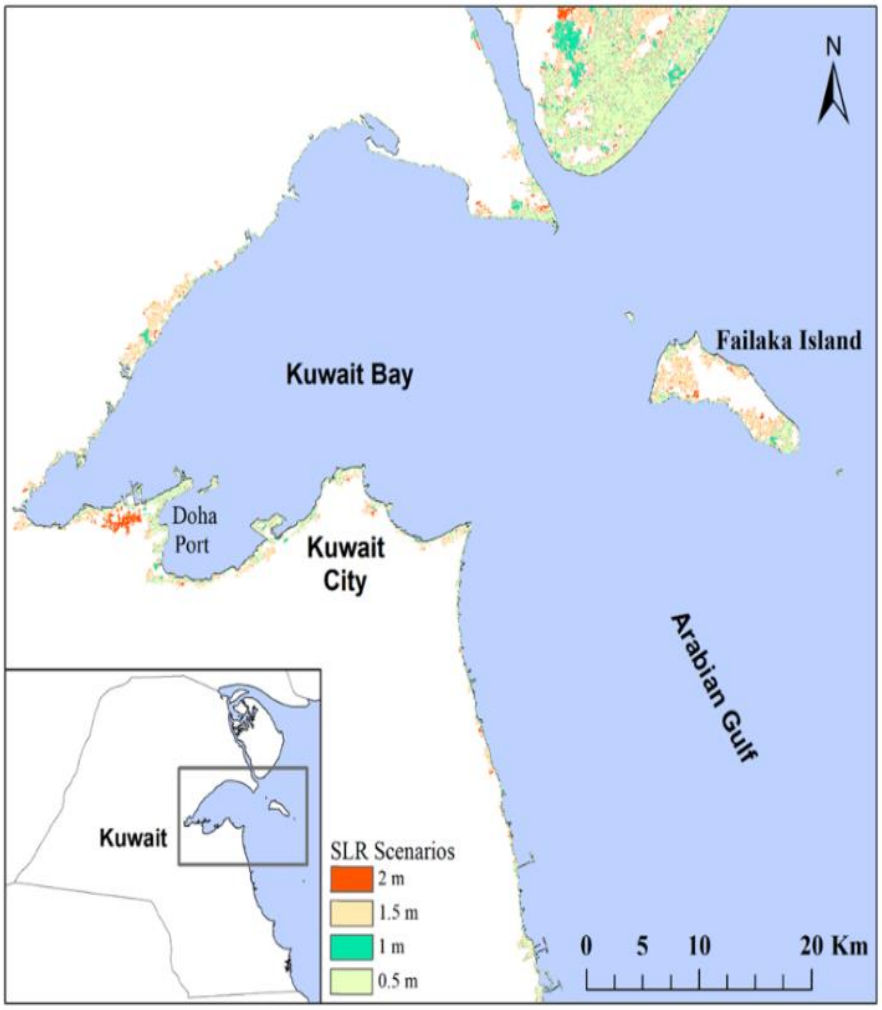


FIGURE 36: COAST FROM DOHA PORT TO KUWAIT CITY

Coast from Doha Port to Kuwait City is highly vulnerable to SLR at the four scenarios. These coasts host very important infrastructures and public services, such as hospitals and academic institutions.

- ***The baseline SLR Scenario (0.5 m)***

The CVI map, produced using eight parameters (i.e., elevation, coastal slope, geomorphology, and distance to 20 m isobath, population, land-use, cultural heritage, and transportation), illustrated that the coastal area under inundation risk in the 0.5 m SLR scenario varies from low vulnerability to very high vulnerability. Most of the coastal

area under inundation had a moderate vulnerability index that ranged in CVI score from 1.50 to 2.49 (Figure 37).

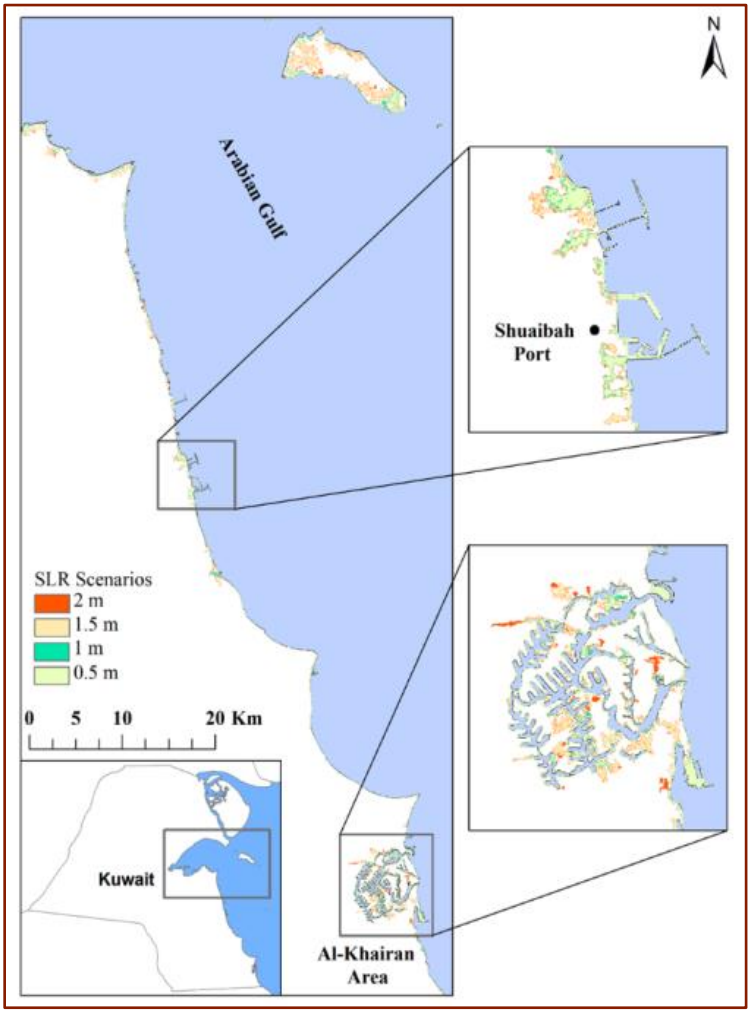


FIGURE 37: SHHUIBAH PORT AND AL-KHAIRAN AREA

Shuaibah Port and Al-Khairan recreational area are the most vulnerable coasts in the south. These areas occupy 150 km^2, about 81% of the area under inundation risk. Most areas with moderate CVI scores extend along the northern islands (Warbah and Boubyan): They received moderate scores because these areas are neither populated nor urbanized (Table 15). Also, Failaka Island facing Kuwait Bay had a moderate CVI score: The island has cultural heritage places, minor anthropogenic activities, and urban areas, but they were neglected when computing the island CVI due to the lack of data.

This lack of data should not affect the overall accuracy of Kuwait coastal vulnerability because these places extend in a very small area.

Most of the extensively urbanized area in Kuwait that extends in the western and southern coasts of Kuwait Bay exhibited high vulnerability to the 0.5 m SLR scenario including some areas in Kuwait City, the capital, Shuwaikh Port, one of the major ports in the Arabian Gulf, and several major hospitals in the country. Also, many recreational sites along the southern coast of Kuwait Bay occupied highly vulnerable areas. Areas with very high CVI scores were distributed in the western and southern coast of Kuwait Bay over limited areas (Table 15). Also, low CVI areas were very sparse along the Kuwait Bay coast. In the southern coast, most vulnerable areas had moderate CVI scores, such as Shuaibah Port and most of the Al-Khairan Area, an important recreational site in southern Kuwait. Areas with high CVI scores were very limited, whereas none of the vulnerable areas on the southern coast seemed to have very high CVI scores (Table 15).

This table shows the area of each class and corresponding CVI score at an SLR of 0.5 m. The percentage reveals the proportion of each class to the total vulnerable area.

TABLE 15: AREA OF EACH CLASS

	Vulnerability	CVI Score	Area (km^2)	Area (%)
0.5 m SLR Scenario	Low	1.00 - 1.49	0.203	0.11
	Moderate	1.50 - 2.49	149.997	80.99
	High	2.50 - 3.49	34.063	18.392
	Very High	3.50 - 4.00	0.941	0.508
			185.203	**100**
1 m SLR	Low	1.00 - 1.49	0.037	0.02

	Moderate	1.50 - 2.49	180.166	78.79
	High	2.50 - 3.49	47.183	20.63
	Very High	3.50 - 4.00	1.283	0.56
			228.670	**100**
1.5 m SLR Scenario	Low	1.00 - 1.49	0.04	0.01
	Moderate	1.50 - 2.49	298.138	78.01
	High	2.50 - 3.49	82.453	21.58
	Very High	3.50 - 4.00	1.529	0.4
			382.160	**100**
2 m SLR Scenario	Low	1.00 - 1.49	0.043	0.01
	Moderate	1.50 - 2.49	358.799	79.1
	High	2.50 - 3.49	93.011	20.5
	Very High	3.50 - 4.00	1.769	0.39
			382.160	**100**

- **The Severe SLR Scenarios (1 m, 1.5 m and 2 m)**

CVI scores of Kuwait coasts at SLR of 1 m were not very different from those scores at SLR of 0.5 m. The total inundation area at SLR of 1 m was about 229 km^2: Coasts with a moderate CVI score occupied about 180 km^2 (About 79% of the inundated area), whereas coasts with a high CVI score extended over about 47 km2 (About 20% of the inundated area). The inundation area at 1.5 m and 2 m SLR scenarios sharply increased to about 382 km^2 and 545 km^2, respectively. Also, the area of high CVI scores increased at these two scenarios illustrating that the Kuwait coastal area would be significantly disturbed at these extreme scenarios.

The geographic extent of potentially inundated areas at the four SLR scenarios revealed that the northern islands would be highly influenced reflecting the sensitivity of these coasts to the SLR.

SLR is expected to be a critical challenge on coastal zones that have already experienced a growing population accompanied by extending urbanization adding extensive pressure

on coastal environments. Designing long-term coastal management plans based on local and regional assessments of coastal vulnerability to SLR is a fundamental step to mitigate the impact of SLR. Two essential components in establishing effective SLR adaptation and mitigating strategies are adaptive coastal land-use policies that restrict establishing major projects on vulnerable coasts and protection of enriched coastal biodiversity.

Kuwait Bay, especially the western part near Doha Port and populated areas, had a high CVI score reflecting the sensitivity of these coasts to the SLR. These coasts host the most important infrastructure in the country.

Vulnerable coasts in the southern area of Kuwait extend generally at Shuaibah Port and most of the Al-Khairan Area, an important recreational site in southern Kuwait.

The Figures below Figure 38, and Figure 39 show fifteen figures of Coastline Sensitivity;

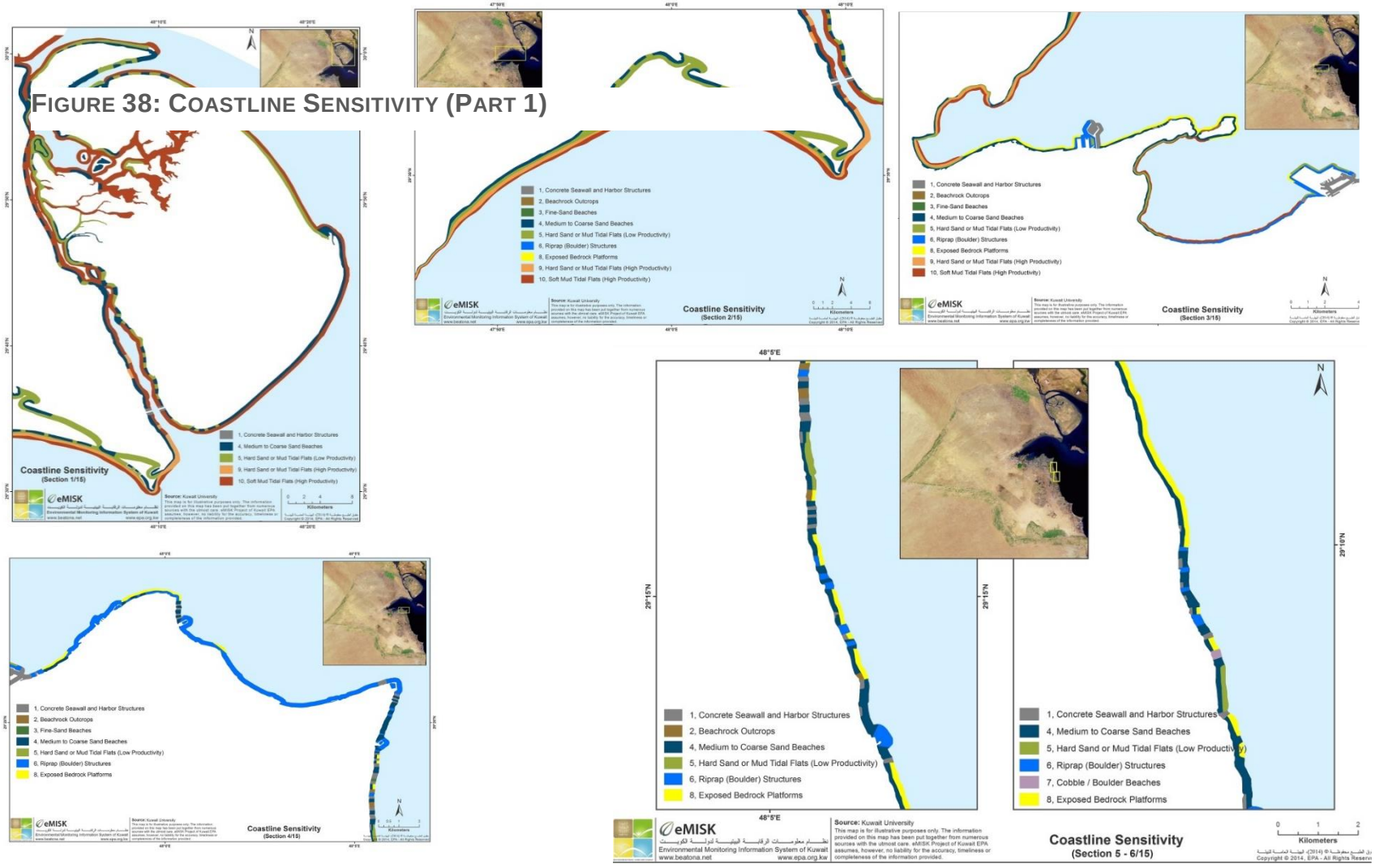
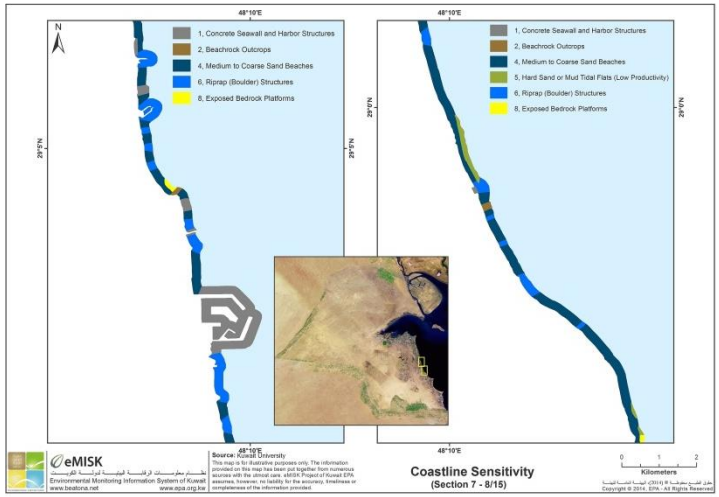
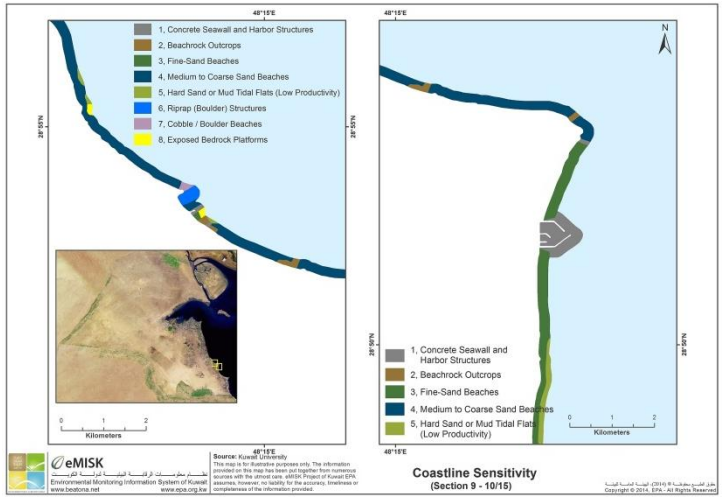
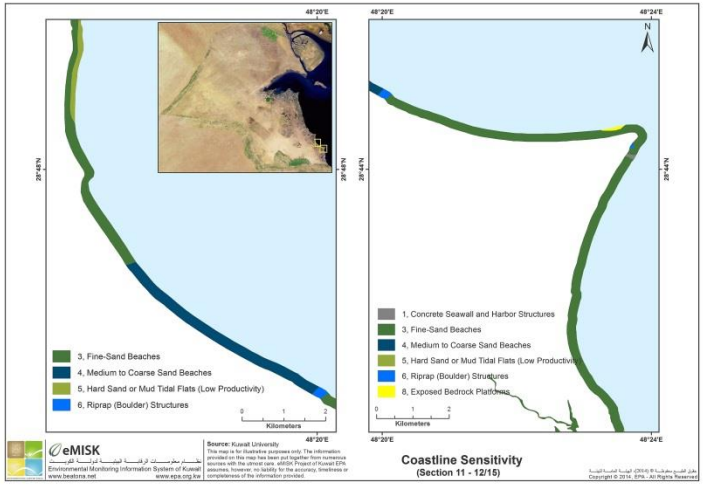


