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nexus

MINARET II

Empowering Municipal Governance for Climate Resilience Using WEF Nexus Approach

# Sustainable Energy and Climate Action Plan (SECAP)

# Ma'an Greater Municipality

MINARET II is supported by the Nexus Regional Dialogues Programme which is implemented by the GIZ and co-funded by the European Union (EU) and the German Federal Ministry for Economic Cooperation and Development (BMZ), and implemented by Royal Scientific Society/National Energy Research Centre. The project is implemented at municipal level targeting Jordan, Lebanon and Tunisia.

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## Executive Summary

Ma'an Governate is the largest governate in Jordan where Ma'an Greater Municipality connects the north to the south and to Aqaba port. The purpose of this report is to set recommended actions that can reduce 40% emissions from the total emissions projected from 2019 onto 2030. This was done through the estimation of a baseline emission index and setting several recommended actions that'll suffice the target. 8 sectors were investigated including:

- Residential Buildings
- Municipal Building and Facilities
- Tertiary Sector Buildings and Facilities
- Street Lighting
- Transportation (Municipal, Public, Commercial, and Private)
- Waste Water Treatment
- Solid Waste
- Livestock.

The municipality consumed 4 sources of energy including Electricity, LPG (Liquified Petroleum Gas), Gasoline, and Diesel. With diesel being the most consumed type of fuel and LPG being the least. The total energy consumption at 2030 is expected to be 2 TWh and a total of 577 ktn$CO_{2eq}$ emissions. A target of 230 ktn $CO_{2eq}$ emission reduction is required to attain the target where the actions have reached 279 ktn $CO_{2eq}$. The total investment for such actions is estimated to reach USD 48 Million.

Despite the municipality having a very small carbon footprint, the transportation sector emits the most of the $CO_2$ (Carbon dioxide) making up to 80% of its total emissions. where all commodities pass through the city. This makes it a focal point to many activities.

The total emissions were 412,949.45 tn $CO_{2eq}$ , while the expected total emissions in 2030 will be 557481.75 tn $CO_{2eq}$. Th total estimated emissions reduction will be 226,744.33 tn $CO_{2eq}$, which represents around 40.6% of the total emission in 2030.

# 1 Introduction

## 1.1. Current status

### 1.1.1. Geographical location

Ma'an Governorate is located in the south of Jordan. It extends in the north from the boundaries of the Capital Governorate to the Saudi-Jordanian borders in the south, and from the boundaries of Wadi Araba (Aqaba Governorate) in the west to the Saudi-Jordanian borders in the east.

It consists of (4) counties, (7) districts, (7) municipalities, and the Petra Development & Tourism Region Authority. Furthermore, it is the largest governorate in terms of area, where its area is estimated at about (32,832) km2, which is 37% of the total area of Jordan.

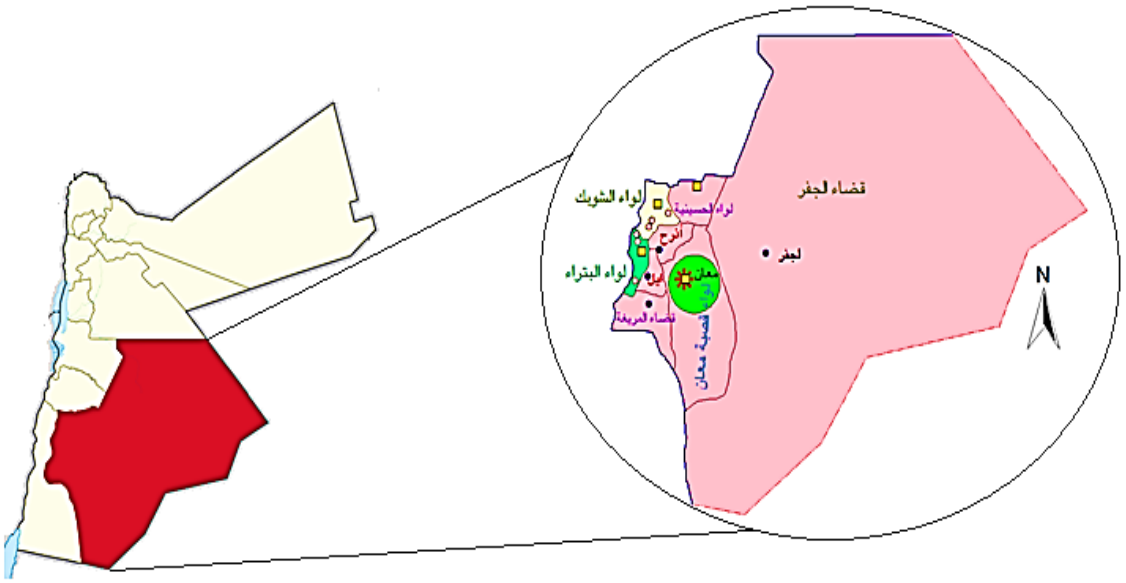



*Figure 1: Ma'an governate geographical location.*

With its strategic geographical location, where it is close to Aqaba Port, and having the Saudi-Iraqi highway crossing the Governorate, Ma'an has many features that fortify its status such as:

a) The availability of some of the natural resources, such as building limestone, silica sand, phosphate, and kaolin.

b) The existence of a number of archeological and historical sites, mainly Petra City, shown in the figure below, Shobak Castle, and the palace of the founder of Jordan, King Abdullah I.

c) Having the phosphate mines, Aqaba Railway Corporation and its offices in Ma'an, and the railways leading to Aqaba.

d) The existence of various agricultural investments in Shobak region, Mudawwarah, Ras Al-Naqab, and Al-Muhammadeyeh.

e) The existence of King Hussein University, and two community colleges (Ma'an and Shobak).

*Figure 2: Al Shobak castle located in Ma'an governate.*

### 1.1.2. Climate characteristics

In Ma'an, the summers are long, hot, arid, and clear and the winters are cold, dry, and mostly clear. Over the course of the year, the temperature typically varies from 2°C to 33°C and is rarely below -1°C or above 37°C.

The hot season lasts for 4.1 months, from May 25 to September 30, with an average daily high temperature above 29°C. The hottest month of the year in Ma'an is August, with an average high of 33°C and low of 18°C.

The cool season lasts for 3.1 months, from December 1 to March 5, with an average daily high temperature below 16°C. The coldest month of the year in Ma'an is January, with an average low of 2°C and high of 13°.

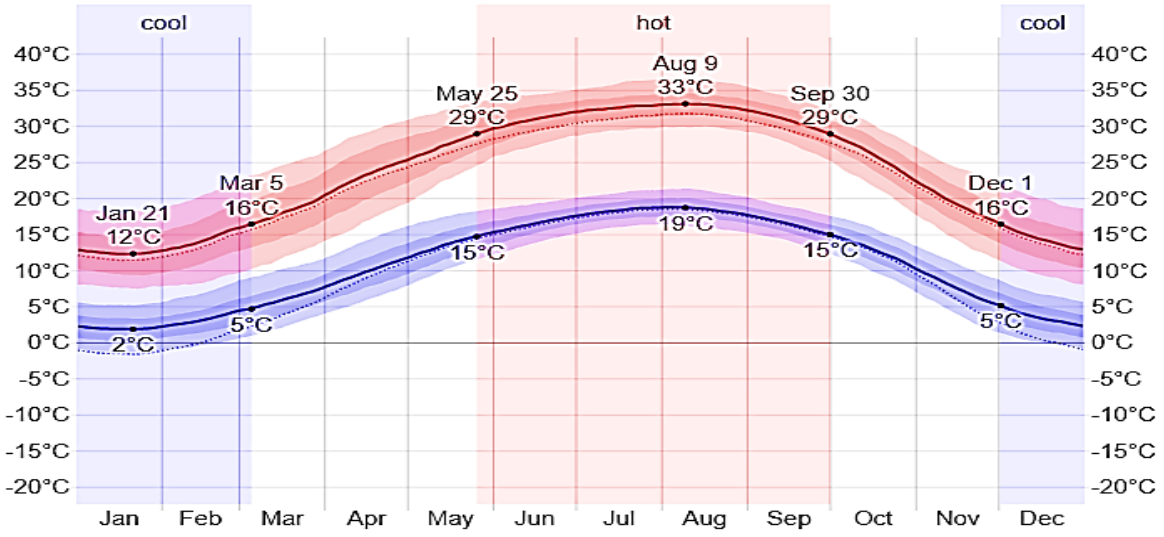



*Figure 3: Minimum and Maximum average monthly temperature*

The figure below shows you a compact characterization of the entire year of hourly average temperatures. The horizontal axis is the day of the year, the vertical axis is the hour of the day, and the colour is the average temperature for that hour and day.

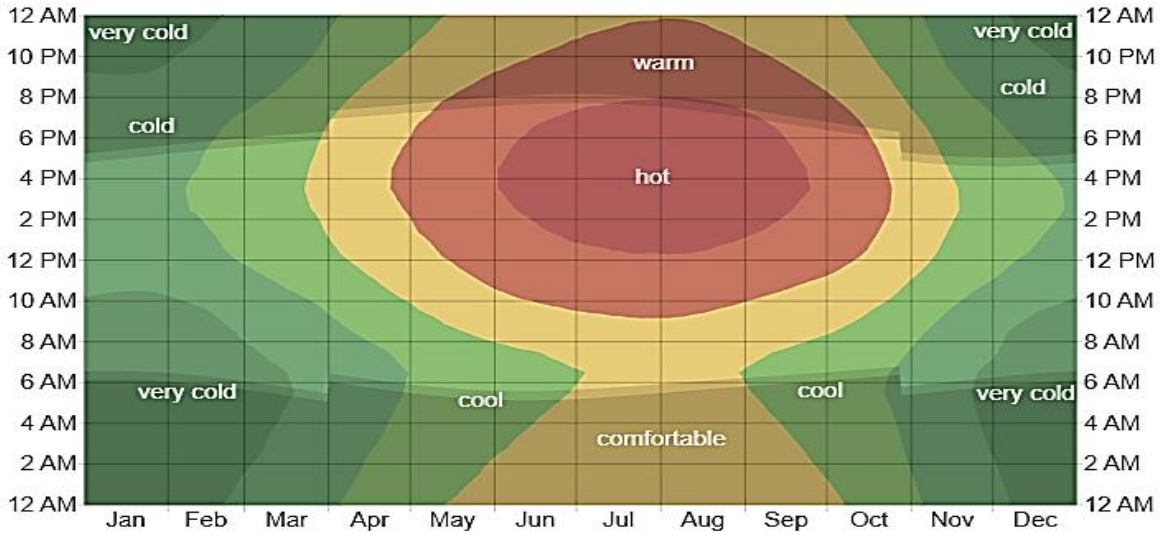



*Figure 4: Hourly average temperatures.*

### 1.1.2.1. Clouds

In Ma'an, the average percentage of the sky covered by clouds experiences significant seasonal variation over the course of the year. The clearer part of the year in Ma'an begins around May 22 and lasts for 5.0 months, ending around October 22.

The clearest month of the year in Ma'an is August, during which on average the sky is clear, mostly clear, or partly cloudy 99% of the time.

The cloudier part of the year begins around October 22 and lasts for 7.0 months, ending around May 22.

The cloudiest month of the year in Ma'an is December, during which on average the sky is overcast or mostly cloudy 33% of the time.

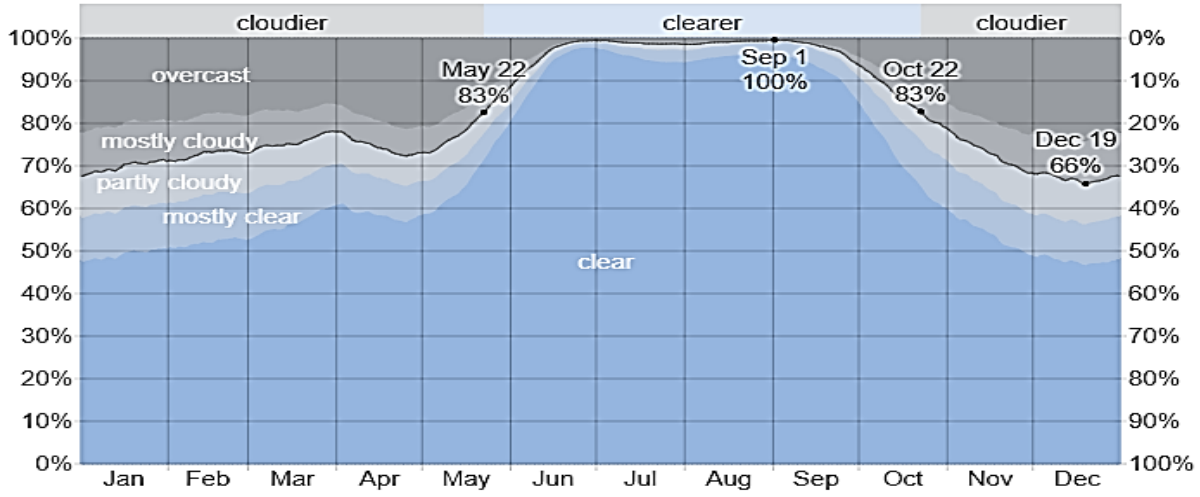



*Figure 5: Average percentage of cloud covering the sky.*

### 1.1.2.2. Precipitation

Ma'an does not experience significant seasonal variation in the frequency of wet days (i.e., those with greater than 1.00 millimeters of liquid or liquid-equivalent precipitation). The frequency ranges from 0% to 9%, with an average value of 3%.

Among wet days, we distinguish between those that experience rain alone, snow alone, or a mixture of the two. The month with the most days of rain alone in Ma'an is February, with an average of 2.1 days. Based on this categorization, the most common form of precipitation throughout the year is rain alone, with a peak probability of 9% on February 2.

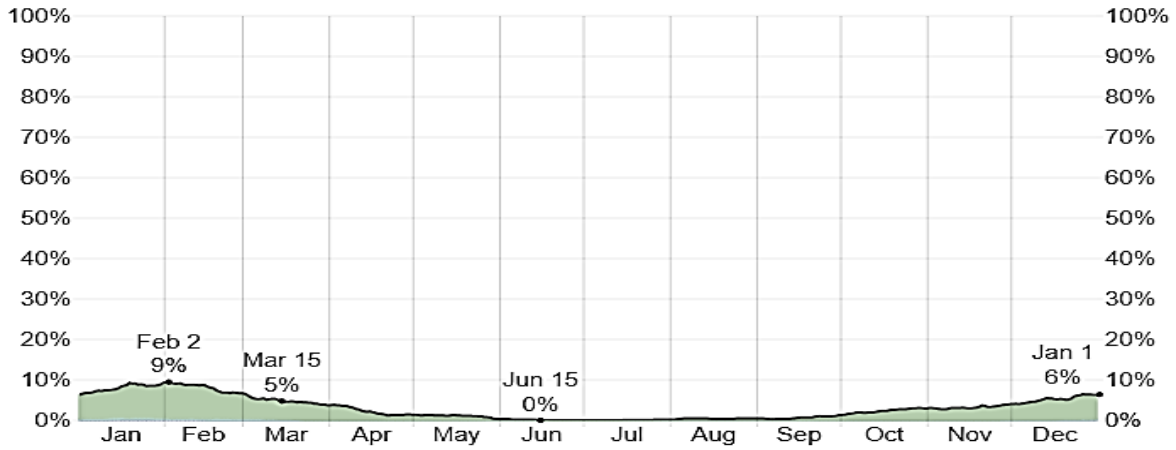



*Figure 6: Frequency of wet days.*

#### 1.1.2.3. Rainfall

To show variation within the months and not just the monthly totals, we show the rainfall accumulated over a sliding 31-day period cantered around each day of the year. Ma'an experiences some seasonal variation in monthly rainfall.

Rain falls throughout the year in Ma'an. The month with the most rain in Ma'an is January, with an average rainfall of 12 millimetres.

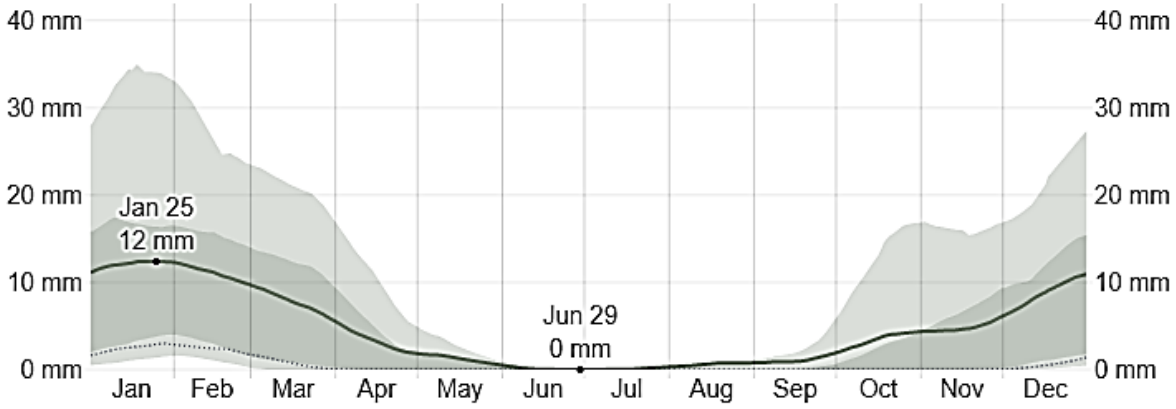



*Figure 7: Average monthly Rainfall.*

#### 1.1.2.4. Humidity

We base the humidity comfort level on the dew point, as it determines whether perspiration will evaporate from the skin, thereby cooling the body. Lower dew points feel drier and higher dew points feel more humid. Unlike temperature, which typically varies significantly between night and day, dew

point tends to change more slowly, so while the temperature may drop at night, a muggy day is typically followed by a muggy night.

The perceived humidity level in Ma'an, as measured by the percentage of time in which the humidity comfort level is muggy, oppressive, or miserable, does not vary significantly over the course of the year, remaining a virtually constant 0% throughout.

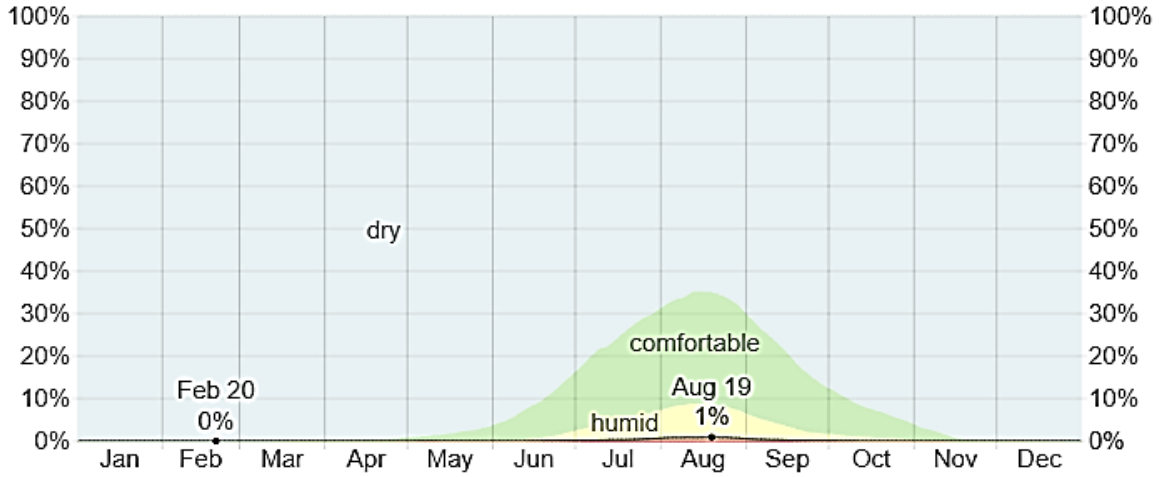



*Figure 8: Average percentage of humidity.*

#### 1.1.2.5. Wind

This section discusses the wide-area hourly average wind vector (speed and direction) at 10 meters above the ground. The wind experienced at any given location is highly dependent on local topography and other factors, and instantaneous wind speed and direction vary more widely than hourly averages.

The average hourly wind speed in Ma'an experiences mild seasonal variation over the course of the year.

The windier part of the year lasts for 7.7 months, from December 23 to August 13, with average wind speeds of more than 3.8 meters per second. The windiest month of the year in Ma'an is February, with an average hourly wind speed of 4.3 meters per second.

The calmer time of year lasts for 4.3 months, from August 13 to December 23. The calmest month of the year in Ma'an is October, with an average hourly wind speed of 3.4 meters per second.

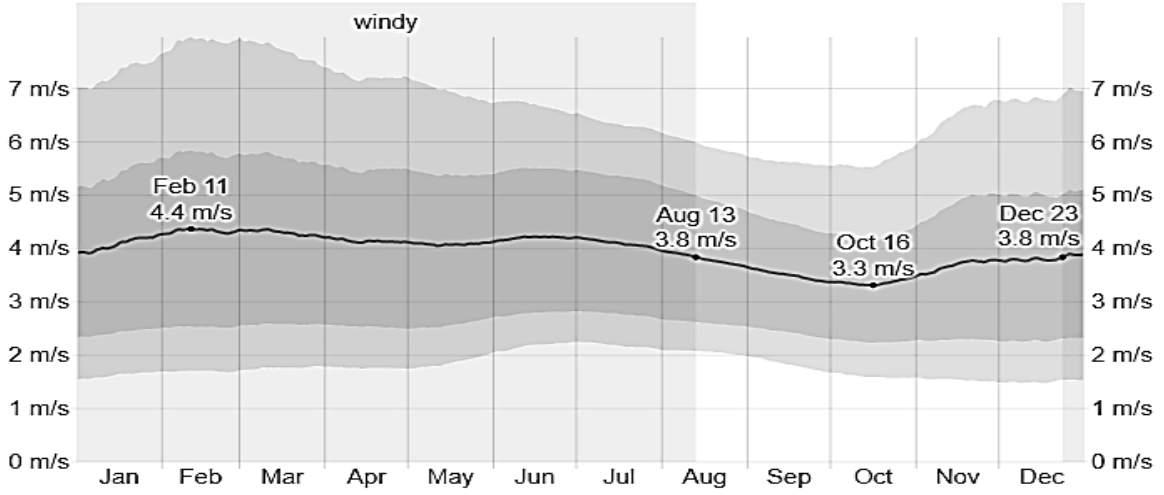



*Figure 9: Average monthly wind speed.*

The wind is most often from the north for 5.7 months, from May 14 to November 5, with a peak percentage of 66% on September 5. The wind is most often from the west for 1.0 weeks, from November 5 to November 12 and for 5.7 months, from November 23 to May 14, with a peak percentage of 31% on November 11. The wind is most often from the east for 1.6 weeks, from November 12 to November 23, with a peak percentage of 32% on November 17.

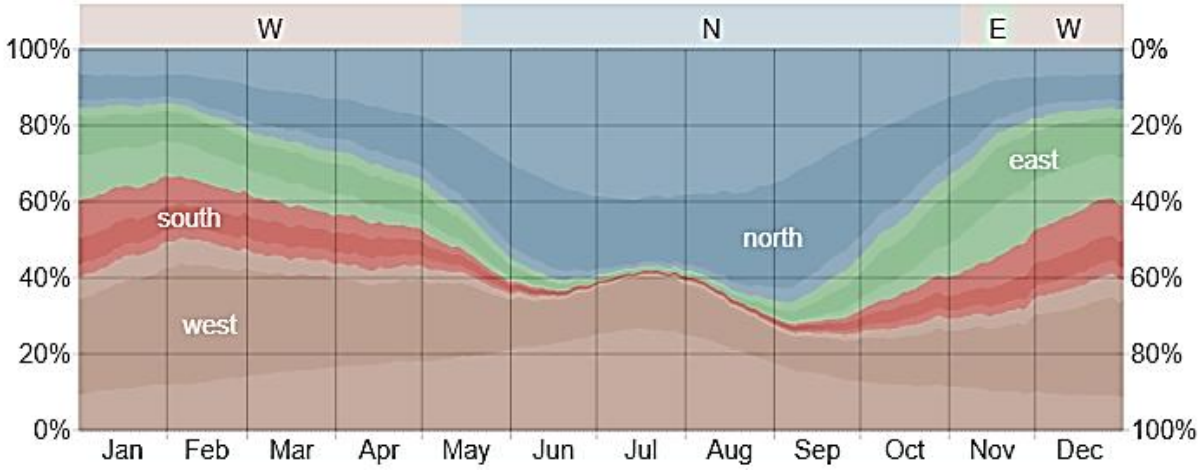



*Figure 10: Average monthly wind speed.*

#### 1.1.2.6. Solar Energy

This section discusses the total daily incident shortwave solar energy reaching the surface of the ground over a wide area, taking full account of seasonal variations in the length of the day, the elevation of the Sun above the horizon, and absorption by clouds and other atmospheric constituents. Shortwave radiation includes visible light and ultraviolet radiation.

