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MINARET II

Empowering Municipal Governance for Climate Resilience Using WEF Nexus Approach

Sustainable Energy and Climate Action Plan (SECAP)

Raoued 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

Raoued is a town and commune in the Ariana Governorate, Tunisia. In 2016 it had a population of 106,000. The city of Raoued is known for its beach, which is located between the beaches of Gammarth and Bizerte. The city was named Raoued in relation to the original inhabitants of the city, "Rawadiya". The number of agricultural lands has clearly become residential lands, and the population of the city has developed significantly since 2005, and the Tunis Financial Port city project is currently being built near the city of Raoued.

Raoued municipality has committed to a 40% reduction of the municipality's GHG emissions as well as to an adaptation in climate change for 2030. The involvement of all citizens and stakeholders of the municipality is considered crucial for achieving the set targets. The citizens are the most important resource for the city, especially in the GHG saving targets. Within the framework of potential participation in the Covenant of Mayors for Climate and Energy Initiative, the scenario of mitigation actions has been developed for Raoued, reaching up to 40% against the calculated 2030 emissions (343,243 tn CO_2). The achievement of this scenario is conditional upon the funding availability from grants, international donors and financing institutions.

The energy balance for Raoued Municipality (Baseline Emissions Inventory) has been developed for 2018, in line with the Covenant of Mayors (COM) guidelines and utilizing the IPCC emission factor approach, for all the compulsory sectors and one optional, namely:

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

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

C. Solid waste management.

D. Livestock breeding.

Although the agricultural sector is a significant contributor in the municipality's economy, it wasn't possible to identify separately reliable data on its energy consumptions, so as to include it in the Baseline Emission Inventory (BEI). The highest energy consumer is the Transportation followed by Residential sector and Tertiary sector, while the municipal sector consumptions are the lowest. A more detailed allocation of the calculated energy consumption in Raoued Municipality (All sectors) is presented in Figure 1 per sector and per fuel.

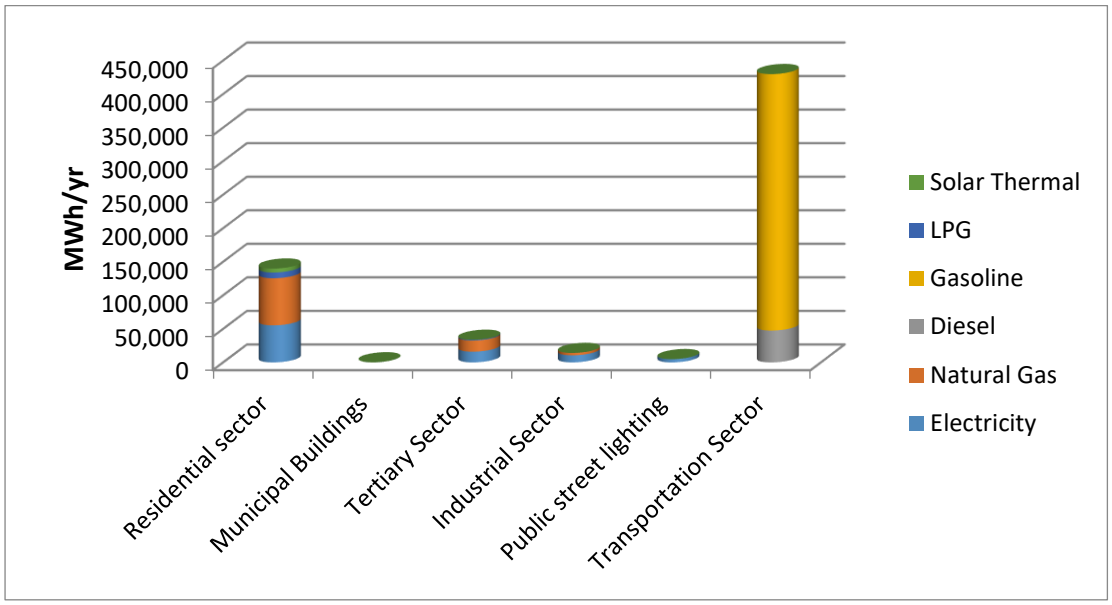


Figure 1: Energy consumption per sector and per fuel.

The respective total emissions for the baseline year, including emissions from waste management, equal 254,255 tnCO_2 and they are presented in the following chart.

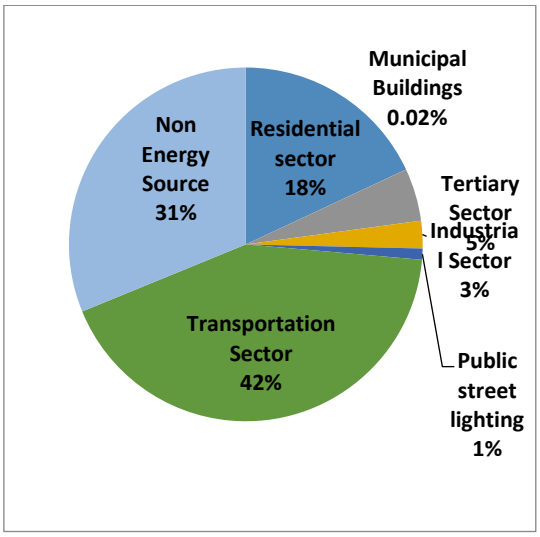


Figure 2: Total CO2 emissions per sector.

In order to set the emission reduction targets, they have to be calculated against the Business as Usual (BAU) scenario, in line with the JRC guidelines for South Municipalities, considering that Tunisia, as a country with developing economy, will face an increase in its energy demand due to the expected economic and population growth. Thus, the forecasted emissions under the BAU scenario for 2030 have been calculated to be 343,243 tn CO_2. As mentioned above.

An overview table of the actions per sector, as well as the calculated emission reductions per action for both scenarios, is presented below.

Table 1: Summary of the mitigation actions.

Action No.	Action	Emission Reductions (tn CO_2)
	Municipal Buildings and facilities	
3.2.1	Green procurement procedures for municipal buildings	2.7
3.2.2	Energy manager appointment in the municipality	1.6
3.2.3	Awareness raising activities for municipal employees	0.5
	Sub-total	**4.8**
	Public Lighting	
3.3.1	Street lighting upgrade	1,031
3.3.2	Astronomical timers	335
3.3.3	Green procurement procedures for future lighting equipment	794
	Sub-total	**2,160**
	Residential Sector	
3.4.1	Awareness raising activities for modification of the residents' consumption behavior and energy saving	9,030
3.4.2	Replacement of existing lamps with LEDs	3,444
3.4.3	Replacement of existing air-conditioners with more efficient ones	3,444
3.4.4	Building envelope improvement for the existing buildings	4,524
3.4.5	Installing 18 MW Photovoltaics on residential rooftops	15,107
3.4.6	Replacing existing water heaters with solar water heaters	14,361
	Sub-total	**49,910**
	Tertiary Sector	
3.5.1	5.1 MWp Photovoltaics on rooftops	4,305
3.5.2	Replacing existing water heaters with solar collectors	374
	Sub-total	**4,679**
	Industrial Sector	
3.6.1	Install photovoltaic systems in the industrial sector	2,849
	Sub-total	**2,849**
	Transportation Sector	
3.7.1	Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract	53.5
3.7.2	Train drivers in eco driving	40
3.7.3	Improve the process of car repair and purchasing new vehicles	26.7
3.7.4	Transfer of taxi stations and regulation of taxi traffic	322
3.7.5	Improve the city bus network	1,274

3.7.6	Raise public awareness of public transport	2,101
3.7.7	Improve and secure bike paths	7,969
3.7.8	Transfer all government departments and institutions to one complex near to the population centers in the city	5,359
3.7.9	Establishing central markets near dense residential areas	4,287
3.7.10	Promotion of using schools' buses rather than private cars	700
3.7.11	Replacing 5% of the existing Taxi vehicles with electric vehicles	1,714
3.7.12	Information events on the new vehicle technologies	996
	Sub-total	**24,842.2**
	Agricultural Sector	
3.8.1	Planting trees (increasing green areas)	8,640
	Sub-total	**8,640**
	Solid Waste Sector	
3.9.1	Promotion of Recycling	1,532
3.9.2	Waste Management	49,500
	Sub-total	**51,032**
	Total	**144,117**

The fourth Chapter of the SECAP concerns the Adaptation to climate change. The last 20 years significant changes in the global climate have occurred which negatively affect life in many aspects. This section presents the current situation in Raoued and the expected problems due to the climate change impacts. Subsequently a set of actions are proposed towards the city protection against the forecasted extreme weather events. Tunisia has already launched the "Tunisia's Third National Communication on Climate Change" report in 2016, which is dealing with the above-mentioned topic. The national targets presented on this report are consistent with the SECAP actions.

1. Introduction

1.1. Raoued 2030 Targets

The overall National target that has been set for 2030 is 45% CO_2 emissions reduction compared to that of the reference year 2010 (according to the Intended Nationally Determined Contributions - INDCs). Which matches the required reduction percentage 40% according to COM requirements, emphasis is placed on working closely with all community actors. The municipality will take all necessary measures on its facilities, establishing a good example for the community, while it will put efforts on collaborating with the public and achieving significant reductions from the residential, tertiary and transport sectors, with waste being also a priority for the local administration. The target of 40% has big challenge and there will be need of more intensive efforts from the Municipality and the Governmental Bodies while it is of utmost importance to attract more donors and funds.

1.2. Current status

1.2.1. Geographical location

Raoued Municipality is one of the Municipalities of the Republic of Tunisia, located in the southeastern region of the province of Ariana. It is 13 kilometers (8 miles) north of Tunis, the capital. It is bordered by the delegation of Al-Andalus Castle from the north and west, the delegation of Soukra and Ariana city from the south and the Mediterranean Sea from the east. Its population was about 134,465 in 2018. The delegation area extends to 56.2 Km^2. [1]

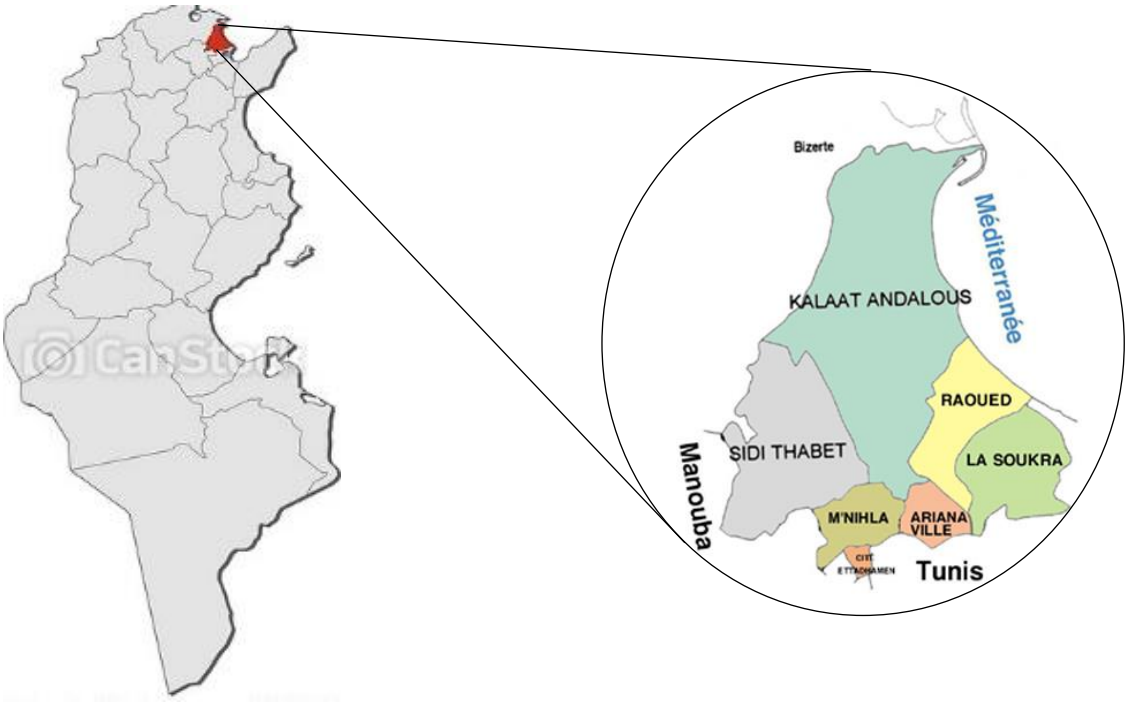


Figure 3: Ariana map including Raoued delegation map. [2&3]

The city witnessed a great development in a short period, as the city was semi-rural (agricultural lands and raising cows and livestock). Recently, it became more architectural, and the number of agricultural lands has clearly decreased to become residential lands. [1]

The city of Raoued is known for its "Raoued Beach" beach, which is located between the beaches of Gammarth and Bizerte. The city is called "Raoued" because of to the original inhabitants of the city, "Raouediyah." The number of agricultural lands has clearly become residential lands. Raoued is considered to have a strategic location due to its proximity to Gammarth, La Marsa, Ariana, which are considered vital cities and places. [1]