FIGURE 38: COASTLINE SENSITIVITY (PART 1)







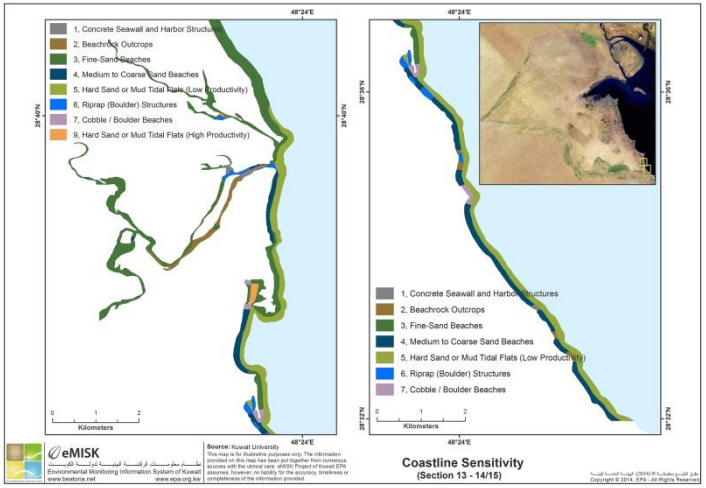


FIGURE 39: COASTLINE SENSITIVITY (PART 2)

3.4.4 Human Health

Kuwait population is young with an average age of 29 years and the natural growth of 2.6%. Kuwait population is exposed to harsh environmental conditions, such as heat wave and dust storms. These environmental conditions create degrade the quality of human environments and consequently expose people to lives to danger. The association between asthma and dust events and risks of heat waves are clear examples of harsh environmental impact on the human health on Kuwait. Dust storms and heat waves are expected to be severe and more frequent due to climate change (Table 16).

Climate stressors and climate risks – Human Health	
Stressors	**Risks**
Increases in occurrence and severity of dust storms	Threaten asthma patients
	Degradation of air quality
	Obstruction of human activities
	Increases health service expenditure
Increased Temperature	Threaten people's lives
	Increases health service expenditure

TABLE 16: CLIMATE STRESSORS AND CLIMATE RISKS - HEALTH

- **Dust storm effects on asthma patients**

Asthma is a serious, chronic epidemiological disease that degrades the general health of those suffering from it and even threatens their lives, especially under inappropriate healthcare. The World Health Organization estimates that 235 million people worldwide suffer from asthma (World Health Organization, 2013). As the number of asthma patients rises, this will not only increase pressure on healthcare facilities but also will lead to

various negative consequences, including increased mortality: Children and elderly people are the most vulnerable age category. In Kuwait, more than 15% of the children and 18% of the adults are suffering from asthma (KEPA, SNC, 2019): Females are more vulnerable than male. Factors contributing to asthma issue are believed to be related to the air quality (Gorai, Tuluri, & Tchounwou, 2014). Thus, climate change consequences depredating the air quality are expected to add more pressure to the vulnerable people in Kuwait. (Figure 40) illustrates the spatial distribution of asthma patients living in Kuwait urban area (KEPA, INC, 2012). The spatial distribution of asthma patients can be a useful mean to manage healthcare services and minimize climate change effects on asthma patients. For instance, hot spots illustrating in the map are expected to be highly vulnerable areas due to climate change. This geographic distribution of asthma patients is subject to changes over time: Thus, continuous monitoring of that distribution is mandatory.

The vulnerability assessment of this important sector must be established to assess decision makes in designing adaptation strategies of climate change in the health sector. Some recommendations that could improve the adaptation capacity in the health sector are adjusting the official working hours during the summer season, raising awareness on how to respond to extreme events and designing national health alert for dust storm (KEPA, SNC, 2019).

The geographic distribution of asthma patients in Kuwait's urban districts. The area shaded in the grey color are either residential areas with no patients' data recorded during the study time or non-residential areas (KEPA, INC, 2012).

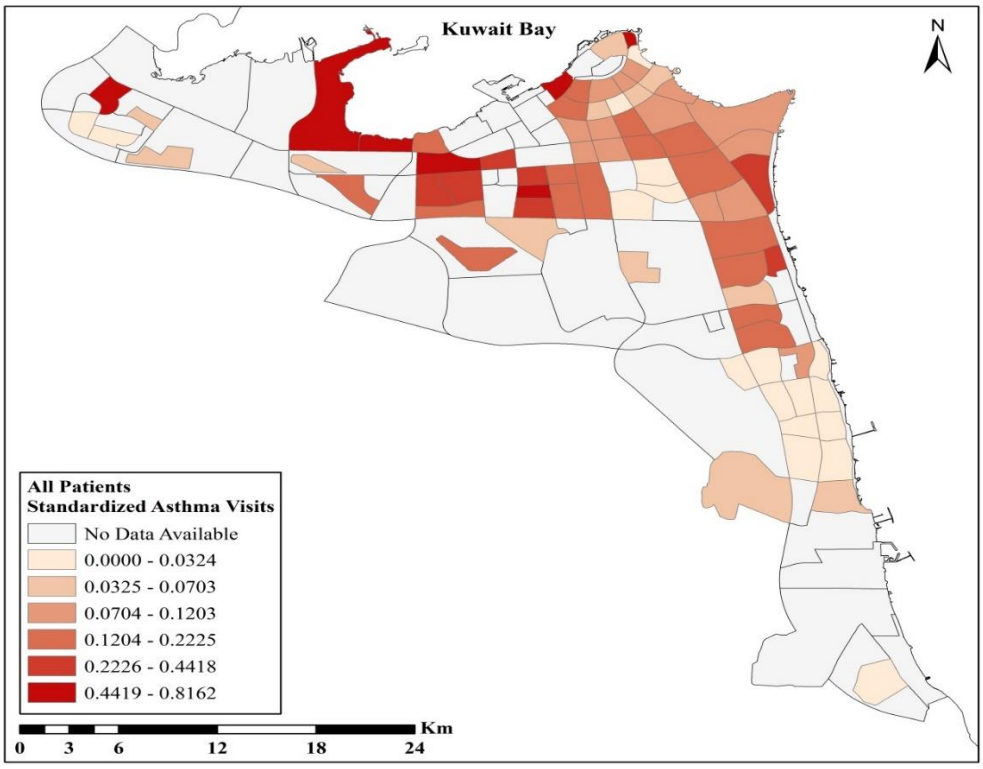


FIGURE 40: STANDARDIZED ASTHMA VISITS

CHAPTER 4: COORDINATION OF ADAPTATION ACTIONS

4.1 Introduction

As part of the NAP process, a stocktaking of the past and on-going climate change adaptation projects and initiatives that have been implemented in the State of Kuwait was prepared. This section helps to analyze the current adaptation projects as well as the gaps and needs of Kuwait. The section includes the adaptation projects and initiatives on the water resources, coastal zones, food security and public health sectors as presented. Also, the major adaptation policies and strategies that were ratified by Kuwait are presented in Table 17.

Kuwait has implemented several projects to adapt to climate change in the water resources sector. These projects include the construction of desalination plants, the application of water conservation technologies and utilizing the Treated Sewage Effluent (TSE) water for irrigation purposes. On the coastal zone sector, Kuwait has implemented projects such as constructing tidal barriers and establishing Coastal Information systems as a climate change adaptation measure. Meanwhile, awareness campaigns were conducted to the public and projects development among the coastal lines to take their precautions. The adaptation to climate change in the public health sector is one of the most important sectors for Kuwait, where frequent sandstorms hit the country causing many health problems. An annual average of 21 days of sand and dust storms were recorded (Al-Dousari et al., 2017). Sandstorms occur more frequently in the summer season specifically in the months of June and July. They can reach 100 km per hour (EPA, 2012). In response, Kuwait has undertaken some adaptation projects such as implementing green belts project and increasing the protected areas to adapt to a dust storm. The green belt projects consist of planted areas with trees and shrubs of 50-180 Km in length and 5-20 Km in width. These projects have started in 2015 for 5-year duration time.

4.2 Projects and National Initiatives

Many projects investing in the agriculture sector are taking place in Kuwait (Al Dosery et al., 2012). More than 50 types of trees for greenery and landscape that can reduce climate change effect, were introduced under the Agriculture Master Plan by Kuwait Institute for Scientific Research (KISR) and the Public Authority for Agricultural Affairs and Fish Resources (PAAFR). Development of new varieties of crops that can adapt to high temperatures and have high resistance to salinity and drought such as Conocarpus, Ficus, Prosopis, and date palm trees, were implemented in Kuwait (Al Dosery et al., 2012). These types of plants are mainly planted in Wafraa and Abdali, Kuwait.

Kuwait Environmental Public Authority (EPA) has established an electronic environmental Monitoring Information System of Kuwait (eMISK) and beatona. The eMISK aims at building and maintaining a comprehensive geo-environmental database of Kuwait and a GIS system to facilitate updating and analyzing environmental data. While beatona initiative aims to increase public awareness through sharing real-time environmental news and information. Many initiatives and campaigns were taken to increase public awareness about the adaptation to climate change. The following points provide a comprehensive summary of ongoing and past climate change adaptation projects and initiatives.

1. *Implementing green belts project and increasing the protected areas to adapt to dust storms.* Kuwait has undertaken some adaptation projects such as implementing green belts project and increasing the protected areas to adapt to a dust storm. The green belt projects consist of planted areas with trees and shrubs of 50-180 Km in length areas with trees and shrubs of 50-180 Km in length and 5-20 Km in width. These projects are the 5-year duration and started in 2015 (KUNA, 2015). Meanwhile, Kuwait has implemented a project called “Kuwait Green Wall Project. This project aims to increase the protected areas by planting 315,000 trees for 420 Km wall along the borderline to hold back the moving sand. The adaptation sector is the Public Health/ Dust Control, and the responsible parties are the governments and NGOs. This project started in 2015 and still ongoing.

2. *Kuwait's agricultural efforts to mitigate climate change in 2012*. Many agricultural projects have been undertaken by Kuwait Institute for Scientific Research (KISR) in order to develop crops that can adapt to high temperatures and different spans of seasons and crops resistant to salinity and drought (Al Dosery et al., 2012). More than 50 types of trees for greenery and landscape that can reduce climate change effect, were introduced under the Agriculture Master Plan by (KISR) and the Public Authority for Agricultural Affairs and Fish Resources (PAAFR). Development of new varieties of crops that can adapt to high temperatures and have high resistance to salinity and drought such as Conocarpus, Ficus, Prosopis, and date palm trees, were implemented in Kuwait (Al Dosery et al., 2012). These types of plants are mainly planted in Wafraa and Abdali, Kuwait. The adaptation sector is Agriculture and Public Health. The parties in charge were Kuwait Institute for Scientific Research (KISR) and Public Authority for Agricultural Affairs and Fish Resources (PAAFR).