The average daily incident shortwave solar energy experiences extreme seasonal variation over the course of the year.

The brighter period of the year lasts for 3.6 months, from May 6 to August 25, with an average daily incident shortwave energy per square meter above 7.8 kWh. The brightest month of the year in Ma'an is June, with an average of 8.8 kWh.

The darker period of the year lasts for 3.0 months, from November 7 to February 7, with an average daily incident shortwave energy per square meter below 4.6 kWh. The darkest month of the year in Ma'an is December, with an average of 3.6 kWh.

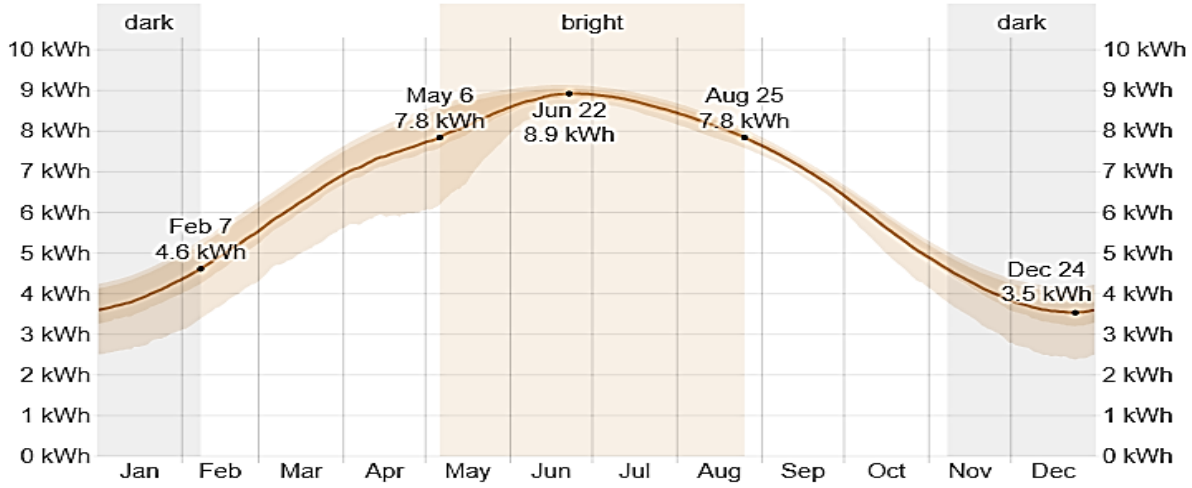



*Figure 11: total daily incident shortwave solar energy.*

### 1.1.3. Demographic tendencies

According to the last population census of 2015, the population living in Ma'an Governorate

was 175,200, consisting of 48% women and 52% men. Concerning the population at the Ma'an Municipality level, this rises up to 46,110.

Between 2007 and 2016, population of Ma'an grew substantially from 92,300 to 148,100 persons rising at an increasing annual rate that reached a maximum of 9.26% in 2013 and then decreased to 2.49% in 2016.

### 1.1.4. Employment

The employees in Ma'an Governorate comprise approximately 75% of its active citizens over 15 years of age, according to the most recent population census (2020). In the part of economically active citizens there is a 25% percentage that is currently unemployed and looking for a job.

*Table 1: Employment in Ma'an.*

| Status | Male | Female | Total |
|---|---|---|---|
| Employed | 23,081 | 6,505 | 29,586 |

| | | | |
|---|---|---|---|
| Unemployed | 6,321 | 3,298 | 9,619 |
| Total | 29,402 | 9,803 | 39,205 |

### 1.1.5. Education

Regarding the total number of schools in Ma'an, it reached 232 Schools with 4172 teachers employed in these schools. 29 % of these schools are male students, while 5% are female students and the remaining are mixed schools. Concerning the number of schools in Ma'an directorate, there is 61 schools allocated for the students in this part of the city, and 1231 teachers. As an indicator for the education in Ma'an, the student to teacher ratio is 10 while the country average is 15.3 and an average of 19 students per classroom. When considering the educational status of Ma'an Governorate's citizens, a percentage of 23% of the total population was enrolled in the education in 2019. The majority of which (83%) was in primary education and only 11% in the secondary education levels.

### 1.1.6. Infrastructures

The registered households in Ma'an Governorate are 35,328, of which there are 34,609 housing units in conventional buildings, according to the 2015 population census. The Governorate provides a public network for access in water and drinking water. 87% of the housing units have access in the water network. The remaining percentage uses, mainly, mineral water for drinking purposes. Concerning the sewage system, almost third of the population have an access to the network, only 34% of the population has access in the public network. The rest of the housing units are being served by cesspools.

Ma'an is accessed by the Desert Highway that connects Amman with the southern regions. The road network in the Governorate consists of 1464 Km of paved and unpaved roads, of which 39% are primary roads, 18% secondary roads, and a final 43% village roads. Based on the data, Ma'an Governate includes the highest length share of road networks in the country, which is normal when comparing the governate area with other governates.

### 1.1.7. Economy

Ma'an is home to the Ma'an Development Area (MDA), a special economic zone with reduced income taxes, no other taxes (including taxes on income from exports), and streamlined regulatory procedures. Construction of the MDA's industrial park began in 2008 and is set to be completed in 2030. The Shams Ma'an Solar Power Plant is located in the MDA.

On top of this, agriculture is one of the most important sectors of the regional economy. As mentioned in the annual statistical book submitted by the Department of statistics, the area of both the Crops and the Livestock holdings is 65040.

### 1.1.8. Renewable Energy Projects

Solar power is seen as a sustainable option for Jordan's long-term energy security, as the country boasts about 330 sunny days per year. The majority of the solar photovoltaic (PV) farms currently under

construction, totalling around 200 MW, are located in and around the Ma'an region, whereas the majority of consumption stems from the capital Amman. The governate potential is not only linked to the solar energy, however, high elevated lands in the region attracted the investors to invest in the wind energy projects. Several Renewable Energy projects have been implemented in the region which illustrate the governate importance in supporting the country's toward achieving its key targets and plans. The following table listing the solar and wind projects implemented in the city.

*Table 2: Renewable Energy Projects in Ma'an Governate.*

| **Project Name** | **Project Size (MW AC)** | **Project Status** |
|---|---|---|
| Direct Proposal/ Round 1 PV/ Scatec Solar | 10 | Operational since June 2016 |
| Direct Proposal/ Round 1 PV/ SunEdison Project | 20 | Operational since July 2016 |
| Direct Proposal/ Round 1 PV/ Ardh Al Amal Project | 13 | Operational since July 2016 |
| Direct Proposal/ Round 1 PV/ Arabia one Project | 10 | Operational since August 2016 |
| Direct proposals/ Round 1 PV/ EJRE | 20 | Operational since August 2016 |
| Direct proposals/ Round 1 PV/ Shams Ma'an | 52.5 | Operational since September 2016 |
| Direct proposals/ Round 1 PV/ Zahrat Alsalam | 10 | Operational since September 2016 |
| Direct proposals/ Round 1 PV/ Alzanbaq | 10 | Operational since September 2016 |
| Direct proposals/ Round 1 PV/ Alward Aljoury | 10 | Operational since September 2016 |

| | | |
|---|---|---|
| Direct proposals/ Round 1 PV/ Falcon Ma'an | 20 | Operational since October 2016 |
| Ma'an Wind Project - Gulf grant | 80 | Main Project(66 M.W) Operational since September 2016 Expansion (14 M.W) Operational since August 2017 |
| Al-Rajif wind Farm | 86 | Operational since October 2018 |
| Fujeij wind | 89.1 | Operational since July 2019 |

# 2 BEI Methodology

## 2.1. Baseline Year

According to the Covenant of Mayors Guidelines for South Signatories, in order to develop the energy balance sheet and consequently specify the $CO_2$ emissions, the year 1990 should be considered as the baseline year. In case where there isn't adequate data for this year, as baseline year should be considered the nearest year to 1990 for which there are complete and reliable data. Thus, for the Ma'an Municipality the baseline year has been set to 2019, since it was the year with the most sufficient and reliable data available.

## 2.2. SECAP administrative body

Following a meeting of the consultants from the Royal Scientific Society/National energy Research Center (RSS/NERC) with the Ma'an representatives, it was agreed that the BEI will cover the administrative boundaries of Ma'an Municipality.

## 2.3. Sectors to be included in the BEI

The sectors for which the appropriate data were gathered and calculations for the total energyconsumption and CO2 emissions are presented below:

A. Buildings, equipment & facilities
- Municipal buildings, equipment and facilities
- Public lighting
- Residential buildings
- Tertiary buildings, equipment and facilities (non-municipal)

B. Transport
   - Municipal fleet
   - Public transport
   - Private and commercial transport

C. Solid waste management

D. Waste water treatment

E. Livestock

The industrial sector is included only as electrical consumption because the collection of its actual data is not normally documented and impossible to obtain otherwise. This decision was further enforced by the fact that the non ETS industrial sector is an optional sector according to the Guidelines, since the municipality has limited potential on actually reducing its consumptions through convincing the respective keystakeholders.

### 2.4. Emission factors and Conversion rates

The emission factors which are used in this SECAP were derived from the Covenant of Mayors Guidebook Table 3, with the only exception of the electricity emission factor, which is characteristic for the country. It was not possible to acquire the electricity emission factor for Jordan directly from the Ministry of Energy and Mineral Resources (MEMR), or any of the utilities servicing the country. Therefore, according to the IPCC measures the emission factor is as below, as the best approach to identify it was considered to be the utilization of available statistical data from the International Energy Agency (IEA) and MEMR. To this end, emission factor for Jordan's electricity consumption according to the Jordan's Second Biennial Update Report in 2018 is shown in the table below:

$$EF = \frac{CO_{2\ emissions\ tot}}{Total\ Electricity\ Production}$$

The available data for is presented in the next table:

*Table 3: Emission Factors & Conversion Rates*

| Fuel/Energy | Emission Factors (ton $CO_2$/MWh) | Conversion Factors |
|---|---|---|
| Electricity Grid Emission Factor | 0.4585[1] | - |

[1] Jordan's Second Biennial Update Report (SBUR) Under The United Nations December 2020 Framework Convention on Climate Change

| | | |
|---|---|---|
| LPG | 0.227 | 13.1 MWh/ton<br>10 MWh/lt |
| Diesel/Heating Oil | 0.267 | 10 kWh/lt |
| Gasoline | 0.249 | 9.2 kWh/lt |
| Kerosene | 0.259 | 790 kg/m$^3$ |
| | | 12.2 MWh/ton |
| Solar (thermal/ PV) | 0 | - |

*Table 4: shows the emission factors by vehicle type.*

| **Vehicle Type** | **$CO_2$ Factor (kg/unit)** | **Units** |
|---|---|---|
| Bus | 0.036 | passenger-km |
| Motorcycle | 0.122 | vehicle-km |
| Passenger Car | 0.229 | vehicle-km |
| Truck | 0.184 | ton-km |

As for Emission factors from livestock breeding, it was obtained from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories as seen in Table 5 below.

*Table 5: Emission factors from livestock breeding*[2]

| **Animal Type** | **kg $CO_2$ eq/head** |
|---|---|
| Sheep | 0.15 |
| Goat | 0.17 |

[2] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry and Other Land Use

| | |
|---|---|
| Camel | 1.92 |
| Hours | 1.64 |
| Mules and Asses | 0.9 |
| Dairy Cow | 2 |
| Cattle | 1 |
| Poultry | 0.02 |
| Rabbit | 0.08 |

Emission of other gases like $CH_4$ and $N_2O$ have higher global warming potential and thus they are multiplied by the magnitudes in Table 6 to obtain their equivalent of $CO_2$ emissions. This is according to the IPCC 4th assessment report AR4. Table 6 shows Global warming potential for gaseous emissions.

*Table 6: Global warming potential (GWP) of different gasious emissions*[3]

| **Emission Gas** | **Symbol** | **GWP (Global Warming Potential)** |
|---|---|---|
| Carbon Dioxide | $CO_2$ | 1 |
| Methane | $CH_4$ | 25 |

The total equivalent $CO_2$ is calculated according to the equation below

$$CO_{2\ equibalent} = CO_2(Weight) + CH_4(Weight) \times 25 + N_2O(Weight) \times 298$$

[3] 2006 IPCC Guidelines for National Greenhouse Gas Inventories

### 2.5. Energy Consumption

The total amount of energy consumed in Ma'an Municipality is 1,420.16 GWh. The allocation ofthis energy consumption among the different sectors, by fuel type, is presented in

Table 7. Further analysis of the consumptions per sector is provided in the following sections.

#### 2.5.1. Electricity

The total amount of electricity in Ma'an municipality is 84,234.09 MWh total distributed between all sectors as shown in the graph below. The data was provided in terms of bills for each subscriber, which was then analyzed and summarized to represent each sector. Figure 12: Total Electricity Consumption in Ma'an Municipality.

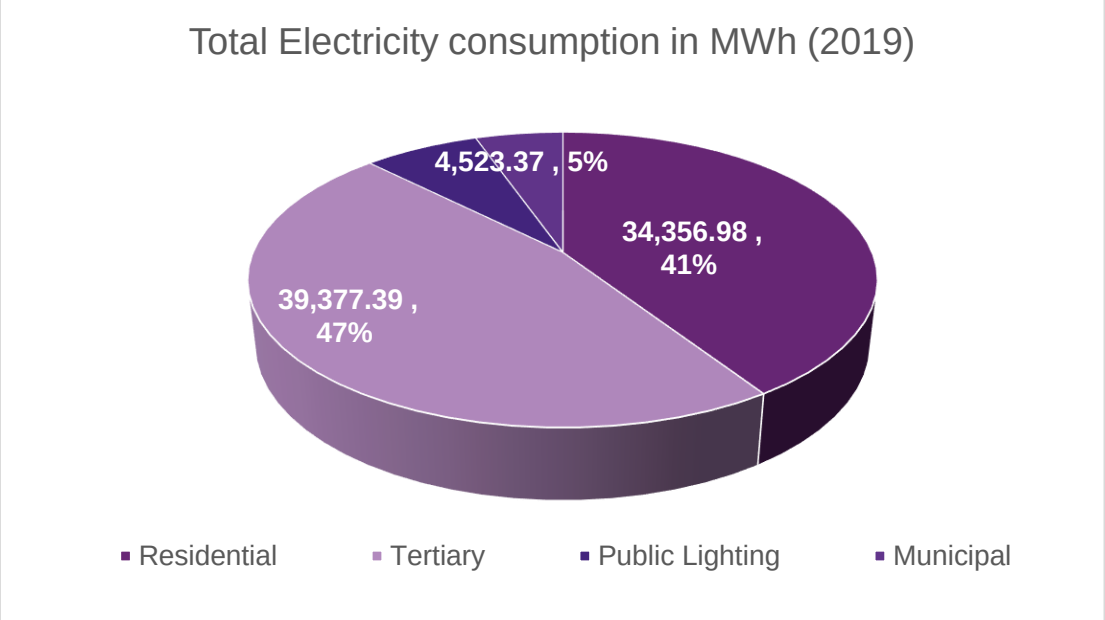



*Figure 12: Total Electricity Consumption*

#### 2.5.2. LPG

As for the Liquefied Petroleum Gas, data obtained from the petroleum refinery, both the residential and tertiary sector consume 638,436 cylinders of 12.5 kg each. According to the IPCC 2006 guidelines, the calorific value of Liquified Petroleum Gas is 13.1 MWh/ton. More specifically, the consumed energy from LPG is calculated using the following equation:

$$\text{Number of cylinders} \times 0.0125 \frac{\text{ton}}{\text{cylynder}} \times 13.1 \frac{MWh}{tn} = \text{Total Energy MWh.}$$

$$638{,}436 \text{ cylinders} \times 0.0125 \frac{\text{ton}}{\text{cylynder}} \times 13.1 \frac{MWh}{tn} = 104{,}519.50 \text{ MWh.}$$

*Table 7: Total Energy consumption per sector*

| MWh / Sector | Electricity | LPG | Heating Oil | Diesel | Gasoline | Kerosene | Solar Thermal |
|---|---|---|---|---|---|---|---|
| Municipal Buildings, Equipment, Facilities | 4,523.37 | 24.40 | - | 2.8 | - | - | - |
| Public Lighting | 5,976.35 | - | - | - | - | - | - |
| Residential Buildings | 34,356.98 | 104,519.50 | - | - | - | - | 1237.50 |
| Tertiary Buildings, Equipment, Facilities | 39,377.39 | | - | - | - | - | - |
| Municipal fleet | - | - | - | 2,518.41 | 69.12 | - | - |
| Public Transport | - | - | - | 2,929.34 | 18,450.20 | - | - |
| Private & Commercial Transport | - | - | - | 1,154,872.22 | 51,301.38 | - | - |

### 2.5.3. Municipal Buildings, Equipment & Facilities

#### 2.5.3.1. Electricity

This sector includes buildings such as the Municipal Hall, libraries, cultural buildings the data given for electricity was provided in the form of bills where we have split those bills to categories. As for the other sources of energy, the municipality buildings mostly use electricity for heating and cooling and doesn't use any type of fuels.

#### 2.5.3.2. Liquefied Petroleum Gas

It's obvious from Figure 13 that most LPG is used in winter, indicating that LPG is mostly used for heating applications.

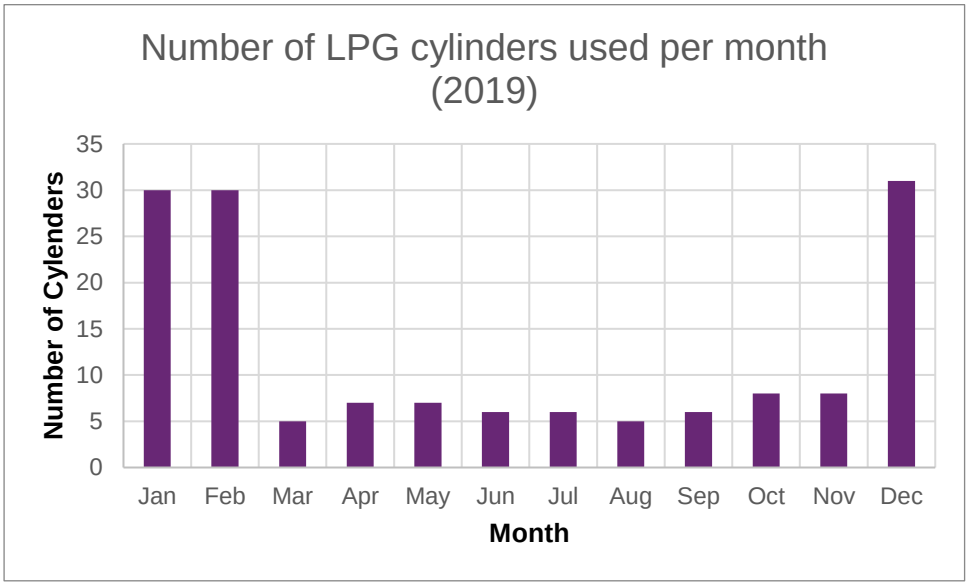



*Figure 13: Number of LPG cylinders used per month (2019)*

As for the Liquefied Petroleum Gas used by the municipality, a total of 149 cylinders. Using the previous method:

$$\text{Number of cylinders} \times 0.0125 \frac{\text{ton}}{\text{cylynder}} \times 13.1 \frac{MWh}{tn} = \text{Total Energy MWh.}$$

$$149 \text{ cylinders} \times 0.0125 \frac{\text{ton}}{\text{cylynder}} \times 13.1 \frac{MWh}{tn} = 24.4 \text{ MWh.}$$

#### 2.5.3.3. Diesel

Diesel consumed in municipal building, just like LPG is very minor but is accounted for. A total of 280 liters are used for an air compressor and using conversion factors in Table 3, the total energy is 2.8 MWh.

#### 2.5.3.4. Municipal Buildings and Facilities Summary

*Table 8 illustrates the total energy consumption in municipal buildings and facilities.*

*Table 8: Energy consumption in Municipal Buildings & Facilities per fuel (MWh)*

| Site Type | Electricity | LPG | Heating Oil | Diesel | Gasoline | Kerosene | Solar Heating | Total (MWh) |
|---|---|---|---|---|---|---|---|---|
| Municipal Buildings | 4,523.37 | 24.40 | - | 2.8 | - | - | - | 4,550.57 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Municipal hall | | | | | | | | |
| Libraries | | | | | | | | |
| Cultural buildings | | | | | | | | |
| Facilities | | | | | | | | |

### 2.5.4. Municipal public lighting

As far as the municipal public lighting is concerned, this sector is related to the street lighting and public areas' lighting. The electricity consumption for this sector is 5,976.35 MWh according to the data from bills that were provided.

### 2.5.5. Residential Buildings

#### 2.5.5.1. Electricity

Ma'an households consume electricity for lighting and electrical appliances such as refrigerator, air conditions and others, as well as in space and water heating (although gas is used as well for space heating).

According to bills and data collected from utility services in the area the overall consumption is estimated to be 34,356.98 MWh.

#### 2.5.5.2. Liquefied Petroleum Gas

LPG is mainly used in cooking and space heating. But no sector specific data could be obtained for the share of LPG in residential. Although it's expected to have a biggest share of all sectors.

#### 2.5.5.3. Solar thermal

For the solar heating, a total of 3,000 $m^2$ was installed in 2019. The total energy in MWh is calculated following the bellow assumptions:

- Solar radiation: 5.5 $kWh/m^3$.day
- Efficiency: 25%
- Radiation days in a year: 300 day/year

The total energy is calculated below:

$$Total\ Solar\ Heating\ Energy = Area \times Solar\ Radiation \times Efficiency \times Number\ of\ Days$$

$$Total\ Solar\ Heating\ Energy = 3{,}000\ m^2 \times \frac{5.5}{1000}\ \frac{MWh}{m^2.day} \times 0.25 \times 300\ days$$

$$= 1237.5\ MWh/year$$

#### 2.5.5.4. Residential Buildings Summary

*Table 9 shows Energy consumption in Residential Buildings per fuel (MWh)*

*Table 9: Energy consumption in Residential Buildings per fuel (MWh)*

| Site Type | Electricity | LPG | Heating Oil | Diesel | Gasoline | Kerosene | Solar Heating | Total (MWh) |
|---|---|---|---|---|---|---|---|---|
| Residential buildings | 34,356.98 | See Table 7 | - | - | - | - | 1237.5 | 35,594.48 |

### 2.5.6. Tertiary Buildings, Equipment & Facilities

#### 2.5.6.1. Electricity

Tertiary sector includes a number of buildings such as hotels, offices, restaurants, industries, educational buildings, military forces, banks, commercial buildings, agricultural facilities, telecommunication entities and water management facilities as well, which provide services to Ma'an's citizens. It should be noted that water management facilities include facilities for drinking water (water pumping) and irrigation. The number provided was impossible to be disaggregated in order to separate the drinking water from the irrigation facilities for agricultural activities. Figure 14 below shows Tertiary Building Electricity Consumption, while

Table *10* shows the Energy consumption in tertiary sector per type of building.