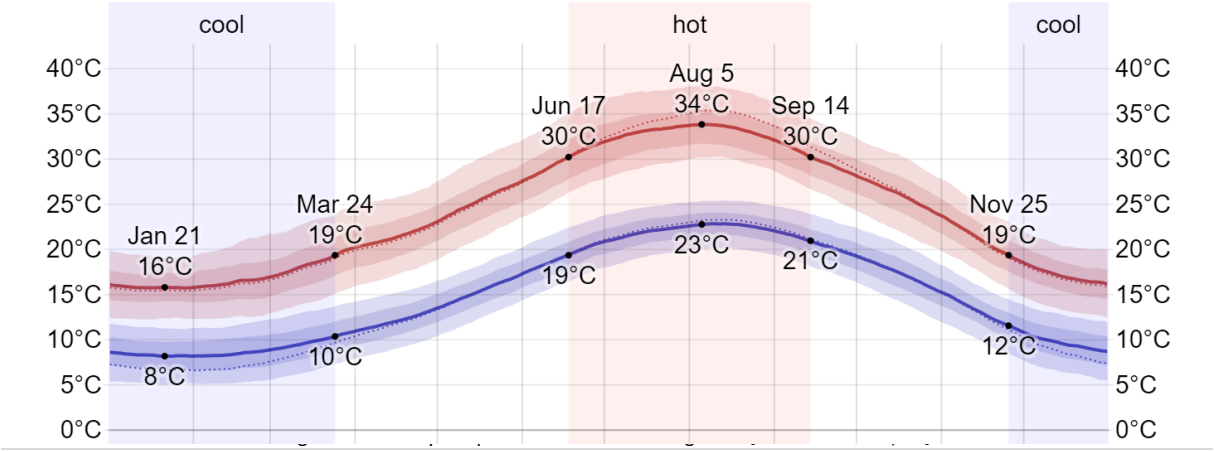
Figure 4: Raoued Beach. [4]

1.2.2. Climate characteristics

In Ariana, the summers are short, hot, humid, dry, and clear and the winters are long, cool, windy and partly cloudy. Over the year, the temperature typically varies from 8°C to 34°C. [5]

The hot season lasts for 2.9 months, from June 17 to September 13, with an average daily high temperature above 30°C. The hottest month of the year is August, with an average high of 33°C and low of 23°C.[5]

The cool season lasts for 4.0 months, from November 25 to March 24, with an average daily high temperature below 19°C. The coldest month of the year is January, with an average low of 8°C and high of 16°C. [5]



The figure below shows 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 color is the average temperature for that hour and day). [5]

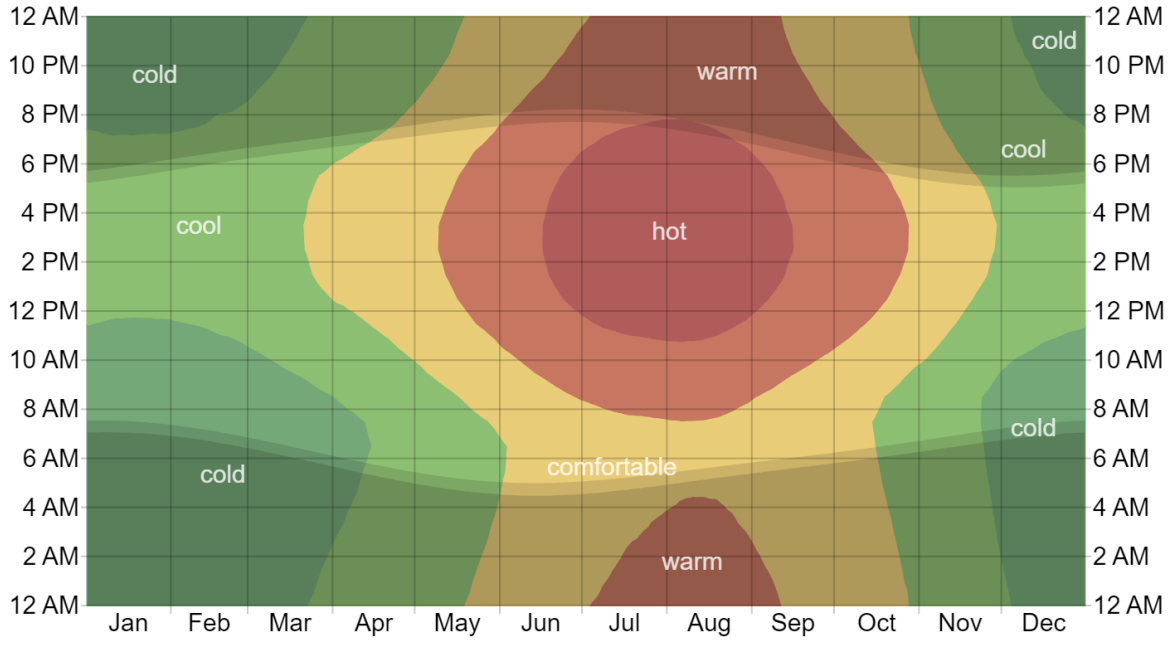


Figure 6: Average Hourly Temperature in Ariana. [Source Weather Spark]

Clouds

In Ariana, 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 begins around June 13 and lasts for 2.9 months, ending around September 9. The clearest month of the year is July, during which on average the sky is clear, mostly clear, or partly cloudy 94% of the time. [5]

The cloudier part of the year begins around September 9 and lasts for 9.1 months, ending around June 13. The cloudiest month of the year in Ariana is October, during which on average the sky is overcast or mostly cloudy 41% of the time. [5]

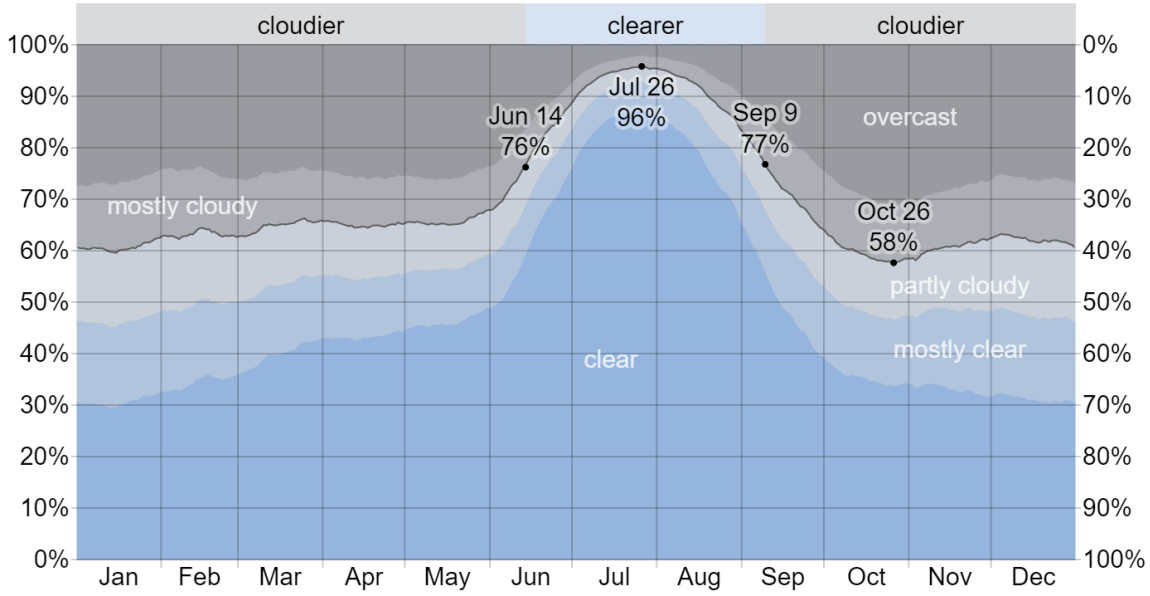


Figure 7: The percentage of time spent in each cloud cover band. [Source Weather Spark]

Precipitation

A wet day is one with at least 1.00 millimeters of liquid or liquid-equivalent precipitation. The chance of wet days in Ariana varies throughout the year. [5]

The wetter season lasts 8.6 months, from August 31 to May 19, with a greater than 13% chance of a given day being a wet day. The month with the wet days is October, with an average of 6.3 days with at least 1.00 millimeters of precipitation. [5]

The drier season lasts 3.4 months, from May 19 to August 31. The month with the fewest wet days in Ariana is July, with an average of 1.2 days with at least 1.00 millimeters of precipitation. [5]

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 is October, with an average of 6.3 days. Based on this categorization, the most common form of precipitation throughout the year is rain alone, with a peak probability of 22% on September 28. [5]

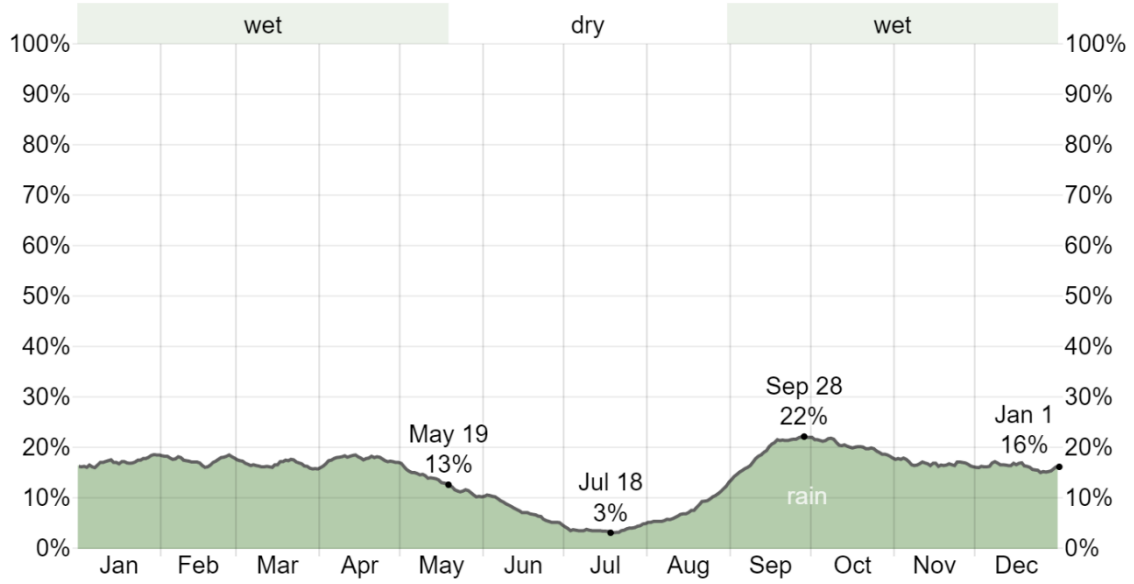


Figure 8: Daily Chance of Precipitation in Ariana. [Source Weather Spark]

Rainfall

To show variation within the months and not just the monthly totals, we show the rainfall accumulated over a sliding 31-day period centered on each day of the year. Raoued experiences some seasonal variation in monthly rainfall. [5]

The rainy period of the year lasts for 9.9 months, from August 19 to June 16, with a sliding 31-day rainfall of at least 13 millimeters. The month with the most rain is October, with an average rainfall of 37 millimeters. The rainless period of the year lasts for 2.1 months, from June 16 to August 19. The month with the least rain is July, with an average rainfall of 5 millimeters. [5]

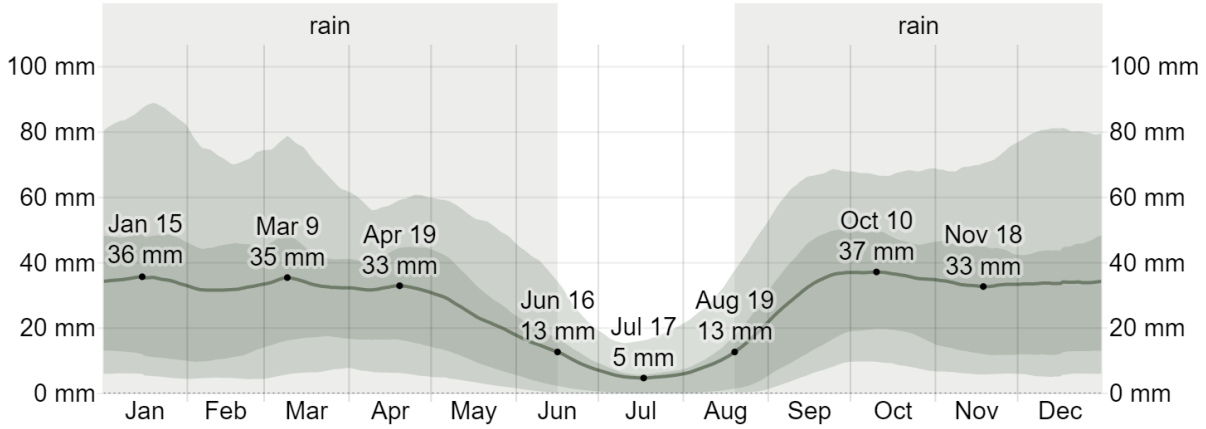


Figure 9: Average Monthly Rainfall in Ariana. [Source Weather Spark]

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. [5]

The muggier period of the year lasts for 4.3 months, from June 14 to October 23, during which time the comfort level is muggy, oppressive, or miserable at least 16% of the time. The month with the muggiest days in Ariana is August, with 18.8 days that are muggy or worse. [5]