3. In 2016, the project "*Food security*" was established. FAO in cooperation with the State of Kuwait planned to undertake twelve projects in the following fields:
    - Fisheries management;
    - Water resource management;
    - Natural resource management;
    - Animal production;
    - Animal health;
    - Technical capacity development.

    These projects have a time frame between 1-5 years under the Food Security Sector. Food and Agriculture Organization (FAO) were the responsible parties for this project, with a budget of $850,000. Some of FAO projects in Kuwait are highlighted in Items 3.1 and 3.2.

4. *Establishment of a regional database and information center to support the fisheries management and aquaculture development*, a joint project between PAAFR in Kuwait and FAO in December 2016. The project aims at establishing a regional database and information center to support the fisheries management and aquaculture development

in the region. Food and Agriculture Organization (FAO) and the Public Authority of Agriculture Affairs and Fish Resources (PAAFR) were the responsible authorities with a budget of $250,000/year.

5. *Fisheries Farms*. Fisheries are considered a vital source of food in Kuwait. The establishment of fisheries farms is an important step to adapt to climate change under the food security sector. Nile tilapia (Oreochromis niloticus) culture is implemented in agriculture farms where crops such as alfa alfa, tomatoes, potatoes, onions are cultivated. These farms are in the Al-Wafra, Abdali and Al-Sulybia areas. Brackish water with a salinity of 5–8 ppt pumped from underground wells is used in these farms. The budget for this project is also $250,000/year. And the responsible parties are the Food and Agriculture Organization (FAO) and the Public Authority of Agriculture Affairs and Fish Resources (PAAFR).

6. *Assessment of historic climate records and future projection*. The project aimed at assessing the historic climate records for the past 70 years and make future projection climatic scenarios until the year 2100. The project started in 2012 by the Kuwait University and UN Environment.
7. *Environmental Monitoring Information System of Kuwait (eMISK)*. eMISK is an electronic system established by the Environment Public Authority (EPA) of Kuwait and aims at building and maintaining a comprehensive geo-environmental database of Kuwait and a GIS system to facilitate updating and analyzing environmental data. The project starts in 2015 by EPA and is still ongoing.

8. *eMISK Industry*; this project aims at establishing a national program for collecting an environmental inventory of industrial facilities in Kuwait. The Adaptation Sector for this project is Public Health.

9. *eMISK Waste*; this project aims at finding and implementing a solution to be able to manage the fleet of industrial liquid waste vehicles and organizing the logistics process. The Adaptation Sector for this project is the Waste Sector.

10. *eMISK Marine*; The project aims at promoting and facilitating information management system in support of policies and programs that enhance integrated coastal and ocean management in Kuwait. The Adaptation Sector for this project is the Coastal Zones/SLR.

11. *Building desalination plants*. In the process of protecting freshwater sources and to maintain ecological stability. Kuwait has constructed several desalination plants in addition to water distribution systems via pipelines and irrigation systems to farmers. In 2016, Kuwait produced around 3.85 MCM/d of desalinated water. Eight additional plants were being commissioned by the government. Al-Zour North IWPP (capacity: 250 Million of Gallons per Day (MGD) for EUR 320 million), Al-Zour South Plant (capacity: 145 MGD), Al Khiran IWPP (capacity: 125 MGD), and Doha desalination plant (60 MGD) are examples of these projects. While, 4 more projects (Al-Nwaiseeb, New Shuaiba, New Doha, Doha RO phase 2) with an additional capacity of around 285 MGD are planned to be tendered as of 2019.

12. *Kuwait is investing USD 5.5 million jointly with MIT to conduct researches on updating the current desalination plants and next-generation desalination plants*. The adaptation Sector for this project is the Water Resources Sector, and the Government is responsible for the implementation of this project since 2016 and it is still ongoing. The budget is 320,000,000 EUR.

13. *Education on household desalination*. Kuwait jointly with United Nations taught the Kuwaiti people in rural areas the “in-house water desalination techniques”, where households can have freshwater at low cost and short time. The Adaptation Sector for this project is the Water Resources and the Awareness sectors. The UNDP started this project up in 2016.

14. *Kuwait Integrated Environmental Information Network Phase-IV*. The KIEIN-IV is an integrated GIS-based system that compiles the environmental indicator data and acts as a spatial decision support system tools (SDSS). This project can:
    - Compile data about environmental indicators for Kuwait.

- Expand and enhance the KIEIN GIS website as an environmental data dissemination tool.
- Promote awareness and usage of the KIEIN GIS website toward protecting Kuwaiti habitats.
- This system can act as a database to access the information, data and GIS maps, which are useful to assess and monitor the change in climate and the adaptation. This project was running from 2012-2014 by the UNDP and EPA with a budget of $1,200,000.

15. *Kuwait Environmental Governance Initiative (KEGI)*. The Project supports the design of the National Adaptation Plan (NAP) of Kuwait and the relevant initiatives linked to water, city planning, and other sectors. This project was running from 2017-2018 by the UNDP and EPA with a budget of $2,000,000.

16. *Establishment of land and marine nature reserves*. The project aims to establish a series of land and marine nature reserves in the State of Kuwait. National reserves were implemented to safeguard the Kuwait marine and land ecosystems. These natural reserves are in Sabah Al-Ahmed natural reserve area and Jahra pool natural reserve area. The Adaptation Sector for this project was the Coastal and Land Sector. This project was running from 2011-2016 by the EPA.

17. *Water Conservation (Partially implemented) Kuwait's Initial National Communications*; the application of water conservation technologies was also one of the adaptation options to reduce water consumption by 20 %. The Water Resources Sector was responsible, and the project started in 2012 and is still ongoing.

18. *Establishing a Coastal information system (CIS)*; Coastal Information System (CIS) was established to help in the protection of coastal zones and marine environments in Kuwait. CIS provides information about Kuwait’s coastal area to planners and decision makers. The CIS system is an important initiative under the technology needs assessment of the coastal zones and shore protection sector as a climate change

adaptation measure. Technology Needs Assessment / Coastal Zones Sector was the responsible sector. The project was started in 2006 by KISR/CIS and is still ongoingg.

19. *Constructing tidal barriers in new developments*; Sabah Al Ahmad Sea City, which is located near the Saudi Arabia border, is a new development which constructed a tidal gate system and offshore breakwater was built to protect the artificial promenade from erosion of waves and to cope with the rising sea levels as the adverse impact of climate change. The project was completed in 2016 under the Technology Needs Assessment / Coastal Zones Sectors by different Developers.

20. *Conducting awareness campaigns and symposiums regarding Sea level rise*; the "Our Seas: Theories, Data, and Policies" Symposium highlighted the importance of human intervention regarding rising sea levels. International specialists, local researchers, and non-governmental organizations attended this symposium. This symposium aimed at increasing the awareness of the concerned stakeholders and the public about the adaptation to sea level rise as an impact of climate change. The project was completed in 2017 under the Technology Needs Assessment / Coastal Zones Sectors by the Kuwait Foundation for the Advancement of Sciences (KFAS).
21. *Coastal Management Program*; the CMP produces physical modeling, numerical modeling and field survey measurements. The CMP was responsible to produce Integrated Coastal Zone Management (ICZM) for Kuwait. The ICZM consists of two phases, Phase 1 has already completed. While phase 2 is still ongoing. The project aims at identifying the best practice guidelines for the development of the coastal zone of Kuwait. The project started in 1979, while phase 2 is still ongoing under the KISR and the Technology Needs Assessment / Coastal Zones Sector.

22. *Establishment of the Water Resources Program*; A water resources development and management program (WRDM) was initiated by the Kuwait Institute for Science and Research (KISR). This program helps to identify ways to optimize the water resources use and management through applied research. WRDM program was designed to develop integrated water policies, management options, and action plans to solve water scarcity problems and increase Kuwait's water security and resilience. The

project is still ongoing under the KISR and the Technology Needs Assessment / Water Resources Sectors.

23. *Constructing Desalination using Multi-Stage Flash technology*; Kuwait has a total of 40 operating Multi-Stage Flash desalination units (MSF), with a total production capacity of 234 MGD. The project was completed by the Government and the MEW under the Technology Needs Assessment / Water Resources Sectors.

24. *Wastewater Treatment and Reclamation Technologies Program*; this program has been initiated by KISR and it aims at conducting research on reclaiming and reusing Kuwait's wastewater to utilize it in irrigation purposes. This is a good example to adapt to climate change stresses on water resources. Ministry of Public Works (MPW) stated that about 65% of its treated wastewater is reused in irrigation already. The project is still ongoing and is under the KISR and MPW supervision and under the Technology Needs Assessment / Water Resources Sectors.

25. *Awareness Campaign* of KEPA Articles 76 and 79; an awareness campaign has been conducted to increase the awareness about Article No. 76 regarding the ambient air and Air Quality Zone Compliance actions and Article No. 79 regarding the emission sources and evaluation. The responsible parties for this project were the EPA and the UNDP and the adaptation sectors for this project were the Technology Needs Assessment / Public Health sectors. The project was completed in 2010.

26. *Beatona Initiative*; Beatona Initiative is a website established by EPA and aims to increase the public awareness of the health sector of the climate change adaptation through sharing real-time environmental news and information with the public. The beatona website includes multi-layers GIS maps such as the monitoring stations of air quality, the noise monitoring locations, the drainage streamlines, and water bodies. The project started in 2012 by the EPA and is still ongoing. The adaptation sector is the Public Awareness Sector.

27. *Tarsheed Campaign*; Tarsheed campaign was an Initiative made to reduce the per-capita consumption of electricity and water. This awareness initiative is a good adaptation step to climate change in water resources. The responsible parties were Kharafi National and the EPA. The project was completed in 2007 under the Public Awareness and Water resources sectors.

28. *Tarsheed Campaign II*; Tarsheed campaign II was an Initiative to encourage the implementation of the "Reduce, Reuse and Recycle" waste management. Such an initiative is useful as a climate change adaptation under the waste sector. The Kharafi National was able to complete this project in 2013 under the Public awareness sector.

29. *Utilizing TSE water generated from Umm Al-Hayman WWTP in Irrigation purposes*; TSE is utilized to irrigate the green areas and agricultural areas and serve the expected population growth of Kuwait, in addition, to mitigate the negative effects on the environment. The Ministry of Public Works (MPW) held this project from 2012-2018 under the Water Resources Sector.

30. *Adjust the official working hours Initiative Source*: the Ministry of Social Affairs and Labor of Kuwait issued a national law in 2005 to stop any outdoor work from 11:00 AM to 16:00 PM during the months of June through August. The EPA started this project in 2018 under the Public Health Sector.

31. *Enabling Kuwait to Prepare it's Second National Communication (SNC) and Biennial Update Report (BUR) to the UNFCCC*; the project aims at supporting Kuwait to prepare and deliver its Second National Communication and first Biennial Update Report. The project also enables Kuwait to fulfill its UNFCCC obligations. The Global Environmental Facility (GEF) started this project in 2014 with a budget of $1,517,000.

32. *The Environmental Pollution and Climate (EPC) Program*; this program aims at assessing the pollution and climate change challenges concerning the atmospheric, aquatic, and terrestrial environment of Kuwait. This project is still ongoing under the responsibility of KISR.

33. *Omniya Plastic bottles recycle*; an initiative to collect the empty plastic bottles and recycling it instead of sending to landfills which is one of few practical initiatives to adapt to climate change in waste sectors. The project started in 2015 by an NGO and is still ongoing under the Waste Sector.

4.3 Policies and Strategies on Climate Change Adaptation

In 1997, a meeting was held in Kyoto, Japan, between representatives from different nations around the world to discuss the establishment of international policy in response to human-influenced climate change. Since the late 1980s, policymakers and relevant stakeholders have devoted their attention and their resources to the global climate change issue. United Nations Framework Convention on Climate Change (UNFCCC) has been established in 1992 and ratified by 149 countries in 1996. In 1998, the World Meteorological Organization in the United Nations Environment Programme has organized the IPCC. IPCC has published several assessments and studies of climate change. The UNFCCC and IPCC comprise the international response to the climate change issue. Kuwait has ratified some agreements and policies in climate change adaptation such as UNFCCC, Kyoto Protocol, UN Convention on the Law of the Sea, FAO Compliance Agreement and Paris Agreement on climate change. Table 17 provides the main policies and strategies on adaptation to climate change that were ratified by Kuwait.

TABLE 17: POLICIES AND STRATEGIES ON ADAPTATION TO CLIMATE CHANGE IN KUWAIT.