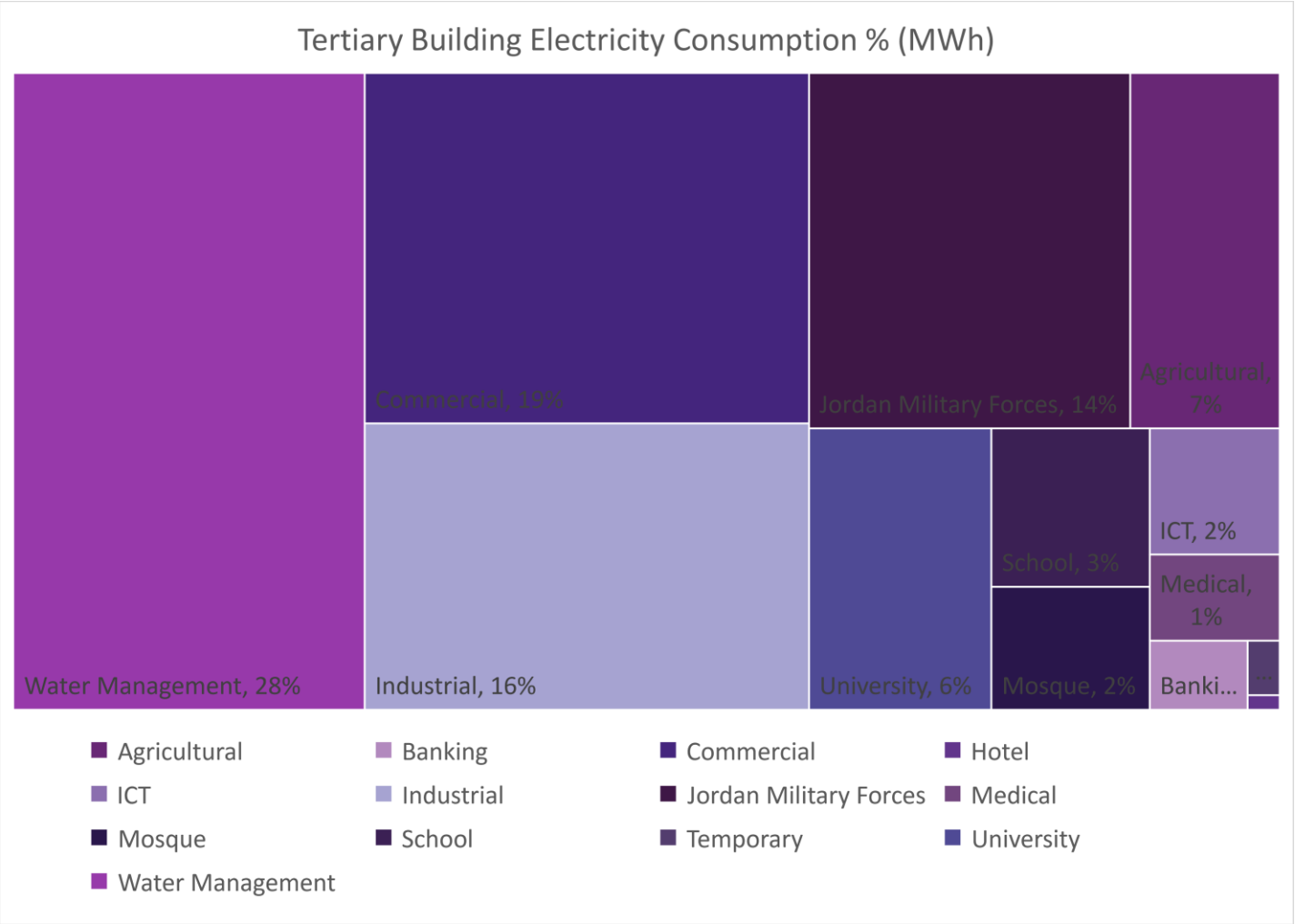



*Figure 14: Tertiary Building Electricity Consumption % (MWh)*

*Table 10: Energy consumption in tertiary sector per type of building*

| **Types of Buildings in the Tertiary Sector** | **Electricity (MWh)** |
|---|---|
| Agricultural | 2,593.26 |
| Banking | 328.87 |
| Commercial | 7,604.52 |
| Hotels | 22.78 |
| ICT (Information and Communication Technology) | 800.51 |
| Small Industrial | 6,209.85 |

| | |
|---|---|
| Jordan Military Forces | 5,575.42 |
| Medical Centres | 546.55 |
| Mosques | 950.78 |
| School | 1,224.15 |
| Temporary Users | 84.80 |
| University | 2,503.91 |
| Water Management | 10,931.98 |
| **Total** | **39,377.39** |

It is obvious that the consumption's allocation in the tertiary sector isdominated by water management facilities, accounting for 28%.

### 2.5.7. Transport

The fuel consumption of vehicles is either estimated or taken from documented records provided by the municipality. Following that, the total energy is estimated using the conversion factors from the table above.

*For some vehicle types, the total fuel consumption was given by the municipality, whereas for others data like traveled distance and the carried load (e.g. Truck Load) was the given data. For the later, the total CO2 emissions were estimated first according to the EPA emission factors shown in Table 4.*

#### 2.5.7.1. Municipal fleet

This sector is concerned with vehicles owned by the municipality. As far as the consumption of the municipal vehicles is concerned, the available data, followedby the vehicles' type, was collected and is presented in Table 11. Ma'an's municipal fleet has total of 65 vehicles which use diesel and gasoline.

*Table 11: Energy Consumption in Municipal fleet of Ma'an*

| Type of Municipal vehicles | Number of vehicles | Diesel (MWh) | Gasoline (MWh) | Total (MWh) |
|---|---|---|---|---|
| Compactor Truck | 15 | 1221.95 | 0 | 1221.95 |
| Tipper Truck | 9 | 306.48 | 0 | 306.48 |
| Waste Water Vacuum Truck | 2 | 3 | 0 | 3 |
| Water Tank Truck | 9 | 253.18 | 0 | 253.18 |

| | | | | |
|---|---|---|---|---|
| Pickup Truck | 11 | 280.26 | 0 | 280.26 |
| Taxi | 2 | 0 | 69.12 | 69.1196 |
| Bus | 3 | 80.66 | 0 | 80.66 |
| Ambulance | 1 | 1.94 | 0 | 1.94 |
| Tractor | 1 | 4.55 | 0 | 4.55 |
| Loader | 4 | 281.94 | 0 | 281.94 |
| Skid-Loader | 1 | 10.77 | 0 | 10.77 |
| Backhoe Loader | 1 | 12.56 | 0 | 12.56 |
| Fork Lift | 1 | 11 | 0 | 11 |
| Crane | 3 | 36.12 | 0 | 36.12 |
| Street Sweeper | 1 | 4.7 | 0 | 4.7 |
| Cooler Truck | 1 | 9.3 | 0 | 9.3 |
| Total | 65 | 2,518.41 | 69.12 | 2587.53 |

#### 2.5.7.2. Public Transport

Public transport refers to buses, taxis, and training cars that serve Ma'an's citizens. The data available for the sector includes the average consumption for taxis and training cars, and as for the busses, the total distance travelled within municipal limits was given by the Municipality.

The data is summarized in Table 12 with the fuel consumption and total energies. To avoid errors in putting assumptions, for busses, the total emission is calculated according to the EPA emission factors in Table 3 using the total distance travelled and the total fuel consumptions was back calculated using the IPCC emission factors and conversion factors in Table 3.

*Table 12: Energy consumption in Public Transport*

| Vehicle Type | Number of vehicles | Diesel (lt/year) | Gasoline (lt/year) | Diesel (MWh) | Gasoline (MWh) | Total (MWh) |
|---|---|---|---|---|---|---|
| Buses | 147 | 292,933.63 | - | 2,929.34 | - | 2,929.34 |
| Taxis | 184 | - | 1,786,456.00 | - | 16,435.40 | 16,435.40 |
| Training Cars | 30 | - | 219,000 | - | 2,014.80 | 2,014.80 |
| Total | 361 | 292,933.63 | 2,005,456.00 | 2,929.34 | 18,450.20 | 21,379.53 |

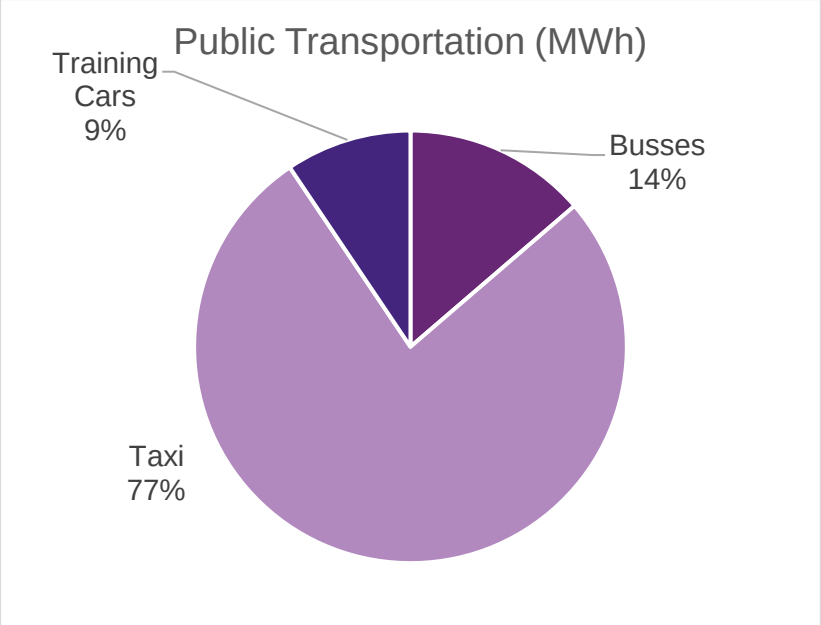



*Figure 15: Public transportation energy consumption in MWh.*

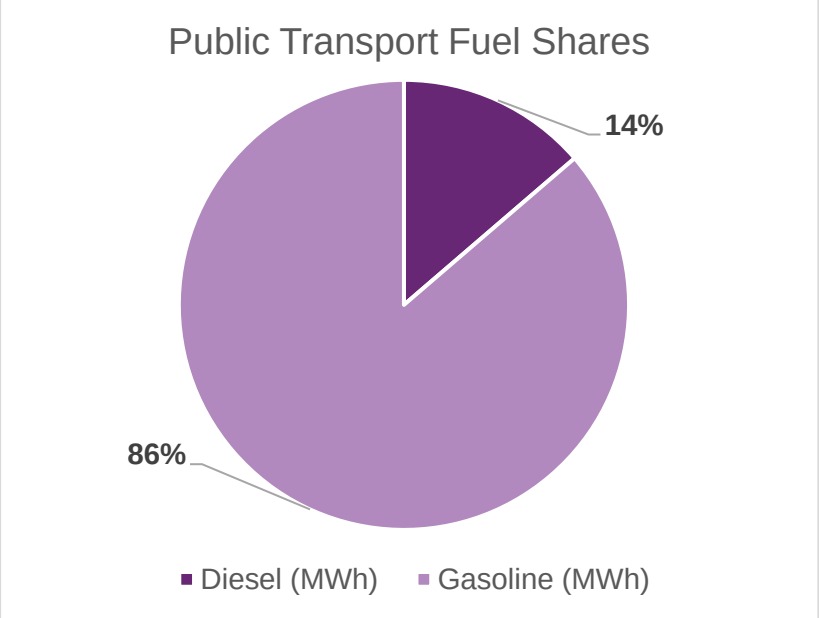



*Figure 16: Public transportation Fuel shares.*

As seen in Table 12, the largest energy consumers are taxis and training cars making 86% of the total energy consumption (mainly taxies) and operating on gasoline.

#### 2.5.7.3. Private and Commercial Transport

For this sector, emissions were calculated first for all vehicles except for construction and agricultural vehicles where the emissions were estimated using the EPA method later to calculate the fuel consumption and thus the total energy. For construction and agricultural vehicles, the daily fuel consumption was given to calculate the final energy and emissions. Table 13 shows Energy consumption in Private and Commercial Transport.

*Table 13: Energy consumption in Private and Commercial Transport*

| Vehicle Type | Number of vehicles | Diesel (lt/year) | Gasoline (lt/year) | Diesel (MWh) | Gasoline (MWh) | Total (MWh) |
|---|---|---|---|---|---|---|
| Motorcycle | 40 | - | 7,801.44 | - | 71.77 | 71.77 |
| Small Private Car | 15,171 | - | 5,527,266.29 | - | 50,850.85 | 50,850.85 |
| Large Private Car | 113 | - | 41,169.41 | - | 378.76 | 378.76 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Shipping Truck | 4,460 | 71,492,356.26 | - | 714,923.56 | - | 714,923.56 |
| Truck Head | 1,476 | 23,659,802.21 | - | 236,598.02 | - | 236,598.02 |
| Truck head and container | 2 | 32,059.35 | - | 320.59 | - | 320.59 |
| Truck head and half container | 8 | 128,237.41 | - | 1,282.37 | - | 1,282.37 |
| Construction Vehicle | 799 | 19,442,333.33 | - | 194,423.33 | - | 194,423.33 |
| Agricultural Vehicle | 301 | 732,433.33 | - | 7,324.33 | - | 7,324.33 |
| **Total** | **22,370** | **115,487,221.90** | **5,576,237.14** | **1,154,872.22** | **51,301.38** | **1,206,173.60** |

Figure 17 presents the proportion between Diesel and Gasoline in the Private and Commercial vehicles.

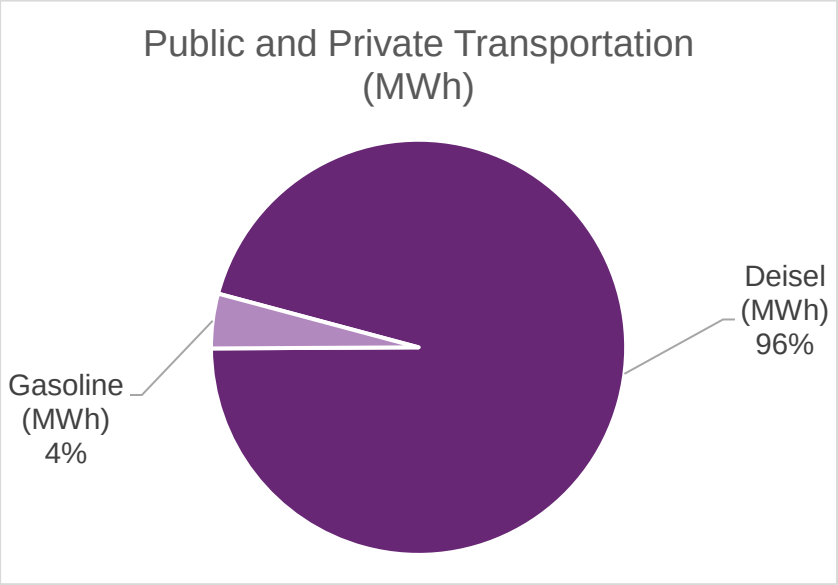



*Figure 17: Energy consumption in Private and Commercial vehicles per fuel*

Figure 17 shows that diesel is the most consumed fuel in the public and commercial transportation sector with 59% of the energy being consumed by shipping trucks.

### 2.5.8. Final Energy Consumption

Table 14 illustrates all the energy consumptions within Ma'an city, totalling 1,420,158.96 MWh.

*Table 14: Total Energy Consumption in Ma'an municipality*

| Sector | FINAL ENERGY CONSUMPTION [MWh] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Fossil fuels | | | | | | | | Renewable energies | | | | | Total |
| | Electricity | Heat/cold | Natural | Liquid gas | Heating oil | Diesel | Gasoline | | | Other fossil fuels | Plant oil | Biofuel | Other biomass | Solar thermal | Geothermal | |
| **BUILDINGS. EQUIPMENT/FACILITIES AND INDUSTRIES** | | | | | | | | | | | | | | | | |
| Municipal buildings. equipment/facilities | 4,523.37 | - | - | 24.40 | - | 2.8 | - | - | - | - | - | - | - | - | - | 4,550.57 |
| Tertiary (non-municipal) buildings, equipment/facilities | 39,377.39 | - | - | 104,519.5 | - | - | - | - | - | - | - | - | - | - | - | 179,491.37 |
| Residential buildings | 34,356.98 | - | - | | - | - | - | - | - | - | - | - | - | 1237.50 | - | |
| Public lighting | 5,976.35 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 5,976.35 |
| Non-ETS | | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Industry | ETS (not recommended) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| **Subtotal** | | **84,234.09** | **-** | **-** | **104,543.90** | **-** | **2.8** | - | - | - | - | - | - | **1237.5** | - | **190,018.29** | |
| **TRANSPORT** | | | | | | | | | | | | | | | | | |
| Municipal fleet | | - | - | - | - | - | 2,518.41 | 69.12 | - | - | - | - | - | - | - | 2,587.53 | |
| Public transport | | - | - | - | - | - | 2,929.34 | 18,450.20 | - | - | - | - | - | - | - | 21,379.54 | |
| Private and commercial transport | | - | - | - | - | - | 1,154,872.22 | 51,301.38 | - | - | - | - | - | - | - | 1,206,173.6 | |
| **Subtotal** | | - | - | - | - | - | **1,160,319.97** | **69,820.7** | - | - | - | - | - | - | - | **1,230,140.67** | |
| **OTHER** | | | | | | | | | | | | | | | | | |
| Agriculture Forestry, Fisheries | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| **TOTAL** | | **84,234.09** | **-** | **-** | **104,543.90** | **-** | **1,160,322.770** | **69,820.7** | - | - | - | - | - | **1237.5** | - | **1,420,158.96** | |

### 2.6. Local electricity production

Ma'an Municipality holds the largest share of wind energy in Jordan of 0.4 GWh. As for solar energy, a total of 9 power generation plants with a capacity of 173.5 MW and 11.6 MW of domestic PV capacity installed in Ma'an. And for heating applications, a total of 900 solar heating systems are installed with a total area of 3000 $m^2$.

*Table 15: Energy Production in Ma'an Municipality aggregated by type.*

| Energy Type | Built Capacity | Capacity Unit | Total Production in 2019 (MWh) |
|---|---|---|---|
| Domestic PV | 11.56 | MW | 23,894.10 |

### 2.7. $CO_2$ emissions

#### 2.7.1. Energy related emissions

In the previous sections the energy consumptions in Ma'an municipality were described, for which the CO2 emissions will be calculated in this section, using the IPCC methodology.

##### 2.7.1.1. Electricity

Emission factor for electricity is obtained from Jordan's Second Biennial Update Report (SBUR)[1]. To be 0.4585 kg$CO_2$/kWh. Using this factor, emissions per sector are described Table 16.

*Table 16: Sectorial $CO_2$ eq emission from electricity consumption.*

| Sector | Sub Sector | $CO_2$ eq ton |
|---|---|---|
| Residential | | 15,752.68 |
| Public Lighting | | 2,740.16 |
| Municipal | | 2,073.97 |
| Tertiary | Agricultural | 1,189.01 |
| | Banking | 150.79 |
| | Commercial | 3,486.67 |
| | Hotel | 10.44 |
| | ICT | 367.03 |
| | Industrial | 2,847.22 |
| | Jordan Military Forces | 2,556.33 |
| | Medical | 250.59 |
| | Mosque | 435.93 |
| | School | 561.27 |
| | Temporary | 38.88 |

| | | |
|---|---|---|
| | University | 1,148.04 |
| | Water Management | 5,012.31 |
| Total | | 38,621.33 |

Making the tertiary sector the largest emitter (with the water management being the biggest emitter of this sector) followed by the residential sector.

#### 2.7.1.2. Fossil Fuels

Emissions selected for this baseline from the IPCC guidelines are given Table 3.

Details to those emission are presented in Table 17.

*Table 17: Emissions from fossil fuel for different sectors.*

| **Sector** | **LPG (MWh)** | **Diesel (MWh)** | **Gasoline (MWh)** | **$CO_2$ eq (ton)** |
|---|---|---|---|---|
| BUILDINGS. EQUIPMENT/FACILITIES AND INDUSTRIES | | | | |
| Municipal buildings. equipment/facilities | 24.4 | 2.8 | | 6.29 |
| Tertiary (non-municipal) buildings, equipment/facilities | 104,519.5 | | | 23,725.9 |
| Residential buildings | | | | |
| Public lighting | | | | |
| Subtotal | 104,543.9 | 2.8 | | 23732.2 |
| TRANSPORT | | | | |
| Municipal fleet | | 2,518.4 | 69.1 | 689.6 |
| Public transport | | 2,929.3 | 18,450.2 | 5376.2 |
| Private and commercial transport | | 1,154,872.2 | 51,301.4 | 321124.9 |

| | | | | |
|---|---|---|---|---|
| Total | 104,543.9 | 1,160,322.7 | 69,820.7 | 350923.0 |

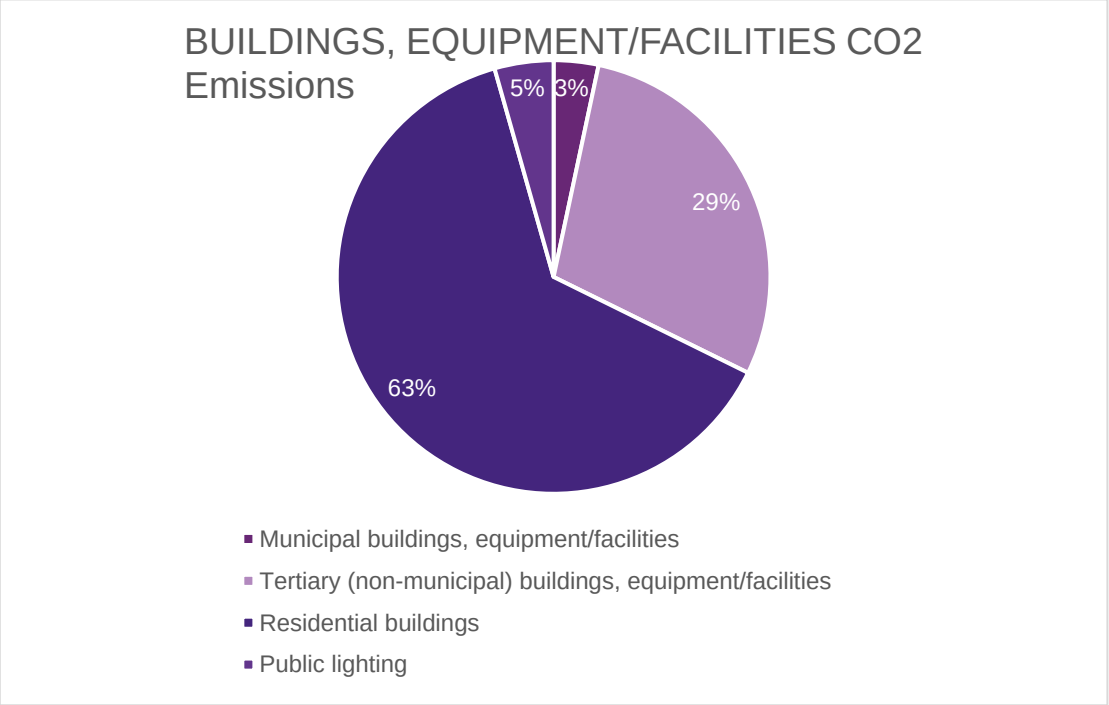



*Figure 18: $CO_2$ Emissions from Municipal Buildings, Tertiary, Residential and public Lighting*

### 2.7.2. Non-energy related emissions

#### 2.7.2.1. Municipal Solid Waste

Apart from the $CO_2$ emissions released from the daily activities there is also a significant amount of Greenhouse Gases derived from waste management. In order to calculate these emissions, the IPCC default method was used as it appears below. [10]

$$Methane\ emissions\ (Gg/yr) = (MSWT \times MSWF \times MCF \times DOC \times DOCF \times F \times 16/12 - R) \times (1 - OX)$$

Where:

- MSWT total MSW generated (Gg/yr)
- MSWF fraction of MSW disposed to solid waste disposal sites
- MCF methane correction factor (fraction)
- DOC degradable organic carbon (fraction) (kg C/ kg SW)
- $DOC_F$: fraction DOC dissimilated
- F: fraction of $CH_4$ in landfill gas (IPCC default is 0.5)

- 16/12 conversion of C to $CH_4$
- R recovered $CH_4$ (Gg/yr)
- OX oxidation factor (fraction – IPCC default is 0)

The IPCC default method assumes that all the potential of $CH_4$ emissions are released during the same year the waste is disposed of. The method introduces various specific default valuesand recommendations, for use in countries with lack of statistical data for Solid Waste.