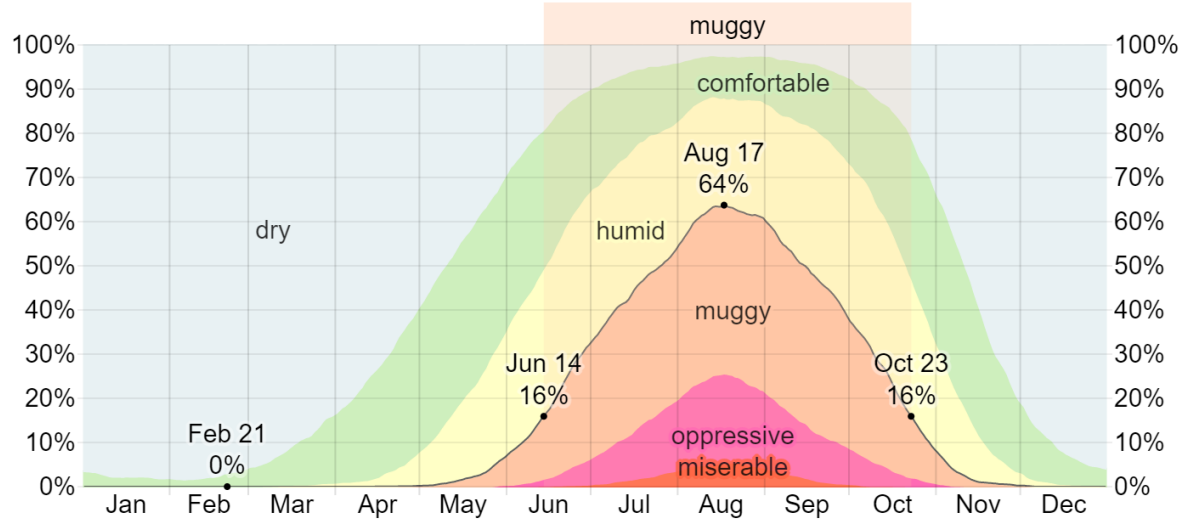


Figure 10: The percentage of time spent at various humidity comfort levels, categorized by dew point. [Source Weather Spark]

The least muggy day of the year is February 21, when muggy conditions are essentially unheard of. [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. [5]

The average hourly wind speed in Ariana experiences mild seasonal variation over the course of the year. [5]

The windier part of the year lasts for 6.3 months, from November 5 to May 13, with average wind speeds of more than 4.7 meters per second. The windiest month of the year in Ariana is February, with an average hourly wind speed of 5.2 meters per second. [5]

The calmer time of year lasts for 5.7 months, from May 13 to November 5. The calmest month of the year in Ariana is August, with an average hourly wind speed of 4.0 meters per second. [5]

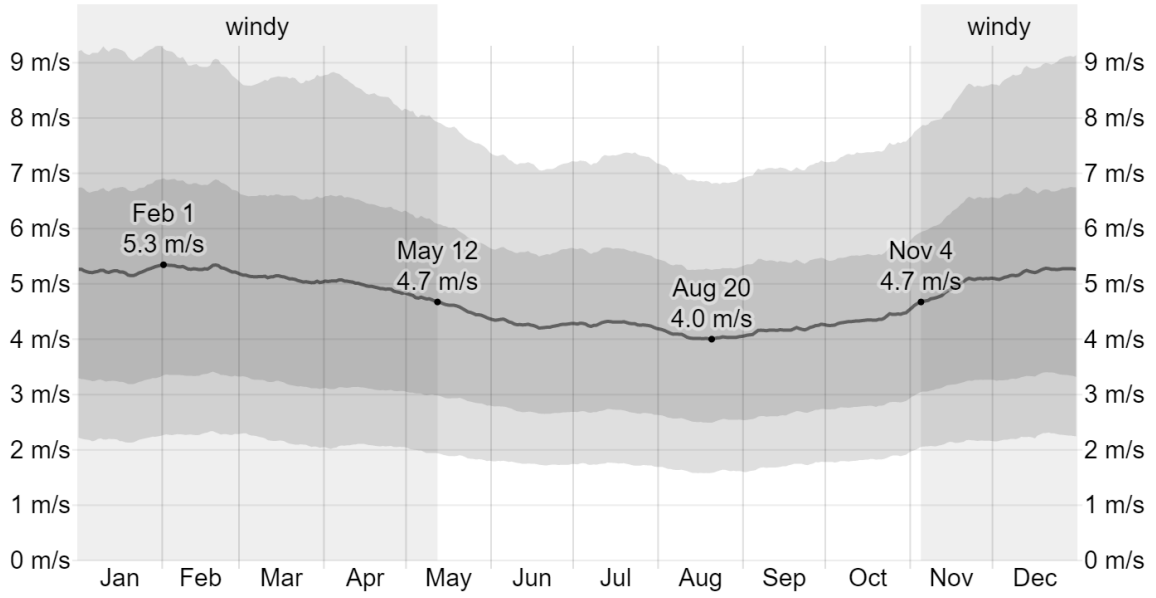


Figure 11: Average Wind Speed in Ariana. [Source Weather Spark]

The predominant average hourly wind direction varies throughout the year. The wind is most often from the north for 4.1 months, from May 23 to September 26, with a peak percentage of 39% on August 19. The wind is most often from the west for 7.9 months, from September 26 to May 23, with a peak percentage of 49% on January 1. [5]

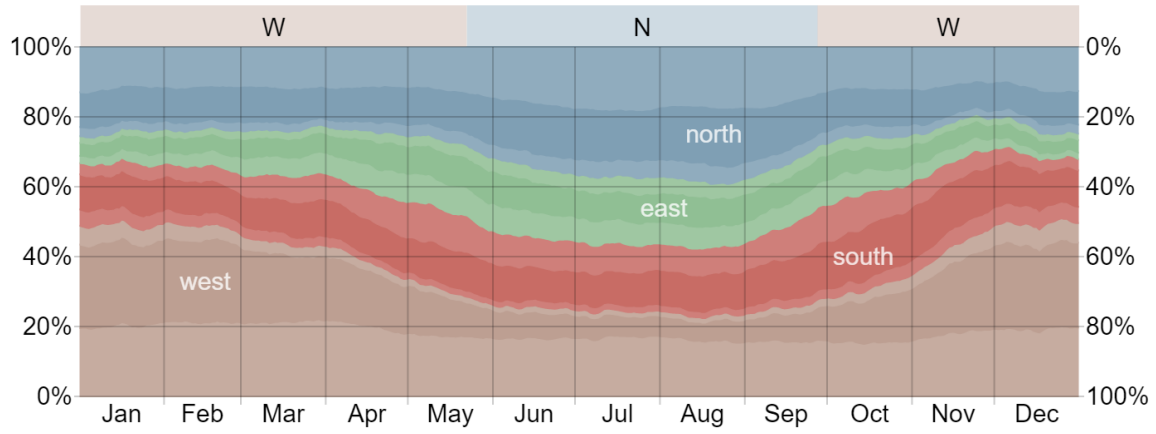


Figure 12: Wind Direction in Ariana. [Source Weather Spark]

Water Temperature

Raoued is located near a large body of water (e.g., ocean, sea, or large lake). This section reports on the wide-area average surface temperature of that water. [5]

The average water temperature experiences extreme seasonal variation over the course of the year. [5]

The time of year with warmer water lasts for 3.0 months, from July 8 to October 7, with an average temperature above 24°C. The month of the year in Ariana with the warmest water is August, with an average temperature of 26°C. [5]

The time of year with cooler water lasts for 4.4 months, from December 24 to May 3, with an average temperature below 17°C. The month of the year in Ariana with the coolest water is February, with an average temperature of 15°C.[5]

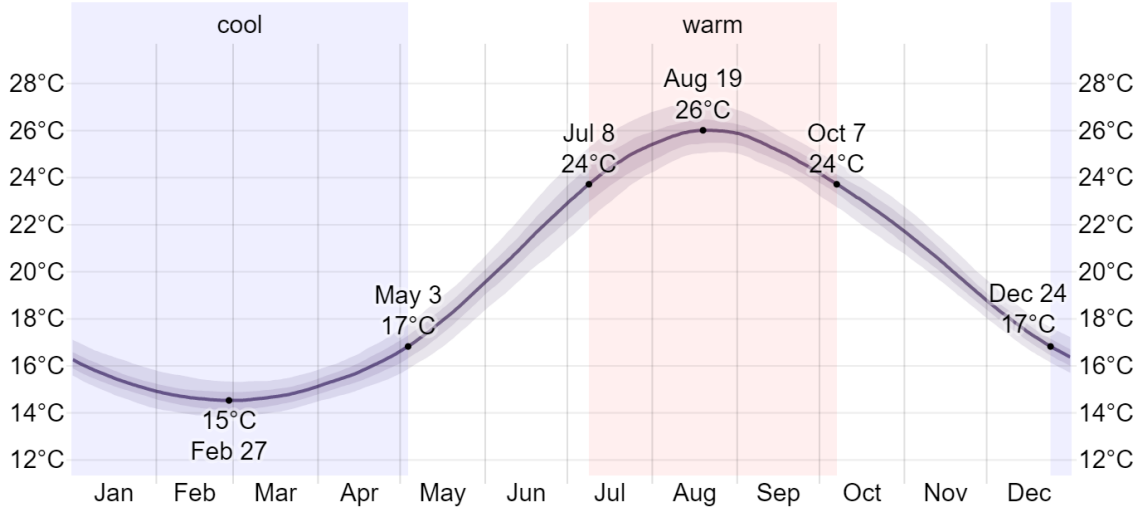


Figure 13: Average Water Temperature in Raoued. [Source Weather Spark]

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. [5]

The average daily incident shortwave solar energy experiences extreme seasonal variation over the course of the year. [5]

The brighter period of the year lasts for 3.4 months, from May 6 to August 19, with an average daily incident shortwave energy per square meter above 6.8 kWh. The brightest month of the year in Ariana is July, with an average of 7.9 kWh. [5]

The darker period of the year lasts for 3.5 months, from October 30 to February 12, with an average daily incident shortwave energy per square meter below 3.4 kWh. The darkest month of the year in Ariana is December, with an average of 2.4 kWh. [5]

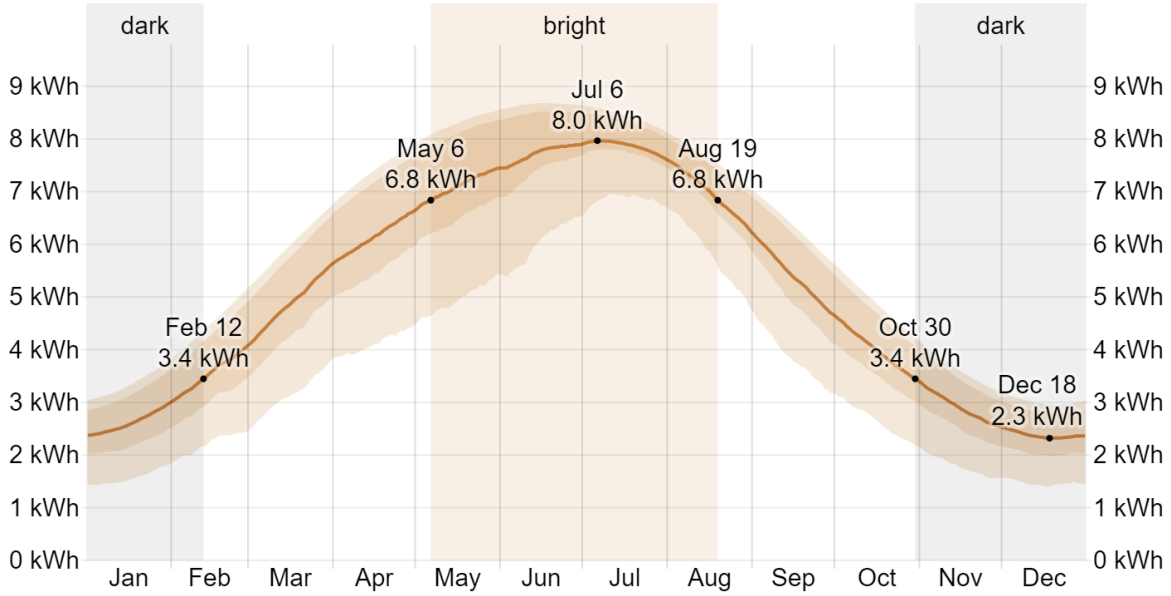


Figure 14: Average Daily Incident Shortwave Solar Energy in Ariana. [Source Weather Spark]

1.2.3. Demographic tendencies

According to the last population census of 2019, the population living in Ariana Governorate was 661,226 inhabitants. Whereas the population for Raoued municipality in 2019 was 136,840 citizens. [6]

1.2.4. Employment

Based on the statistics that were done in 2012, the employees in Ariana Governorate comprise approximately 44.4% of its population over 15 years old. [7] The following breakdown figure represents the percentages of professions in Ariana Governorate:

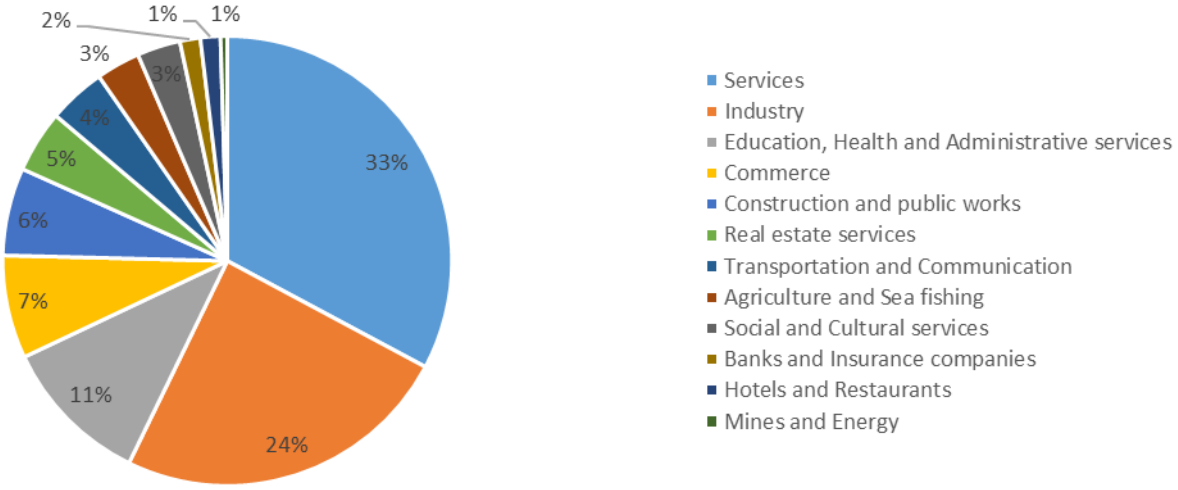


Figure 15: Breakdown represents the percentages of professions in Ariana Governorate.