No.	Policy	Content description	Adaptation Sector	Date	Responsible Party
1.	UNFCCC Ratification	Kuwait has ratified the UNFCCC.	General	1995	EPA/ Kuwait
2.	Kyoto Protocol Ratification	Kuwait has ratified the Kyoto protocol.	General	2005	EPA/ Kuwait

3.	UN Convention on the Law of the Sea	Kuwait is Party to the 1982 UN Convention on the Law of the Sea.	General	1986	EPA/ Kuwait
4.	FAO Compliance Agreement	Kuwait is Party to the 1993 FAO Compliance Agreement.	General	2002	EPA/ Kuwait
5.	Paris Agreement on climate change	Kuwait has ratified the Paris Agreement on climate change.	General	2016	EPA/ Kuwait
6.	CBD Ratification	Monitor the biological diversity of Kuwait. Build the necessary institutional structure to deal with biodiversity issues in Kuwait[36].	General	2002	EPA/Kuwait / UNDP
7.	UNCCD Ratification	Kuwait has ratified the UNCCD.	General	1995	EPA/ Kuwait
8.	The Montreal Protocol	The protocol concerning the Substances that Deplete the Ozone Layer. Kuwait has ratified it.	General	1992	EPA/ Kuwait
9.	The Unified Systems on Substances	The Unified Systems on Substances that Deplete the Ozone Layers of the Gulf Cooperation Council (GCC)	General	2015	EPA/ Kuwait
10.	Convention on the Protection and Conservation of Wild Life and Natural Habitats in the GCC countries	This convention took place in Amman, Jordan in 2001	General	2002	EPA/ Kuwait

[36] THE NATIONAL BIODIVERSITY STRATEGY FOR THE STATE OF KUWAIT Environment Public Authority, State of Kuwait, 1998, United Nations Development Programme (UNDP), Kuwait with Technical Assistance from IUCN – The World Conservation Union

11.	CITES	Convention on the International Trade in Endangered Species of Wild Fauna and Flora, in Washington	General	2002	EPA/ Kuwait
12.	Cartagena Protocol on Biosafety	It took place in Tunis in 2000.	General	2017	EPA/ Kuwait
13.	Nagoya Protocol	The protocol on Access and Benefit-sharing	General	2017	EPA/ Kuwait
14.	Basel Convention	The Convention was on the control of Transboundary Movements of Hazardous Wastes and their Disposal, in Basel	General	1993	EPA/ Kuwait
15.	Amendments to the Basel Conventions	Amendments to the Basel Convention on Control of Transboundary Movements of Hazardous Wastes and their Disposal, in Basel	General	2006	EPA/ Kuwait
16.	Rotterdam Convention	For the Prior Informed Consent (PIC) on hazardous Chemical	General	2006	EPA/ Kuwait
17.	Minamata Convention	A convention on Mercury	General	2006	EPA/ Kuwait
18.	POPs	Stockholm Convention on Persistent Organic Pollutants. It's been ratified	General	2006	EPA/ Kuwait
19.	MARPOL	The International Convention for the Prevention of Pollution of the Sea from Ships. Ratified.	General	1987	EPA/ Kuwait
20.	Vienna Convention	The convention was for the Protection of the Ozone Layer, in Vienna	General	1992	EPA/ Kuwait

21.	Montreal Protocol	The Protocol on Substances that Deplete the Ozone Layer, in Montreal	General	1987	EPA/ Kuwait
22.	Amendment to the Montreal Protocol	Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer, in Copenhagen, London	General	1994	EPA/ Kuwait
23.	The Convention on Wetlands	The convention was on Wetlands of International Importance especially waterfowl habitat, in Ramsar, Iran.	General	2014	EPA/ Kuwait
24.	ROPME	Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution	General	1978	EPA/ Kuwait
25.	Kuwait Protocol	This protocol concerns Regional Cooperation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency	General	1978	EPA/ Kuwait
26.	ROPME Protocol	This Protocol for the Protection of the Marine Environment Against Pollution from Land-Based Sources	General	1992	EPA/ Kuwait
27.	ROPME Protocol	This Protocol on the Control of Marine Transboundary Movement of Hazardous Waste and Other Waste	General	2000	EPA/ Kuwait
28.	Law of the Sea	The United Nations Convention on the Law of the Sea	General	1986	EPA/ Kuwait
29.	Issuing new Articles No. 76 and 79.	Article No. 76 regarding the ambient air and Air Quality Zone Compliance actions and Article No. 79 regarding the emission sources and evaluation.	Air Quality /Public Health	2010	EPA/Kuwait

30.	Environmental Research National policy	National policy has been adopted for funding the Environmental Research Projects in Kuwait, especially the projects dealing with the impacts of oil pollution and burning oil wells.	General	1991	EPA/ Kuwait
31.	Environment Protection Law No. 42/2014	Adapting to the adverse impacts of climate change. The protection of land and soil, reducing desertification, management of natural reserves and water resources and creating plans for disaster management.	General/ Safety and Health	2014	The Environmental Public Authority / Environmental Supreme Council / / Kuwait
32.	Law No. 16/1996	Established the Kuwait Environmental Public Authority and gave it the power to regulate any activity that may pollute the environment	General / Environment	1996	EPA / Kuwait
33.	Article 3	Protects the Environment, evaluates the Environmental Impact Assessment Studies projects before implementation, controls activities that may lead to pollution, and combats and minimizes environmental pollution	Environmental		EPA / Kuwait
13.	Article 13	Enforces that the pollution, whether person or a factory, shall be responsible for and pay for any rehabilitation actions.	General		EPA/Kuwait
14.	Decision Number 6/2004	Tackles problems concerning the environment in the industrial area.	General	2004	EPA/ Kuwait

4.4 NAP Coordination and Implementation

4.4.1 Concerned National Institutions

For the coordination and implementation of the NAP's activities, the Government of Kuwait will put in place the needed intuitional arrangement, and financial and human resources. The implementation of the different actions in the NAP will require the involvement and contribution of all the stakeholders across the different sectors and levels. The specific roles are in line with these institutions mandate as summarized below:

4.4.1.1 National Public Institutions

The National governmental institutions will advance the implementation of the NAP by allocating the needed financial resources, integrating the NAP into sectoral strategies and action plans as well as into other projects and initiatives; designating staff or may be creating new unit(s) with adequate staff and resources to coordinate the mainstreaming and integration of the NAP and other relevant strategies into the national institutions' mandates. Main national public institutions mandated to advance its work in relation to climate change are presented below.

- **Environmental Public Authority (KEPA);** a governmental institution acting independently to carry out environmental actions in Kuwait. "The Environment Public Authority serves as the epicenter of governmental action regarding the preservation of the environment in Kuwait". The organization was founded in 1995 under law number 21. In 2014 KEPA established "Environment Protection Law" which ensures the passing of beneficial and relevant policies and regulations concerning the environment in Kuwait. The National Environmental Strategy was developed by KEPA among other several actions. There are several departments in KEPA that are dedicated to the planning and development of assessment plans such as the Planning and Environment Impact Assessment Department, The Office of Strategic Planning, Coastal and Desertification Monitoring Department, Research and Studies Office, Public Affairs and Environmental Awareness Department, Air Quality

Monitoring Department, Environmental Inspection and Environmental Emergencies Department, Water Pollution Department.

- **Ministry of Health** provides attention and healthcare to individuals in Kuwait. Advancements and development occur through interaction between all other sectors in Kuwait. The preparation, anticipation, and prevention of health issues related to climate change have been the responsibility of the Ministry of Health and other responsible sectors in Kuwait. The ministry plays a massive role in the assistance of improving the Health sector in Kuwait by hosting and sending experts to attend international conferences and workshops to improve the medical field in Kuwait. Conferencing concerning the nervous system diseases was held, along with workshops about epilepsy, Parkinson's, strokes and multiple sclerosis and the latest diseases and treatment methods in the world. Other responsibility and roles of the MOH are to improve health services and efficiency and effectiveness of the health system.
- **Ministry of Oil;** located in Kuwait City, it was formed in 1975. **The Supreme Petroleum Council** and **the Kuwait Petroleum Corporation** and the Ministry of Oil are all responsible for protecting and developing the country's natural resources. The ministry of oil assists the Supreme Petroleum Council in responsibility and tasks in maintaining and upholding its regulations and resolutions, as appointed by the Emiri Decree on the ministry's establishment. The Ministry of Energy is a part of this government body as of 2003. Another government company in charge of the oil fields in Kuwait is **The Kuwait Oil Company (KOC)**. KOC has developed Sustainable Environmental Economic Development (SEED), as a long-term sustainable development strategy. The main strategy of the Ministry of Oil in Kuwait is responsible for the supervision of the wealth and finances in Kuwait, and the development of this wealth. It is also the main governmental institution responsible for the information about oil and petroleum, the regulation of the laws to preserve revenues and wealth related to oil, conduct and hold plans and programs. The organization is also the backbone of the national economy and the main source of income. It is the official authority responsible for international organizations and relations

related to oil. The ministry oversees technical, financial, safety, monitory and regulatory control over the oil sector in Kuwait. The sharing of information about the location of oil fields, investments, opportunity and areas of work and any relevant information with the private and other government sectors is also a vital role of the Ministry of Oil.

- According to the Ministry of Oil of Kuwait, there are several Objectives to be implemented in Kuwait;
    - "Proposal to the public policy of the oil and gas sector on the basis of balance, maintaining the sources of oil wealth, achieve optimal development and exploration of resources in order to ensure the development of state revenues and increase national income".
    - "Maintaining the level of the price of Kuwait crude oil to meet the financial obligations of the state and development plans, and provide the needs of future generations, and the preservation of the status of oil as a strategy and a key source and strengthen the position of Kuwait in the global market".
    - "Highlighting the international standing of the state of Kuwait and to strengthen its role in organizations, regional bodies and relevant international spheres, such as the oil OPEC, OAPEC, the co-operation council for the Arab Gulf States, and organizations of the United Nations in the areas of Oil and Energy.
    - "Securing the needs of the domestic market of oil derivatives, gas, and its pricing proposals".
    - "Assisting the Supreme Petroleum Council in the tasks and responsibilities to oversee the implementations of its decisions".
    - "Activating the control of the plans, programs and activities of the representatives of oil sector, Petroleum Corporations and its subsidiaries and the foreign oil companies operating in the country, and direct rights of the state in order to increase performance and maximize the effectiveness of the financial benefits, and ensure the safety of workers and oil installations, the development of national experiences".

- "The application of laws and legislation on the environment, and to devote the concept of preserving the environment through the active participation of the work and programs of the Public Authority for the environment and review the operations and projects of the oil sectors to verify they meet the requirements of the environmental legislation of the state of Kuwait and the international standards."
- "Closer cooperation and coordination with the institutions, governmental and parliamentary bodies and the private sector in the affairs related to wealth and the oil industry, to promote the work and the exchange of information and the work of specialized studies and research to achieve the objectives of development plans of the state".
- "Increasing the contribution of the oil sector in supporting the national economy".
- "Contribute seminars and conference specializing in oil and energy, and the establishment of information center of oil, and to disseminate the culture of oil and petroleum industry awareness within the country and support the research work".

- **Ministry of Electricity and Water;** is a government organization established in 1952. It is responsible for all water bodies in Kuwait and the use of aquifer and groundwater. The 2010 - 2014 Kuwait Development Plan includes a great increase in the generation of desalinated Water and Electricity to better match the demand and supply of these two elements in Kuwait. It was studied and modeled by the Ministry of Electricity and Water that the prices accounted to facilitate these amenities does not match the revenues coming at US$ 2.84/1000 gal as of 2014. The responsibilities of this organization are vast, some of which are; general plan for water resources conservation, it's the data center of all water-related information in Kuwait, it conducts frequent studies, surveys, and assessments to find and develop the best methods to help the natural resource and the citizens of Kuwait, it is responsible for monitoring and evaluating networks, the construction of new wells according to regulations in Kuwait, provide technical assistance and training and education in the sector.

4.4.1.2 Research Institutions

Academic and research institutes play a critical role in building Kuwait's capacity in relation to climate change adaptation and mitigation. Academia supports the government with the needed scientific evidence for knowledge-based decision-making. Academic can orient its research to support decision-making processes by improving the understanding of climate change and variability in Kuwait in the present and in the future. Providing scientific information, conducting downscaling climate modeling, calculating the climate risks and vulnerability help the Kuwaiti governments in designing the appropriate adaptation actions. Main academic institutions in relation to climate change work in Kuwait are presented below.

- **Kuwait University;** the Vice-president's office for Research provides the financial support and research projects management. Funding for master's and Ph.D. students carrying out their graduation projects through the Graduate Studies Department. The Department of Earth and Environmental Sciences also participates in projects and studies concerning Environment and Climate Change.
- **Kuwait Institute for Scientific Research (KISR);** is an independent organization founded in 1967 through Japan's Arabian Oil Company Limited. It funds and carries out major Environmental research projects such as Biodiversity, Climate Change, Conservation, etc. projects. One of the Research Centers of KISR is the **Environment and Life Sciences Research Center (ELSC)** where research is undergoing about multiple environmental issues such as the assessment and management of pollution risks, restoring the ecosystem, preserving the natural resources, poor air quality due to erratic sand movement and dust storms, water resources management, coastal line protection.
- **Kuwait Foundation for the Advancement of Science (KFAS);** the main organization that funds research institutions, scientists and projects, mainly Kuwait University and KISR. Shareholder companies in Kuwait supply the funding coming from KFAS. The organization also encourages students to

participate in contests concerning environmental research by proving and offering monetary prizes and funding for young researchers.

- **Public Authority for Applied Education and Training (PAAET);** the program was established to meet the country's needs in Education and training. The Department of Environmental Science offers full educational scholarships for bachelor's degrees since 2008.

4.4.1.3 Non-Governmental Organizations (NGOs)

There are several NGOs in Kuwait that are involved in aiding environment programmes and projects, like the Kuwait Environmental Protection Society (KEPS). Better incorporation between the NGOs would go a long way to better benefit Kuwait.

4.4.2 Proposed Implementation Roles

The institutional structure to advance the work in relation to climate change and the implementation of the NAP can be described in FIGURE 41, as follows:

- The ***Kuwait Environment Public Authority (KEPA)*** as the principal government institution acting as independently to carry out environmental actions in Kuwait, the lead agency of the government on national climate change actions, and delivery of operational coordination, shall report to the Cabinet through the Director of KEPA. Among other several actions, KEPA is working on setting targets and coordinate actions for building resilience to climate change and enhancing adaptive capacity; developing the National Determined Contribution (NDC) Report and preparing and submitting the SNC report.
- The KEPA shall, among others, provide technical support to the implementation of the different actions of the NAP (cooperate with ministries and agencies responsible for the water, oil, coastal areas, marine, and fisheries sectors), and oversee the climate change adaptation activities that KEPA is responsible for.

- The ***General Secretariat of the Supreme Council for Planning and Development (SCPD)*** was established by in 2008, under the Decree Number 323. It is chaired by the Prime Minister or his Delegate and the membership of the Deputy Minister and Foreign Minister, Deputy Prime Minister and Mister of State for Cabinet Affairs, and Ministers of Health, Finance, State for Housing Affairs, State of Development Affairs, Oil, Electricity and Water, Public Works, State for Municipal Affairs, Education and Higher Education, Social Affairs and Labor, Information, and Governor of the Central Bank of Kuwait in addition to knowledgeable members to represent the private sectors and civil society organizations.
- The SCPD shall, among others, ensure the mainstreaming of climate change adaptation actions by other national agencies, ensure that climate change adaptation plans are mainstreamed in the State's strategic goals and the designed development strategies and plans, and propose an appropriate financial mechanism to ensure implementation of the sectoral adaptation plans.

- ***Cabinet of Kuwait:*** The Cabinet of Kuwait is the chief executive body of Kuwait. Gives update regularly to Parliament on the status of implementation of international agreements and obligations on different environmental issues including climate change. The Cabinet is given the needed powers and duties, through the KEPA, to provide technical support on climate change adaptions and related work.