The calculation of the degradable correction factor (DOC) is based in the following equation.

$$DOC = 0.4 \times A + 0.17 \times B + 0.15 \times C + 0.3 \times D$$

Where

A: Percentage of paper and textiles in SW

B: Percentage of garden and park waste and other organic putrescible in SW

C: Percentage of Food waste in SW

D: Percentage of wood and straw waste in SW

The form of this suggested equation wasn't followed directly because in the case of Ma'an municipality there was a different composition of solid waste. New factors were found in order to calculate the DOC.

The total quantity of solid waste for 2019 was 35,000 ton. The entire amount is landfilled because there is no recycling. Waste composition, as well as the results from the calculationsis presented in Table 18 and Table 19..

*Table 18: Solid waste composition in Ma'an, 2019*

| **Solid waste composition** | **Percentage** | **Quantity(ton)** |
|---|---|---|
| garden waste | 0% | 0 |
| Paper & Cardboard | 20% | 7,000 |
| wood & Straw | 0% | 0 |
| glass | 5% | 1,750 |
| Organic Waste | 40% | 14,000 |
| metal | 15% | 5,250 |

| | | |
|---|---|---|
| plastic | 20% | 7,000 |
| Textiles | 0% | 0 |
| others | 0% | 0 |
| **Annual Quantity of Solid waste (ton)** | **100%** | **35,000** |

*Table 19: results of Solid waste Calculations*

| **Variables** | **Values** |
|---|---|
| $MSW_t$: | 35,000 |
| $MSW_f$: | 1 |
| MCF: | 0.4 |
| DOC: | 0.14 |
| $DOC_f$: | 0.5225612 |
| F: | 0.5 |
| 16/12: | 1.3333 |
| R: | 0 |
| OX: | 0 |

Where $DOC_f$=0.014*T+0.28 (T: average temperature in Ma'an, 17.33°C)

All things considered, 823.20 ton of methane are released annually due to the waste management. Additionally, an equal volume of $CO_2$ is produced and the amount is calculated through molecular balance to amount for 2,258.67 ton of $CO_2$.

$$Total\ CO_2eq = \sum Gas\ Weight_i \times GWP_i$$

Gas Weight: is the weight of emission estimated according to the mentioned methodology.

GWP: According to the IPCC and given in Table 6

i: Type of gas

Given that $CH_4$ and $CO_2$ gases are estimated, then:

$$Total\ CO_2eq = (Total\ weigh\ CH_4 \times 25) + (Total\ weight\ CO_2 \times 1)$$

$$Total\ CO_2eq = (823.2 \times 25) + 2{,}258.67$$

This quantity equals to 22,838.67 ton of equivalent $CO_2$.

#### 2.7.2.2. Waste Water Treatment

Water treatment in Ma'an is treated through aerobic digestion at which multiple municipalities feed into the plant. The total feed to the plant is equal to 947,091 $m^3$/year. According to the IPCC[4], the BOD kg/year needs to be estimated for the following calculations to be done

$$Total\ CH_4 \frac{ton}{a} = 1000 \times (U \times T \times EF) \times (TOW - S) - R$$

Where:

U: Urbanization index according to the IPCC = 0.34

T: Degree of utilization according to the IPCC = 0.34

EF: emission factor is estimated below according to the IPCC

TOW: Represents the BOD inflow and can be estimated using the population or obtained from the water facility. In our case the TOW is documented by the WWTP and was given by the municipality with a value of 747,841.11 kg BOD/year

S: Recovered BOD and is equal to 0 in the case of Ma'an

R: Recovered $CH_4$ and is equal to 0 in the case of Ma'an

$$EF = B * MCF = 0.6 \times 0.3 = 0.18$$

B: 0.6 kg $CH_4$/kg BOD

MCF: is estimated from the table according to the IPCC (0.3)

$$Total\ CH_4 \frac{ton}{a} = ((0.34 \times 0.34 \times 0.18) \times (747841.11 - 0) - 0)/1000$$

| | | |
|---|---|---|
| Total $CH_4$ | 15.56 | ton $CH_4$/year |
| Total $CO_2$ eq | 389.03 | ton $CO_2$ eq/year |

#### 2.7.2.3. Cattle and Animal Breeding

$CO_2$ emissions from cattle is calculated using following equation:

$$CO_{2\,eq} = EF(kg\ CO_2/head/a) \times Number\ of\ Heads$$

EF: Emission factor is animal specific and is found in Table 5.

[4] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5: Wastewater Treatment And Discharge

*Table 20: Emission from livestock breeding.*

| Animal Type | Heads | $CH_4$ kg/year |
|---|---|---|
| Sheep | 21,000 | 3,150 |
| Goat | 0 | 0 |
| Camel | 540 | 1,037 |
| Horse | 0 | 0 |
| Mules and Asses | 0 | 0 |
| Dairy Cow | 0 | 0 |
| Cattle | 70 | 70 |
| Poultry | 142,000 | 2,840 |
| Rabbit | 0 | 0 |
| **Total Emission $CH_4$** | **7.09680** | **ton $CH_4$**/year |
| **Total $CO_2$ eq** | **177.42** | **ton**/year |

### 2.7.3. Final CO2 emissions

The emissions of CO2 for the sectors that have been described in the previous sections are available, in total, in Table 21.

*Table 21: Total $CO_2$ emissions for the Ma'an municipality*

| Sector | | $CO_2$ emissions [ton] / $CO_2$ eq. emissions [ton] | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Fossil fuels | | | | | | | | Renewable energies | | | | | |
| | | Electricity | Heat/cold | Natural gas | Liquid gas | Heating Oil | Diesel | Gasoline | Lignite | Coal | Other fossil fuels | Biofuel | Plant oil | Other biomass | Solar thermal | Geother mal | Total |
| **BUILDINGS, EQUIPMENT/FACILITIES AND INDUSTRIES** | | | | | | | | | | | | | | | | | |
| **Municipal buildings, equipment/facilities** | | 2,073.97 | | | 5.5388 | | 0.7476 | | | | | | | | | | 2,080.25 |
| **Tertiary (non-municipal) buildings, equipment/facilities** | | 18,054.53 | | | 23725.927 | | | | | | | | | | | | 57,533.13 |
| **Residential buildings** | | 15,752.68 | | | | | | | | | | | | | | | |
| **Public lighting** | | 2,740.16 | | | | | | | | | | | | | | | 2,740.16 |
| **Industry** | Non-ETS | | | | | | | | | | | | | | | | |
| | ETS (not recommended) | | | | | | | | | | | | | | | | |
| **Subtotal** | | **38,621.33** | | | **23,731.47** | | **0.75** | | | | | | | | | | **62,353.54** |
| **TRANSPORT** | | | | | | | | | | | | | | | | | |
| **Municipal fleet** | | | | | | | **672.42** | **17.21** | | | | | | | | | 689.63 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Public transport** | | | | | | **782.13** | **4,594.10** | | | | | | | | | 5,376.23 |
| **Private and commercial transport** | | | | | | **308,350.88** | **12,774.04** | | | | | | | | | 321,124.93 |
| **Subtotal** | | | | | | 309,805.43 | 17,385.35 | | | | | | | | | 327,190.79 |
| **OTHER** | | | | | | | | | | | | | | | | |
| **Agriculture, Forestry, Fisheries** | | | | | | | | | | | | | | | | |
| **OTHER NON-ENERGY RELATED** | | | | | | | | | | | | | | | | |
| **Waste management** | **22,838.67** | | | | | | | | | | | | | | | **22,838.67** |
| **Waste water management** | **389.03** | | | | | | | | | | | | | | | **389.03** |
| **Other non-energy related (Cattle Breeding)** | **177.42** | | | | | | | | | | | | | | | **177.42** |
| **Subtotal** | **23,405.12** | | | | | | | | | | | | | | | **23,405.12** |
| **TOTAL** | **38,621.33** | | | **23,731.47** | | 309,806.18 | 17,385.35 | | | | | | | | | **412,949.45** |

## 2.8. Results' Graphical Analysis

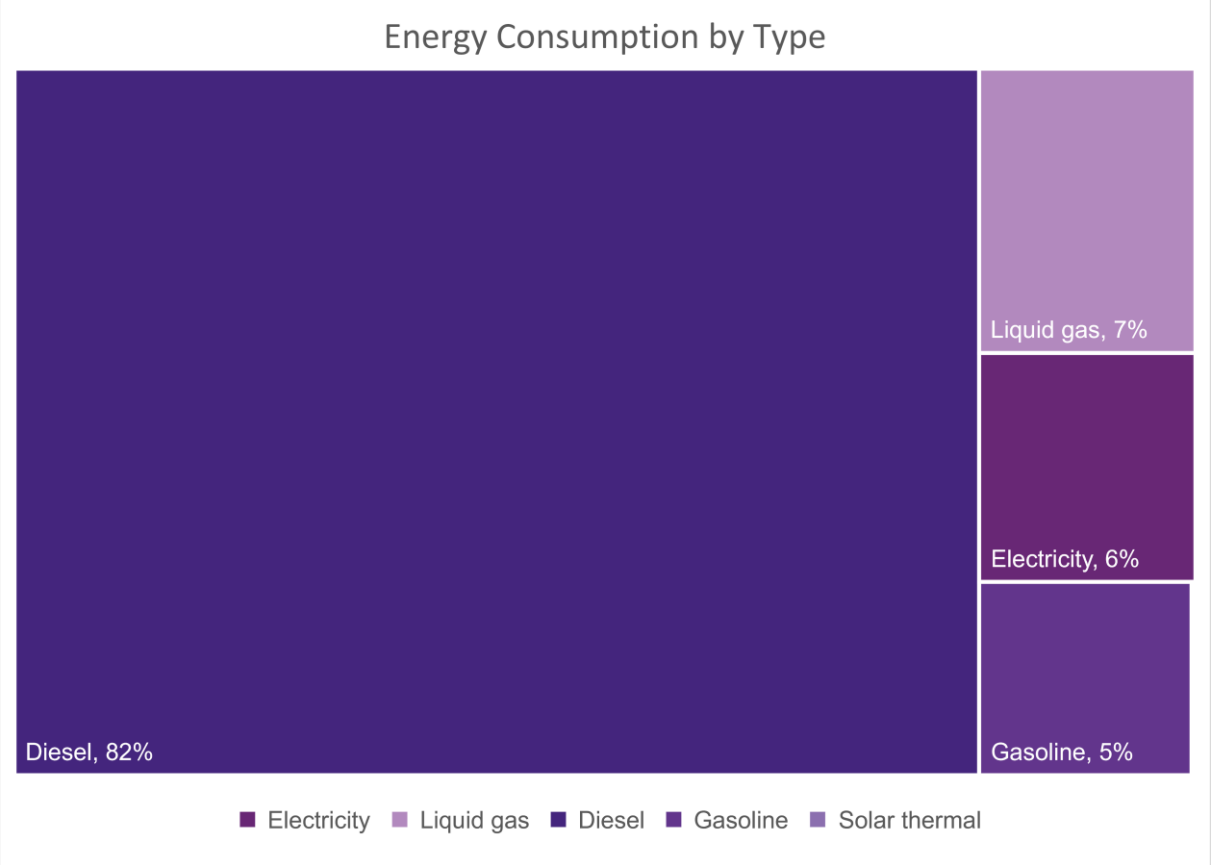



*Figure 19: Final Energy consumption per fuel.*

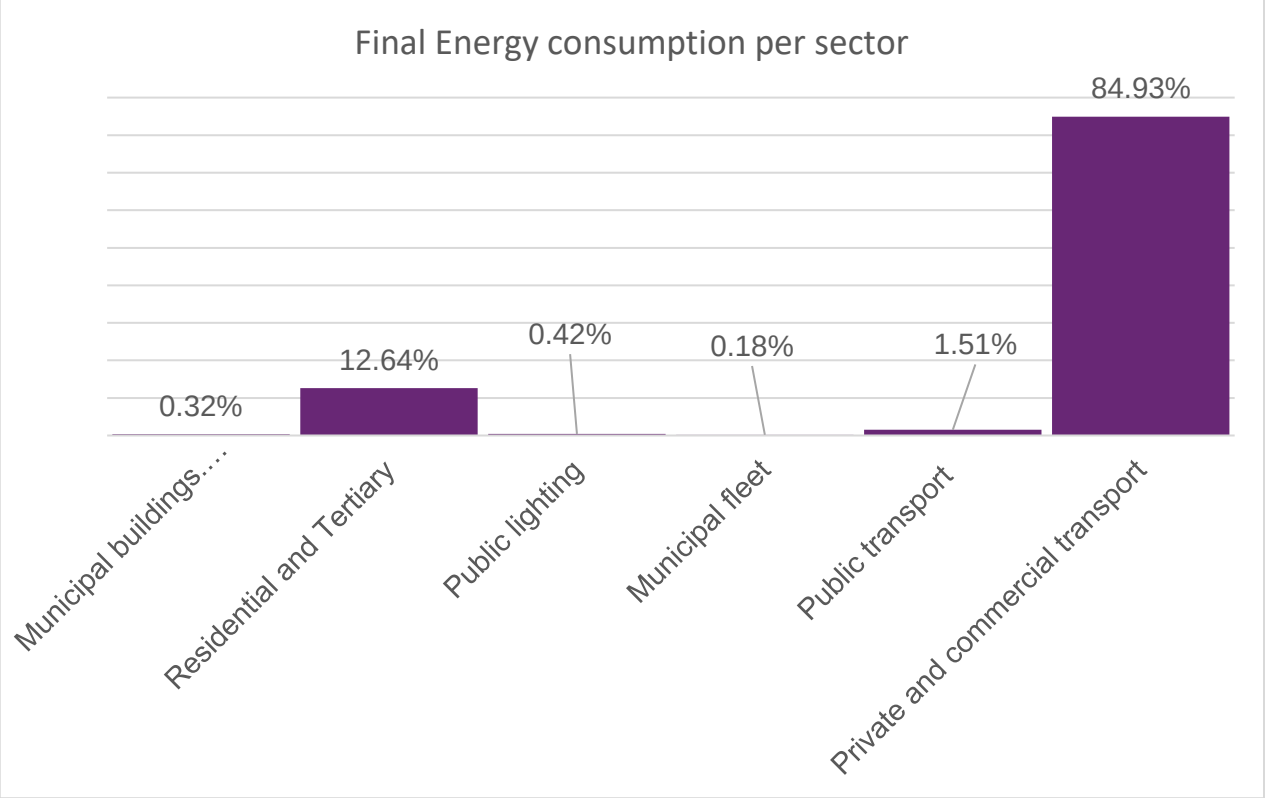



*Figure 20: Final Energy consumption per sector.*

*Figure 21: Total $CO_2$ emissions per fuel.*


*Figure 22: Total $CO_2$ emissions per sector*

# 3 SECAP Actions

## 3.1. Target for 2030

The Municipality of Ma'an is called upon to take double role in the efforts towards CO2 reduction, both as a demonstrator giving the good example to its citizens, as well as a triggering power and coordinator for all activities in the area. The first role, giving the good example, should be realized through the adoption of actions to reduce the emissions resulting from the buildings/ facilities / vehicles etc. under its direct responsibility. Emissions from waste are another sector under the direct responsibility of Ma'an Municipality. Nevertheless, the municipal direct related emissions are only a relatively low percentage of the total. Therefore, it should act as a triggering power and coordinator of the activities to be realized by the private sector in a series of activity fields. According to the BEI, the sectors contributing the most to the carbon footprint are the transport (80%), the Tertiary (4.4%), the residential (9.6%) and the Solid Waste (5.5%). Thus, the Municipality should focus on the actions and measures concerned with the transport sector mainly in order to reduce the CO2 emissions from their activities. At the same time, actions in the other sectors will be suggested as well.

In this respect, the first step is the calculation of the Business as Usual (BAU) scenario, in line with the JRC guidelines for South Municipalities, considering that Jordan, as a country with its economy under development, will face an increase in its energy demand due to the expected economic and population growth. Considering the use of the BAU scenario for the calculation of the 2030 emission levels and in turn the respective reduction target, the following calculations are realized according to the guidelines.

$$Emissions_{CO2}^{2030} = Emissions_{CO2}^{Baseline\ year} \times k$$

In Ma'an, the emissions for the baseline year, 2019, were 409,318 tn CO2 eq. The national coefficient k for the baseline year of 2019 in Jordan is 1.41. Therefore, the forecasted emissions for 2030 are

$$Emissions^{2030} = 409{,}318 \times 1.41 = 577{,}138\ tn\ CO_2\ eq$$

The emission reduction target for Ma'an Municipality according to Covenant of Mayors the target should be at least 40% (230,855 tn CO2 eq) against the calculated 2030 emissions compared with the BAU scenario.

On the other hand, in order for the 40% target to be achieved, strict measures are needed which should be enforced through the development and implementation of the respective legislative framework.

Calculations for 40% reduction have been realized based on the suggested actions. In the next sections a more detailed analysis per action for each sector is provided. It should be noted that for awareness raising activities conducted by the municipality, besides the implementation cost born by the municipality and its potential funding sources, the amount of the private funds mobilized is reported as well where relevant. This cost doesn't participate in the

calculation of the NPV value. Moreover, it should be clarified that externalities costs are not considered in the calculation of the NPV; this result sometimes in actions with a negative NPV from the strict economic calculation, although their overall impact could be considered positive if additional benefits were considered.

### 3.2. Municipal Buildings, Equipment/Facilities

This sector contribution in the carbon footprint is less than 1%. Nevertheless, the possible actions to be implemented in the Municipal Buildings could set an example for the citizens and the employees. Municipality acknowledged the measures which best fit its needs so as to achieve energy savings and emission reductions. In the following sections, a comprehensive set of actions is being analysed.

The suggested actions for this sector consist of energy conservation and green energy production measures. Focus has been placed on energy saving activities and PVs on building's roof, since these are considered to be easily implemented, unlike the large-scale RES facilities requiring more time and more free spaces available.

Apart from these categories of actions, there are also some envisaged actions which target the user through awareness raising activities. These actions aim to make the inhabitants' behaviour environmentally friendly, as well as to properly educate the new generations in environmental and energy related issues.

An overview of this sector's actions and achieved reductions is presented in Table 22 below.

*Table 22: Actions in Municipal Buildings, Equipment/Facilities*

| Action No. | Action | Emission Reduction (tn $CO_2$) |
|---|---|---|
| **3.2.1** | Green procurement procedures for municipal buildings | 247 |
| **3.2.2** | Energy manager appointment in the municipality | 12 |
| **3.2.3** | Awareness raising activities for municipal employees | 46 |
| **3.2.4** | Strict application of green building codes in new municipal buildings | 617 |
| **3.2.5** | Install 400 kW PV plant | 300 |

| | |
|---|---|
| **Total** | **1222** |

### 3.2.1. Green procurement procedures for municipal buildings

Green procurement is the procedure where the municipality seeks to purchase goods and services with a reduced environmental impact throughout their life cycle. By Selecting products of high efficiency that minimize the environmental impacts, it is possible to consume less energy thus reduce the CO2 emissions and achieve cost savings. The action is envisaged to be applied to all new office equipment that the municipality plans to purchase for their increasing needs and for the gradual substitution of old, inefficient one. Especially for high energy consuming office equipment, high efficiency products will be targeted, while minimum efficiency standards and requirements will be set in all relevant municipal tenders.

Table 23 shows calculations regarding the cost, the savings and the financial viability of the action.

*Table 23: Action 3.2.1 in numbers*

| **3.2.1 Green procurement procedures** | |
|---|---|
| Duration | 2024 - 2025 |
| Total Implementation Cost (USD) | 20,000 |
| Annual Energy Savings (MWh) | 513.30 |
| Annual Emission Reduction (tn $CO_2$) | 247 |
| Funding Source | Own funds + Sida Funds |
| Net Present Value (NPV) | >0 |

### 3.2.2. Energy manager appointment in the municipality

The creation of municipal administrative structures, in order to establish the working team to implement and monitor the progress of the SECAP activities, is one of the prerequisites for the municipality's adhesion to the Covenant of Mayors. In this regard, this action goes far beyond the satisfaction of the previously mentioned prerequisite.

The energy manager will not only be the responsible person to monitor the energy consumptions and provide the necessary solutions when a problem is identified, but will act proactively in order to ensure the good coordination of the whole municipal team for the proper implementation of the envisaged SECAP actions.

The benefits related to the energy manager's appointment are considered multi-dimensional since strong coordination of the overall initiative is required, although strictly economic indicators are not encouraging. In case a member of the existing municipality staff is appointed to this position, this will have a positive NPV for the municipality.

*Table 24: Action 3.2.2 in numbers*

| **3.2.2 Energy manager appointment in the municipality** | |
|---|---|
| **Duration** | 2023 - 2030 |
| **Total Implementation Cost (USD)** | 9000 |
| **Annual Energy Savings (MWh)** | 25.67 |
| **Annual Emission Reduction (tn $CO_2$)** | 12 |
| **Funding Source** | Own funds |
| **Net Present Value (NPV)** | <0 |

### 3.2.3. Awareness raising activities for municipal employees

An important step to achieve the planned targets is to have properly communicated the municipality's intentions to the people working within those building. In this respect, this action comprises of a set of targeted awareness raising activities towards the municipal employees. The aim of these activities is to encourage the municipal employees to change their behavior and habits in order to achieve the envisaged results.

The set of awareness raising and training actions to be realized for the municipal employees includes the following:

- Training workshops and seminars for the team members directly involved in the SECAP implementation and monitoring. This activity aims at the capacity building regarding SECAP development and project implementation of the employees directly involved in the SECAP implementation team. These workshops and seminars could be targeted on how to attract financing from international donors, to manage the project implementation or even focus on the exchange of best practices and ideas with other municipalities in Jordan and abroad that face the same challenges. Workshops on the latest available know how in terms of energy efficiency and RES technologies are envisaged as well.
- Development and circulation of promotional material through the employees' e-mails on the benefits of energy efficiency and how simple behavior changes impact the total consumption.
- Municipal contest for the administrative building with the highest energy savings achieved (in terms of %) due to users' behavior change. This contest prize could be any

incentive provided to the employees, such as two additional days off that year or the development of posters with the pictures and names of the employees that contributed to the goal. The aim would be to achieve energy savings through strictly behavioral change, such as turning off the lights, the air conditioners ACs and office equipment when leaving the office, not leaving open windows with the AC on etc. This measure could be used during the first couple of years, when the rest of the energy efficiency interventions will be gradually taking place.

*Table 25: Action 3.2.3 in numbers*

| **3.2.3 Awareness raising activities for municipal employees** | |
|---|---|
| **Duration** | 2023-2030 |
| **Total Implementation Cost (USD)** | 10,000 |
| **Annual Energy Savings (MWh)** | 96.24 |
| **Annual Emission Reduction (tn CO2)** | 46 |
| **Funding Source** | Own funds + external fund |
| **Net Present Value (NPV)** | >0 |

### 3.2.4. Strict application of green building codes in new municipal buildings

Due to the expected economic and population growth in 2030 horizon, citizens' needs will be increased; therefore, the municipality's services should be extended. As a result, new buildings will be constructed to meet city's needs and consequently there will be an increase in energy consumption, as envisaged in the BAU scenario. In order to mitigate this increase, the construction of new buildings should strictly abide with the Energy Efficient Building Codes.

These measures include the adoption of natural lighting and ventilation, insulation in exterior surfaces, as well as shading in the glazing. In addition to the above, the use of cool colors especially in roofs will also contribute significantly to the reduction of energy losses. Moreover, the building's orientation should be taken into consideration.

All the above measures (plus other appropriate bioclimatic principles where it is possible), as well as strict application of the existing Energy Efficient Building Code will be implemented in all new buildings so as to reduce the expected increase in energy and $CO_2$ emissions.

*Table 26: Action 3.2.4 in numbers*

| **3.2.4 Strict application of green building codes in new municipal buildings** |
|---|

| | |
|---|---|
| **Duration** | 2024 - 2027 |
| **Total Implementation Cost (USD)** | 500,000 |
| **Annual Energy Savings (MWh)** | 1,283.26 |
| **Annual Emission Reduction (tn $CO_2$)** | 617 |
| **Funding Source** | Own and governmental funds |
| **Net Present Value (NPV)** | >0 |

### 3.2.5. Install 400 kW PV plant

It is well known that Jordan has a great solar potential especially Ma'an area. The Municipality intends to take advantage of this benefit and install a PV plant of 400 kW to cover partially the electricity consumption for municipal building. By doing so, its dependency on the grid will be reduced through a renewable source of energy, thus achieving $CO_2$ reductions as well.