In the part of economically active citizens, a 13.7% is currently unemployed and looking for a job. [7]

1.2.5. Education

The total illiteracy rate among the population in Ariana Governorate was around 11.5% in 2012 over 10 years old, and this percentage is considered low comparing with the illiteracy rate in the whole republic, which is 18.1%.[7]

26.4% of the population of the governorate hold a certificate below high school, 38.7% hold the high school certificate and 23% of the total population have higher educational level (Diplomas, Masters, PhD, etc.). [7]

1.2.6. Infrastructures

The Governorate provides a public network for access in water and drinking water. 99.8% of the housing units have access in the water network. In addition, it seems that there is not a fully developed public sewage system and thus there is 91.6% of the population has access to the public network. [2019] [6]

The road network in Raoued Municipality consists of 34.7 Km of paved and unpaved roads, of which 85.6% are main roads and 14.4% are agricultural roads. [2019] [6]

1.2.7. Economy

The economy of Raoued depends on tourism, sea fishing and industry. Shatranah industrial zone (located in Raoued municipality) includes 58 factories with total number of employees reached 2,113 in 2019. [6]

In addition, Raoued is characterized by Sea fishing, where number of fishing boats are 110 with total Sea fishing production of 37 tons per year. Whereas the total number of workers in sea fishing were around 250 in 2019. [6]

As for tourism in Raoued, the beach is the most visited tourist destination but the delegation does not contain tourist units, as all hotels in the Governorate are located in Ariana city. [6]

2. Baseline Emission Inventory (BEI)

2.1. BEI Methodology

2.1.1. 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 aren't adequate data for this year, as a baseline year should be considered the nearest year to 1990 for which there are complete and reliable data. Thus, for Raoued Municipality in Tunis, the baseline year has been set to be 2018, since it was the year with the most sufficient and reliable data available[1].

2.1.2. BEI administrative boundaries

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

2.1.3. Sectors to be included in the BEI

Data collection needed for the preparation of the BEI covered the following sectors:

A. Buildings, Equipment & Facilities

- Municipal Buildings, Equipment and Facilities.
- Public lighting.
- Residential buildings.
- Tertiary buildings, equipment and facilities (non-municipal).
- Water and Waste water facilities.
- Industrial Sector.

B. Transport

- Municipal fleet.
- Urban Public transport.
- Urban Private and Commercial transport.
- Off-Road Transport.

C. Solid waste management.
D. Livestock breeding.
E. Waste Water Treatment.

With regard to agriculture, although there is an agricultural activity in the region, it has not been possible to separate the consumptions for this sector from the tertiary one, and especially the water pumping for irrigation.

[1] Ref: How to develop a Sustainable Energy Action Plan (SEAP)-Guidebook, European Union, 2010, http://www.eumayors.eu/IMG/pdf/seap_guidelines_en.pdf.

2.1.4. Emission factors and Conversion rates

The emission factors which are used in this BEI were derived from the Covenant of Mayors Guidebook in Table 1. With the only exception of the electricity emission factor depends on the energy mix of the country. So, the emission factor was calculated based on the Tunisian energy mix and the electricity consumption. According to the IPCC calculation approaches (JRC-COM-NEEEFE_1900-2018), the electricity emission factor in Tunisia in 2018 is 0.538 $tnCO_{2equivalent}$/MWh.

Table 2: Emission Factors & Conversion Rates.

	Emission Factor (tn CO_2/MWh)	Conversion Factors	Source
Electricity	0.538	-	JRC-COM-NEEFE_1990-2018-IPCC approach
Natural Gas	0.202	11.6 MWh/tn	CoM / IPCC
LPG	0.227	13.1 MWh/tn	CoM / IPCC
Diesel	0.267	10 KWh/lt	CoM / IPCC
Gasoline	0.249	9.2 KWh/lt	CoM / IPCC
Solar (thermal/ PV)	0	-	

Furthermore, emissions from the biomass were calculated according to the IPCC method. Waste separation process, Sewage Sludge and livestock breeding create methane emissions (CH_4) which are converted to CO_2 emissions according to the equivalence "1 tn CH_4 = 25 tn CO_2".

2.2. Energy Consumption

The total amount of energy consumed in Raoued Municipality is **622,116 MWh**. The allocation of this energy consumption among the different sectors, by fuel type, is presented in Table 3. Further analysis of the consumptions per sector is provided in the following sections.

Table 3: Total Energy consumption per sector.

MWh / Sector	Electricity	Natural Gas	Diesel	Gasoline	LPG	Solar Thermal	Total
Residential sector	55,257	70,231	0	0	8,587	5,746	139,821
Municipal Buildings	75	0	0	0	0	0	75
Tertiary Sector	16,007	16,533	150	0	954	0	33,644
Industrial Sector	10,592	3,472	0	0	0	0	14,064
Public street lighting	4,805	0	0	0	0	0	4,805
Transportation Sector	0	0	47,514	382,193	0	0	429,707
Total	**86,736**	**90,236**	**47,664**	**382,193**	**42,511**	**7,987**	**622,116**

2.2.1. Municipal Buildings & Facilities

Tunisian Electricity & Gas Company (STEG) provided electricity consumptions for the year 2018 for municipal buildings, which include: Administration, warehouses, slaughterhouse and

Gardens. The total electricity consumption of buildings and facilities in the municipality reached **75 MWh**.

2.2.2. 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 **4,805 MWh** according to the provided bills from STEG (Société tunisienne de l'électricité et du gaz) for 2018.

2.2.3. Residential Buildings

***Electricity* & Natural Gas (NG)**

Raoued's households consume electricity for lighting and electrical appliances such as refrigerator, air conditions and others, whereas natural gas (NG) is used for space heating, water heating and cooking in the houses. According to the provided data from STEG, the annual consumed electricity and NG in this sector was **55,257 MWh** and **70,231 MWh,** respectively in 2018.

Liquefied Petroleum Gas (LPG)

LPG is mainly used as portable bottles for cooking and space/water heating for the households that not connected to the NG network. Thus, the annual LPG consumption in residential sector for Raoued Municipality was around 3,361 bottles (13 kg/bottle capacity) with annual energy consumption of **8,587 MWh**.

Solar thermal

In addition, number of households that own solar water heaters is provided as 5% of the total households in Raoued municipality (equivalent to 1,681 systems), thus they consume solar power in order to heat water. Based on that, the annual solar thermal consumption at the municipal level is calculated to be **5,746 MWh**.

Summary

Gathering all the data of the residential sector, it seems that the residents consume 4 distinct energy sources. In Table 4 and Figure 16 below, the final consumption per fuel type for this sector is presented.

Table 4: Total energy consumption in the residential sector.

MWh/year	Residential Sector
Electricity (MWh)	55,257
Natural Gas (MWh)	70,231
LPG (MWh)	8,587
Solar Thermal (MWh)	5,746
Total (MWh)	**139,821**

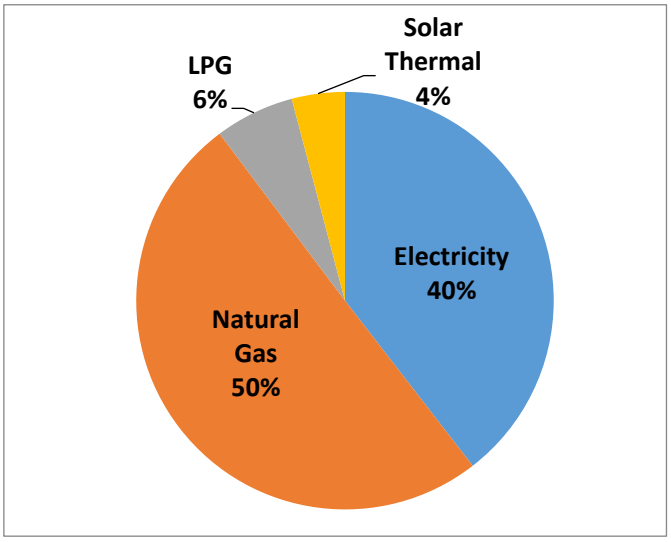


Figure 16: Energy consumption per fuel in Residential Sector.

2.2.4. Tertiary Buildings, Equipment & Facilities

Tertiary sector includes all buildings that not referred to the municipal and industrial sectors, which includes the commercial buildings such as shops, restaurants, hotels, offices, hospitals. Also this sector includes the educational buildings (Schools and Universities), public buildings, agriculture and water management facilities as well, which provide services to Raoued's citizens. It should be noted that water management facilities include facilities for water pumping and waste water treatment.

In case of public and commercial buildings, the annual LPG consumption at municipal level is calculated to be **954 MWh**.

The annual electricity and natural gas consumptions were given according to the provided data from STEG and by MDIIC statistics, with total value of **16,007 MWh** for electricity and **16,533 MWh** for NG.

Regarding diesel consumption in agricultural sector, there are around 20 hectares of farms use diesel-powered pumps for irrigation purposes, which is estimated to consume around 150 MWh of energy per year by considering an average pump diesel consumption of (2.19 Gallons/acre-inch) [11] with considering an annual irrigated water of 37 in/yr as most of crops in Raoued are from clover [12]. The collected data are presented in the Table 5 below.

Table 5: Energy consumption in tertiary sector per type of sub-sector.

Types of Buildings in the Tertiary Sector	Electricity (MWh)	Natural Gas (MWh)	LPG (MWh)	Diesel (MWh)	Total (MWh)
Public & Commercial buildings	15,483	16,437	918	0	**32,838**
Tourism	80	95	36	0	**211**
Agricultural	110	0	0	150	**260**

Water & Waste Management Facilities	334	0	0	0	**334**
Total	**16,007**	**16,532**	**954**	**150**	**33,643**

As can be seen in Figures 18 and 19, it is obvious that the consumption's allocation in the tertiary sector is dominated by commercial & public buildings.

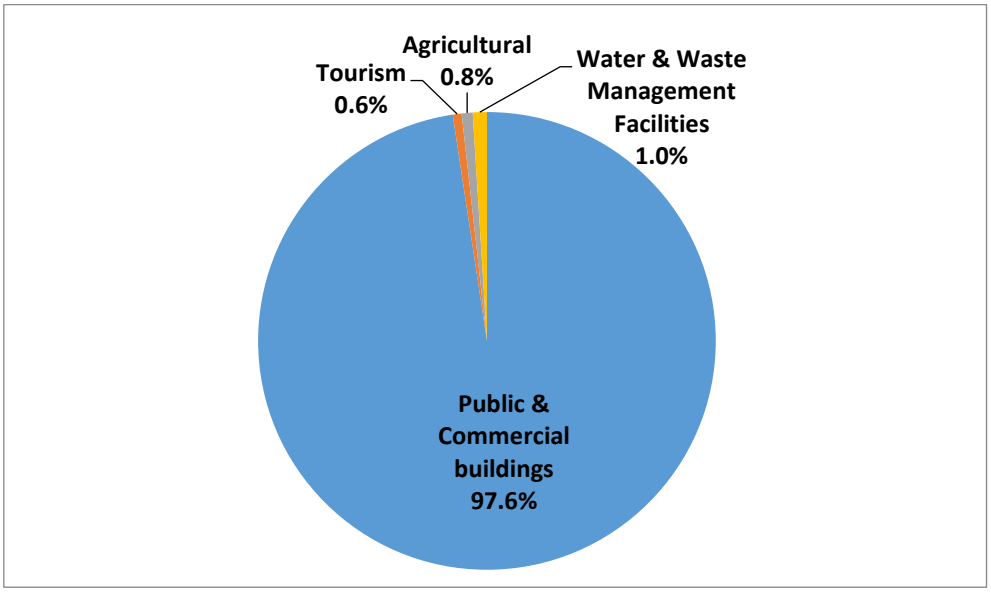


Figure 17: Energy consumption in tertiary sector per type of building.

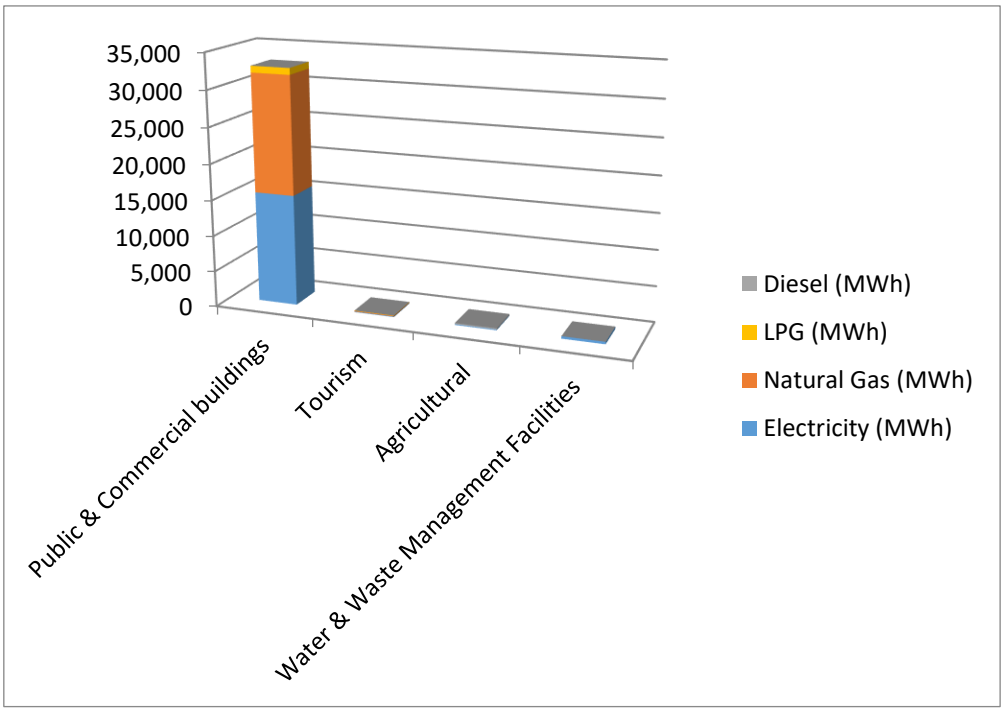


Figure 18: Energy consumption in tertiary sector per type of building and fuel.