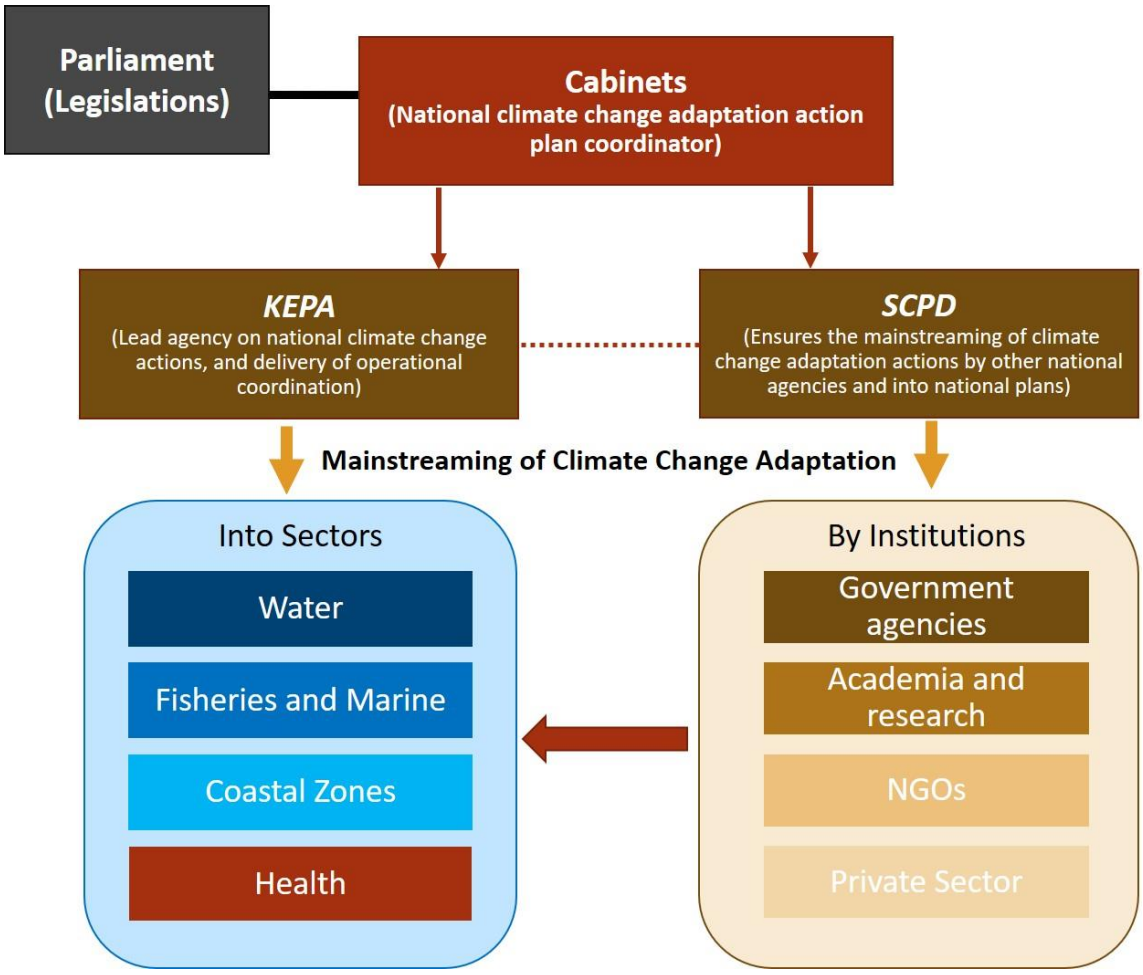


FIGURE 41: PROPOSED CLIMATE CHANGE ADAPTATION PLANS IMPLEMENTATION INSTITUTIONAL COORDINATION STRUCTURES

CHAPTER 5: ADAPTATION ACTION PLAN

5.1 Introduction

Adaptation to climate change is the response to the global warming phenomenon. It aims at reducing the vulnerability of social and biological systems and adapting to the change of climate. The extreme weather events to occur in Kuwait such as the heat waves, precipitation reduction, heavy rain, sea level rise, and the frequent dust storms are induced climate change disasters.

5.2 Gaps Identification

Kuwait has implemented key adaptation measures to cope with climate change impacts. Kuwait has invested in the water, health, food security, marine and coastal zone sectors in their adaptation to climate change impacts. The adaptation measures comprise building designation plants under the water sector, construction of natural reserves, green belt and protected areas under the health sector, fisheries management and farms under the food security and marine sectors, and the establishment of coastal information system and building tidal barriers in the new coastal developments under the coastal sector.

However, there are major gaps and still more to do in all sectors according to the First and Second National Communications of Kuwait and based on interviews conducted with representatives from several local authorities. The climate change adaptation gaps, among other things like the development of national and local strategies on climate change and carbon abatement, have been made possible as of recently with the aid of a national emissions inventory system. The national emission factor and national waste inventory database, insufficient inclusion of health sector in Kuwait's climate change adaptation programs, scarcity of the drought-resistant vegetation that reduce the dust effect and land degradation, inefficient water management and bad consumer behavior for the water resources and lack of reverse osmosis desalination modern technologies, the coastal information systems (CIS) are not regularly updated, and low public awareness as well as insufficient investment in policy development to include the assembly of useful information to analyze the adaptation policies and incentives.

The Climate Change Department/Directorate at the Kuwait Environment Public Authority (KEPA) is coordinating national activities in the field of climate change and is in need for more capacity development investments in all aspects of climate change. This will ensure high-quality management and coordination performance of the climate change unit parallel to the on-going technical and institutional capacity building process at the Ministry of Environment. Specific issues in capacity development include improve GHG inventory in the 6 related emissions and sink sources, improve the quality of future national communication reports, enforce and sustain GHG inventory process, energy evaluation and emission factors, adaptation and mitigation programs.

The major gaps that need to be bridged in order to adapt to climate change in different sectors such as waste, health, water resources, coastal zones, and fisheries, are listed below as follows:

5.2.1 Major Gaps in the Fisheries and Marine Sector

One of the main sectors highlighted in the second national communication of Kuwait is the fisheries sector, which is considered as a main food source in the country. The following gaps shall be considered to adapt to climate change in this sector:

1. Lack of integration of fisheries and marine sectors into adaptation and development plans and projects in Kuwait to help in meeting the local food security requirements as well as the absence of a strategic adaptive framework capable to respond to the emergency situations and hazardous crises.
2. Insufficient information and studies on the impact of the change in seawater temperature on the biodiversity and marine ecosystem.
3. Inadequate control of grazing in the natural reserved areas and low public awareness about the importance of the natural reservation areas and their role to adapt to climate change.
4. Lack of erosion and sedimentation control measures nearby the marine environments along the Kuwait coasts.

5.2.2 Major Gaps in the Water Sector

Despite many projects were implemented in the water resources sector in order to adapt to the climate change such as building desalination plants and applying water conservation measures, however, the following gaps are still required to be covered:

1. Poor water resources management and threats of water scarcity due to the bad consumer behavior in consuming the water resources are of major gaps facing the climate change adaptation in Kuwait. This is because of the lack of awareness, technical knowledge, policies, and strategies on climate change adaptation in the water resources sector.
2. Lack of modern technologies in the desalination of the seawater, noting that seawater desalination is the main source of freshwater in Kuwait.
3. Inadequate infrastructures networks and facilities to treat and transmit treated sewage effluent (TSE) water all over the country to cover all the irrigation needs of water, which increase the stresses on the freshwater resources.
4. Lack of information and studies on the groundwater resources, wells, and aquifers including their quality, quantity, extraction and safe yield. Meanwhile, lack of rehabilitation and remediation projects to polluted wells and aquifers because of oil or seawater intrusion.
5. Lack of knowledge to harvest rainfall water and use it for domestic, agriculture purposes or groundwater recharge instead of wasting it as runoff to the sea. Moreover, inadequate stormwater drainage systems in the new cities and developments.

5.2.3 Major Gaps in the Coastal Zone Sector

Kuwait is a coastal country and the adaptation to the sea level rise is a major concern. Protection of the livelihood, coastal developments and establish buildable areas at a safe distance inland from coastal inundation zones are of the main needs of Kuwait. The following gaps to adapt to the sea level rise are critical:

1. Lack of communication, access to data and updated information and data on the coastal characteristics, dynamics, and patterns of human behavior in Kuwait, which are necessary to understand the potential consequences of climate change.
2. Inadequate consideration of decision makers to include sea level rise scenarios into adaptation and development projects, plans and policies in Kuwait.
3. Lack of restrictions, legislation and policies to limit and control building new constructions within the coast of Kuwait under risk.

5.2.4 Major Gaps in the Human Health Sector

The adaptation with the climate change in the health sector was highly emphasized in the initial and second national communications of Kuwait. Several projects and initiatives were implemented in this sector as highlighted in the projects and initiatives section, however, the following gaps are still required to be addressed:

6 Insufficient climatic information and early warning systems to provide alerts before extreme weather events such as dust storms.

7 Lack of awareness of the public and the media about climate change impacts on health, and adaptation measures.

8 Lack of communication, access to data and information on climate change caused diseases such as their life cycle, distribution and geographical spread in Kuwait.

9 Inadequate integration of health into adaptation and development plans and other sector plans and policies in Kuwait.

10 Lack of financial and physical capacities among health-care units and practitioners as well as a lack of public awareness in addressing and understanding climate change impacts on health.

5.2.5 Major Gaps in the Waste Sector

The waste sector was one of the main concerns of the EPA to adapt to climate change and it was highlighted in the Second National Communication (SNC) of Kuwait. The major gaps in the waste sector can be identified as follows:

1. Lack of information and absence of a national waste inventory database including the national emissions inventory system and national emission factor.
2. Inefficient utilization of the landfill areas after being closed as well as the poor maintenance for the existing landfills and. Also, the absence of sanitary and e-waste landfills in Kuwait.
3. Lack of awareness, technical knowledge, policies, and strategies are major issues for waste management and climate change adaptation. In addition to the weak public participation and poor public attitude.
4. Insufficient knowledge of modern waste-management options in municipalities to include all kind wastes such as e-waste, solid waste, industrial waste and wastewater disposal in Kuwait.

5.2.6 Major Gaps in the Policy Making and Programs Development

NAPs shall have a connection with national visions and need to derive legitimacy through instruments such as policies, parliament acts, national directives, and decrees.

Investment in the new policy development and updating the existing ones by including climate change information in analyzing the adaptation policies and incentives shall be considered. In addition, Integration between the development needs and adaptation objectives, policies, plans, and programmes is essential. The following are some general items that can bridge the gaps to climate change adaptation:

1. Lack of financial and political support for the implementation of adaptation policies and strategies as well as low awareness of the public about climate change adaptation, in general, starting from schools through to universities.
2. Weak Institutional and technical capacity development for the Climate Change Department/Directorate at Kuwait Environmental Public Authority.

3. Inefficient communication, collaboration, and integration between the research institutions and the different authorities of the government regarding climate change adaptation in all sectors.
4. The absence of a specialized research center for climate change studies including adaptation and mitigation studies in all relevant impacted sectors

5.3 Sectoral Adaptation Actions

Adaptation to climate change can be in different forms depending on national context. It may include; water reuse for domestic purposes as an adaptation measure to save water resources; using the treated sewage effluent for irrigation purposes; implementing cropping systems that can reduce water runoff and increase the water retention capability of soil which decreases the negative impacts of droughts; constructing dikes and dams to adapt to the extreme flood events; investing in the shore protection of the coastal areas by building groins trap sediments to protect the coastline against erosion, constructing breakwater coastal structures that act as shelters from waves and currents, and establishing artificial reefs to reduce wave energy and protect the shore from erosion; applying soft adaptation measures in urban planning and design by issuing standards and codes that can be introduced for more sustainable design and construction of buildings; and promoting the awareness level for the altered conditions under climate change adaptation.

The following subsections present the sectorial adaptation options and highlight physical effects, vulnerabilities, impacts and socio-economic outcomes for each sector. The adaptation actions are divided into three categories: i) short-term actions, which should be implemented in less than a year; ii) medium-term actions, which needs 1-3 years to be achieved; and iii) long-term actions, which needs between 3 and 5 years to be achieved.

5.3.1 Adaptation Plans to enhance the resilience of the Fisheries and Marine Sector.

Climate change stressors are expected to affect the marine and fisheries sector: The potential risks threaten coral reef communities and other aquatic communities. The susceptibility of these invaluable ecosystems to climate change is increasing due to non-climate change stressors. The coastal and marine ecosystems degradation is expected to multidirectional socio-economic outcomes: for instance, poor seawater quality would require sophisticated pretreatments that increase the coast water (Andrianne & Alardin, 2003). Thus, controlling these non-climate change stressors is a mandatory adaptation option to increase the resilience of this sector to climate change. Other adaptation options are initiating researches to assess the impact of spatial and temporal distributions of SST, salinity. pH and SDD on coastal and marine ecosystems and enhancing the existed coastal and marine monitoring systems by integrating remote sensing technologies.