The Key data on the investment are presented in Table 2 7 below.

*Table 27: Action 3.2.5 in numbers*

| **3.2.5 PV plant 400 KW** | |
|---|---|
| **Duration** | 2023-2030 |
| **Total Implementation Cost (USD)** | 600,000 |
| **Annual Energy Production (MWh)** | 624 |
| **Annual Emission Reduction (tn $CO_2$)** | 300 |
| **Funding Source** | Donor |
| **Net Present Value (NPV)** | >0 |

### 3.3. Street Public Lighting

The municipal public lighting includes street lighting and public areas' lighting. It is estimated that with the appropriate upgrades of this system there will be significant energy savings and respective emission reductions.

An overview of this sector's actions is presented in Table 31, while a detailed analysis with calculations for each action follows in the next paragraphs.

*Table 28: Actions in Municipal Public Lighting*

| Action No. | Action | Emission Reductions (tn CO2) |
|---|---|---|
| **3.3.1** | Street lighting upgrade to LED | 2431 |
| **3.3.2** | Astronomical timers | 1013 |
| **Total** | | **3444** |

#### 3.3.1. Street lighting upgrade

Various types of lamps are used for street lighting, more specifically the High-Pressure Sodium. The Municipality intends to replace all of the existing lamps with LEDs, which are more efficient and provide great luminosity quality. This action will ensure great cost savings for Ma'an and significant reduction in electricity consumption.

The key data on the action is presented in Table 29 below.

*Table 29: Action 3.3.1 in numbers*

| **3.3.1 Street lighting upgrade** | |
|---|---|
| **Duration** | 2019- 2025 |
| **Total Implementation Cost (USD)** | 3,490,000 |
| **Annual Energy Savings (MWh)** | 5,055.99 |
| **Annual Emission Reduction (tn CO2)** | 2431 |
| **Funding Source** | Own and Sida fund |

| | |
|---|---|
| **Net Present Value (NPV)** | >0 |

### 3.3.2. Astronomical timers

The operation of street lighting is controlled manually by the operators. This control method could be replaced with astronomical timers' control, which are more accurate and precise compared to personal behavior. This action will reduce the electricity consumption by approximately 20%, as explained in the following figure that shows the sunrise and sunset timing where the manual control acts little before/after timing and counts for loss of around 365 hours of operation per year.

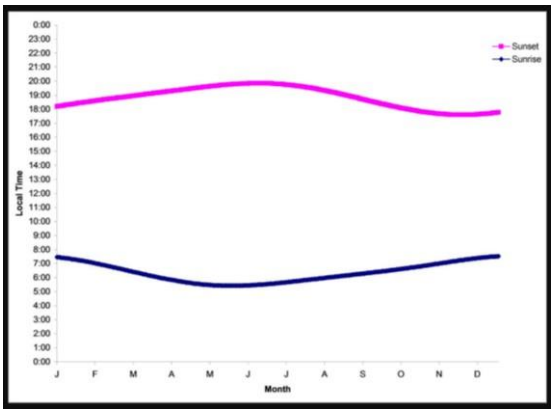



*Figure 23: Timing for sunset and sunrise in Jordan*

*Source: http://file.scirp.org/Html/4-6401175_24420.htm*

The astronomical timers' use would also help in precise timing for switching and programming the actual operation after 20 min of sunset and almost 30 min before sunrise, which is an acceptable trimming as light, will be still there.

Key data on the investment are presented in the table below.

*Table 30: Action 3.3.2 in numbers*

| **3.3.2 Astronomical timers** | |
|---|---|
| **Duration** | 2024-2030 |
| **Total Implementation Cost (USD)** | 106,000 |
| **Annual Energy Savings (MWh)** | 2,106.66 |

| | |
|---|---|
| **Annual Emission Reduction (tn CO2)** | 1013 |
| **Funding Source** | Own funds |
| **Net Present Value (NPV)** | >0 |

### 3.4. Residential Buildings

This sector includes the energy consumption of all the private residents related to activities in each household such as lighting, heating, use of electric appliances etc. This consumption constitutes 10 % of the total energy consumption with 9.56% contribution to the $CO_2$ emissions.

The initial actions are informative and could be initiated by Ma'an Municipality. Because the Municipality does not have the ability to intervene directly in project implementation, a series of actions will be planned to encourage residents to implement the proposed measures to reduce their energy consumption and carbon emissions.

An overview of this sector's planned actions is presented in Table 31.

*Table 31: Actions in Residential Buildings*

| Action No. | Action | CO2 Reduction (tn/a) |
|---|---|---|
| 3.4.1 | Awareness raising activities for modification of the residents' consumption behaviour and energy saving | 10,453 |
| 3.4.2 | Replacement of existing air-conditioners with more efficient ones | 7215 |
| 3.4.3 | Building envelope improvement for the existing buildings | 954 |
| 3.4.4 | Installing Photovoltaic systems on residential rooftops | 6903 |
| Total | | 25,525 |

### 3.4.1. Awareness raising activities for modification of the residents' consumption behaviour and energy saving

The initial step is that the municipality should organize frequent awareness raising activities within the horizon of 2030 for Ma'an Citizens'. Engaging Citizens in these activities is crucial as residential sector is responsible for less than 10% of the total carbon emissions.

*Table 32: Action 3.1 Awareness raising activities for modification of the residents' consumption behaviour and energy saving*

| **3.4.1 Awareness raising activities for modification of the residents' consumption behaviour and energy saving** | |
|---|---|
| **Duration** | 2023 - 2030 |
| **Private Funds mobilized (USD)** | 80,000 |
| **Annual Energy Savings (MWh)** | 21,731.68 |
| **Annual Emission Reduction (tn $CO_2$)** | 10453 |
| **Funding Source** | External funds |
| **Net Present Value (NPV)** | >>0 |

### 3.4.2. Replacement of existing air – conditioners with more efficient ones

The hot climate in the region evokes the intense use of cooling systems in buildings and as a result a quite high percentage of electricity consumption is due to this need. In order to cut down the energy consumption, it is suggested to replace the existing A/Cs with units of higher energy class. Since A/Cs can constitute a significant part of the household's electricity bill, it is considered that within the 2030 horizon through following intensive awareness raising activities by the Municipality, the residents who are going to install/replace an A/C unit, will prefer one with relatively high-performance standards.

Related calculations on the action in terms of initial cost and emission savings are presented in Table 33 below.

*Table 33: Action 3.4.2 in numbers*

| 3.4.2 Replacement of existing air conditioners with more efficient ones | |
|---|---|
| **Duration** | 2019 - 2030 |
| **Private Funds mobilized (USD)** | 4,500,000 |
| **Annual Energy Savings (MWh)** | 15000 |
| **Annual Emission Reduction (tn CO2)** | 7215 |
| **Funding Source** | External funds |
| **Net Present Value (NPV)** | >>0 |

### 3.4.3. Building envelope improvement for the existing buildings

Glazing replacement is an additional action with limited but not insignificant savings. Although summers in Ma'an are extremely hot, heating systems are required to achieve thermal comfort inside buildings during the winter. These heating systems use LPG, and it is possible to reduce their consumption by 15% by lowering the building's heating losses by replacing single glazing with double glazing.

This action can also have impact in the electricity consumption, especially if it is to be combined with roof thermal insulation (around 600 MWh).

*Table 34: Action 3.4.3 in numbers*

| 3.4.3 Building envelope improvement for the existing buildings | |
|---|---|
| **Duration** | 2020 - 2030 |
| **Private Funds mobilized (USD)** | 14,000,000 |
| **Annual Energy Savings (MWh)** | 4434 (Diesel) + 600 (Electricity) |
| **Annual Emission Reduction (tn CO2)** | 954 |
| **Funding Source** | External funds |
| **Net Present Value (NPV)** | >0 |

### 3.4.4. Photovoltaics in residential rooftops

As mentioned before, the solar energy potential is very high in the region. The households have the opportunity to install PV panels in the buildings' rooftops in order to substitute a part of the current electricity consumption with "green" energy from Renewable Energy Sources. Overall, 9.2 MW of PV panels respectively are expected to be installed within the 2030 horizon. In that way, and since electricity from solar energy has zero emission factor, the $CO_2$ emissions will be reduced. The municipality will conduct activities for the communities to ensure installing these targets such as awareness activities on PV technology, Tax exemptions and others.

We consider that the project would cover 10% of electrical consumption in the residential sector, or 9.2 MWp. Such a capacity would generate approximately 14352 MWh of electricity in 2030.

This action consists in setting up, within the municipality, an incentive plan for the installation of systems solar photovoltaic in households by communicating on their economic benefits and support available funding agencies.

Key data on the action are presented in Table 35 below.

*Table 35: Action 3.4.4 in numbers*

| **3.4.4 MW Photovoltaics in residential rooftops** | |
|---|---|
| **Duration** | 2024 - 2030 |
| **Total Implementation Cost (USD)** | 6,300,000 |
| **Annual Energy Production (MWh)** | 14,352 |
| **Annual Emission Reduction (tn CO2)** | 6903 |
| **Funding Source** | Private funds, Banks Loans |
| **Net Present Value (NPV)** | >>0 |

### 3.5. Tertiary Sector

This sector includes the energy consumption of public and commercial buildings, which include the consumption of water management facilities (making around one third of the total consumption of this sector), lighting, cooling, heating, use of electric appliances etc.). This consumption constitutes 2.8% of the total consumption in the city, with 4.37% contribution to the $CO_2$ emissions.

The initial actions are informational and they could be organized by Ma'an Municipality. Municipality does not have direct interventions in terms of projects' realization, thus a series

of actions will be planned aiming at encourage building managers/owners to take the proposed measures in order to reduce their energy consumption and carbon emissions.

An overview of this sector's planned actions is presented in Table 36 below.

*Table 36: Actions in Tertiary Sector Buildings*

| Action No. | Action | Emission Reductions (tn CO2) |
|---|---|---|
| **3.5.1** | Upgrade water facilities | 2728 |
| **3.5.2** | Photovoltaics for water facilities 2.5 MW | 1876 |
| **Total** | | 4604 |

### 3.5.1. Upgrade Water Facilities

In addition to the previous action, energy audits for the water pumping stations is needed to conducted, because the share of these stations in $CO_2$ emissions is about 28% of the total tertiary sector. In the other hand, energy assessment for the irrigation systems in the agriculture sector should be conducted also. The expected energy efficiency improvement is around 15% of the total energy consumption in water facilities. Summary of calculation result is shown in Table 37 below.

### 3.5.2. Install 2.5 MW PV system

Also installing 2.5 MW of PV systems will to cover 25% of the electricity consumption in the water facilities and irrigation systems in the city, and partially avoid using fuel source for irrigation and pumping. Summary of calculation result is shown in Table 38 below.

*Table 37: Action 3.5.1 in numbers*

| **3.5.1 Upgrade water facilities** | |
|---|---|
| **Duration** | 2025 - 2030 |
| **Private Funds Mobilized (USD)** | 3,000,000 |
| **Total Implementation Cost (USD)** | 45,000 |
| **Annual Energy saving (MWh)** | 5,672 |
| **Annual Emission Reduction (tn CO2)** | 2728 |

| | |
|---|---|
| **Funding Source** | Private funds, External funds |
| **Net Present Value (NPV)** | >0 |

*Table 38: Action 3.5.2 in numbers*

| **3.5.2 Photovoltaics in rooftops 2.5 MWp** | |
|---|---|
| **Duration** | 2025 - 2030 |
| **Total Implementation Cost (USD)** | 60,000 |
| **Annual Energy saving (MWh)** | 3900 |
| **Annual Energy Production (MWh)** | 3900 |
| **Annual Emission Reduction (tn CO2)** | 1,876 |
| **Funding Source** | Private funds, External funds |
| **Net Present Value (NPV)** | >0 |

### 3.6. Transport

The share of the Transportation sector, including the municipal fleet, private and commercial transport and public transport is 80% out of the total energy consumption in Ma'an Municipality, with 79% contribution in $CO_2$ emissions. The proposed actions for this sector are presented in Table 39 and a more detailed analysis for each one is following.

*Table 39: Actions in Transport*

| **Sub-sector** | **Action #** | **Action** | **Annual Emission Reduction (tn CO2)** |
|---|---|---|---|
| Municipal Fleets | 3.6.1 | Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract. | 243.09 |

| | | | |
|---|---|---|---|
| | 3.6.2 | Set up a management unit for the fleet of vehicles of the municipality | 243.09 |
| | 3.6.3 | Restructuring and strengthening vehicle maintenance | 48.62 |
| | 3.6.4 | Train drivers in eco driving | 97.24 |
| | 3.6.5 | Carry out an Urban Mobility Plan and set up the required actions | 145.86 |
| Total Municipal Fleets | | | 777.9 |
| Public Transportation | 3.6.6 | Improve the city bus network | 1,516.10 |
| | 3.6.7 | Carry out periodic prevention maintenance and training | 333.54 |
| | 3.6.8 | Raise public awareness of public transport | 303.22 |
| | 3.6.9 | promotion of using school buses rather than private cars | 269 |
| | 3.6.10 | Improve and secure bike paths | 606.44 |
| | 3.6.11 | Transfer all government departments and institutions to one complex near to the population centers in the city | 379.02 |
| | 3.6.12 | Replacing 5% of the existing Taxi vehicles and busses with electric vehicles | 121.29 |
| Total Public Transportation | | | 3,528.61 |
| Private Transportation | 3.6.13 | Private Transportation - Carry out an Urban Mobility Plan | 2,701.71 |
| | 3.6.14 | Establishing central markets near dense residential areas | 720.46 |

| | | | |
|---|---|---|---|
| Total Private Transportation | | | 3,422.17 |
| Commercial Transportation | 3.6.15 | Commercial Transportation – Producing Biodiesel | 25,779.26 |
| | 3.6.16 | Increasing trailer fuel efficiency by enhancing vehicle parts, aerodynamics, predictive maintenance, and training drivers | 60,151.61 |
| | 3.6.17 | Promoting the use of long combination vehicles | 73,041.25 |
| Total Commercial Transportation | | | 158,972.12 |

### 3.6.1. Municipal Fleet - Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract.

This action aims to carry out an audit on the energy consumption of the fleet of vehicles of the municipality. This audit will serve to define an action plan for reducing consumption, but also to optimize overall expenses related to maintenance, oil change, etc. The gains linked to this action are generated by the implementation of the recommended action plan. The audit as well as the action plan covers the entire fleet of vehicles. Taking conservative targets, we consider savings of about 25% of the total fleet consumption (i.e. around 243.1 tCO2).

The reductions presented below consider the fact that some of the following actions result from the audit and therefore realize part of the expected 25% savings. The potential savings from these shares are expected to reach 243.1 tCO2. This leaves only the gains achievable by additional actions, which would be identified by the audit.

*Table 40: Action 3.6.1 in numbers*

| **3.6.1 Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract.** | |
|---|---|
| **Duration** | 2023 |
| **Total Implementation Cost (USD)** | 20,000 |
| **Annual Emission Reduction (tn CO2)** | 243.09 |

| | |
|---|---|
| **Funding Source** | Own funds |
| **Net Present Value (NPV)** | <0 |

### 3.6.2. Set up a management unit for the fleet of vehicles of the municipality

This action must be undertaken in conjunction with the previous action (Audit and program contract of the municipal fleet). It consists of the establishment, within the municipality of Ma'an, of a "unit of rolling stock management ". The responsibilities of this unit may include:

- The implementation of optimized working procedures and methods;
- Monitoring of administrative documents of vehicles;
- Control of the use of vehicles using the information provided by the GPS systems to edge;
- Mileage tracking;
- Monitoring consumption;
- Monitoring of operating expenses;
- Monitoring the implementation of performance improvement and energy saving actions.

This project requires the acquisition of fleet management software and computer hardware. The vehicles must also be equipped with GPS tracking systems. The municipality can be assisted by an IT expert and / or fleet management. The reduction in fuel consumption linked to this action comes mainly from improving vehicle performance by quickly identifying the problems as well as the optimization of the use of the equipment (in particular the journeys made).

This action should also generate additional financial gains linked to the reduction in consumption, oil, spare parts, etc. This action would result from the energy audit; thus, the GHG impacts of this action has been subtracted from the total potential of 25%, which would result from the implementation of the actions recommended by the audit.

*Table 41: Action 3.6.2 in numbers*

| **3.6.2 Set up a management unit for the fleet of vehicles of the municipality.** | |
|---|---|
| **Duration** | 2020 - 2030 |
| **Total Implementation Cost (USD)** | 80,000 |
| **Annual Emission Reduction (tn CO2)** | **243.09** |

| | |
|---|---|
| **Funding Source** | Own funds |
| **Net Present Value (NPV)** | >0 |

### 3.6.3. Restructuring and strengthening vehicle maintenance

This action must be an integral part of the "Audit and contract program of the municipal fleet" action, and supported by the action "setting up a management unit for the municipality's vehicle fleet". The objective of this project is to improve the performance of the rolling stock maintenance units of the municipality in through the following sub-actions:

- Implementation of a preventive maintenance unit triggered and managed by the fleet management unit;
- Establishment of procedures relating to maintenance management;
- Implementation of an IT maintenance management solution;
- Reinforcement of the material means of these units;
- Improvement of the skills of technical staff.

Carrying out this action can reduce fuel consumption by 5%. By improving the mechanical state of the vehicles and the control tire pressure. This action would result from the energy audit; this action has been subtracted from the total potential of 25%, which would result from the implementation of the actions. thus, the GHG impacts of recommended by the audit.

*Table 42: Action 3.6.3 in numbers*

| **3.6.3 Restructuring and strengthening vehicle maintenance** | |
|---|---|
| **Duration** | 2020-2030 |
| **Total Implementation Cost (USD)** | 15,000 |
| **Annual Emission Reduction (tn $CO_2$)** | 48.62 |
| **Funding Source** | Own funds |
| **Net Present Value (NPV)** | >0 |

### 3.6.4. Train drivers in eco driving

This action consists of sensitizing the municipality's drivers to economical driving techniques and road safety through training courses. In most cases, these training courses are provided

by a specialized organization. The energy gains expected from this action would amount to 10% of the fleet's total consumption. This action must be linked to the installation of a GPS/GPRS monitoring system.

*Table 43: Action 3.6.4 in numbers*

| **3.6.4 Train drivers in eco driving** | |
|---|---|
| **Duration** | 2020 – 2022 |
| **Total Implementation Cost (USD)** | 15,000 |
| **Annual Emission Reduction (tn $CO_2$)** | 97.24 |
| **Funding Source** | Own Funds |
| **Net Present Value (NPV)** | >0 |

### 3.6.5. Carry out an Urban Mobility Plan and set up the required actions

The transport sector is one of the largest emitters of GHGs in the territory of the commune of Ma'an. Therefore, this is the strategic focus of the plan Action.

An urban transport plan is a planning document, which determines the organization of the transport of people and goods, traffic and parking in the city. All modes of transport are concerned, which results in the implementation of actions in favour of alternative modes of transport to the private cars, public transport, two wheels, walking, etc. The implementation of the action plan generates gains in terms of city shows.

As an illustration, here is an example of some measures that may be implemented:

- Simple and low-cost measures: clearing sidewalks, reducing wild parking, development of pedestrian spaces, redevelopment of intersections with markings on the ground, implementation consistency of timetables for different modes of public transport, optimization of traffic lights;
- Achievements: crossroads layout, layout of relay parking, implementation of a parking plan, development of multimodal platforms, development public spaces.

To implement this action, it is recommended to form an executive committee with legitimacy to decide to implement the recommendations in close coordination with relevant stakeholders and the Ministry of Transport.

It is estimated that this plan can save more than 15% of vehicle consumption in the city.

*Table 44: Action 3.6.5 in numbers*

| **3.6.5 Carry out an Urban Mobility Plan** | |
|---|---|
| **Duration** | 2020-2030 |
| **Total Implementation Cost (USD)** | 150,000 |
| **Annual Emission Reduction (tn CO2)** | 145.86 |
| **Funding Source** | Governmental Funds |

### 3.6.6. Public Transport - Improve the city bus network

Various actions can be taken to improve the city's public transport offer:

- Improve the timing of buses and extend schedules;
- Create, extend or modify bus lines;
- Improve connections between lines, and synchronization of crossing times;
- Offer attractive pricing for users;
- Modernize the bus fleet;
- Inform citizens about the public transport offer;

This action can be carried out through a study carried out by a company expert in transport and be complementary to the energy audit.

Improving the bus network would increase the number of trips by public transport by 20% common on the perimeter of the commune (due to the modal shift from the private car to the bus) compared to the baseline scenario.

Table 61: Action 3.6.6 in numbers

| **3.6.6 Improve the city bus network** | |
|---|---|
| **Duration** | 2020-2030 |
| **Total Implementation Cost (USD)** | 150,000 |

| | |
|---|---|
| **Annual Emission Reduction (tn CO2)** | 1,516.10 |
| **Funding Source** | Private & external funds |

### 3.6.7. Carry out periodic prevention maintenance and training

Carrying out periodic maintenance of the companies' bus fleet is crucial to reduce carbon emissions. So, the following action could be considered:

- Tire inflation- generalization of tires tubeless.
- Driver training on rational driving.
- Improvement of services maintenance and strengthening their capacities.
- Network restructuring

$CO_2$ reduction by implementing the action plan will be around 4.4% of the transport emission within Ma'an city borders.

*Table 45: Action 3.6.7 in numbers*

| **3.6.7 Carry out periodic prevention maintenance and training** | |
|---|---|
| **Duration** | 2020-2030 |
| **Total Implementation Cost (USD)** | 500,000 |
| **Annual Emission Reduction (tn CO2)** | 333.54 |
| **Funding Source** | Private & external funds |

### 3.6.8. Raise public awareness of public transport

This action entails communicating about the city's public transportation options and alternative modes of transportation in order to encourage residents to reduce their reliance on private automobiles. This project could be undertaken by the municipality's transportation and/or communication services in collaboration with relevant stakeholders. Increased use of soft transport reduces transportation sector emission levels due to a modal shift away from the private car and toward these lower-emitting modes of transportation.

Various communication and awareness-raising actions can be envisaged, a few examples of which are stated below:

- A day promoting cycling trips with events, demonstrations, races, etc.

- A day without a car to promote alternative modes of transport to the car (bus, bikes, walking…).
- Poster or information campaigns for public transport;

To evaluate this action, it was assumed that a modal shift of 5% from private transport to the bus and the cycling following these events (assuming a reduction of 4 / 5th of the carbon intensity of travel affected), an overall emission reduction of 4%This action consists in communicating on the offer of public transport in the city and the modes of transport soft to encourage residents to reduce their travel by private car.

*Table 46: Action 3.6.8 in numbers*

| **3.6.8. Raise public awareness of public transport** | |
|---|---|
| **Duration** | 2020-2023 |
| **Total Implementation Cost (USD)** | 10,000 |
| **Annual Emission Reduction (tn CO2)** | 303.22 |
| **Funding Source** | Private funds |

### 3.6.9. promotion of using school buses rather than private cars

The overarching goal of providing buses to schools is to improve student mobility and reduce fuel consumption. The municipality's role in this case is to encourage public schools to use buses for student mobility and to organize public awareness-raising activities to educate citizens about the environmental and economic benefits of using school buses.

*Table 47: Action 3.6.9 in numbers*

| **3.6.9 promotion of using school buses rather than private cars** | |
|---|---|
| **Duration** | 2020-2023 |
| **Total Implementation Cost (USD)** | 5,000 |

| | |
|---|---|
| **Annual Emission Reduction (tn CO2)** | 269 |
| **Funding Source** | Own funds |

### 3.6.10. Improve and secure bike paths

The bicycle is, in some cities, one of the most efficient and most used means of transport. In Jordan, its potential is generally under-exploited. This action consists in setting up an action plan, linked with the pedestrian action plan, in order to promote transport by bicycle. The following actions can be envisaged:

- Raise awareness of the fact that cycling is an efficient means of transport;
- Develop / improve cycle facilities as well as bicycle-car cohabitation;
- Connect the bicycle and public transport;
- Offer self-service bike offers;
- Subsidize the purchase of bicycles by individuals;
- Install bicycle parking lots.