2.2.5. Buildings' & facilities Synopsis

The consumed energy allocation for all the buildings and facilities in Raoued Municipality is presented in the Figure 19.

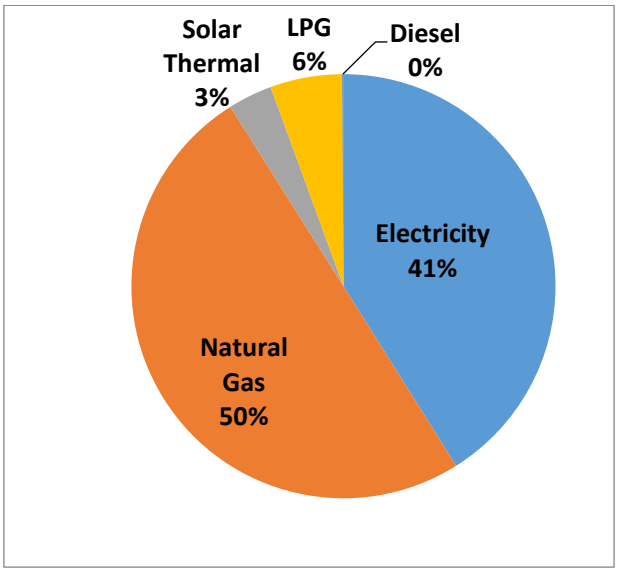


Figure 19: Energy consumption in buildings and facilities per fuel.

2.2.6. Industrial Sector

Raoued Municipality has 61 industries within its boundaries, which concentrated in Shotrana area. Electricity and NG consumption for the industrial sector was given according to data provided by STEG with total annual consumption of **10,592 MWh** for electricity and **3,472 MWh** for NG.

2.2.7. Transport Sector

2.2.7.1. Municipal fleet

As far as the consumption of municipal vehicles is concerned, and according to the available data, Raoued's municipal fleet has 88 vehicles which use diesel and gasoline. Table 6 shows the consumption per type of fuel and vehicles.

Table 6: Annual Energy Consumption in Municipal fleet of Raoued.

Type of Municipal vehicles	Number of vehicles	Diesel		Gasoline		Total
		Lit	(MWh)	Lit	(MWh)	(MWh)
Waste transportation Vehicles and heavy vehicles	59	93,528	935	0	0	935
Small Passengers Vehicles	29	0	0	49,969	460	460
Total	**88**	**93,528**	**935**	**49,969**	**460**	**1,395**

2.2.7.2. Urban Road Public & Private Transport

The data for fuel consumptions were calculated based on a previous study conducted by GREATER TUNIS URBAN PLANNING (GTUP) in cooperation with the Municipality for the traffic plan of Raoued Municipality [13], which stated that 6% of the total traffic comes from Public transport (5% comes from taxis) in Raoued Municipality. Whereas 86% of the total recorded traffic comes from Passengers cars, 4% comes from Motorcycles, and 4% for Heavy goods vehicles. Daily traffic through the main roads in the municipality was monitored and recorded in the aforementioned study, which showed that there are 38,133 vehicles recorded daily in Fathi Zuhair Street, which considered as the most active main road within Raoued Municipality borders. The total distance of the main Municipality's roads is around 30 km according to MDIIC statistics [9]. Thus, by knowing the total daily traffic amount and the percentages of the different vehicles' types with the total distance of the roads, then the daily fuel consumption within Raoued municipality limits can be calculated and reflected on annual basis. (See appendix A for more details).

2.2.7.3. Off-Road Transport

For agricultural tractors, the expected annual energy consumption is around **1,140 MWh/yr** by considering that each hectare consumes 60 liters of diesel for ploughing, sowing and cultivating processes [14] and a total plowed area of 1,900 hectares according to statistics by MDIIC [9]).

Table 7 and Figure 20 summarize the overall energy consumption and share for each category of transportation sector, which show that the overall energy consumption is **429,708 MWh/yr**, whereas urban road private transportation take the largest share with percentage of 92.49%.

Table 7: Total energy consumption for transportation sector within Raoued municipality borders.

Vehicle Type	Diesel (MWh/yr)	Gasoline (MWh/yr)	Total MWh
Municipal Fleets	935	460	1,395
Urban Public Transport	9,088	20,633	29,721
Urban Private and Commercial Transport	36,351	361,101	397,452
Off-Road Transport	1,140	0	1,140
Total	**47,514**	**382,194**	**429,708**

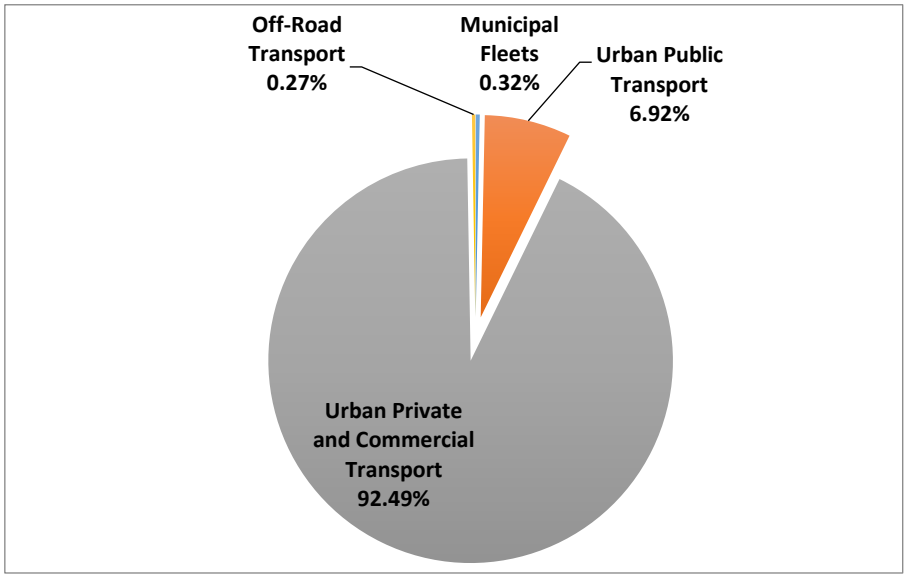


Figure 20: Energy consumption distribution in transportation sector.

2.2.8. Final Energy Consumption

Table 8 shows energy consumptions within Raoued municipality, with a total energy consumption of **622.117 GWh**.

Table 8: Total Energy Consumption in Raoued municipality.

Sector		FINAL ENERGY CONSUMPTION [MWh]						
		Electricity	Fossil fuels				Renewable energies	Total
			Natural Gas	LPG	Diesel	Gasoline	Solar thermal	
Residential sector		55,257	70,231	8,587	0	0	5,746	**139,821**
Municipal Buildings		75	0	0	0	0	0	**75**
Tertiary Sector		16,007	16,533	954	150	0	0	**33,644**
Industrial Sector		10,592	3,472	0	0	0	0	**14,064**
Public street lighting		4,805	0	0	0	0	0	**4,805**
Transportation Sector	Municipal Fleets	0	0	0	935	460	0	**1,395**
	Public Transportation	0	0	0	9,088	20,633	0	**29,721**
	Private Transportation	0	0	0	36,351	361,101	0	**397,452**
	Off-Road Transportation	0	0	0	1,140	0	0	**1,140**
Total		**86,736**	**90,236**	**9,541**	**47,664**	**382,194**	**5,746**	**622,117**

Figure 22 below shows the energy consumption distribution for all Raoued's sectors, which can be noted that the energy consumption is almost dominated by transport and residential sectors.

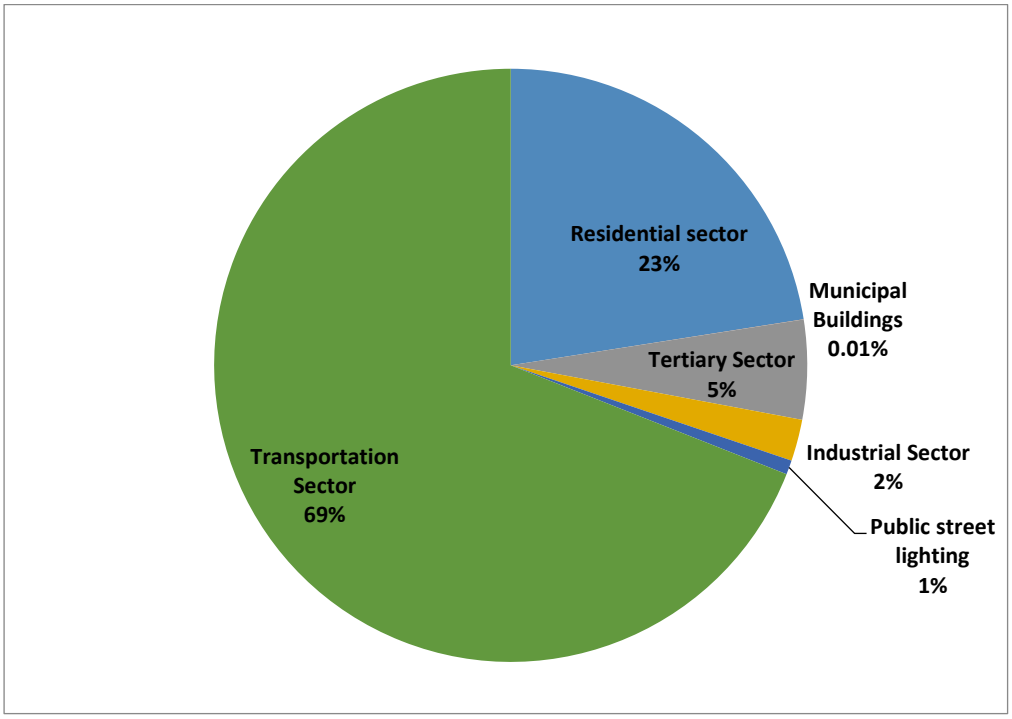


Figure 21: Energy consumption distribution for all sectors in Raoued Municipality.

2.3. Local electricity production

It is expected that 5% of the total households (equivalent to 1,681 households) in the Municipality of Raoued have On-Grid Roof-Top PV systems with average capacity of 4 kWp per household. The total capacity for these systems is around 6.7 MW with total electricity production of **10,400 MWh/yr**.

2.4. CO_2 emissions

2.4.1. Energy related emissions

In the previous sections, the energy related consumptions in Raoued municipality were described and the CO_2 emissions can be calculated using the IPCC emission factors. [15]

Electricity

In order to calculate the local emission factor for electricity, the following equation is used:

$$EFE = \frac{(TCE - LPE - GEP) * NEEFE + CO_2 LPE + CO_2 GEP}{TCE}$$

Where:

EFE: Local emission factor for electricity (tn/MWh)
TCE: Total electricity consumption in the local authority (MWhe)
LPE: Off-Grid Local electricity production (MWhe)
GEP: Green electricity purchased by the local authority (MWhe)
NEEFE: National or European emission factor for electricity (tn/MWh_e)
CO2LPE: CO_2 emissions due to the local production of electricity (tn)
CO2GEP: CO_2 emissions due to production of certified green electricity purchased by the local authority (tn)

$$EFE = \frac{(86736-0-0)*0.538+0+0}{86736} = 0.538 \text{ tn } CO_2/MWh$$

Diesel
According to the SECAP guidelines the CO_2 emission factor for the diesel used in vehicles is 0.267 tn/MWh. No biodiesel is being blended.

Gasoline
According to the SECAP guidelines the CO_2 emission factor for gasoline is 0.249 tn/MWh.

Natural Gas
According to the SECAP guidelines the CO_2 emission factor for NG is 0.202 tn/MWh.

LPG
According to the SECAP guidelines the CO_2 emission factor for LPG is 0.227 tn/MWh

Solar thermal
The solar thermal power hasn't emissions thus its emission factor is zero according to the guidelines.

2.4.2. Non-energy related emissions

Apart from the CO_2 emissions released from the daily activities, also there is a significant amount of Greenhouse Gases derived from waste management and waste water treatment plants.

Here is the CO_2 emission contribution of the biomass in the municipality:

A- Municipal solid waste

In order to calculate the emissions from municipal solid waste, the IPCC default method was used as it appears below:

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

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)
- DOCF: fraction DOC dissimilated
- F: fraction of CH4 in landfill gas (IPCC default is 0.5)
- 16/12: conversion of C to CH4
- R: recovered CH4 (Gg/yr)
- OX: oxidation factor (fraction – IPCC default is 0)

The IPCC default method assumes that all the potential of CH4 emissions releases during the same year the waste is disposed of. The method introduces various specific default values and recommendations, for use in countries with lack of statistical data for Solid Waste.