Increase the resilience of the fisheries and marine sector to climate change	
Summary	The shorelines of Kuwait are being threatened by Sea Level Rise due to changes in the climate. The recent estimation of IPCC to SLR reveals that sea level would rise from 0.26 to 0.82 m by the end of the 21st century. A CVI for Kuwait coasts was computed using four physical parameters; elevation, coastal slope, geomorphology, distance and four socioeconomic parameters, like; population, land-use, cultural heritage, and transportation. The area near Shuaibah Port, in the south coast, as is the coastline from Doha City to Kuwait By, are the most influenced by SLR. In addition, the number of people at risk due to SLR is 30,453 (about 0.8% of Kuwait population). Fisheries are the second important sector after oil sector for Arabian Gulf countries, including Kuwait.
Physical effects	▪ Increased Sea-Surface Temperature. ▪ Increased salinity. ▪ Ocean acidification.
Physical hazards/ vulnerabilities	▪ Coral reef disturbance (bleaching). ▪ Fish migration. ▪ Effecting aquatic organisms' production. ▪ Reducing the growth of many aquatic organisms. ▪ Negatively affects biotic and abiotic processes. Disturbing microplankton, such as foraminifera
Impacts	▪ Reducing the aquatic biodiversity. ▪ Reducing the reproduction of fish and other organisms. ▪ Decreasing seawater quality.
Socio-economic risks	▪ Loss of income of fishermen. ▪ Increase seafood cost. ▪ Increase the cost of water desalination (indirect impact)

Ongoing projects and initiatives	▪ KEPA has established an electronic environmental Monitoring Information System of Kuwait (eMISK). ▪ KEPA has established the eMISK: Marine. ▪ Establishment of a regional database and information center to support the fisheries management and aquaculture development (FAO/PAAFR). ▪ Establishment of land and marine natural reserves (EPA).
Gaps	▪ Limited integration of agriculture, fisheries and marine sectors into development plans; ▪ Insufficient information and studies on the impact of the change in seawater temperature on the biodiversity and marine ecosystem; and ▪ Low awareness concerning climate change and its impact on the sector. ▪ Limited studies on the impact of climate change on marine life and fisheries in Kuwait.
Short-term actions	▪ Enhance awareness by involving the local community in the protection and sustainable consumption of marine life. ▪ Provide financial and technical support to institutions and sectors responsible for marine life protection. ▪ Increase awareness about the Marine Ecosystem and the impact of climate change on it. ▪ Undertake risk and vulnerability assessment of the fishers' value chain. ▪ Enhance technical (individual and institutional) capacities on the impact of climate change on fisheries.
Medium-term actions	▪ Designation of new marine protected areas. ▪ Develop and implement local marine conservation and restoration options.

	▪ Develop adaptation and development plans for Marine life and Fisheries. ▪ Support research and initiatives to gather and obtain enough information on the impact of Climate Change on the marine ecosystem in Kuwait. ▪ Develop medium-term initiatives to conserve marine biodiversity in the rapidly changing climate.
Long-term actions	▪ Prepare of marine ecosystem-based adaptation strategy measures in areas at risk of climate change impacts. ▪ Develop adaptive management to rapidly changing marine regimes with Climate Change. ▪ Develop prediction capacity to anticipate possible future consequences of Climate Change and most threatened ecosystems in the marine. ▪ Develop monitoring capacity to prevent overfishing. ▪ Model of the impact of climate change on marine life and fisheries for use in policymakers for conservation, recovery and sustainable use of marine resources. ▪ Develop a crisis plan and management to confront climate change effects.
Budget	3.4 million USD
Responsibility	• Public Authority for Agricultural Affairs and Fish Resources (PAAFR). • Kuwait Environment Protection Authority (KEPA) • Kuwait Institute for Scientific Research (KISR). • The General Secretariat of the Supreme Council for Planning and Development (SCPD)

5.3.2 Adaptation Plans to enhance the resilience of the Water Resources

Water resources sector relies on three water resources: desalinated water, brackish groundwater and treated wastewater to fulfill its water demand in domestic, agriculture, and industrial sectors. The desalinated water is the main source of freshwater in Kuwait. Increased air-water temperature, saltwater intrusion, decreasing seawater quality (the ultimate source of desalinated water), and decreasing the quantity of groundwater due to increasing drought events are the main physical effects of climate change on this sector. These effects are expected to decrease the availability of freshwater for human consumption and increase demands of water for irrigations. Potential impacts of these physical effects are the decline in safe water availability for human consumption, loss of green areas due to limited water for irrigation and increases in CO_2 emissions due to increased demand of desalinated water.

Climate change risks are expected to cause significant negative socio-economic outputs: Increased cost of water desalination and loss of farmers' income are the most potential socioeconomic outcomes. Thus, enhancing the resilience of systems for water supply and management is a mandatory adaptation step to minimize the impact of climate change on this sector. Increasing water block-tariff to control unnecessary water consumptions, reducing physical leakages, utilizing technologies to reduce water consumption, and adopting efficient irrigation methods to reduce water losses are short-term adaptation options that can minimize the effects of climate change on this sector.

Improve the resilience of systems for the water sector	
Summary	Kuwait extends in arid and semi-arid regions. It relies on three water resources: desalinated water, brackish groundwater and treated wastewater to fulfill its water demand in domestic, agriculture, and industrial sectors. The TSE is mainly used for irrigation of highway landscapes, households' greening, public parks, and artificial wetlands. The SNC highlighted some recommendations to reduce water consumption, including employing new water a block-tariff, reducing physical leakages, utilizing water conservation technologies, improving irrigation systems one project was initiated to identify ways to optimize the water resources use and management through applied research. WRDM program was designed to develop integrated water policies, management options, and action plans to solve water scarcity problems and increase Kuwait's water security and resilience. The second model was based on the three scenarios: normal growth of demand, and the two climate scenarios (RCP 4.5 and RCP 8.5). The model had three main inputs: water supply, water demand, and water transmission.
Ongoing projects and initiatives	- Water Resources Development Program (WRDM)/ KISR; - Building desalination plants. - Water Conservation (Partially implemented) - Combined Water tariffs and water conservation (Partially implemented) - Technology Needs Assessment: Water Resources - Utilizing TSE water generated from Umm Al-Hayman WWTP in Irrigation purposes (MPW)

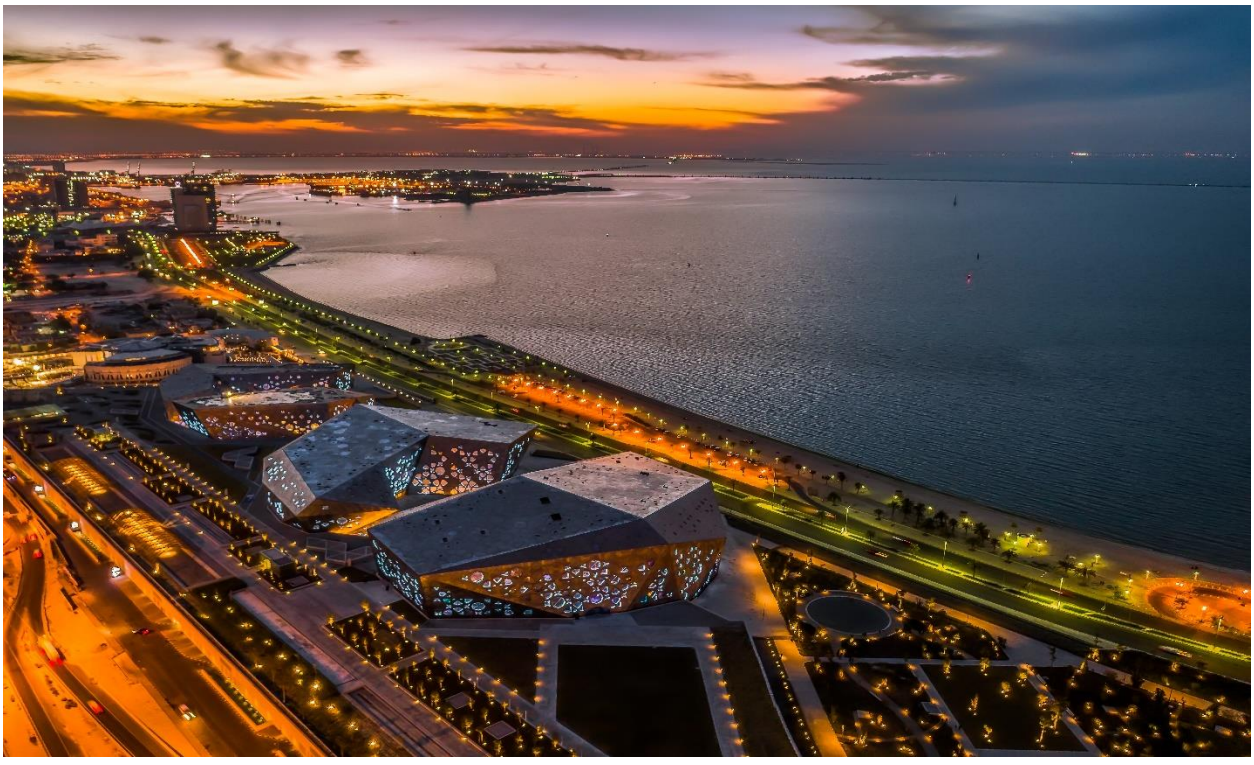
Gaps	• Insufficient water resources management and threats of water scarcity due to the unsustainable consumer behavior, this is because of the limited awareness, technical knowledge, policies, and strategies on climate change adaptation in the water resources sector; • Inadequate infrastructures networks and facilities to treat, transmit, and reuse treated sewage effluent (TSE); • Limited information and studies on the groundwater resources, wells, and aquifers including their quality, quantity, extraction and safe yield; • Limited plans and initiatives to harvest rainfall water and use it for domestic, agriculture purposes or groundwater recharge. • Inadequate stormwater drainage systems in the new cities and developments.
Physical effects	▪ Increased air temperature. ▪ Saltwater intrusion. ▪ Decreased seawater quality (the ultimate source of drinking water). ▪ Decreased the quantity of groundwater due to increased drought events.
Physical hazards/ vulnerabilities	▪ Decreased the availability of fresh water for human consumption. ▪ Increased the demand of water for irrigation.
Impacts	▪ Decreased the availability of safe water for human consumption. ▪ Decreased the availability of water for irrigation. ▪ Loss of green areas due to limited water for irrigation. ▪ Increased use of energy for water desalination.

	▪ Increased CO_2 emission due to increased demand for water desalination.
Socio-economic risks	▪ The increased cost of water desalination. ▪ Loss of farmers' income.
Short-term actions	▪ Raise awareness of Climate Change Effects on Water Resources in the country. ▪ Utilize water conservation technologies. ▪ Develop risk assessment on water resources depletion in the face of Climate Change conditions in Kuwait.
Medium-term actions	▪ Incorporate measures for adaptation to climate change into actions carried out by the Ministry of Electricity and Water. ▪ Invest in high end and accurate programs to refer to information about water level based on hydraulic models. ▪ Control water prices such as water consumption are fair and reasonable by all consumers. ▪ Increase water block-tariff to control unnecessary water consumption. ▪ Utilize technologies to reduce water consumption. ▪ Adapt efficient irrigation methods to reduce water losses. ▪ Improve irrigation systems to help utilize and conserve water in a more sustainable way, like bio-diverse planting, hydro-zoning, and PO irrigation.
Long-term actions	▪ Design effective policies to preserve and protect water resources. ▪ Support research and development to model the impact of climate change on water resources.

	▪ Involve more environmentally sustainable methods of water treatment like Reverse osmosis, where the net energy consumption is lower than other methods. ▪ Invest in the installment of water-efficient devices in homes, where the consumption of water is better regulated and limited. ▪ Develop integrated climatic and hydrological models and assess climate change impacts on water resources management.
Budget	6.2 million USD
Responsibility	• Ministry of Electricity and Water • KISR. • Kuwait Environment Protection Authority (KEPA) • The General Secretariat of the Supreme Council for Planning and Development (SCPD) • Kuwait Municipality • The oil sectors.

5.3.3 Adaptation Plans to enhance the resilience of the Coastal Zone

Inundation of low lying areas due to SLR will have a great influence on human settlements and terrestrial and aquatic ecosystems of the coastal zone. Damage of infrastructure and important facilities, saltwater intrusion, loss of terrestrial habitats, disturbance of coastal and marine ecosystems, increase in coastal erosion, decrease in water transparency due to increasing coastal erosion, and shoreline retreat are significant SLR hazards and impacts. Designing adaptive long-term coastal plans to restrict establishing major projects on vulnerable coasts is very urgent action that must be taken. to establish such adaptive plans, more researches assessing the impacts of SLR on the coastal zone of Kuwait are needed. Also, raising awareness among decision-makers in Kuwait to incorporate SLR scenarios into upcoming development plans is an important adaptation step. SLR risks are expected to disturb the coastal wildlife: An adaptation option to enhance the resilience of coastal wildlife is to legislate laws that restrict negative anthropogenic activities in the coastal zone.



Enhancing the resilience of coastal zones to face SLR risks	
Summary	The non-urbanized coast of Kuwait bay in the north, and the middle and southern coast, where urbanization is more extensive, are the coastal lines of Kuwait and are vulnerable to sea level rise. The Coastal Vulnerability Index (CVI) of Kuwait was based on the calculations of three scenarios, 1m, 1.5m and 2m, especially the Boubyan Island, and the coastline from Doha Port to Kuwait City. Coastal Information System (CIS) was established to help in the protection of coastal zones and marine environments in Kuwait. CIS provides information about Kuwait's coastal area to planners and decision makers. The CIS system is an important initiative under the technology needs assessment of the coastal zones and shore protection sector as a climate change adaptation measure. The projects aim at identifying the best practice guidelines for the development of the coastal zone of Kuwait.
Ongoing projects and initiatives	- Establishing eMISK Marine (KEPA). - Establishing a Coastal information system (CIS); - Coastal Management Program (KEPA) - Establishment of land and marine natural reserves (KEPA)
Gaps	▪ Lack of communication, access to data and updated information and data on the coastal characteristics, dynamics, and patterns of human behavior in Kuwait; ▪ Inadequate consideration of decision makers to include sea level rise scenarios into adaptation and development projects, plans and policies in Kuwait;

	▪ Lack of restrictions, legislation and policies to limit and control building new constructions within the coast of Kuwait under risk.
Physical effects	▪ Inundation of low-lying areas (SLR)
Physical hazards/ vulnerabilities	▪ Shoreline retreat ▪ Increased coastal erosion ▪ Loss of terrestrial habitats ▪ Decreased water transparency due to increased coastal erosion
Impacts	▪ Damages to coastal protection structures ▪ The decline in beach stability ▪ Loss of lands ▪ Disturbance of coastal and marine ecosystems
Socio-economic risks	▪ Damage of infrastructure and important facilities (power and desalination plants, ports, hospitals, and educational institutions) ▪ Damage of recreational areas
Short-term actions	▪ Develop vulnerability and risk assessment reports ▪ Provide open access for information and communication networks for parties and sectors responsible ▪ Capacity-building for government and non-government stakeholders on the deployment of adaptation activities. ▪ Increase decision-makers awareness of the risks of SLR and the damages to nearby urban areas. ▪ Review existed projects and update them based on SNC and NAP findings.