The implementation of this action can help encourage the modal shift from the private car to the bicycle and therefore reduce emissions linked to the transport sector in the city.

For the calculation of avoided emissions, it was considered that 8% of journeys made by public vehicle in the city are replaced by the bicycle.

*Table 48: Action 3.6.10 in numbers*

| **3.6.10 Improve and secure bike paths** | |
|---|---|
| **Duration** | 2020-2030 |
| **Total Implementation Cost (USD)** | 1,500,000 |
| **Annual Emission Reduction (tn CO2)** | 606.44 |
| **Funding Source** | Own, governmental and external funds |

### 3.6.11. Transfer all government departments and institutions to one complex near to the population centres in the city

One of the main transportations and traffic problems in Ma'an city is the locations of the government departments and institutions and the distance between each other, which the people need to drive or take public transport to move from one to another in order to complete

their Governmental and civil transactions. This problem will lead to drive more and create a traffic jams in the connecting road. One of the best solutions is to transfer all related government departments and institutions to one complex near to the population centres in the city in order to avoid take transportation in the movement.

For the calculation of avoided emissions, it was considered that 5% of journeys made by private and public vehicles in the city could be avoided after bringing these institutions together and easy to reach them by walking.

*Table 49: Action 3.6.11 in numbers*

| **3.6.11 Transfer all government departments and institutions to one complex near to the population centres in the city** | |
|---|---|
| **Duration** | 2020-2030 |
| **Total Implementation Cost (USD)** | 2,500,000 |
| **Annual Emission Reduction (tn $CO_2$)** | 379.02 |
| **Funding Source** | Own, governmental and external funds |

### 3.6.12. Replacing 5% of the existing Taxi vehicles with electric vehicles

The inefficiencies of today's transportation systems can translate into deteriorating service, excess cost, energy use and environmental impact. As mentioned in the public transportation section, there are 30 Taxi cars move within Ma'an city, which most of them are old. If 5% of them (30 Taxi car) were replaced with Hybrid cars, then a higher energy efficiency and thus fuel and monetary savings will be achieved. This action is envisaged through the provision of the respective legislative framework that supports exemptions for replacing taxis with electric cars.

For the calculation of avoided emissions, it was considered that 1.6% of CO2 emissions by public transportation can be avoided by solving this problem.

*Table 50: Action 3.6.12 in numbers*

| **3.6.12 Replacing 5% of the existing Taxi vehicles with electric vehicles** | |
|---|---|
| **Duration** | 2020-2025 |

| | |
|---|---|
| **Total Implementation Cost (USD)** | 60,000 |
| **Annual Emission Reduction (tn CO2)** | 121.29 |
| **Funding Source** | Private Funds |

### 3.6.13. Private Transportation - Carry out an Urban Mobility Plan

An urban mobility plan considers a sustainable plan to enhance the lively hood and quality of life for the community through many factors that would consider the growth of the city. Such plans would consider not only the traffic, but work and life flow patterns and businesses to create a functional urban area. Such planning can cut 15% of the total emissions.

*Table 51: Action 3.6.13 in numbers*

| **3.6.13 Private Transportation - Carry out an Urban Mobility Plan** | |
|---|---|
| **Duration** | 2023-2030 |
| **Total Implementation Cost (USD)** | Joint action as in action 5.5 |
| **Annual Emission Reduction (tn CO2)** | 2,701.71 |
| **Funding Source** | Own and Governmental Funds |

### 3.6.14. Establishing central markets near dense residential areas

A big challenge in Jordan is that many markets are developing away from cities due to the low cost of rent. But it’s important to keep those markets close to the main activities so that the community can have a better quality of life. In this case 4% of private transport emissions can reduced and a better quality of life can be attained.

*Table 52: Action 3.6.14 in numbers*

| **3.6.14 Establishing central markets near dense residential areas** | |
|---|---|
| **Duration** | 2019 - 2027 |
| **Total Implementation Cost (USD)** | 1,500,000 |
| **Annual Emission Reduction (tn CO2)** | 720.46 |
| **Funding Source** | Own and Governmental Funds |

### 3.6.15. Commercial Transportation – Producing Biodiesel

With the large amount of commercial transport passing through Ma'an, it's mere impossible to cut the target emission just through efficient fuel consumption, other means like the use of energy from waste can offset emission by mixing the current diesel with bi-diesel produced using plastic waste. The municipality already has a sorting facility making the main infrastructure available for such projects. The biodiesel potential from plastic waste amounts to 105,707.70 MWh or 11,829 tons of bio-diesel, making up 6% of the total diesel demand in 2030%.

*Table 53: Action 3.6.15 in numbers*

| **3.6.15 Producing Biodiesel** | |
|---|---|
| **Duration** | 2023-2030 |
| **Total Implementation Cost (USD)** | 3,500,000 |
| **Annual Emission Reduction (tn CO2)** | 25,779.26 |
| **Funding Source** | External funds and other investors |

### 3.6.16. Increasing trailer fuel efficiency by enhancing vehicle parts, aerodynamics, predictive maintenance, and training drivers

Constant maintenance and monitoring of trucks can become impossible and tedious, but with the installation of new technology of vehicle AI monitoring systems can analyse the performance of trucks and predict certain issues that could be fixed as well as the fuel consumption efficiency. Using such technology, advancing the truck system is possible and can help in reducing the fuel consumption by 14%.

*Table 54: Action 3.6.16 in numbers*

| **3.6.16 Increasing trailer fuel efficiency by enhancing vehicle parts, aerodynamics, predictive maintenance, and training drivers** | |
|---|---|
| **Duration** | 2023 - 2030 |
| **Total Implementation Cost (USD)** | 6,000,000 |
| **Annual Emission Reduction (tn $CO_2$)** | **60,151.61** |
| **Funding Source** | Own and Governmental Funds |

### 3.6.17. Promoting the use of long combination vehicles

A study has proven that the use of long combination vehicles can reduce the fuel consumption up to 17%. Since Ma'an is the main passage to the rest of Jordan, it's important to promote the enhancement of truck technology and reducing the consumption of logistics.

*Table 55: Action 3.6.17 in numbers*

| **3.6.17 Promoting the use of long combination vehicles** | |
|---|---|
| **Duration** | 2023-2030 |
| **Total Implementation Cost (USD)** | 30,000 |
| **Annual Emission Reduction (tn $CO_2$)** | 73,041.25 |
| **Funding Source** | Own and Governmental Funds |

## 3.7. Agriculture Sector

### 3.7.1. Planting trees (increasing green areas)

Planting forest trees will contribute in reducing the GHG through absorbing the $CO_2$ emission. The forest trees absorb the $CO_2$ through the photosynthesis. The municipality will plant forest trees and support planting such trees by the local community to contribute in reducing the $CO_2$ emissions.

Table below illustrates the information that present the action.

*Table 56: Action 3.7.1 in numbers*

| **3.7.1 Planting Trees (increasing green areas)** | |
|---|---|
| **Duration** | 2023-2030 |
| **Total Implementation Cost (USD)** | 1,000,000 |
| **Number of Trees** | 1,000,000 |
| **$CO_2$ Captured (Tn $CO_2$)** | 25,000 |
| **Funding Source** | Own and external funds |

## 3.8. Waste Water Treatment Plant

3.8.1. Biogas Production from Sludge for self-sufficient WWTP)

Waste water plants produce sludge waste which is usually transferred to landfills for safe disposal. This waste cannot be utilized for agriculture as it's categorized as hazardous waste and is not permitted for such use according to the law. Instead of direct disposal, sludge can be used to produce bio-gas which can in return supply the waste water treatment plant with the needed electricity to run it. This is by case studies, able to eliminate all emissions from the WWTP.

*Table 57: Action 3.8.1 in numbers*

| **3.8.1 Biogas Production from Sludge for self-sufficient WWTP)** | |
|---|---|
| **Duration** | 2026-2029 |
| **Total Implementation Cost (USD)** | 1,500,000 |
| **$CO_2$ Captured (Tn $CO_2$)** | 548.53 |

| | |
|---|---|
| **Funding Source** | Own and external funds |

### 3.9. Actions' Overview

In the next table, the complete list of the SECAP Actions is presented followed by the respective energy savings/production and the $CO_2$ reduction.

*Table 58: Summary of the mitigation actions*

| No. | Action | CO2 Reduction (Ton) |
|---|---|---|
| **Municipal Buildings** | | |
| **3.2.1** | Green procurement procedures for municipal buildings | 247 |
| **3.2.2** | Energy manager appointment in the municipality | 12 |
| **3.2.3** | Awareness raising activities for municipal employees | 46 |
| **3.2.4** | Strict application of green building codes in new municipal buildings | 617 |
| **3.2.5** | Install 400 kW PV plant | 300 |
| **Total Municipal Buildings** | | **1222** |
| **Public Lighting** | | |
| **3.3.1** | Street lighting upgrade to LED | 2431 |
| **3.3.2** | Astronomical timers | 1013 |
| **Total Public Lighting** | | **3444** |
| **Residential Buildings** | | |
| 3.4.1 | Awareness raising activities for modification of the residents' | 10453 |

| | | |
|---|---|---|
| | consumption behaviour and energy saving | |
| 3.4.2 | Replacement of existing air-conditioners with more efficient ones | 7215 |
| 3.4.3 | Building envelope improvement for the existing buildings | 954 |
| 3.4.4 | Installing Photovoltaic systems on residential rooftops | 6903 |
| **Total Residential Buildings** | | **25525** |
| **Tertiary Sector** | | |
| 3.5.1 | Upgrade water facilities | 2728 |
| 3.5.2 | Photovoltaics for water facilities 2.5 MW | 1876 |
| **Total Tertiary Sector** | | **4604** |
| **Transportation** | | |
| **Municipal Fleets** | | |
| 3.6.1 | Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract. | 243.09 |
| 3.6.2 | Set up a management unit for the fleet of vehicles of the municipality | 243.09 |
| 3.6.3 | Restructuring and strengthening vehicle maintenance | 48.62 |
| 3.6.4 | Train drivers in eco driving | 97.24 |

| | | |
|---|---|---|
| 3.6.5 | Carry out an Urban Mobility Plan and set up the required actions | 145.86 |
| **Total Municipal Fleets** | | **777.9** |
| **Public Transportation** | | |
| 3.6.6 | Improve the city bus network | 1,516.10 |
| 3.6.7 | Carry out periodic prevention maintenance and training | 333.54 |
| 3.6.8 | Raise public awareness of public transport | 303.22 |
| 3.6.9 | promotion of using school buses rather than private cars | 269 |
| 3.6.10 | Improve and secure bike paths | 606.44 |
| 3.6.11 | Transfer all government departments and institutions to one complex near to the population centers in the city | 379.02 |
| 3.6.12 | Replacing 5% of the existing Taxi vehicles and busses with electric vehicles | 121.29 |
| **Total Public Transportation** | | **3,528.61** |
| Private Transportation | | |
| 3.6.13 | Private Transportation - Carry out an Urban Mobility Plan | 2,701.71 |
| 3.6.14 | Establishing central markets near dense residential areas | 720.46 |
| **Total Private Transportation** | | **3,422.17** |

| | | |
|---|---|---|
| **Commercial Transportation** | | |
| 3.6.15 | Commercial Transportation – Producing Biodiesel | 25,779.26 |
| 3.6.16 | Increasing trailer fuel efficiency by enhancing vehicle parts, aerodynamics, predictive maintenance, and training drivers | 60,151.61 |
| 3.6.17 | Promoting the use of long combination vehicles | 73,041.25 |
| **Total Commercial Transportation** | | **158,972.12** |
| **Agricultural** | | |
| 9.1 | Plating 1,000,000 trees | 25,000 |
| **Total Agriculture** | | **25,000** |
| **Wastewater treatment sector** | | |
| 10.1 | Biogas Production from Sludge for self-sufficient WWTP | 548.53 |
| **Total Wastewater treatment sector** | | **548.53** |
| **Total 229,649.88** | | **226,744.33** |

Regarding the costs, for Ma'an Municipality will require 48 million USD approximately of total fund in order to achieve the 40% target, the Ma'an Municipality and the Government should place intensive and consecutive efforts towards the strict implementation of the SECAP and seek for agreements and grants with national and international organizations.

### 3.10. Monitoring

Monitoring of the Municipality's progress against the set targets is very significant, especially since it has to be realized in a frequent basis. The following table includes the suggested indicators to monitor each action's progress against the initial objectives, in order any deviations from the target to be noticed quickly, and appropriate correction measures to be taken.

These indicators will be also utilized during the production of the actions' monitoring report in line with the Covenant of Mayors requirements, as well as common practice, in order to demonstrate the achieved progress and results.

*Table 59: suggested indicators to monitor each action's progress*

| Action No. | Action | Key Performance Indicators | Measurement units |
|---|---|---|---|
| **Municipal Buildings and facilities** | | | |
| **3.2.1** | **Green procurement procedures for municipal buildings** | - **Number of equipment bought with green procurement procedures** | - **Equipment number/year** |
| **3.2.2** | **Energy manager appointment in the municipality** | - **Years that the Energy Manager is appointed and active**<br>- **Quantity of municipal infrastructure under his supervision**<br>- **Energy savings under his** | - **Number of years**<br>- **Number and % of municipal infrastructure being supervised**<br>- **KWh** |

| | | | |
|---|---|---|---|
| | | **supervision** | |
| **3.2.3** | **Awareness raising activities for municipal employees** | - **Number of training seminars that were implemented**<br>- **Municipal employees that were trained** | - **Number of seminars Number of employees** |
| **3.2.4** | **Strict application of green building codes in new municipal buildings** | - **Number of new buildings with bioclimatic principles** | - **Number of buildings** |
| **3.2.5** | **Install 400 kW PV plant** | - **Installed PV capacity**<br>- **Percentage of installed capacity against the initial target** | - **KWp**<br>- **% out of 400 kWp** |
| **Public Lighting** | | | |
| **2.3.1** | **Street lighting upgrade** | - **Lamps that were replaced with energy**<br>- **efficient ones** | - **Number of lamps** |
| **2.3.2** | **Astronomical timers** | - **Percentage of astronomical timers** | - **%** |

| | | | |
|---|---|---|---|
| | | - against initial target | |
| **Residential Sector** | | | |
| 3.4.1 | Awareness raising activities for modification of the residents' consumption behaviour and energy saving | - Number of seminars & information days<br>- Attendants in each event | - Number of activities<br>- Number of people attending each event |
| 3.4.2 | Replacement of existing air-conditioners with more efficient ones | - Number of A/Cs replaced with new ones | - Number of A/Cs |
| 3.4.3 | Building envelope improvement for the existing buildings | - Number of Buildings benefited | - Number of Buildings benefited |
| 3.4.4 | Installing Photovoltaic systems on residential rooftops | - Installed PV capacity on roofs<br>- Percentage of installed capacity against the initial target | -<br>- % of 3.3 MWp |
| **Tertiary Sector** | | | |
| 3.5.1 | Upgrade water facilities | - Number of SCADA systems installed | - Number of systems |

| | | | |
|---|---|---|---|
| **3.5.2** | **Photovoltaics for water facilities 2.5 MW** | **- Installed PV capacity on roofs<br>- Percentage of installed capacity against<br>- the initial target** | **- MWp<br>- % out of 2.5MWp** |
| **Transportation Sector** | | | |
| **Municipal Fleet** | | | |
| **3.6.1** | **Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract.** | **- Human resources, technical, financial) available** | **- Number of km traveled<br>- Number of liters consommé** |
| **3.6.2** | **Set up a management unit for the fleet of vehicles of the municipality** | **- Human resources, technical, financial) available** | **- Number of km traveled<br>- Number of liters consommé** |
| **3.6.3** | **Restructuring and strengthening vehicle maintenance** | **- Human resources, technical, financial) available** | **- Number of km traveled<br>- Number of liters consommé** |

| | | | |
|---|---|---|---|
| **3.6.4** | **Train drivers in eco driving** | **- Number of drivers trained**<br>**- Number of trainings business** | **- Number of km traveled**<br>**- Number of liters consommé** |
| **3.6.5** | **Carry out an Urban Mobility Plan and set up the required actions** | **- Advancement of carrying out the study**<br>**- Action tracking implemented** | **- Number of vehicles / km**<br>**- Number of passagers.km**<br>**- Number of tons / km** |
| **Public Transportation** | | | |
| **3.6.6** | **Improve the city bus network** | **- Number of persons**<br>**- sensitized** | **- Number of**<br>**- passenger / year** |
| **3.6.7** | **Carry out periodic prevention maintenance and training** | **- Advancement of carrying out the study**<br>**- Action tracking implemented** | **- Number of Trained Drivers**<br>**- Number of Maintenance workshop introduced.** |
| **3.6.8** | **Raise public awareness of public transport** | **- Number of actions**<br>**- business** | **- Number of activities organized** |

| | | | |
|---|---|---|---|
| | | | - **Number of attendees.** |
| **3.6.9** | **promotion of using school buses rather than private cars** | - **Number of buses introduced** | - **Number of avoided km by private cars** |
| **3.6.10** | **Improve and secure bike paths** | - **Number of km from bike path Finished** | - **Number of km cycled** |
| **3.6.11** | **Transfer all government departments and institutions to one complex near to the population centers in the city** | - **number of institutions transferred** | - **No. of visitors for each institution** |
| 3.6.12 | **Replacing 5% of the existing Taxi vehicles and busses with electric vehicles** | - **Number of Hybrid & EV Taxis** | - **Number of Hybrid Taxis & EV** |
| **Private Transportation** | | | |
| **3.6.13** | **Private Transportation - Carry out an Urban Mobility Plan** | - **Action Plan Developed**<br>- **Advancement of carrying out the study**<br>- **Action tracking implemented** | - **Number of vehicles / km**<br>- **Number of passagers.km**<br>- **Number of tons / km** |

| | | | |
|---|---|---|---|
| **3.6.14** | **Establishing central markets near dense residential areas** | **- Number of actions**<br>**- business** | **- Number of**<br>**- passengers** |
| **Commercial Transportation** | | | |
| 3.6.15 | **Commercial Transportation – Producing Biodiesel** | **- % biodiesel of total diesel consumed in commercial transportation** | **- Tons of biodiesel produced** |
| 3.6.16 | **Increasing trailer fuel efficiency by enhancing vehicle parts, aerodynamics, predictive maintenance, and training drivers** | **- Fuel consumption of trucks** | **- % reduction in fuel consumption** |
| 3.6.17 | **Promoting the use of long combination vehicles** | **- % long combinations trucks from main** | **- % long combinations trucks from main** |
| **Agriculture sector** | | | |
| **9.1** | **Planting trees** | **- Number of planted trees** | **- Number of trees** |
| **Waste Water Treatment** | | | |
| **10.1** | **Biogas Production from Sludge for self-sufficient WWTP** | **- Sludge Reused**<br>**- Energy Produced** | **- Tones recycled**<br>**- MWh** |

| | | | |
|---|---|---|---|
| | | - **Biogas Production**<br>- **Offset energy consumption** | - **m3**<br>- **MWh offset** |

# 4 Adaptation to climate change

## 4.1. Introduction on climate change impact

The Earth's climate is changing and the global climate is projected to continue to change over this century and beyond. The magnitude of climate change beyond the next few decades will depend primarily on the amount of greenhouse (heat-trapping) gases emitted globally and on the remaining uncertainty in the sensitivity[5] of the Earth's climate to those emissions. With significant reductions in the emissions of greenhouse gases (GHGs), global annual averaged temperature rise could be limited to 2°C or less. However, without major reductions in these emissions, the increase in annual average global temperatures, relative to preindustrial times, could reach 5°C or more by the end of this century.

Observed changes over the 20th century include increases in global air and ocean temperature, rising global sea levels, long-term sustained widespread reduction of snow and ice cover, and changes in atmospheric and ocean circulation as well as regional weather patterns, which influence seasonal rainfall conditions. These changes are caused by extra heat in the climate system due to the addition of greenhouse gases to the atmosphere. These additional greenhouse gases are primarily input by human activities such as the burning of fossil fuels (coal, oil, and natural gas), deforestation, agriculture, and land-use changes. These activities increase the amount of 'heat-trapping' greenhouse gases in the atmosphere. The pattern of observed changes in the climate system is consistent with an increased greenhouse effect. Other climatic influences such as volcanoes, the sun and natural variability cannot alone explain the timing and extent of the observed changes [1].

As a result, countries across the world take actions necessary to anticipate and plan for future changes in climate to protect human health and the environment. Furthermore, they ensure their programs, policies, rules, enforcement and compliance assurance activities, and operations consider current and future impacts of climate change and how those impacts will disproportionately affect certain communities. Through climate change adaptation planning and implementation, nations across the world will continue to protect human health and the environment by reducing risks from climate change impacts while also working to reduce greenhouse gas emissions. This could be achieved by developing and implementing measures to

[5] https://climateknowledgeportal.worldbank.org/overview U.S. Environmental Protection Agency Climate Adaptation Action Plan, October 2021.

protect its workforce, facilities, supply chains, and procurement processes from risks posed by climate change[6].

Adaptation is defined as the adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. This term refers as well to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change. The Paris Agreement on Climate Change in 2015 has identified the global goals on adaptation, which include enhancing the adaptive capacity, resilience and reducing the vulnerability in order to contribute to sustainable development[7].

### 4.2. Climate change profile in Jordan

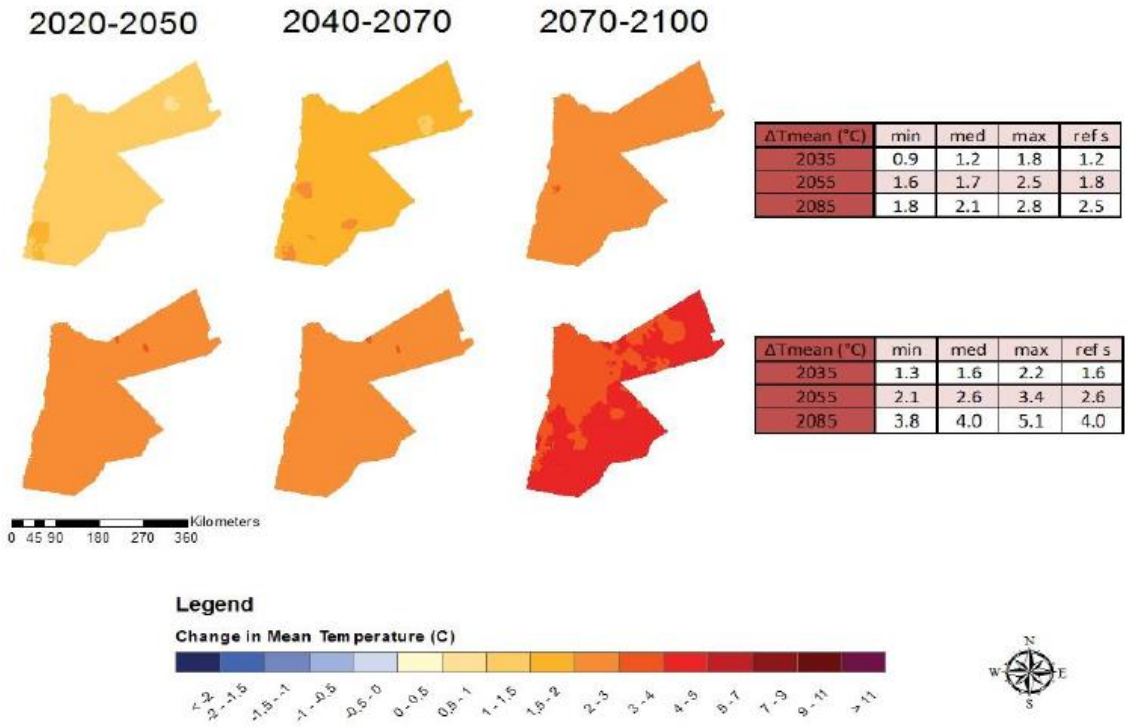
Jordan is located in West Asia region, and characterized by dry to semi-dry climate conditions with an annual precipitation that falls under 50 millimetres in most areas. Jordan faces several challenges with the need to import of 98% of its energy; while severe aridity and water scarcity make it environmentally sensitive to climate change. Climate-related hazards are affecting Jordan, such as extreme temperatures, droughts, flash floods, storms, and landslides. These hazards are increasing in frequency and intensity due to climate change. Flooding has caused serious implications in the last years where lives have been lost, and several square kilometres of agricultural lands were destroyed in addition to sever damages to infrastructure. Landslides and erosion problems have occurred as well, and they were concentrated on the steep slopes of mountains and wadis. Climate change affects various sectors including agricultural, coastal areas, biodiversity, urban systems, society, water, and health sectors, where adaptation options are required to mitigate its effects.