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

$$DOC = 0.4 * A + 0.17 * B + 0.15 * C + 0.3 * D \text{ ..... } (2)$$

Where:

- A Percentage of paper and textiles in SW
- By Percentage of garden and park waste and other organic putrescibles in SW
- C Percentage of Food waste in SW
- D Percentage of wood and straw waste in SW

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

The total quantity of solid waste for Raoued Municipality is 108,000 tn. The entire amount is thrown in landfill. The average waste composition, as well as the results from the calculations is presented in Tables 9 & 10.

Table 9: Solid waste composition in Raoued, 2018.

Solid waste composition	Percentage	tn/a
Garden waste	3%	3,240
Paper	8%	8,640
Wood	1%	1,080
Glass	1%	1,080
Organic Waste	61%	65,880
Metal	5%	5,400
Plastic	13%	14,040
Textiles	5%	5,400

Others	3%	3,240
Total annual waste in tn	**100%**	**108,000**

Table 10: Waste Emissions Calculation factors.

Variables	Values
MSW_t:	108,000 tn/year
MSW_f:	1
MCF:	0.4
DOC:	0.1516
DOC_f:	0.574
F:	0.5
16/12:	1.3333
R:	0
OX:	0

Where $DOC_f = 0.014 * T + 0.28$ (T: average temperature in Raoued, 21 °C)

According to the available data on solid waste, it was found that 2,500 tn of methane and 6,876 tn of CO_2 have been released to the atmosphere. This Methane quantity equals to 62,650 tn of equivalent CO_2 (According to the guidelines the factor which was used for the conversion is 25) with total equivalent CO_2 emissions of **69,529 tn/yr**.

B- Waste Water Treatment Plant (WWTP)

In Raoued municipality, there is a wastewater treatment plant (Shotrana WWTP), which treats the waste water that produced from the Raoued municipality and other neighbor Municipalities.

In order to calculate the emissions from WWTP, the IPCC default method was used as it appears below:

CH4 emissions = $(U_i * T_{i,j} * EF_j) * (TOW-S) - R$
Where:

- Ui : fraction of population in income in inventory year
- Ti,j : degree of utilization of treatment pathways or system
- EFi: emission factor
- R : amount of CH4 recovery in inventory year.
- S : organic component removed in inventory year as sludge
- TOW : total organics in waste water during inventory year

The calculation of the emission factor (EFi) is based on the following equation.

$EFi = B_\circ * MCFj$
where:

- B◦ : Maximum CH4 production Capacity
- MCFj : methane correction factor

The following equation was used to calculate the total organics in waste water in inventory year (TOW).
TOW= P * BOD * 0.001 * I *365
where:

- P : population
- BOD : Biochemical Oxygen Demand (BOD)
- I : correction factor for additional industrial BOD discharged into sewers (equals to 1.25)

The plant treats daily about 80,000 m^3 of waste water (40,000 kg BOD/day). Waste composition, as well as the results from the calculations are presented in the Table 11:

Table 11: Sewage Emissions Calculation factors.

Ui	0.34
Ti,j	0.34
EFi	0.18
R	0
S	0
TOW	18,250,000

According to the available data on solid waste, it was found that 380 tn of methane has been released to the atmosphere. This quantity equals to **9,494 tn** of equivalent CO_2. (According to the guidelines the factor which was used for the conversion is 25).

C- Livestock Breeding Sector

In Raoued Municipality there is a small livestock breeding sector. There are cows, sheep and poultry breeding in the Municipality.

Table 12 below shows the number of heads from each type of livestock in addition to the annual emission factor:

Table 12: Number of heads and emission factor for livestock breeding in Raoued Municipality.

Type of livestock	Number of heads	Emission factor (Kg CH_4/year)
Cows	2,000	4,000
Poultry	140,000	2,800
Sheep	30,000	4,500

According to the available data on solid waste, it was found that 11.3 tn of methane has been released to the atmosphere. This quantity equals to **282.5 tn of equivalent CO_2**. (According to the guidelines the factor which was used for the conversion is 25).

2.4.3. Final CO_2 emissions

The emissions of CO_2 equivalent for the sectors that have been described in the previous sections are available, in total, in Table 13.

Table 13: Total CO2eq emissions for Raoued Municipality.

Sector		CO_2 emissions (tn CO_2/year)						
		Electricity	Fossil fuels				Renewable energies	Total
			Natural Gas	LPG	Diesel	Gasoline	Solar thermal	
Residential sector		29,728	14,187	1,949	0	0	0	**45,864**
Municipal Buildings		40	0	0	0	0	0	**40**
Tertiary Sector		8,612	3,340	217	40	0	0	**12,209**
Industrial Sector		5,698	701	0	0	0	0	**6,399**
Public street lighting		2,585	0	0	0	0	0	**2,585**
Transportation Sector	Urban Municipal Fleets	0	0	0	250	114	0	**364**
	Urban Public Transportation	0	0	0	2,426	5,138	0	**7,564**
	Urban Private Transportation	0	0	0	9,706	89,914	0	**99,620**
	Off-Road Transportation	0	0	0	304	0	0	**304**
Sub-Total		**46,663**	**18,228**	**2,166**	**12,726**	**95,166**	**0**	**174,949**
Non Energy Sources								
Waste Water treatment Plant								**9,494**
Livestock breeders								**283**
Solid waste								**69,529**
Sub-Total								**79,306**
Total		**46,664**	**18,256**	**2,166**	**12,726**	**95,166**	**0**	**254,255**

2.5. Results' Graphical Analysis

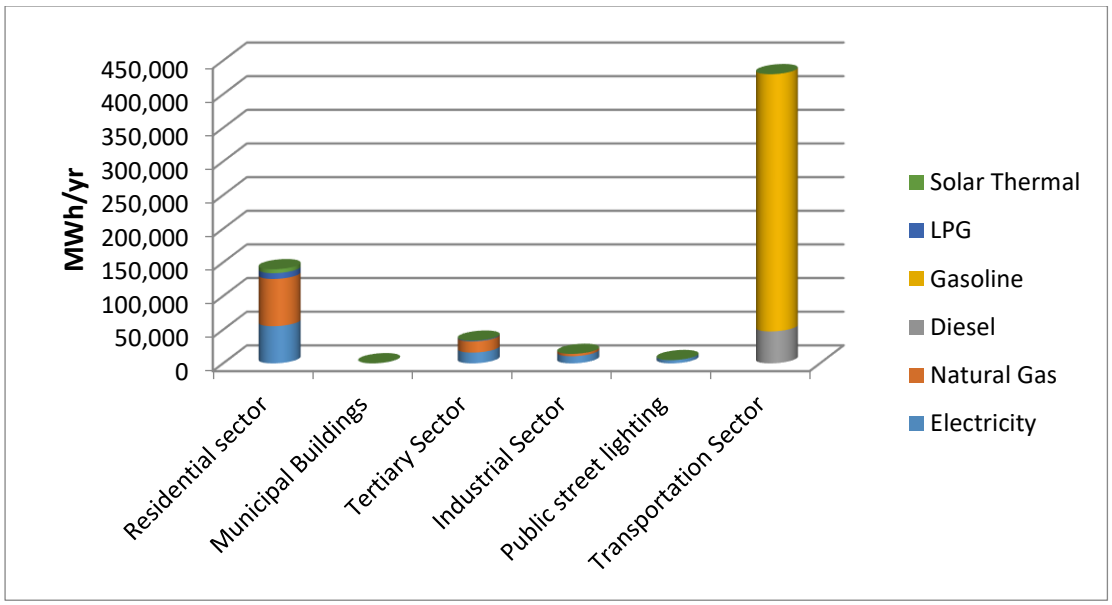


Figure 22: Final Energy consumption per sector and per fuel.

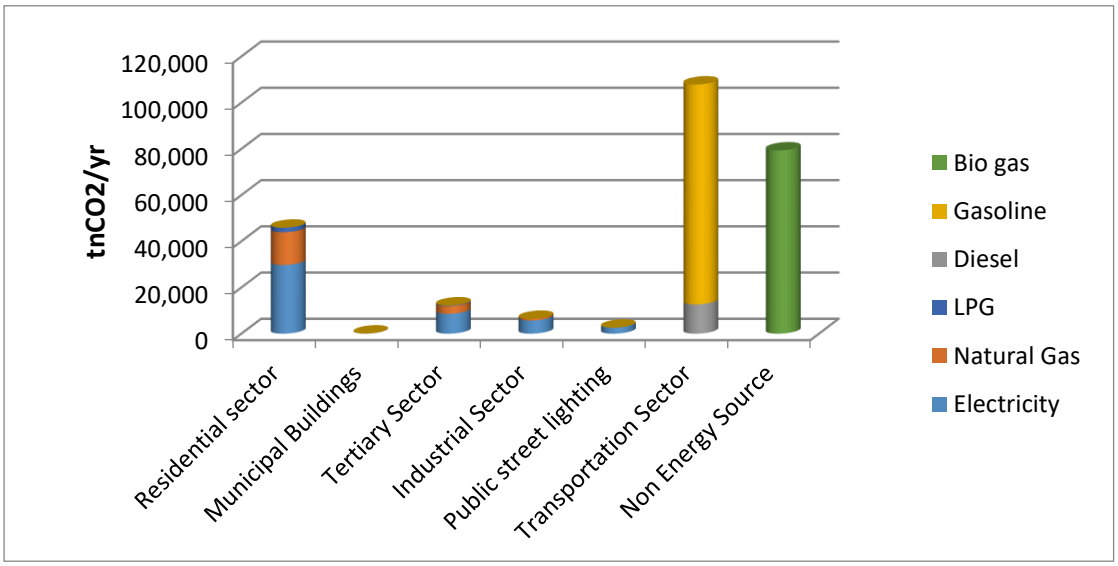


Figure 23: Total CO_2 emissions per sector and per fuel.

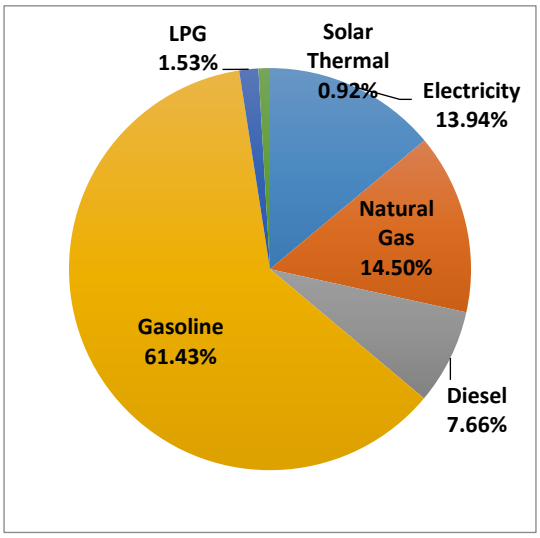


Figure 24: Final Energy Consumption per fuel.

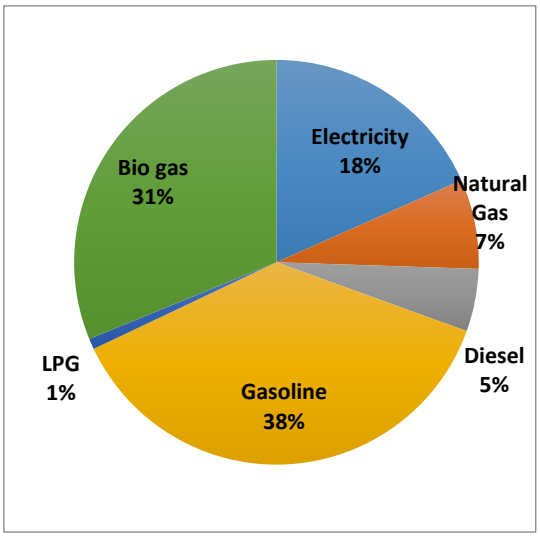


Figure 25: Total CO_2 emissions per fuel.

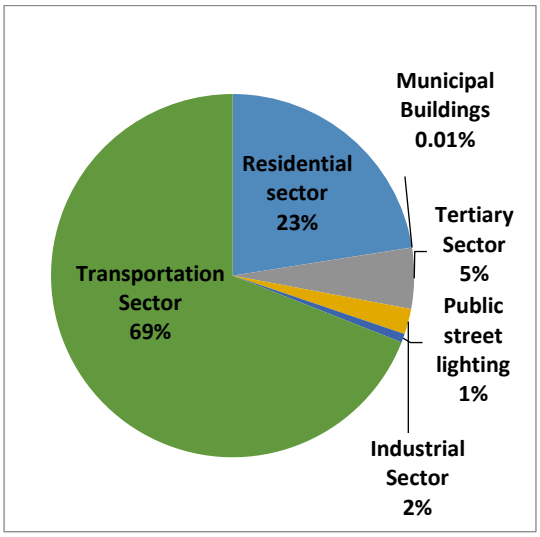


Figure 26: Final Energy Consumption per Sector.

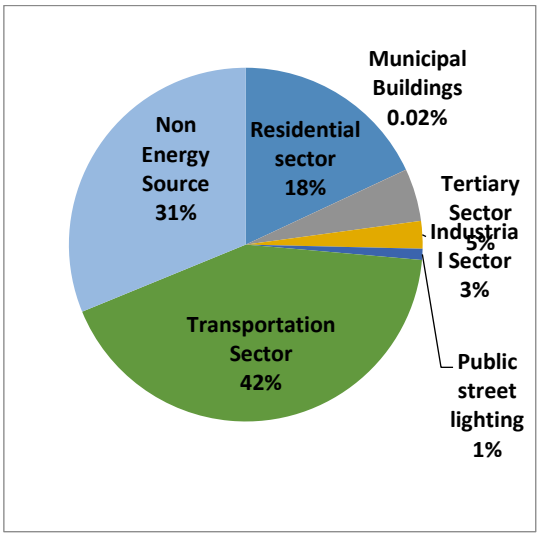


Figure 27: Total CO_2 emissions per Sector.