Medium-term actions	▪ Provide financial aid for preventative and protective actions for coastal damage. ▪ Make sure that the required resources to undergo projects and initiatives concerning the construction, research or communication are available. ▪ Raising awareness among decision-makers in Kuwait to incorporate SLR scenarios into development plans ▪ Legislating laws to restrict negative anthropogenic activities in the coastal zones to maintain the coastal wildlife
Long-term actions	▪ Establish a specialized center for coastal management and build and organize information and tools for climate risk modeling and generation of qualified responses within the Coastal Zone. ▪ Protect coastlines from SLR by constructing protection barriers. ▪ Develop better and more intensive laws and policies regarding coastline protection and conservation. ▪ Prepare for better adaptation potential for future setbacks and scenarios (i.e. new construction projects near the high-risk coastline should withstand SLR scenario in the future).
Budget	7.8 million USD
Responsibility	• Kuwait Environment Protection Authority (KEPA) • The General Secretariat of the Supreme Council for Planning and Development (SCPD). • KISR • Kuwait University • Ministry of Municipal Affairs.

	• Municipalities. • Ministry of Electricity and Water. • Kuwait Ports Authority. • Kuwait National Petroleum Company - KNPC • Ministry of Public Works. • Ministry of Finance. • Kuwait Integrated Petroleum Industries Company- KIPIC.

5.3.4 Adaptation Plans to enhance the resilience of the Human Health Sector

Increasing dust events and heat waves are the most significant physical effects of climate change on the health sector. Dust events significantly contribute to degrading the air quality increasing risks of chronic diseases and deaths. Also, heat waves are expected to increase risks of injuries and deaths. The potential socio-economic outcomes of these risks are the loss of work capacity and productivity and an increase in the treatment cost of chronic diseases, such as asthma. Enhancing the building capacity of the health sector to be prepared for increased risks due to climate change must be set as an objective of climate change adaptation for this sector. Immediate adaptation actions should be taken to ensure the achievement of this objective. These adaptation actions include but not limited to initiating researches to investigate the risks of climate change induced diseases, adjusting the office working hours to avoid working during maximum temperature in the day, raising the awareness of how to respond to dust and heat waves events and establishing national health alerts for dust and heat wave events.

Enhance and building the capacity of the health sector to be prepared for increased health risks due to climate change	
Summary	The association between asthma and dust events and risks of heat waves are clear examples of harsh environmental impact on the human health on Kuwait. Dust storms and extreme weather events (thunderstorms, heavy rainfall, heat waves, and flash floods) are expected to be severe and more frequent due to climate change. Factors contributing to asthma issue are believed to be related to the air quality. The project helps to adapt the climate change impacts in the public health sector. The project aimed to collect the previous data of air quality and weather data and to evaluate and review them against existing air regulations. Gaps and improvement opportunities were identified. The project has created the National Emissions Database Implemented an Air Quality Management Information System (AQMIS).
Ongoing projects and initiatives	- eMISK Industry. - Warning systems for sand storms. - Kuwait Integrated Environmental Management System (KIEMS);
Gaps	▪ Insufficient climatic information and early warning systems to provide alerts before extreme weather events such as dust storms; ▪ Lack of awareness of the public and the media about climate change impacts on health, and adaptation measures; ▪ Lack of communication, access to data and information on the climate change caused diseases;

	▪ Inadequate integration of health into adaptation and development plans and other sector plans and policies in Kuwait; ▪ Lack of financial and physical capacities among health-care units and practitioners as well as a lack of public awareness in addressing and understanding the climate change impacts on health.
Physical effects	▪ Increased dust events. ▪ Increased heat waves. ▪ Heavy rain and flash flood ▪ Thunderstorms and associated Asthma events.
Physical hazards/ vulnerabilities	▪ Increased risks of food and water-borne diseases ▪ Decreased air quality
Impacts	▪ Increased risks of injuries and deaths due to heat waves ▪ Increased risks of chronic diseases, such as asthma
Socio-economic risks	▪ Loss of work capacity and productivity ▪ The increased cost of asthma treatment due to the increasing number of patients. ▪ Increased energy & economic demand for cooling.
Short term actions	▪ Increase public awareness of climate changes effects and impacts on general health. ▪ Conduct risk assessments and vulnerability to Climate Change on the general public. ▪ Involve the media in carrying the message of issues of Health, as people get more influenced and receive the message more directly and subconsciously through advertisement and social media sites.

	▪ Adjust the official working hours to avoid working during maximum temperatures in the day (study and issue a new threshold). ▪ Raising awareness of how to respond to dust and heat waves events. ▪ Establishing national health alerts for dust storms and heat waves.
Medium-term actions	▪ Develop warning systems for extreme weather conditions combined with a communication strategy for alerts. ▪ Increase drought-proof vegetation to reduce dust fallout from dust storms.
Long-term actions	▪ Include information and instructions about Climate Change Effects on Health in the early education curriculum. ▪ Establish a research and monitoring network on climate and health, with a focus on analyzing the expected climate change impact on health.
Budget	4.1 million USD.
Responsibility	Ministry of Health Ministry of Higher Education Ministry of Electricity and Water KEPA. Ministry of Finance. Ministry of Services Affairs. Ministry of Information

	Meteorological department – Civil Aviation

BIBLIOGRAPHY

Public Authority of Civil information - https://www.paci.gov.kw/stat/

National Legislation – DOALOS/OLA – United Nations (1969).

Food and Agricultural Organization of the United Nations, 2016, AQUASTAT. http://www.fao.org/nr/water/aquastat/countries_regions/KWT/index.stm.

Y. VILLACAMPA (2008), *Sustainable Irrigation Management, Technologies and Policies II*, University of Alicante, Spain, C.A., WIT Transaction on Ecology and the Environment, Vol 112, www.witpress.com, ISSN 1743-3541 (online).

Mukhopadhyay & A. Akber (2018), *Sustainable Water Management in Kuwait: Current Situation and Possible Correlation Measures*, Water Research Center, Kuwait Institute for Scientific Research, Kuwait, Int. J. Sus. Dev. Plann. Vol. 13, No. 3 (2018) 425–435.

Abdel-Jawad, M., Eltony, N., Al-Shammari, S. & Al-Atram, F. (1997), *Municipal wastewater desalination by reverse osmosis* (Report No. KISR5224). Kuwait Institute for Scientific Research, Kuwait.

Aldababseh, A.; Temimi, M.; Maghelal, P.; Branch, O.; Wulfmeyer, V. Multi-Criteria Evaluation of Irrigated Agriculture Suitability to Achieve Food Security in an Arid Environment. *Sustainability* 2018, *10*, 803.

Food and Agriculture Organization (2013), *Global Map of Irrigation Area (GMIA)*, University Bonn and Aquastat, http://www.fao.org/nr/water/aquastat/irrigationmap/kwt/index.stm.

Al-Oula Shamal Azzour, 2017, https://www.aznoula.com/csr/kuwaits-native-animals/

Trading Economics, 2018, https://tradingeconomics.com/kuwait/co2-emissions-from-electricity-and-heat-production-total-percent-of-total-fuel-combustion-wb-data.html.

Mike D. Goodwin, *The Iraq-Kuwait Crisis of 1961 'A Lesson in Interregional and Econoomics'*

Shafeeq Ghabra (2014), *Kuwait: At the Crossroads of Change or Political Stagnation*, Middle East Institution, Policy Papers Series, MEI Policy Paper 2014-2.

United Nations Development Programme on Governance in the Arab Region (POGAR) (2001), *Mechanisms of Accountability in Arab Governance: The Present and Future of Judiciaries and Parliaments in the Arab World* by Nathan J. Brown.

UNDP, *Human Development Indices and Indicators*: 2018 Statistical Update.

WHO, *Health Systems Profile* – Kuwait, 2006.

E. Al Bassam and A. Khan (2004), *Air Pollution and Road Traffic in Kuwait, Environmental and Urban Development Division*, Kuwait Institution for Scientific Research, Kuwait, Urban Transport X, C.A. Brebbia & L. C. Wadhwa (Editors), WIT Press, www.witpress.com, ISBN 1-85312-716-7.

Niall McCarthy (2016), *The economies most dependent on oil*, The Statistics Portal, https://www.statista.com/chart/4284/the-economies-most-dependent-on-oil/

Salman Zafar (2018), *MSW Generation in the Middle East*, EcoMENA, Echoing Sustainability in MENA, https://www.ecomena.org/solid-waste-middle-east/

Jasem M. Al Awadhi (2014), *Measurement of Air Pollution in Kuwait City Using Passive Samplers*.

Afaf Y. Al-Nasser and N.R. Bhat (1998), *Protected Agriculture in the State of Kuwait*, Kuwait Institute for Scientific Research, Safat, Kuwait, https://www.researchgate.net/publication/237258098_Protected_Agriculture_in_the_State_of_Kuwait.

Jaber Almedeij (2012), *Modeling Rainfall Variability over Urban Areas: A Case Study for Kuwait*, The Scientific World Journal, doi: 10.1100/2012/980738.

The Government of Kuwait, *Nationality By Religion and Nationality*.

United Nations Economic and Social Council, *Kuwait Integration Segment*, 2015.

Mounif Kilwani, Economic and Commercial Councilor (2014), *Building and Construction Sector in Kuwait*, invest-export.brussels, Embassy of Belgium.

The Global Cement Report (2016-18), ICR Research, International Cement Review Kuwait.

Country Profiles for Population and Reproductive Health, Policy Developments and Indicators 2005, produced jointly by UNFPA and Population Reference Bureau

Harold R.P. Dickson, *Kuwait and Her Neighbors* (London: George Allen & Unwin, Ltd., 1956).

Crystal, J. (1990). *Oil and Politics in the Gulf: Rulers and Merchants in Kuwait and Qatar*, Cambridge Middle East Library, Cambridge: Cambridge University Press. Doi:10.1017/CBO9780511558818.

L Archer, P Barnes, C Caffarra, J Dargay, P Horsnell, C van der Linde, I Skeet and Ala'a Al-Yousef, and Directed by R Mabro (1990), *The First Oil War: Implications of the Gulf Crisis in the Oil Market,* Oxford Institute for Energy Studies.

CNN Transcript (2001), "*The Unfinished War: A Decade Since Desert Storm"* http://web.archive.org/web/20080317110507/http://www.cnn.com/SPECIALS/2001/gulf.war/facts/gulfwar/.

Al Dosery, N., Mathew, M., Suresh, N., & Al-Menaie, H. S. (2012), *Kuwait's Agricultural Efforts to Mitigate Climate Change*, Energy Procedia, 18, 1441-1445.

Al-Dousari, A., Doronzo, D., & Ahmed, M. (2017). Types, indications and impact evaluation of sand and dust storms trajectories in the Arabian Gulf. Sustainability, 9(9), 1526.

Aldousari, E., & Alsahli, M. M. (2017). Studying the Spatial Distribution of Asthma Patients in the State of Kuwait Using GIS. Journal of the Social Sciences, 45(1).

Al-Abdulrazzak, D., Zeller, D., Belhabib, D., Tesfamichael, D., & Pauly, D. (2015). Total marine fisheries catch in the Persian/Arabian Gulf from 1950 to 2010. Regional Studies in Marine Science, 2, 28–34. https://doi.org/10.1016/J.RSMA.2015.08.003

Al-Gabandi. (2011). Boubyan Port: The Eastern Gate of Kuwait (Arabic Title). Beatona, 16–25.

Al-Husaini, M., Bishop, J. M., Al-Foudari, H. M., & Al-Baz, A. F. (2015). A review of the status and development of Kuwait's fisheries. Marine Pollution Bulletin, 100(2), 597–606. https://doi.org/10.1016/j.marpolbul.2015.07.053

Al-Rashed, M., Al-Senafy, M. N., Viswanathan, M. N., & Al-Sumait, A. (1998). Groundwater utilization in Kuwait: Some problems and solutions. International Journal of Water Resources Development. https://doi.org/10.1080/07900629849529

Al-Rashidi, T. B., El-Gamily, H. I., Amos, C. L., & Rakha, K. A. (2009). Sea surface temperature trends in Kuwait Bay, Arabian Gulf. Natural Hazards. https://doi.org/10.1007/s11069-008-9320-9

AL-Yamani, F. Y., Bishop, J., Ramadhan, E., AL-Husaini, M., & Al-Ghadban, A. N. (2004). Meteorological Conditions of Kuwait. In Oceanographic Atlas of Kuwait's Waters (pp. 64–79). Kuwait: Kuwait Insitute for Scientific Research.

Alsahli, M. M. M., & AlHasem, A. M. (2016). The vulnerability of the Kuwait coast to sea level rise. Geografisk Tidsskrift-Danish Journal of Geography, 116(1), 56–70. https://doi.org/10.1080/00167223.2015.1121403

Annual Statistical Abstract (ASA). (2011). Statistical Review. State Of Kuwait: Central Statistical Bureau.

Bakri, D. A. L., & Kittaneh, W. (1998). Physicochemical characteristics and pollution indicators in the intertidal zone of Kuwait: Implications for benthic ecology. Environmental Management. https://doi.org/10.1007/s002679900116

Barnett, A. G., Fraser, J. F., & Munck, L. (2012). The effects of the 2009 dust storm on emergency admissions to a hospital in Brisbane, Australia. International Journal of Biometeorology. https://doi.org/10.1007/s00484-011-0473-y

Bauman, A. G., Feary, D. A., Heron, S. F., Pratchett, M. S., & Burt, J. A. (2013). Multiple environmental factors influence the spatial distribution and structure of reef communities in the northeastern Arabian Peninsula. Marine Pollution Bulletin. https://doi.org/10.1016/j.marpolbul.2012.10.013

Carpenter, K. E., Kuwait Inst. for Scientific Research, S. (Kuwait) eng, Harrison, P. L., Hodgson, G., Alsaffar, A. H., & Alhazeem, S. H. (1997). The corals and coral reef fishes of Kuwait. Safat (Kuwait) KISR.

El-Sheikh, M. A. E., El-Ghareeb, R. M., & Testi, A. (2006). The diversity of plant communities in coastal salt marshes habitat in Kuwait. Rendiconti Fisiche Accademia Lincei.

George, J. D., & John, D. M. (1999). High sea temperatures along the coast of Abu Dhabi (UAE), Arabian Gulf—their impact upon corals and macroalgae. Reef Encounter, 25, 21–23.