Based on long historical data obtained from Ministry of Water and Irrigation (MWI) and Jordanian Meteorology Department (JMD), climatic variables are changing significantly at both national and station level indicating that climate change is becoming more apparent. Based on the tests, the annual precipitation tends to decrease significantly by time in a rate of 1.2 mm per year until 2100. On the contrary, the mean, maximum and minimum air temperature tends to increase significantly by 0.02, 0.01, and 0.03 °C/year, respectively.

[6] https://climateknowledgeportal.worldbank.org/overview U.S. Environmental Protection Agency Climate Adaptation Action Plan, October 2021.

[7] The National Climate Change Adaptation Plan of Jordan, 2021.

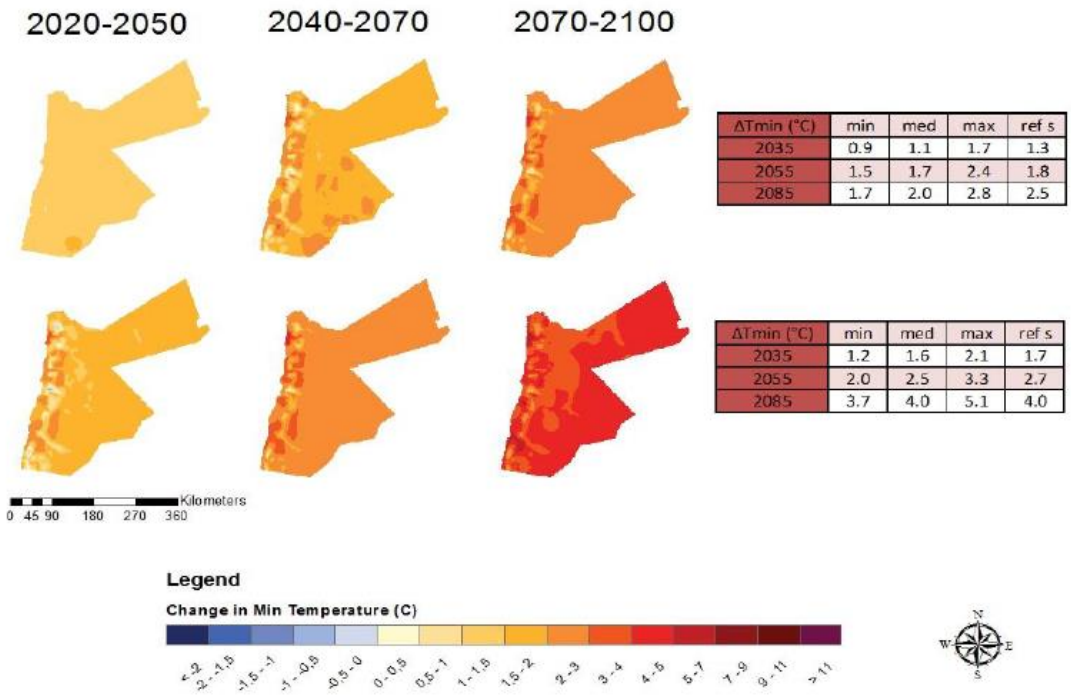
In 2070-2100, average temperature increase could be between +2.1°C and +4°C. Figures below present the results for the mean, minimum and maximum annual temperature, for the three-time horizons considered. In addition, the dynamic projections predict a drier climate, in 2070-2100, the cumulated precipitation could decrease on average 15% and by – 21%. The decrease would be more marked in the western part of the country.




| ΔTmean (°C) | min | med | max | refs |
|---|---|---|---|---|
| 2035 | 0.9 | 1.2 | 1.8 | 1.2 |
| 2055 | 1.6 | 1.7 | 2.5 | 1.8 |
| 2085 | 1.8 | 2.1 | 2.8 | 2.5 |

| ΔTmean (°C) | min | med | max | refs |
|---|---|---|---|---|
| 2035 | 1.3 | 1.6 | 2.2 | 1.6 |
| 2055 | 2.1 | 2.6 | 3.4 | 2.6 |
| 2085 | 3.8 | 4.0 | 5.1 | 4.0 |

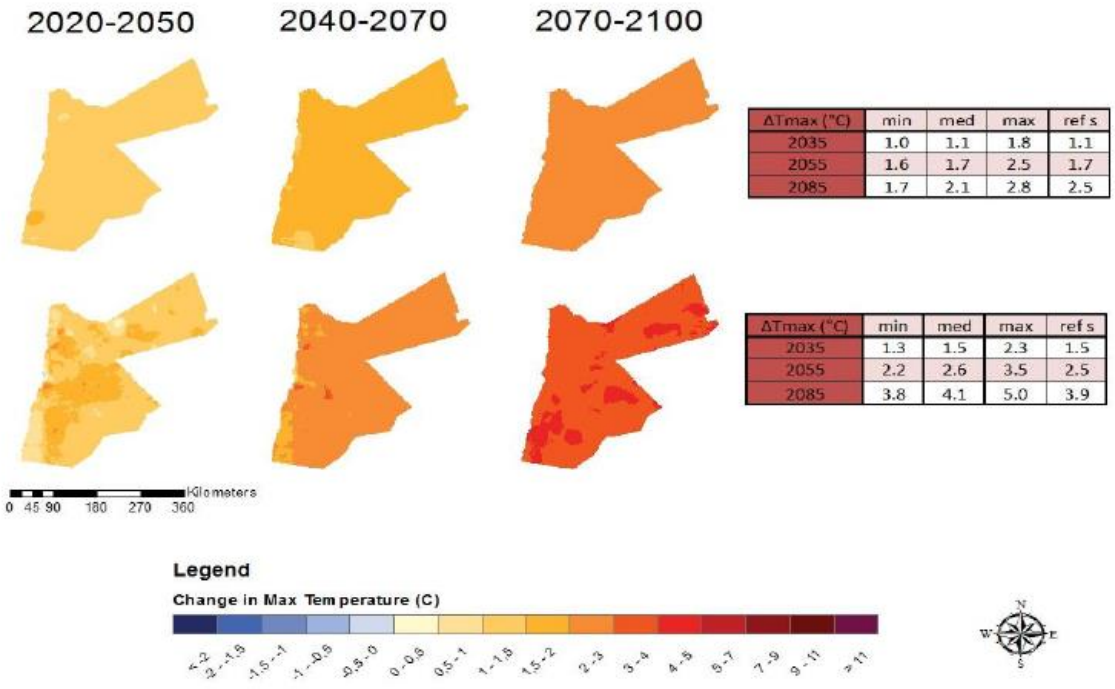
*Figure 24: Changes in annual mean temperature (°C) over Jordan, reference model, for 2035, 2055 and 2085 times-horizons*




| ΔTmin (°C) | min | med | max | ref s |
|---|---|---|---|---|
| 2035 | 0.9 | 1.1 | 1.7 | 1.3 |
| 2055 | 1.5 | 1.7 | 2.4 | 1.8 |
| 2085 | 1.7 | 2.0 | 2.8 | 2.5 |

| ΔTmin (°C) | min | med | max | ref s |
|---|---|---|---|---|
| 2035 | 1.2 | 1.6 | 2.1 | 1.7 |
| 2055 | 2.0 | 2.5 | 3.3 | 2.7 |
| 2085 | 3.7 | 4.0 | 5.1 | 4.0 |

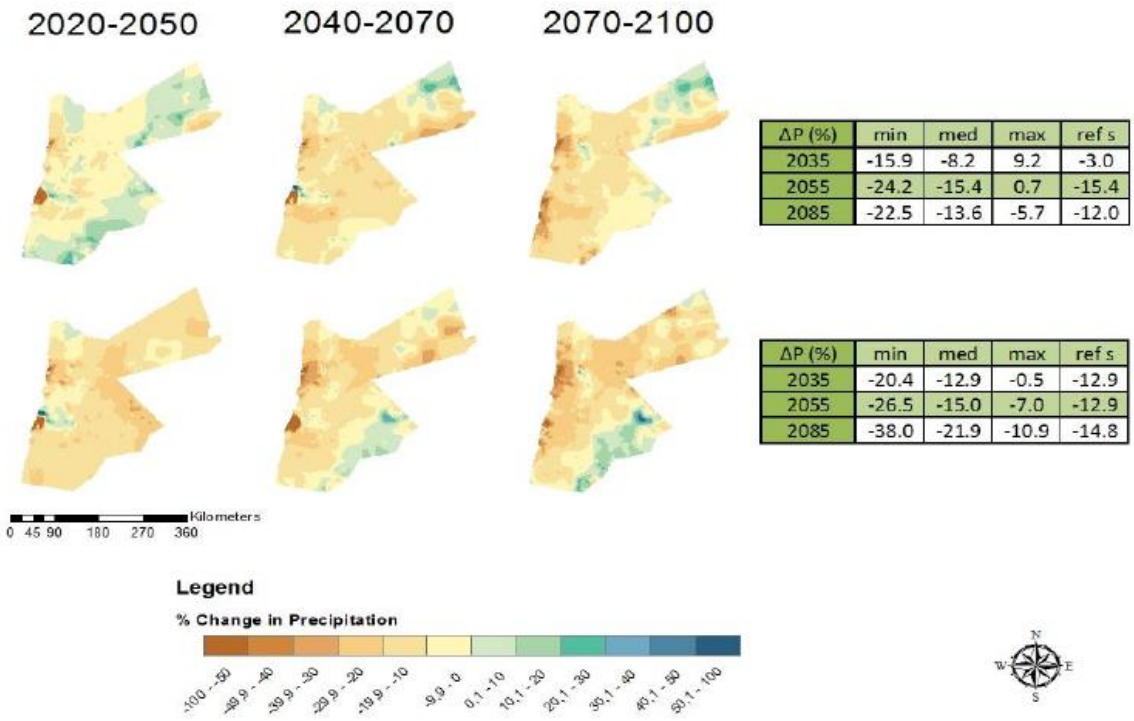
*Figure 25: Delta annual minimum temperature (°C) over Jordan, reference model, for 2035, 2055 and 085 times-horizon*




| ΔTmax (°C) | min | med | max | ref s |
|---|---|---|---|---|
| 2035 | 1.0 | 1.1 | 1.8 | 1.1 |
| 2055 | 1.6 | 1.7 | 2.5 | 1.7 |
| 2085 | 1.7 | 2.1 | 2.8 | 2.5 |

| ΔTmax (°C) | min | med | max | ref s |
|---|---|---|---|---|
| 2035 | 1.3 | 1.5 | 2.3 | 1.5 |
| 2055 | 2.2 | 2.6 | 3.5 | 2.5 |
| 2085 | 3.8 | 4.1 | 5.0 | 3.9 |

*Figure 26: Changes in annual maximum temperature (°C) over Jordan, reference model, for 2035, 2055 and 2085 times-horizons*




| ΔP (%) | min | med | max | ref s |
|---|---|---|---|---|
| 2035 | -15.9 | -8.2 | 9.2 | -3.0 |
| 2055 | -24.2 | -15.4 | 0.7 | -15.4 |
| 2085 | -22.5 | -13.6 | -5.7 | -12.0 |

| ΔP (%) | min | med | max | ref s |
|---|---|---|---|---|
| 2035 | -20.4 | -12.9 | -0.5 | -12.9 |
| 2055 | -26.5 | -15.0 | -7.0 | -12.9 |
| 2085 | -38.0 | -21.9 | -10.9 | -14.8 |

*Figure 27: Changes in annual precipitation (mm) over Jordan, reference model, for 2050, 2070 and 2100 times-*

The future projections indicated a warmer summer, drier autumn and winter with medium confidence. The warming would be more significant in summer, and the reduction of precipitation more important in autumn and winter than in spring, with for instance median value of precipitation decrease reaching -35% in autumn in 2070-2100. The dynamic projections predict more heat waves with high confidence and the analysis of summer temperature, monthly values and the inter-annual variability reveal that some thresholds could be exceeded. For instance, in pessimistic but possible projections, for a summer month, the average of maximum temperature for the whole country could exceed 42-44°C.

The future projections also indicate more droughts, where the maximum number of consecutive dry days would increase in the reference model of more than 30 days for the 2070-2100 period. In contrast, annual values still show possible heavy rainy events at the end of the century. More intense droughts would be (partly) compensated by rainy years, in a context of a general decrease of precipitation. Potential evaporation would increase. Finally, the future projections indicate no trend for intense precipitations or strong winds with low confidence. The number of days with

heavy rain (>10 mm) does not evolve significantly, nor does the maximum wind speed or the direction of winds[8].

### 4.3. National climate change strategies

The Ministry of Environment (MoEnv) is the focal point to the United Nations Framework Convention on Climate Change (UNFCCC). Although, the Ministry was established in 2003, but the Government of Jordan had initiated its efforts toward climate change since 1999, where it was the first developing country that has submitted the Initial National Communication to the UNFCCC including a comprehensive vulnerability analysis.

#### 4.3.1. Updated NDC (2021)

The Jordanian government has pledged to reduce GHG emissions by 1.5% in 2030 compared to business-as-usual without conditions and increase this pledge to 12.5% conditioned to international support. Jordan's updated 1st Nationally Determined Contributions (NDC) document enhances its commitment to the international climate change governance system by raising its macroeconomic GHG emission reduction target from 14% in the 1st NDC to 31% in the current updated NDC, both compared to Business as Usual (BAU) scenario. (Updated NDC).

#### 4.3.2. National Vision and Strategy (NVS)

In 2015, the government launched Jordan’s 2025 National Vision and Strategy (NVS). This is the reference for all development pathways in the country, “and sets a holistic economic and social framework based on equal opportunities for all”. It contains over 400 policies, including ones on environment and climate.

#### 4.3.3. Green Growth National Action Plan (2021-2025)

The Ministry of Environment has been taking solid action to support Jordan’s green growth transformation. In 2017, the Cabinet approved the National Green Growth Plan, which established green growth as a top national priority. The next step in implementing this vision, the Green Growth National Action Plan 2021-2025 was published. The development of this plan lies at the heart of continuous efforts and ambitions to support environmental and climate action in Jordan, while also achieving Jordan sustainable economic growth objectives.

The National Green Action plan 2021-2025 targets 6 sectors; agriculture, energy, tourism, transport, waste and water sectors. The Energy Sector Green Growth Action National Action Plan

[8] The National Climate Change Adaptation Plan of Jordan, 2021.

2021-2025 (GG-NAP) outlines a green growth framework and actions for the sector aligned with the National Green Growth Plan (NGGP), Jordan Vision 2025, and Nationally Determined Contributions (NDCs) under the Paris agreement.

### 4.3.4. Climate Change National Adaptation Plan (NAP) (2021)

The NAP document was prepared based on the Climate Vulnerability Assessment of the Third National Communication Report, and adopts the values and principles of the NAP Framework. It provides a clear vision for adaptation and identifies measures to be addressed in various sectors to guide institutions from different sectors such as governmental, academic, CBOs, and private sectors entities to implement adaptation initiatives, develop partnership relations and synergies with each other, to reach the required adaptation goals. The plan includes a description of sectoral adaptation programmes and measures through enhancing the resilience of urban structure to climate change impacts and supporting sustainable urbanization.

Jordan has developed several laws, regulations and policy instruments that govern environmental protection. Some of them still work without being updated such as Air Protection Bylaw (2005), while some of them had already been updated to adapt to the national context and perspectives.

In general, the Jordanian government has taken many measures to develop the regulatory and legislative framework through the issuance of several laws and legislations including:

- National Environment Protection Law No. (6) of year 2017. The NOU has recently endorsed the Instructions for year 2021 to manage and control the ODS and the ODS Alternatives (in particular HFCs). These Instructions issued pursuant to Article (4) and (30) of the National Environment Protection Law No. (6).
- Climate change bylaw No. 79 for the year 2019, the MoEnv declared this bylaw to ensure full engagement of all stakeholders including both technical and decision makers. The bylaw set the procedures for climate change projects, to be ratified by the national climate change committee that include stakeholders from all governmental entities. The committee has the right to invite and consult with experts when needed.
- Air Protection Bylaw No. (28) of 2005, which stated that any entity shall comply to the national regulations of the use of the substances under the control of Montreal Protocol.
- Jordan Environment Fund 2018 bylaw and its amendments, to encourage development initiatives aimed at the optimal use of environmental components and natural resources toward sustainable development.

### 4.4. Adaptation Scoreboard

The adaptation scoreboard is part of the SECAP template developed by the JRC. The municipality is intended to realize a self-assessment of its adaptation status, putting a grade from A to D, in line with its progress.

Climate Adaptation Chapter Suggested Structure – CES MED Internal Guidelines More specifically:

- "A", corresponds to completion level of 75 - 100%.
- "B", corresponds to completion level of 50-75%.
- "C", corresponds to completion level of 25-50%. Finally,
- "D", corresponds to completion level of 0-25%.

The municipality will put one of these four grades to each one of the adaptation cycle specific steps, as presented Table 60.

*Table 60 Municipality's score in the Adaptation Cycle Specific Steps (SECAP template)*

| Adaptation Cycle Steps | Actions | Grade |
|---|---|---|
| Step 1: Preparing the ground for Adaptation | Adaptation commitments defined/integrated into the local climate policy | |
| | Human, technical and financial resources identified | |
| | Adaptation team (officer) appointed within the municipal administration and clear responsibilities assigned | |
| | Horizontal (e.g. across departments) coordination mechanisms in place | |
| | Vertical (e.g. across governance levels) coordination mechanisms in place | |

| | | |
|---|---|---|
| | Consultative and participatory mechanisms set up, fostering the multi stakeholder engagement in the adaptation process | |
| | Continuous communication process in place | |
| Step 2: Assessing risks and vulnerabilities to climate change | Mapping of the possible methods and data sources for carrying out a Risk &Vulnerability Assessment conducted | |
| | Assessment of climate risks and vulnerabilities undertaken | |
| | Possible sectors of actions identified and prioritized | |
| | Available knowledge periodically reviewed and new finding integrated | |
| Steps 3 and 4 – Identifying, assessing and selecting adaptation options | Full portfolio of adaptation actions compiled, documented and assessed | |
| | Possibilities of mainstreaming adaptation in existing policies and plans assessed, possible synergies and conflicts identified | |
| | Adaptation actions developed and adopted | |
| Step 5: Implementing | Implementation framework set with clear milestones | |
| | Adaptation actions implemented and mainstreamed as defined in the SECAP document | |

| | | |
|---|---|---|
| | Coordinated action between adaptation and mitigation set | |
| Step 6: Monitoring and evaluation | Monitoring framework in place for adaptation actions | |
| | Appropriate monitoring and evaluation indicators identified | |
| | Regular monitoring of the progress and reporting to the relevant decision makers | |
| | Adaptation strategy and/or Action Plan updated, revised and readjusted according to the findings of the monitoring and evaluation procedure | |

### 4.5. Risk Assessment and Vulnerability Analysis

In order to conduct a risk assessment and vulnerability analysis, as a first step, the climate hazard types should be identified. These hazard types in general and for the Maghreb and Mashreq countries in particular, are presented in Table 2, while those applicable for Ma'an have been identified.

*Table 61 Climate Hazard Types*

| **General Climate Hazard Types** | **Applicable for Ma'an region** |
|---|---|
| Extreme heat | X |
| Extreme cold | |
| Landslides | X |
| Storms | |

| | |
|---|---|
| Droughts | X |
| Sea level rise | |
| Floods | X |
| Extreme precipitation | X |
| Forest fires | |
| Ice and snow | X |

The municipalities are called in to assess the impact that each climate hazard type has on a series of Vulnerable/ Impacted sectors, such as:

- Health
- Infrastructure (Energy, Water, Transport)
- Built environment
- Economy (Tourism, Agriculture and Forestry)
- Biodiversity (Green zones/ forests)

These sectors have been identified as the most relevant for the Maghreb / Mashreq region, utilizing info from Future Cities Adaptation Compass Tool, Mayors' Adapt, as well as the European Climate Adaptation Platform website. Ma'an Municipality has filled in table 3, in order to conduct the vulnerability analysis, based on sources such as the Future Cities Adaptation Compass Tool and UNFCCC, as well as the CES MED Internal Guidelines for the Climate Adaptation Chapter.

*Table 62 Vulnerability analysis (based on the Future Cities Adaptation Compass tool)*

| **Receptors** | | **Extreme weather event** | **Potential effects** | **Who/What is affected** |
|---|---|---|---|---|
| Population | Public Health | Extreme heat | - Deaths due to cardiovascular diseases<br>- Spread of vector born and infectious diseases<br>- Altered allergic pattern<br>- Heat stress | Everyone, but especially elderly people, babies, children, workers in outdoor environments and sensitive groups of people |
| | | Landslides | - Injuries and deaths | All people living or working in the area |
| | | Droughts | - Asthma and cardiovascular diseases<br>- Accumulation of trace elements | All people living or working in the area |
| | | Floods | - Injuries and deaths<br>- Water-borne diseases<br>- Asthma and respiratory allergies | All people living or working in the area |
| | | Extreme Precepetation | - The spread of insects and diseases such as malaria. | All people living or working in the area |
| Infrastructure | Transport | Extreme heat | - Rail and road network damages<br>- Change in behavior patterns<br>- Air quality problems | Roads, rail roads, public transport, people mobility |

| | | | | |
|---|---|---|---|---|
| | | | - Higher maintenance costs | |
| | | Landslides | - Damages<br>- Mobility difficulties in afflicted areas | Roads, rail roads, public transport, people mobility |
| | | Droughts | - Difficult transport of bulk material | Waterways, water management |
| | | Floods | - Damages<br>- Mobility difficulties in afflicted areas | Roads, rail roads, public transport, people mobility |
| | | Extreme Precipitation | - Damages.<br>- Road sliding. | Roads, rail roads, public transport |
| | Energy | Extreme heat | - Altered electricity peaks/demand<br>- Damages<br>- Cooling problems<br>- Reduction of efficiency yield from conventional power plants and distribution grid<br>- Higher maintenance costs | Conventional power plants, electricity providers and consumers |
| | | Landslides | - Damages<br>- Operational difficulties | All facilities in the electricity generation (including RES such as PVs), as well as the electricity transmission and distribution grid |

| | | | | |
|---|---|---|---|---|
| | | Droughts | - No/lower production from hydro power plants<br>- Energy supply and demand patterns' shift<br>- Higher maintenance costs<br>- Cooling problems | Conventional and renewable energy facilities (hydro, PVs, etc.) |
| | | Floods | - Damages<br>- Operational difficulties | All facilities in the electricity generation, transmission and distribution grid in the affected areas |
| | | Extreme Precipitation | - Higher maintenance costs.<br>- Network outage. | Electrical network. |
| | Water | Extreme heat | - Higher water demand<br>- Water quality issues<br>- Higher maintenance costs | Public health, water infrastructures |
| | | Landslides | - Damages<br>- Water quality issues | Public health, water infrastructures |
| | | Droughts | - Water scarcity<br>- Water quality issues<br>- Higher maintenance costs | Public health, water infrastructures |
| | | Floods | - Water quality issues<br>- Water management issues<br>- Damages | Public health, water infrastructures |

| | | | | |
|---|---|---|---|---|
| | | | - Higher maintenance costs | |
| | | Extreme Precipitation | - Extreme mismatches between water supply and demand.<br>- Reduce the groundwater supply. | Water resources. |
| | Social | Extreme heat | - Higher electricity demand to cover cooling needs<br>- Changes in behavior patterns, e.g. living outdoors<br>- Burdening of the health care facilities due to the increased number of patients in hospitals | Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities |
| | | Landslides | - Damages in social facilities in afflicted areas | Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities |
| | | Droughts | - Difficulties in meeting water demand for athletic facilities (e.g. swimming pools) and green public spaces | Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities |

| | | | | |
|---|---|---|---|---|
| | | Floods | - Flooding of social facilities in afflicted areas<br>- Burdening of the health care facilities due to the increased number of patients in hospitals | Hospitals, schools, public places, municipal facilities, athletic facilities |
| | | Extreme Precipitation | - Damages in social facilities | Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities |
| Built Environment | Building stock and material | Extreme heat | - Concrete's damages<br>- Increased cooling demands<br>- Higher maintenance costs<br>- Urban heat island effect | All building infrastructure |
| | | Landslides | - Extensive damages | All building infrastructure in afflicted areas |
| | | Droughts | - Higher water demand | All building infrastructure |
| | | Floods | - Damages<br>- Higher maintenance costs | All building infrastructure in afflicted areas |
| | | Extreme Precipitation | - Partial destruction of infrastructures | All building infrastructure |

| | | | | |
|---|---|---|---|---|
| Economy | Tourist | Extreme heat | - Increased demand for cooling<br>- Lower touristic flows during the impacted seasons<br>- Higher water demand | Tourists, tourist infrastructure, tourist related economy |
| | | Landslides | - Lower touristic flows<br>- Damages in touristic infrastructure | Tourists, tourist infrastructure, tourist related economy |
| | | Droughts | - Increased pressure on water resources, escalating water scarcity issues<br>- Increased water supply costs | Tourists, tourist infrastructure |
| | | Floods | - Damages in touristic infrastructure and related costs for repairs | Tourists, tourist infrastructure |
| | | Extreme Precipitation | - Reduced the length of tourist season | Tourists, tourist infrastructure, tourist related economy |
| | Agriculture | Extreme heat | - Changes in growth cycle<br>- Damages / loss of harvest<br>- Livestock loss and impacts on health<br>- Lower crop yields | Farmers, food industry, consumers |

| | | | | |
|---|---|---|---|---|
| | | Landslides | - Damages / loss of harvest in afflicted areas / loss of livestock<br>- Potential property loss in afflicted areas<br>- Loss of soil resources | Farmers, food industry, consumers |
| | | Droughts | - Damages / loss of harvest<br>- Lower crop yields<br>- Livestock loss and impacts on health<br>- Land degradation | Farmers, food industry, consumers |
| | | Floods | - Damages / loss of harvest in afflicted areas / loss of livestock | Farmers, food industry, consumers |
| | | Extreme Precipitation | - Destruction of food crops. | Food industry |
| Biodiversity | Coastal zone ecosystems | Extreme heat | - Increased coral bleaching<br>- Migration of coastal species towards higher altitudes<br>- Reduction of vulnerable fishing stock<br>- Altered flora and fauna, new and invasive species | Ecosystem, fish industry, consumers |
| | | Landslides | - No effects | - No effects |

| | | | | |
|---|---|---|---|---|
| | | Droughts | - Increase of coastal water salinity<br>- Loss of species<br>- Altered flora and fauna, new and invasive species | Ecosystem |
| | | Floods | - Loss of species<br>- Altered flora and fauna, new and invasive species | Ecosystem |
| | | Extreme Precipitation | - Cut down trees | Forest and private trees |