3. SECAP Actions

3.1. Target for 2030

The Municipality of Raoued is requested to take double role in the efforts towards CO_2 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 Raoued 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 activities. According to the BEI, the sectors contributing the most to the carbon footprint are the transport (42%), the residential (18%) and the Bio waste (31%). Thus, the Municipality should focus on the actions through which the citizens will be encouraged and take the appropriate measures in order to reduce the CO_2 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 Tunisia, 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.

$$Emissions\ CO_2\ 2030 = Emissions\ CO_2\ Baseline\ Year \times K$$

In Raoued, the emissions for the baseline year, 2018, were **254,255 tn CO_{2eq}.** The national coefficient k for the baseline year of 2018 in Tunisia is 1.35. Therefore, the forecasted emissions for 2030 are:

$$Emissions\ CO_2\ 2030 = 254{,}255 \times 1.35 = \mathbf{343{,}244\ tn\ CO_{2eq}}$$

The emission reduction target for Raoued Municipality according to Covenant of Mayors should be at least 40% (**137,298 tn CO_{2eq}**) 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 leads to actions with a negative NPV from the strict economic calculation, although their overall impact could be considered positive if additional benefits were considered.

Table 14 below shows the BAU scenario per sector for year 2030:

Table 14: BAU scenario per sector for year 2030.

BAU Scenario per sector	MWh	tCO_2
Municipal buildings & facilities	101	54
Public Lighting	6,487	3,490
Residential buildings	188,758	61,916
Tertiary buildings	45,419	16,482
Industrial sector	18,986	8,639
Municipal fleet	1,883	491
Public transport	40,123	10,211
Private & Commercial transport	536,560	134,487
Off-Road transport	1,539	410
Solid waste sector	--	93,864
Wastewater treatment plant	--	12,817
Livestock breeding sector	--	382
Total	839,856	343,243

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 analyzed.

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 that require 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' behavior

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 on the Table 15 below.

Table 15: Actions in Municipal Buildings, Equipment/Facilities.

Action No.	Action	Emission Reductions (tn CO_2)
3.2.1	Green procurement procedures for municipal buildings	2.7
3.2.2	Energy manager appointment in the municipality	1.6
3.2.3	Awareness raising activities for municipal employees	0.5
	Total	**4.8**

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 with high-efficiency that minimize the environmental impacts, it is possible to consume less energy thus reduce the CO_2 emissions and achieve tangible cost savings. The action is intended to be applied to all new office equipment that the municipality plans to purchase to meet their growing needs and to gradually replace old, inefficient ones, especially for high energy consuming office equipment, high-efficiency products will be targeted, while minimum efficiency standards and requirements will be set to all relevant municipal tenders. An average Carbon reduction of 5% against BAU consumptions is anticipated.

Table 16 summaries the results of calculations related to the cost, savings and the financial viability of the action are presented.

Table 16: Action 3.2.1 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	28,000
Annual Energy Savings (MWh)	5
Annual Emission Reduction (tn CO_2)	2.7
Funding Source	Own 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 17: Action 3.2.2 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	9,000
Annual Energy Savings (MWh)	3
Annual Emission Reduction (tn CO_2)	1.6
Funding Source	Own funds
Net Present Value (NPV)	<0

3.2.3. Awareness raising activities for municipal employees

A significant 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 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 Tunisia 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 18: Action 3.2.3 in numbers.

Duration	2023 - 2028
Total Implementation Cost (USD)	1,000
Annual Energy Savings (MWh)	1
Annual Emission Reduction (tn CO_2)	0.5
Funding Source	Own funds
Net Present Value (NPV)	>0

3.3. Municipal Public Lighting

Municipal public lighting includes street lighting and lighting for public areas. It is estimated that appropriate upgrades to this system will result in significant energy savings and emission reductions.

Table 19 provides an overview of this system actions, while the following paragraphs provide a detailed analysis with calculations for each action.

Table 19: Actions in Municipal public lighting.

Action No.	Action	Emission Reductions (tn CO_2)
3.3.1	Street lighting upgrade	1,031
3.3.2	Astronomical timers	335
3.3.3	Green procurement procedures for future lighting equipment	794
	Total	2,160

3.3.1. Street lighting upgrade

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

The key data on the action is presented in Table 20 below.

Table 20: Action 3.3.1 in numbers.

Duration	2023 - 2030
Total Implementation Cost (USD)	1,327,584

Annual Energy Savings (MWh)	1,917
Annual Emission Reduction (tn CO_2)	1,031
Funding Source	Own funds
Net Present Value (NPV)	>0

3.3.2. Astronomical timers

The operation of street lighting is controlled manually by the operators or photo cells. This control method could be replaced with astronomical timers' control, which are more accurate and precise compared to other techniques. This action will reduce the electricity consumption by at least 15%, 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.

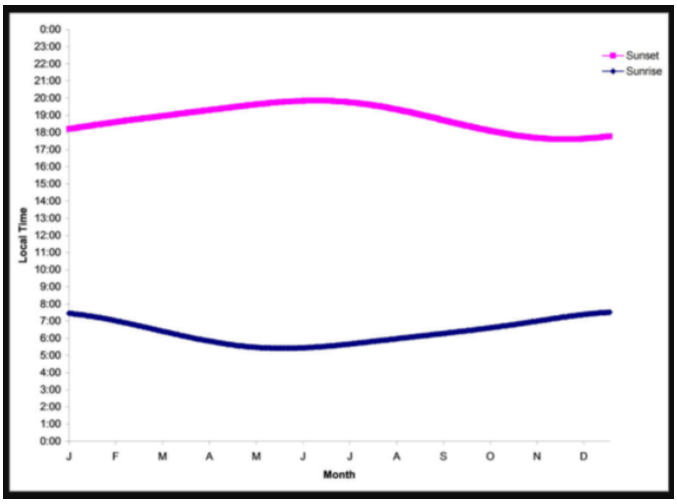


Figure 28: Timing for sunset and sunrise in Tunisia (Source: http://file.scirp.org/Html/4-6401175_24420.htm).

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 available.

Key data on the investment are presented in the Table 21 below.

Table 21: Action 3.3.2 in numbers.

Duration	2023 - 2027
Total Implementation Cost (USD)	33,000
Annual Energy Savings (MWh)	620
Annual Emission Reduction (tn CO_2)	335
Funding Source	Own funds

Net Present Value (NPV)	>0

3.3.3. Green procurement procedures for future lighting

Green procurement is a procedure where the municipalities seek to procure goods with reduced environmental impact throughout their life cycle and reach high-efficiency standards. In this way, the selection of products will be according to the highest standards that ensures the desired quality, which in turn minimize environmental impacts and carbon emissions. This action is envisaged for the future lighting equipment purchases within the 2030 horizon, since it is expected that the network will expand due to the city's growth. Key data on the action is presented in Table 22 below and have been calculated against the BAU scenario.

Table 22: Action 3.3.3 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	623,000
Annual Energy Savings (MWh)	1,476
Annual Emission Reduction (tn CO_2)	794
Funding Source	Own funds
Net Present Value (NPV)	>0

3.4. Residential Buildings

This sector includes the homes energy consumption of all residents related to lighting, heating, use of electric appliances etc. This consumption constitutes 23% of the total consumption with 18% contribution to the CO2 emissions.

The initial actions are informative and could be initiated by Raoued 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 the Table 23 below.

Table 23: Actions in Residential Buildings.

Action No.	Action	Emission Reductions (tn CO_2)
3.4.1	Awareness raising activities for modification of the residents' consumption behavior and energy saving	9,030
3.4.2	Replacement of existing lamps with LEDs	3,444
3.4.3	Replacement of existing air-conditioners with more efficient ones	3,444
3.4.4	Building envelope improvement for the existing buildings	4,524

3.4.5	Installing 6.4 MW Photovoltaics on residential rooftops	6,157
3.4.6	Replacing existing water heaters with solar water heaters	14,361
	Total	40,960

3.4.1. Awareness raising activities for activities for the community about (RE &EE)

The initial step is that the municipality should organize frequent awareness raising activities within the horizon of 2030 for Raoued Citizens'. Engaging Citizens in these activities is crucial as residential sector is responsible for almost 23% of the total energy consumption. The aim is to enhance the environmental consciousness of the citizens through the following activities:

- Organization of "Energy info days"; in these energy days, the focus will be on the importance of energy saving and protecting the environment through simple actions such as changing of energy consumption behavior, replacing inefficient lamps with LED lamps, purchasing high energy efficiency class appliances, installation of solar panels for water heating in existing buildings etc.
- Projection of freely available environmental documentaries.
- Participation in "Earth hour" event by WWF, where people across the world turn their lights off for one hour on a designated day.

Related calculations on the action in terms of initial cost and emission savings are presented in Table 24 below.

Table 24: Action 3.4.1 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	10,000
Annual Energy Savings (MWh)	16,785
Annual Emission Reduction (tn CO_2)	9,030
Funding Source	Own funds
Net Present Value (NPV)	>>0

3.4.2. Replacement of existing lamps with LED lamps

Currently, the use of LED lamps in the residential sector is relatively limited. The use of LED technology is suggested, since it can lead to energy and cost savings on one hand, while these lamps provide great luminosity quality on the other. Their cost is higher than the conventional ones, but they have long life expectancy and a quite positive cost benefit ratio. It is expected that through the awareness raising activities citizens will be encouraged to implement such measures and reach a penetration rate of 30%, thus contributing to the energy savings and CO2 reduction in the city.

In addition, if the Municipality takes an intensive awareness campaign, the penetration rate for high efficiency lamps such as LEDs will reach 100%. Key data on the action are presented in Table 25.

Table 25: Action 3.4.2 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	355,970
Annual Energy Savings (MWh)	6,403
Annual Emission Reduction (tn CO_2)	3,444
Funding Source	Own funds
Net Present Value (NPV)	>>0

3.4.3. Replacement of existing air – conditioners with more efficient ones

Due to the region's hot climate, cooling systems in buildings are used extensively, accounting for a sizable portion of electricity consumption. To reduce energy consumption, it is recommended that existing A/Cs be replaced with efficient AC units. The municipality, in collaboration with other stakeholders such as Local Community Organizations, could launch awareness campaigns to encourage people to buy new efficient air conditioners and reduce their energy consumption by 40%, and contribute to achieving the municipality's carbon reduction target by 2030.

Related calculations on the action in terms of initial cost and emission savings are presented in Table 26 below.

Table 26: Action 3.4.3 in numbers.

Duration	2023 - 2031
Total Implementation Cost (USD)	4,681,774
Annual Energy Savings (MWh)	6,403
Annual Emission Reduction (tn CO_2)	3,444
Funding Source	Own funds
Net Present Value (NPV)	>>0

3.4.4. Building envelope improvement for the existing buildings

Glazing replacement is an additional action with limited but not insignificant savings. Although summers in Raoued 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.

Table 27: Action 3.4.4 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	26,880,000
Annual Energy Savings (MWh)	8,410
Annual Emission Reduction (tn CO_2)	4,524
Funding Source	External funds
Net Present Value (NPV)	>0

3.4.5. Installing 18 MW Photovoltaics on 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, 7 MW_p of PV panels 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.

The project is expected to cover 15% of residential electrical consumption. In 2030, such a capacity would produce approximately 28,080 MWh of electricity (assuming an annual average solar irradiation of 1,560 kWh/kWp), enough to power 4,500 households (considering 4 kWp per household).

This action entails the municipality establishing an incentive scheme for the installation of solar photovoltaic systems in households by communicating the economic benefits with financial support from ANME. This scheme will be implemented in collaboration with ANME and STEG, which will be able to provide technical and economic data on photovoltaics.

Key data on the action are presented in the Table 28 below.

Table 28: Action 3.4.5 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	23,579,500
Annual Energy Savings (MWh)	28,080
Annual Emission Reduction (tn CO_2)	15,107
Funding Source	Private funds, ANME, Banks Loans
Net Present Value (NPV)	>>0

3.4.6. Replacing existing water heaters with solar water heaters

Hot water for domestic use is a constant requirement in every household. As a result, this activity currently consumes a significant amount of electricity and gas. Replacing existing

electricity and gas water heating systems with solar water heaters will significantly reduce energy consumption and carbon emission.

The size of solar water heaters that could be implemented through this action has been estimated cover around 50% of households by 2030 (about 13,500 households), considering that Raoued will work towards this direction with its citizens through awareness raising activities and dedicated events.

Table 29: Action 3.4.6 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	7,603,200
Annual Energy Savings (MWh)	26,694
Annual Emission Reduction (tn CO_2)	14,361
Funding Source	Private funds, ANME, Banks Loans
Net Present Value (NPV)	>>0

3.5. Tertiary Sector

This sector includes the energy consumption of public and commercial buildings, Water supply facilities…etc. This consumption constitutes 5% of the total consumption, with 5% contribution to the CO_2 emissions.

The initial actions are informative and will be carried out by Raoued Municipality. Since the municipality does not have the authority to intervene directly in project implementation, a series of actions will be planned to encourage building managers/owners to implement the proposed measures to reduce energy consumption and carbon emissions.

An overview of this sector's planned actions is presented in the Table 30.

Table 30: Actions in Tertiary Sector.