Geravandi, S., Sicard, P., Khaniabadi, Y. O., De Marco, A., Ghomeishi, A., Goudarzi, G., … Sadeghi, S. (2017). A comparative study of hospital admissions for respiratory diseases during normal and dusty days in Iran. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-017-9270-4

Gorai, A. K., Tuluri, F., & Tchounwou, P. B. (2014). A GIS-based approach for assessing the association between air pollution and asthma in New York State, USA. International Journal of Environmental Research and Public Health. https://doi.org/10.3390/ijerph110504845

Intergovernmental Panel on Climate Change. (2014). Climate Change 2014 Mitigation of Climate Change. Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9781107415416

Lapshin, A. M. (2000). Cascade of Hydroelectric Units on the Euphrates River in Syria. Hydrotechnical Construction, 34(8), 448–456. https://doi.org/10.1023/A:1004178906971

Lioubimtseva, E., & Henebry, G. M. (2009). Climate and environmental change in arid Central Asia: Impacts, vulnerability, and adaptations. Journal of Arid Environments. https://doi.org/10.1016/j.jaridenv.2009.04.022

Ministry Of Electricity & Water. (2017). Statistical Year Book: Electrical Energy. Retrieved from https://www.mew.gov.kw/Files/AboutUs/Statistics/

Mohammad Alsahli, Price, K. P., Buddemeier, R., Fautin, D. G., & Egbert, S. (2012). Mapping Spatial and Temporal Distributions of Kuwait SST Using MODIS Remotely Sensed Data. Applied Remote Sensing Journal.

Omar Asem, S., & Roy, W. Y. (2010). Biodiversity and climate change in Kuwait. International Journal of Climate Change Strategies and Management. https://doi.org/10.1108/17568691011020265

Pereira, L. S., Oweis, T., Zairi, A., & Santos, L. (2002). Irrigation management under water scarcity. Agricultural Water Management. https://doi.org/10.1016/S0378-3774(02)00075-6

Rahi, K. A., & Halihan, T. (2010). Changes in the salinity of the Euphrates River system in Iraq. Regional Environmental Change. https://doi.org/10.1007/s10113-009-0083-y

World Health Organization. (2013). Asthma. Retrieved October 7, 2018, from http://www.who.int/en/news-room/fact-sheets/detail/asthma

Yang, C. Y., Tsai, S. S., Chang, C. C., & Ho, S. C. (2005). Effects of Asian dust storm events on daily admissions for asthma in Taipei, Taiwan. Inhalation Toxicology. https://doi.org/10.1080/08958370500241254

Al-Harbi, M., Eidan, H., Al-Holan, N., Al-Abdullrazaq, F., Alsahli, M., Hassan, A., … Hussein, S. (2018). The second national communication report: vulnerability and adaptation to climate change. Unofficial Draft. Kuwait City, Kuwait.

Alsahli, M. M. M., Price, K. P., Buddemeier, R., Fautin, D. G., & Egbert, S. (2012). Mapping Spatial and Temporal Distributions of Kuwait SST Using MODIS Remotely Sensed Data. Applied Remote Sensing Journal.

Baby, S. (2014). Assessing morphological landscape carrying capacity for coastal areas in Kuwait. Indian Journal of Geo-Marine Sciences, 43(8), 1–16.

Brown, B. E. (1997). Coral bleaching: causes and consequences. Coral Reefs. https://doi.org/10.1007/s003380050249

Bureau, K. C. S. (2013). Migration Statistical Report. Retrieved from http://www.csb.gov.kw/Socan_Statistic_EN.aspx?ID=56

Fabry, V., Seibel, B., Feely, R., & Orr, J. (2008). Impacts of ocean acidification on marine fauna and ecosystem processes. ICES Journal of Marine Science. https://doi.org/10.1093/icesjms/fsn048

Franz, B. A., Kwiatowska, E. J., Meister, G., & McClain, C. R. (2008). Moderate Resolution Imaging Spectroradiometer on Terra: limitations for ocean color applications. Journal of Applied Remote Sensing, 2(1), 023525. https://doi.org/10.1117/1.2957964

Hansen, L., Hoffman, J., Drews, C., & Mielbrecht, E. (2010). Designing climate-smart conservation: Guidance and case studies: Special section. Conservation Biology. https://doi.org/10.1111/j.1523-1739.2009.01404.x

Kim, Y., Calzada, A., Scott, O., & Zermoglio, F. (2018). DESIGNING CLIMATE VULNERABILITY ASSESSMENTS. Washington, DC.

Kurbjeweit, F., Schmiedl, G., Schiebel, R., Hemleben, C., Pfannkuche, O., Wallmann, K., & Schäfer, P. (2000). Distribution, biomass, and diversity of benthic foraminifera in relation to sediment geochemistry in the Arabian Sea. Deep-Sea Research Part II: Topical Studies in Oceanography. https://doi.org/10.1016/S0967-0645(00)00053-9

Kuwait Environmental Public Authority (KEPA). (2015). Water quality parameters. Kuwait.

Sebastian, M., & Kaaya, L. T. (2018). Impacts of Sea Surface Temperature on Coral Reefs in Mafia Island, Tanzania. Journal of Marine Science: Research & Development, 8(3), 5.

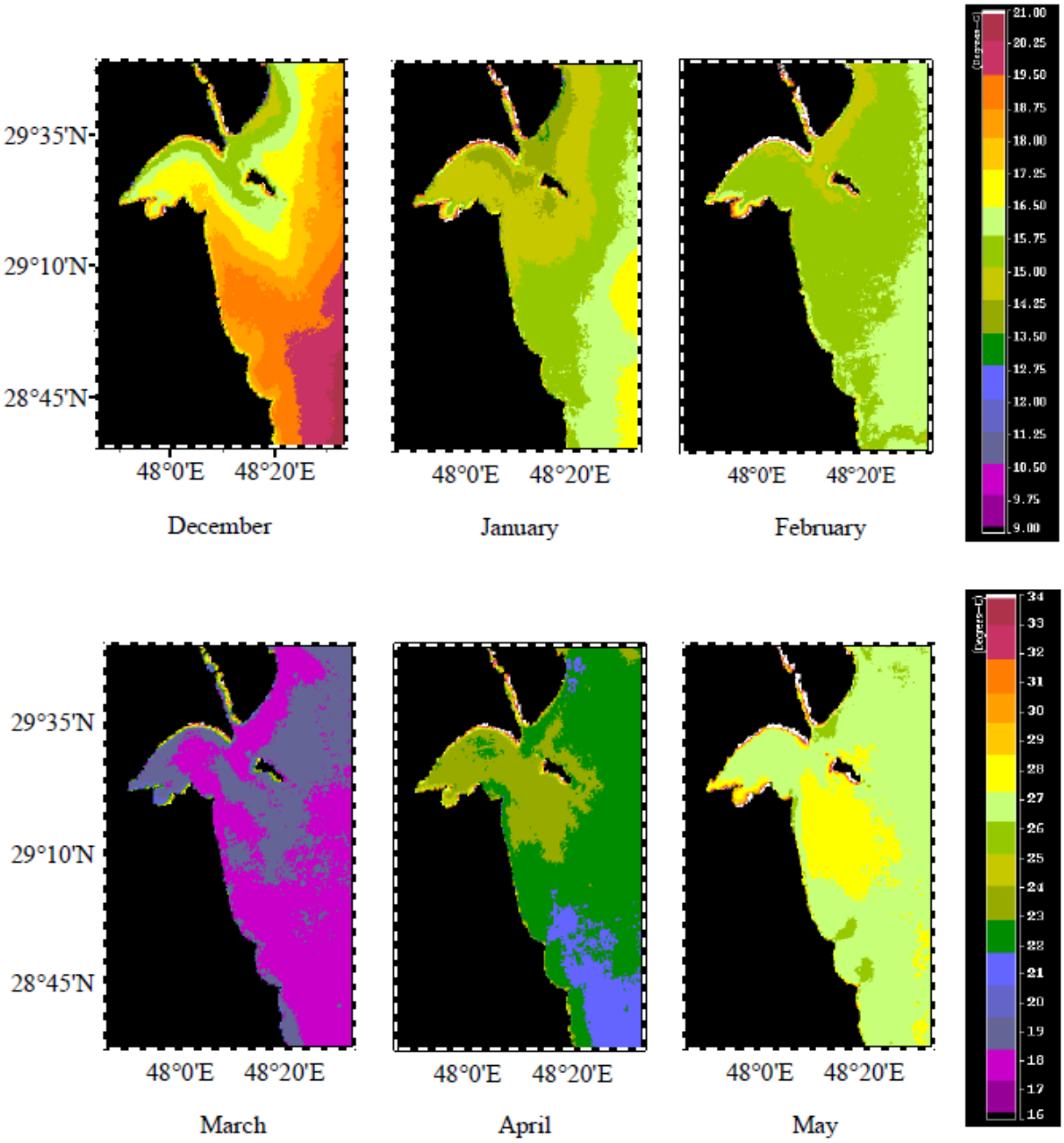
Segar, D. A. (2018). Chapter 12: Foundation of life in the oceans. In Introduction to Ocean Sciences.

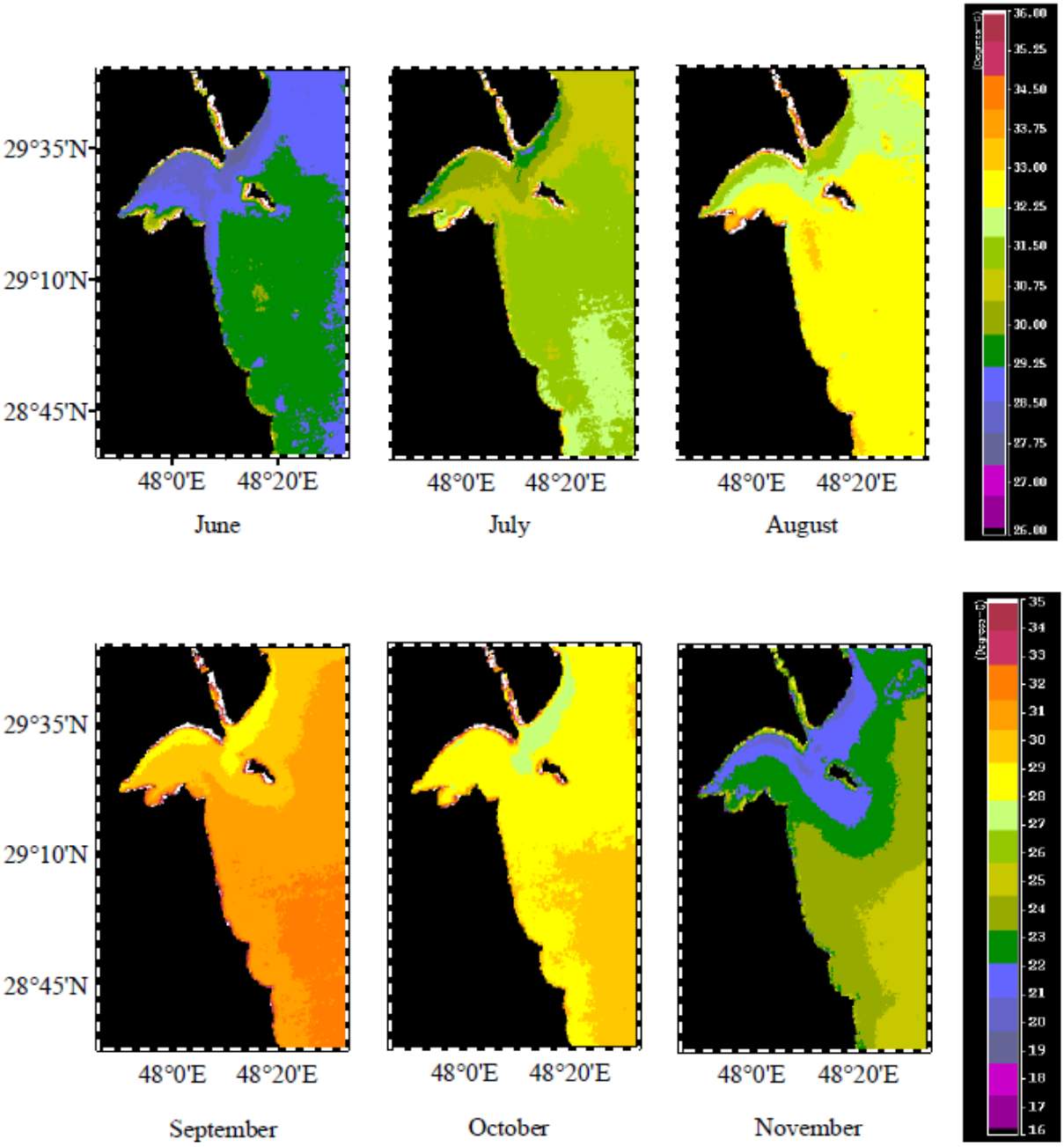
Warren, R. F., Wilby, R. L., Brown, K., Watkiss, P., Betts, R. A., Murphy, J. M., & Lowe, J. A. (2018). Advancing national climate change risk assessment to deliver national adaptation plans. Phil. Trans. R. Soc. A, 376(2121), 20170295.

Ian Simm, (2018), Newsbase Ltd., https://newsbase.com/topstories/kuwait-looks-complete-al-zour-next-year.

Appendix A

Spatial and temporal distributions of SST within Kuwait waters were calculated using MODIS level-2 images (2003 – 2007). The remotely sensed SST images were calibrated using in situ data (KEPA, INC, 2012).




29°35'N
29°10'N
28°45'N
48°0'E
48°20'E
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Appendix B

MODIS (Aqua) images (downloaded from NASA website: https://oceancolor.gsfc.nasa.gov/) acquired in January and August 2017 were used to model SST within Kuwait Waters. MODIS Aqua launched in May 2002 is covering the entire Earth's surface in one to two days with a varying spatial resolution of 250 m to 1000 m and an image swath width of 2330 km. MODIS Aqua overpasses Kuwait waters approximately at 1:00 P.M. (local time) (Franz, Kwiatowska, Meister, & McClain, 2008). MODIS level-1 images were processed to level-2 using SeaWiFS Data Analysis System (SeaDAS 7.5) software to derive the level-2 SST ocean product. SST images were then calibrated within an error of ± 0.7 oC (r2= 0.98) using the KEPA, INC, 2012 model:

Calibrated SST = 1.0194 * MODIS SST - 0.731