*Table 63: Risk assessment*

| **Receptors** | | **Weather Sensitivity** | **Future Risk** | **Impact** |
|---|---|---|---|---|
| Population | Public Health | Extreme heat | - Increased number of deaths<br>- Reinforcement of heat stress<br>- Increased infectious diseases<br>- Altered allergic patterns<br>- Chronic respiratory diseases<br>- Vector Born Diseases (VBD)<br>- Skin diseases Melanoma and sunburn | Medium |
| | | Landslides | - Increased number of injuries and deaths<br>- More respiratory problems | Medium |

| | | | | |
|---|---|---|---|---|
| | | Droughts | - Increased allergic incidents<br>- Decreased air quality<br>- More respiratory problems<br>- Consumption and use of unsafe (contaminated) water for drinking due to water scarcity<br>- Malnutrition<br>- Food shortages | Medium |
| | | Floods | - Limitations to the healthcare access<br>- Increased numbers of injuries and deaths<br>- Epidemics of water and foodborne diseases | Low |
| | | Extreme Precipitation | - Increased number of deaths - Reinforcement of heat stress - Increased infectious diseases - Altered allergic patterns - Chronic respiratory diseases - Vector Born Diseases (VBD) | Medium |
| Infrastructure | Transport | Extreme heat | - Damages on road and rail network<br>- Modification of transport frequency and means<br>- Air quality problems<br>- Higher maintenance costs | Medium |
| | | Landslides | - Damages on road and rail network<br>- Modification of transport frequency and means<br>- Higher maintenance costs | Medium |

| | | | | |
|---|---|---|---|---|
| | | Droughts | - Difficult transport of bulk material | Medium |
| | | Floods | - Damages<br>- Mobility problems | High |
| | | Extreme Precipitation | - Damages on road and rail network<br>- Modification of transport frequency and means<br>- Higher maintenance costs | High |
| | Energy | Extreme heat | - Blackouts and inability to cover demand load<br>- Damages, especially in the thermal power plants | High |
| | | Landslides | - Damages in the transmission and distribution grid -<br>- Damages in any power generating plants, including RES (PVs) in afflicted areas | Medium |
| | | Droughts | - Blackouts and inability to cover demand load<br>- Higher maintenance costs<br>- Cooling problems in power plants | Medium |
| | | Floods | - Damages / power cuts | Medium |
| | | Extreme Precipitation | - Damages in the transmission and distribution grid<br>- Damages in any power. | High |
| | Water | Extreme heat | - Water scarcity<br>- Water quality issues | High |

| | | | | |
|---|---|---|---|---|
| | | Landslides | - Water scarcity due to infrastructure damages<br>- Water quality issues due to infrastructure damages | Medium |
| | | Droughts | - Water scarcity<br>- Water quality issues | Medium |
| | | Floods | - Increased damages and related maintenance costs<br>- Water management issues<br>- Water quality issues | Low |
| | | Extreme Precipitation | - Water scarcity<br>- Water quality issues | Medium |
| | Social | Extreme heat | - Increased needs for air conditioned public spaces | Medium |
| | | Landslides | - Damages<br>- Mobility problems<br>- Increase in the numbers of people burdening the health care facilities | Medium |
| | | Droughts | - Increased numbers of people presenting respiratory problems and burdening the health care facilities<br>- Inability to cover the water demand<br>- Difficulties in the operation of certain facilities due to lack of water (e.g. swimming pools) | Medium |

| | | | | |
|---|---|---|---|---|
| | | Floods | - Damages<br>- Increased maintenance costs<br>- Flooding at the city level of the afflicted public building infrastructure (schools, hospitals, etc.) - Difficulties in providing the envisaged services | Low |
| | | Extreme Precipitation | - Damages | Medium |
| Built Environment | Building stock and material | Extreme heat | - Concrete's damages<br>- Increased cooling demands<br>- Higher maintenance costs<br>- Urban heat island effect | Low |
| | | Landslides | - Damages | Low |
| | | Droughts | - Higher water demand | Medium |
| | | Floods | - Damages<br>- Increased maintenance costs | Medium |
| | | Extreme Precipitation | - Concrete's damages.<br>- Infrastructure Damages | Medium |
| Economy | Tourist | Extreme heat | - Change of the tourism season – lower touristic flows<br>- Reduction of the tourism related economy | Medium |
| | | Landslides | - Potential damage to touristic infrastructures and sites | Low |

| | | | | |
|---|---|---|---|---|
| | | Droughts | - Increased water supply costs<br>- Potential increase of indirect costs for the tourists (infrastructure related) and reduction of touristic flows | Low |
| | | Floods | - Damages to touristic facilities<br>- Potential effects on the touristic flows, in areas with flooding history | High |
| | | Extreme Precipitation | - Change of the tourism season – lower touristic flows<br>- Reduction of the tourism related economy | Medium |
| | Agriculture | Extreme heat | - Changes in growth cycle<br>- Damages / loss of harvest<br>- Livestock loss and impacts on health<br>- Lower crop yields<br>- Increased fire risks | High |
| | | Landslides | - Damages/ loss of harvest<br>- Loss of soil and reduction of cultivated lands | Medium |
| | | Droughts | - Damages / loss of harvest<br>- Lower crop yields<br>- Livestock loss and impacts on health<br>- Land degradation<br>- Increased fire risks | High |

| | | | | |
|---|---|---|---|---|
| | | Floods | - Damages/ loss of harvest in afflicted areas<br>- Livestock loss<br>- Surface soil erosion | High |
| | | Extreme Precipitation | - Damages/ loss of harvest.<br>- Loss of soil and reduction of cultivated lands | High |
| Biodiversity | Green zones/ Forests | Extreme heat | - Fires and destruction of the ecosystem, flora and fauna | High |
| | | Landslides | - Destruction of agricultural lands | Medium |
| | | Droughts | - Fires and destruction of the ecosystem, flora and fauna | High |
| | | Floods | - Soil erosion | High |
| | | Extreme Precipitation | - Destruction of agricultural lands | Low |

### 4.6. Adaptation Actions

The municipality, having compiled the vulnerability analysis and risk assessment, needs to identify a specific set of actions that will allow it to adapt to the situation it faces. A list of adaptation actions, identified from the international literature and best practices available, are presented in the following tables, for each one of the five sectors studied above. Of course, these lists are not exhaustive and the consultants can look for additional measures, depending also on the local needs and situation; however, they are considered a good starting point. For each one of the five sectors, a further distinction of the adaptation actions in four categories is realized:

- Strategic actions. Actions regarding the formulation of action plans, or strategic policy planning documents, that set the basis for all the actions to come in the specific sector.
- Alert /Communication actions. These are focusing on alerting the citizens on a situation, such as an extreme climate event or hazard (high temperatures, floods, tsunamis etc.).

- Educational actions. The focus in this case is given on increasing the awareness raising level of the citizens on a specific threat or situation that the municipality is faced and requires the citizens' collaboration in one way or another.
- Technical actions. Activities that are directly addressing in a technical the specific climate hazard.

### 4.6.1. Public Health

The first sector to be examined, Public Health is of utmost importance since it has direct impacts on population and their living. Table 5 below focuses on a set of suggested adaptation actions on the population and public health.

*Table 64: Suggested adaptation actions for population and public health*

| Actions' characteristic | Adaptation Actions |
|---|---|
| Strategic | Improved understanding of the potential risk on health sector due to climate change |
| | Provide access to air-conditioned public buildings during heat waves or other extreme events, for those citizens that lack the infrastructure to protect themselves (people living in underground apartments during floods, or lacking AC during extreme temperatures etc.) |
| Alert / Communication | Developing an early warning system to alert citizens in the case of extreme weather events |
| Educational | Educational and awareness raising campaigns about health-related effects of extreme events |
| Technical | Regular cleaning and maintenance of the sewage and drainage system |

**Understanding of the potential risk on health sector due to climate change**

This programme aims at enhancing collective knowledge about the potential and observed impacts of climate change on health conditions for individuals and communities. The programme measure should mobilize related institutions and experts to conduct studies and observations of climate

impacts on health in terms of changing climate conditions or the emergence of climate related infectious diseases in Ma'an. Key measures to be applied under this programme include:

1. Building the needed capacities to conduct health vulnerability assessments

2. Educating and informing the public of the needed measures to protect health from the adverse impacts of climate change

3. Developing climate-informed disease control programmes and surveillance systems using meteorological services to target vector control in time and space

4. Introducing new indicators that are useful for protecting health, such as Air Quality Index, UV index, in cooperation with the relevant institutions

5. Developing new methods and tools for preparing for, coping with, and recovering from outbreaks of climate-sensitive diseases, such as early warning systems based on environmental information

**Provide access to public buildings during extreme events**

There is a part of the population which lacks the infrastructure to protect themselves during extreme weather events. The Municipality may provide air-conditioned spaces in public buildings for those who have not ACs in their residences so as to eliminate the health impacts due to high temperatures. Moreover, public buildings may be provided as well, to citizens living in underground apartments, in case of floods.

**Developing an early warning system to alert citizens in the case of extreme weather events**

Following the forecasting of an extreme event, immediate notification of the public and all those participating in the response is critical to ensure safety. The warning system should include early meteorological announcements followed by protection and medical advices. The aim is to alert those citizens who are most at risk so as to take the appropriate precautions. These extreme weather events consider heat waves, floods, droughts, as well as landslides in specific areas. This action should be realized in coordination to a national action at this level, or cooperation with other municipalities, as it is a high cost and difficulty activity for Ma'an municipality.

**Educational and awareness raising campaigns about health-related effects of extreme events**

Campaigns should include information and advices for citizens on how they can protect themselves in case of extreme heats, floods, landslides, vector borne diseases etc. so as to prevent impacts and infections. The aim is to communicate the risks disseminating public messages through media, informational material and social media. Special efforts should be made to reach vulnerable population such as elderly people, children, citizens with chronic diseases and employees working outdoors. The estimated cost for this action is 30,000 JOD.

**Regular cleaning and maintenance of the sewage and drainage system**

A rise in temperature due to climate change will increase microorganisms' growth. In addition, floods as a result of extreme rainfall leads to disruption of water purification and contamination with sewage disposal systems, leading to increase the probability of epidemics. Subsequently the regular cleaning and maintenance of the sewage and drainage system is vital in order to mitigate the health risks.

### 4.6.2. Infrastructure

The next section regards infrastructure and actions to mitigate the climate impacts on them are presented.

*Table 65: Suggested adaptation actions for infrastructure*

| Actions' characteristic | Adaptation Actions |
|---|---|
| Strategic | Regulations and incentive measures in residential buildings |
| | Plan for a network of public chargers for electric vehicles |
| | Modelling predicted supply changes in the electricity from the locally available RES |
| Alert / Communication | Improving rainfall early warning systems and reducing flood risks |
| Technical | Promote water-harvesting techniques at all levels of economic development and water use (buildings, agriculture, industry, etc…) based on suitable local conditions. |
| | Promote the use of non-conventional water sources especially treated wastewater for non-domestic water use and harvest rainwater in the urban areas from rooftops and greywater reuse both at the institution level and at household level to support vulnerable households and communities |

**Regulations and incentive measures in residential buildings**

This action involves a wholistic approach to ensuring that new residential buildings are sustainable and go beyond current national standards, including: Energy efficiency and renewable energy measures in new residential constructions, namely:

1. Building regulations that consider energy use in new constructions / major renovations of existing buildings (residential buildings) – going beyond the requirements of national legislation

2. Encouraging through financial support the use of renewable energy / efficient energy sources (residential buildings) - Typical measure usually includes solar PV or water heating, or biomass, or heat pumps.

**Plan for a network of public chargers for electric vehicles**

The aim of this measure is to support the planning of charging stations for electric vehicles (EV) in a city in which the objective is to maximize the number of serviced vehicles under a fixed budget for building the stations. Accelerated electric vehicles adoption gives local governments and municipalities the chance to meet sustainability goals, reduce the carbon emissions, and attract more visitors to the community. Furthermore, according to the Free Zones Vehicle Sector, in 2022, the demand for electric vehicles has risen by 250 percent, compared with last year. The demand for the electric vehicles will increase next year, noting that the market share of electric vehicles was 30 percent of the total of vehicles cleared in 2022. Therefore, establishing Electric charging stations is a must to encourage the municipality's residents to buy electric vehicles and to cover the increasing numbers during the next few years.

**Modelling predicted supply changes in the electricity from the locally available RES**

A certain part of electricity consumption in Ma'an, but also in all Jordan, depends on Renewable Energy Sources. The extreme weather events may cause malfunctions in the energy supply leading in major problems in the city (e.g. patients who lives in their homes under technical assistance). Subsequently, problems should be predicted via prediction models in order for Municipality to plan what actions should take to face the situation in each case.

**Rainfall early warning systems**

The programme aims at addressing one of the major acute threats of climate change in Jordan which is represented by the increasing frequency of flashfloods due to heavy and erratic rainfall that caused immediate risks on lives, livelihoods, economic assets and infrastructures. With such phenomena expected to increase in the future it is important to address this risk systematically.

**Promote water-harvesting techniques**

Water is a key resource for all developmental activities especially agriculture, industry and healthcare. In a future where climate change will multiply the expected scarcity of water resources due to increased population growth and economic development, it is essential that water efficiency measures become a necessary approach in water management to enhance climate resilience and improve productivity of water use. Key measures to be applied under this programme include:

1. Introducing water saving technologies in irrigation schemes such as drip, micro-spray, and night irrigation with careful consideration of environmental impacts on soil salination.

2. Enhancing the use of water efficiency technology at household and business levels in urban and rural settings

3. Enhancing the adaptive capacity of small farmers through water user associations for increasing use of reclaimed water for irrigation purposes.

4. Increasing community awareness, behavioural change and adoption of water conservation measures through WASH cantered community behavioural change initiatives.

**Promote the use of non-conventional water sources and harvest the use of rainwater in urban areas**

This programme aims to increase the contribution on non-conventional water resources for augmentation of freshwater resources for irrigation, industrial and domestic use. This contribution will help to save more freshwater resources for drinking and sanitation practices that are associated with life at a warmer and more disease prone world.

### 4.6.3. Built Environment

The next section summarizes the proposed actions to be implemented in order to enhance the built environment and protect it from the future climate repercussions.

*Table 66: Suggested adaptation actions for built environment*

| Actions' characteristic | Adaptation Actions |
|---|---|
| Strategic | Improving readiness for climate related disaster risk reduction in urban areas |
| | Integrated land use planning with zoning system depending on the different areas |

| | |
|---|---|
| Educational | Educational campaigns on informing the citizens on the benefits of adopting the suggested actions in their premises |
| Technical | Supporting urban green infrastructure interventions for climate resilience |
| | Improving building efficiency for adapting to increased heat in urban centers. |
| | Adoption of methods to reduce water demand |

**Improving readiness for climate related disaster risk reduction**

This programme aims at enhancing institutional readiness of municipalities and community organization to anticipate and manage climate related disaster and risks, especially in the form of floods in urban areas. This programme includes mapping of flood prone areas in cities and designing alternative runoff routes to minimize risks.

**Integrated land use planning with zoning system depending on the different areas**

This action is basically the integration in the land use planning of the mapping of the region conducted before, depending the high, medium and low risk for phenomena such as flooding and landslides for characterizing certain zones. This action will be realized internally by the municipality upon the completion of the mapping.

**Educational campaigns on informing the citizens on the benefits of adopting the suggested actions in their premises**

Ma'an Municipality should organize educational campaigns in order to inform inhabitants about the risks and climate hazards on the region and propose the appropriate measures via guidebooks or other material. Thus, citizens will be able to modify their residences and businesses and convert them to more safe places which could resist floods and heat. Since Ma'an Municipality is going to implement a series of awareness activities in the mitigation and adaptation thematic fields, it is the Municipality's intention to group where possible these activities for better coordination.

**Supporting urban green infrastructure interventions for climate resilience**

This programme aims at introducing and applying green infrastructure measures in urban areas to address climate change vulnerability and impact through sustainable interventions at neighborhood levels with community participation. One of the key measures is to introduce climate responsive building techniques and elements to reduce the effect of heat and reduce demand on energy for cooling and to promote Rainwater Harvesting in urban areas from rooftops.

**Improving building efficiency for adapting to increased heat in urban centers**

This programme aims at improving the building resilience to climate change impacts through better insulation, sustainable cooling and energy efficiency measures among other interventions. The programme requires modifications in building codes and other policy and regulatory approaches to improve efficiency in buildings.

**Adoption of methods to reduce water demand**

Since water scarcity is a major problem for Jordan in general, and Ma'an especially, a solution is to adopt methods to reduce its use. Using proper showerheads, toilet flushes with adjustable flow, wash machines only when they are full are easy activities to follow in order to save water and adapt to the increasing problem of water scarcity. The estimated cost for this action is 10,000 JOD for implementation of such measures in selected Municipal buildings. Potential replication of the results is also envisaged, including awareness raising (to be combined with previous actions) targeting the residents.

### 4.6.4. Economy

Climate changes and extreme events affect the economy sector and create problems that have to be addressed promptly.

*Table 67: Suggested adaptation actions for economy*

| Actions' characteristic | Adaptation Actions |
|---|---|
| Strategic | Enhancing local adaptive capacity to climate change impacts through local climate action plans |
| | integrating climate adaptation into national poverty reduction policies |
| Educational | Integrating climate change impacts and adaptation into education curricula |

| | |
|---|---|
| Technical | Improving irrigation system efficiency |
| | Improving sustainable productivity of food chains |

**Local climate action plans to enhance the local adaptive capacity**

This programme aims to increase local capacities at institutional and individuals' levels to undertake local climate vulnerability analyses and develop, in a community participation approach local climate adaptation plan at municipal and/or governorate levels. The program ensures engagement of local community in planning and designing of local climate change adaptation plans (community participatory approach). Moreover, it will enhance climate related basic services to rural and vulnerable communities to reduce the negative impact of expected climate change effects.

**integrating climate adaptation into national poverty reduction policies**

This programme aims to highlight the importance of addressing climate resilience and climate adaptation measures in socioeconomic development plans with special emphasis on poverty reduction plans and improving services and sustainable livelihoods for communities in poverty-stricken areas.

**Integrating climate change impacts and adaptation into education curricula**

This programme will ensure that climate change is incorporated from an early age to ensure that communities are equipped to adapt to the impacts of climate change. The program will Raise the awareness through formal and informal education means in climate change, environment and sustainable development in the community and among children and young people. In addition to Develop an enhanced, unified, common entry level education curriculum that includes new themes on climate change and environment.

**Improving irrigation system efficiency**

Enhancing the efficiency of irrigation systems is the most important objective of a climate resilient agriculture in Jordan. This programme aims to enhance this effectiveness through various interventions at policy and practice levels. Key measures to be applied under this programme include

1. Develop a soil-water-plant monitoring programmes (e.g. crop/environment forecasting, RS and GIS, lysimetric, etc)

2. water harvesting techniques, maximizing treated waste water re-use in agriculture, improving water use efficiency and the augmentation of drip irrigation in irrigated areas

3. Improving soil water storage and retention to maximize plant water availability by maximizing infiltration of rainfall

4. Use of supplemental irrigation from harvested rainwater in the critical stages of crop growth achieved through on farm rainwater harvesting and management system

5. Reduce soil erosion through community management, use of Ecosystem based Adaptation (EbA) measures and harvesting of rainwater amongst small farmers in rural areas

**Improving sustainable productivity of food chains**

This programme aims to improve the contribution of agricultural sector to food security and self-sufficiency under climate change conditions and against emergency conditions. The programme targets the agricultural production and marketing value chain to ensure the continuity of affordable and sufficient food production to domestic markets while adapting to climate related challenges. Which could be achieved by Promoting efficiencies in the food chain and the reduction of post-harvest losses and food waste in a sustainable manner, increasing the efficiency of nitrogen use, improving livestock productivity.

### 4.6.5. Biodiversity

Biodiversity – the variety of life on the planet – is essential for the economy and for people well-being, but one of the main environmental challenges facing the planet is the loss of it. Conserving biodiversity and maintaining nature's capacity to deliver the related goods and services is became a priority at global scale.

*Table 68: Suggested adaptation actions for Biodiversity Table*

| Actions' characteristic | Adaptation Actions |
|---|---|
| Strategic | Improving conservation measures and enforcement for climate threatened species and habitats |
| | Establishment of a fire management plan |
| Technical | Trees planting |

**Improving conservation measures and enforcement for climate threatened species and habitats**

This programme aims at identifying the key climate sensitive habitats and species in Ma'an and developing special conservation measures that take into considerations changes in climate conditions and niches of the different sensitive species to protect them from extinction. The program involves updating and identifying key ecosystems that are highly sensitive to climate change, establishing a clear research design to target indicator species of fauna, flora and ecosystems in order to better understand the climate effects and apply adaptation measures, and developing a recovery and restoration plans for highly threatened ecosystems and species of fauna and flora including the development of clear ex-situ conservation, captive breeding programmes and re-introduction and restoration programmes.

**Establishment of a fire management plan**

The municipality will adapt a firefighting plan in order to prevent the negative effect of the fire and conduct a quick control on the fire.

**Trees planting**

An important action towards the protection of biodiversity is the tree planting and the expansion of green areas with friendly drought-tolerant plants. Trees not only contribute to the preservation of the natural habitat of fauna but they can also prevent floods and soil erosion. Moreover, they are significant actors in air cleaning which means that more trees and plants will reduce more the greenhouse gasses. This action illustrated as an action in mitigation section.