Action No.	Action	Emission Reductions (tn CO_2)
3.5.1	1.9 MWp Photovoltaics in rooftops	6,052
3.5.2	Replacing existing water heaters with solar collectors	198
	Total	6,250

3.5.1. 5.1 MW_p Photovoltaics on rooftops

The solar energy potential of the country and the Raoued region is enormous. As a result, businesses will be encouraged to capitalize on this opportunity by installing PVs to offset some of their electricity consumption. 5.1 MWp of PV rooftop systems are proposed to be installed. Because solar energy produces no emissions, the reduction in carbon emissions will be significant.

The following assumptions were made for calculating the estimated emission reduction of this action:

- Average solar production in Tunisia is 1,560 kWh / kWp per year;
- 50% of the electrical energy consumption of the tertiary sector (except water facilities and agriculture sector) in the city of Raoued would be replaced by solar, which corresponds to the installation of around 5.1 MW_p and to production of more than 8,003 MWh per year;
- An average cost of 4,000 TND / kWp in Tunisia.

Key data are presented in Table 31 below.

Table 31: Action 3.5.1 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	6,720,157
Annual Energy Savings (MWh)	8,003
Annual Emission Reduction (tn CO_2)	4,305
Funding Source	Private funds, ANME, Banks Loans
Net Present Value (NPV)	>>0

3.5.2. Using of Solar Water Heaters

Several tertiary sector businesses, such as schools and hotels, rely heavily on hot water to meet their daily needs. Because SWH penetration in the sector was very low in the baseline year, there is a significant potential for energy savings through SWH adoption.

It is assumed that 25% of the total energy consumption for water heating of the tertiary sector in the city of Raoued would be replaced by solar water heaters.

Key data on the action are presented in the following Table 32.

Table 32: Action 3.5.2 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	250,000
Annual Energy Savings (MWh)	695
Annual Emission Reduction (tn CO_2)	373
Funding Source	Private funds, ANME, Banks Loans
Net Present Value (NPV)	>0

3.6. Industrial Sector

The share of the industrial sector is 2% out of the total energy consumption and CO2 in Raoued Municipality with 3% contribution in CO_2 emissions. The proposed actions are presented in Table 33 and more detailed analysis for each one is following.

Table 33: Actions in Industrial Sector.

Action No.	Action	Emission Reductions (tn CO_2)
3.6.1	Install photovoltaic systems in the industrial sector	530
	Total	**530**

3.6.1. Install 3.4 MW photovoltaic systems in the industrial sector.

It was assumed that solar would replace 50% of the city of Raoued's industrial electricity consumption. The proposed PV system size is around 3.4 MW.

Table 34: Action 3.6.1 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	4,453,900
Annual Energy Savings (MWh)	5,296
Annual Emission Reduction (tn CO_2)	2,849
Funding Source	Private funds, ANME, Banks Loans
Net Present Value (NPV)	>0

3.7. Transport

The share of the Transportation sector, including the municipal fleet, private and commercial transport and public transport is 69% out of the total energy consumption in Raoued Municipality, with 42% contribution in CO_2 emissions. The proposed actions are presented in Table 35. More detailed analysis for each one is following.

Table 35: Actions in Transportation sector.

Action No.		Action	Emission Reductions (tn CO_2)
3.7.1	Municipal fleet	Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract	53.5
3.7.2		Train drivers in eco driving	40
3.7.3		Improve the process of car repair and purchasing new vehicles	26.7
3.7.4	Public & Private Transport	Transfer of taxi stations and regulation of taxi traffic	322
3.7.5		Improve the city bus network	1,274
3.7.6		Raise public awareness of public transport	2,101
3.7.7		Improve and secure bike paths	7,969

3.7.8	Transfer all government departments and institutions to one complex near to the population centers in the city	5,359
3.7.9	Establishing central markets near dense residential areas	4,287
3.7.10	Promotion of using schools' buses rather than private cars	700
3.7.11	Replacing 5% of the existing Taxi vehicles with electric vehicles	1,714
3.7.12	Information events on the new vehicle technologies	996
Total		24,842.2

3.7.1. Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract.

This action aims to conduct an audit of the municipality's vehicle fleet's energy consumption. This audit will serve to define an action plan for reducing consumption, as well as to optimize overall maintenance, oil change, and other expenses. ANME normally finances 70% of this type and also supports the implementation of the audited actions through support from the Fund of Energy Transition of close to 20% of the investment cost, capped according to consumption levels. Benefits associated with this action are generated by implementing the recommended action plan. The audit and action plan should be applied to the entire vehicles fleet. The estimated carbon reduction will be approximately 25% of total fleet emissions (approximately 53.5 t CO2).

The gains presented below consider the fact that some of the following actions result from the audit and therefore realize part of the expected 25% gain. The gains from these shares have therefore been cut off with a total potential of 53.5 tCO2. This leaves only the gains achievable by additional actions, which would be identified by the audit.

Table 36: Action 3.7.1 in numbers.

Duration	2023
Total Implementation Cost (USD)	20,000
Annual Emission Reduction (tn CO_2)	53.5
Funding Source	Own funds
Net Present Value (NPV)	<0

3.7.2. 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 37: Action 3.7.2 in numbers.

Duration	2023 - 2025
Total Implementation Cost (USD)	120,000
Annual Emission Reduction (tn CO_2)	40

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

3.7.3. Improve the process of car repair and purchasing new vehicles

This action focuses on two essential tasks for optimizing economic performance and energy of the municipal fleet, namely performing maintenance of existing vehicles and purchasing of new vehicles.

- Vehicles' Maintenance: Initially, this activity allows the municipality to determine the current state of the vehicle fleet. As a result, the municipality will be able to distinguish between vehicles that require maintenance and those that must be replaced. A committee comprised of concerned municipal staff could be formed to carry out this activity in accordance with a predetermined criterion for performing maintenance or purchasing new ones.

Concerning the identified vehicles for maintenance, the following actions can be taken to improve the performance of existing vehicles.

- Establishment of procedures relating to maintenance management;
- Implementation of an IT maintenance management system;
- Reinforcement of the material means of these units;
- Training and capacity building of the technical staff to improve their technical skills.

Carrying out this action can reduce fuel consumption by 5%.

- Purchasing new vehicles: The municipality may adopt minimum performance criteria for purchasing new vehicles in order to have a fleet of suitable and efficient vehicles in terms of fuel consumption.

These two actions result in optimizing the quality of the municipality's vehicle fleet and therefore reduce fuel consumption in the long term. However, the purchase of vehicles is rather at a national level, and therefore there should be regulations imposing performance levels on the markets.

Table 38: Action 3.7.3 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	4,000
Annual Emission Reduction (tn CO_2)	26.7
Funding Source	Own funds, ANME
Net Present Value (NPV)	>0

3.7.4. Transfer of taxi stations and regulation of taxi traffic

Because public transportation is almost insufficient in Tunisia, the taxi and rental industry has grown rapidly and has often been poorly regulated. The lack of organization in this sector is reflected in traffic problems, which are exacerbated by an increase in the use of private cars.

The STS specifically recognizes how taxi traffic hinders bus exits and suggests considering organizing taxi stations to alleviate congestion in the city center. This action aims to study the layout of taxi stations and relocate and organize the taxis stations to reduce traffic jam in the city. This action could be carried out by the municipality's technical services, with the assistance of a transportation expert if necessary.

Optimizing this situation could reduce overall traffic in the city by reducing travel time, the amount of fuel used and produced emissions as well as fuel cost paid by the transportation sector/taxis/rentals.

At this point, precisely implementing this action seems difficult, as several options/methods could be available for implementation. However, in the context of this SECAP, it is estimated that the reduction in city congestion as a result of this measure's implementation could result in a 0.5% reduction in overall energy consumption in the transportation sector. This action would be carried out within the framework of the PDU, but the benefits are listed separately here.

Table 39: Action 3.7.4 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	86,250
Annual Emission Reduction (tn CO_2)	322
Funding Source	Own funds, ANME
Net Present Value (NPV)	>0

3.7.5. Improve the city bus network

This action entails collaborating with the Security & Telecom Systems (STS) to improve the city's bus transportation options. This action can be part of the Urban Development Plan (PDU)implementation. Various actions can be taken to improve the city's public transport:

- Improve bus timing and schedule expansion;
- Create, extend, or change bus routes;
- Improve line connections and synchronization of crossing times;
- Provide users with appealing pricing;
- Upgrade the bus fleet;
- Inform citizens about the availability of public transportation.;

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

Improving the bus network would increase the number of public transportation trips by 20% in the city's perimeter (due to a modal shift from private car to bus) compared to the baseline scenario.

This action could be carried out within the framework of the PDU. Calculation results of this action are presented in Table 40 below.

Table 40: Action 3.7.5 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	-----
Annual Emission Reduction (tn CO_2)	1,274
Funding Source	Private & External Funds

3.7.6. 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 the ANME and the STS. 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 is considered independent of the PDU.

Table 41: Action 3.7.6 in numbers.

Duration	2023 - 2026
Total Implementation Cost (USD)	17,250
Annual Emission Reduction (tn CO_2)	2,101
Funding Source	Own funds, ANME

3.7.7. Improve and secure bike paths

The bicycle is, in some cities, one of the most efficient and most used means of transport. In Tunisia, 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 private vehicle in the city are replaced by the bicycle and that the network of cycle track makes a distance of 20 km (for a cost of 115,000 USD per km).

Table 42: Action 3.7.7 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	2,000,000
Annual Emission Reduction (tn CO_2)	7,969
Funding Source	Own, governmental and external funds

3.7.8. Transfer all government departments and institutions to one complex near to the population centers in the city

One of the main transportation and traffic problems in Raoued city is the distance between government departments and institutions, which forces people to drive or take public transportation to get from one to the other in order to complete their government and civil transactions. This issue will cause people to drive more, causing traffic jams on the connecting road. One of the best solutions is to consolidate all related government departments and institutions into a single complex near the city's population centers in order to avoid using transport services.
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 43: Action 3.7.8 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	1,000,000
Annual Emission Reduction (tn CO_2)	5,359
Funding Source	Own, governmental and external funds

3.7.9. Establishing central markets near dense residential areas

Due to the Central Market's remote location from the majority of city households, people must drive or take public transportation to get to the Central Market and shop. By

establishing new similar central markets near densely populated areas, people can shop without using public transportation, reducing emissions from passenger vehicles.

For the calculation of avoided emissions, it was considered that 4% of CO2 emissions can be avoided (4,287 tn CO_2) by solving this problem.

Table 44: Action 3.7.9 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	3,000,000
Annual Emission Reduction (tn CO_2)	4,287
Funding Source	Own, private and external funds

3.7.10. Promotion of using schools' 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 45: Action 3.7.10 in numbers.

Duration	2023 - 2026
Total Implementation Cost (USD)	15,000
Annual Emission Reduction (tn CO_2)	700
Funding Source	Own and external funds

3.7.11. Replacing 5% of the existing Taxi vehicles with electric vehicles

Inefficiencies in today's transportation systems can result in poor service, increased costs, increased energy consumption, and negative environmental impact. The majority of working taxis are old. If they were replaced with hybrid vehicles, fuel consumption efficiency would improve, resulting in fuel and cost savings. This action is planned as a result of a provision in the relevant legislative framework that allows for exemptions for replacing taxis with electric vehicles.
For the calculation of avoided emissions, it was considered that 1.6% of CO_2 emissions by public transportation can be avoided (1,714 tn CO_2) by solving this problem.

Table 46: Action 3.7.11 in numbers.

Duration	2023 - 2026
Total Implementation Cost (USD)	200,000
Annual Emission Reduction (tn CO_2)	1,714
Funding Source	Private funds

3.7.12. Information events on the new vehicle technologies

Private and commercial vehicles consume the most energy when compared to other modes of transportation. It is proposed that the Municipality organize awareness raising activities to inform citizens about new technology cars and dual fuel cars, as well as the economic and environmental benefits of these vehicles. The next step will be for citizens to buy these cars instead of traditional ones, such as replacing gasoline cars with hybrid or electric vehicles and diesel vehicles with more efficient ones.

For the calculation of avoided emissions, it was assumed that 5% of passenger cars would be replaced with hybrid/electric vehicles, with a 1% reduction in CO2 emissions from private transportation (996 tn CO_2).

Table 47: Action 3.7.12 in numbers.

Duration	2023 - 2028
Total Implementation Cost (USD)	400,000
Annual Emission Reduction (tn CO_2)	996
Funding Source	Own and Governmental Funds

3.8. Agriculture Sector

3.8.1. Planting trees (increasing green areas)

Planting forest trees will help to reduce GHG emissions by absorbing CO2 emissions through the photosynthesis process, which allows plants to create oxygen and energy from sunlight, water, and carbon dioxide. To reduce CO2 emissions, the municipality will plant forest trees and encourage the local community to do the same.

Table 48 below illustrates the information that present the action.

Table 48: Action 3.8.1 in numbers.

Duration	2023 - 2033
Total Implementation Cost (USD)	5,000,000
Number of Trees	500,000
CO_2 Captured (Tn CO_2)	8,640
Funding Source	Own and Governmental Funds

3.9. Solid Waste Sector

3.9.1. Promotion of Recycling

Raoued Municipality is committed to actively implementing awareness activities to promote the recycling processes, as waste accounts for 27% of total municipal emissions. The goal is to reach 15% recycling rates by 2030. The promotional campaign will include information days, promotional materials such as leaflets and posters, and even messages in local media (TV, radio, and social media) about the benefits of recycling and how to do it. The municipality will

also ensure that adequate infrastructure (recycling bins and vehicles) is available for waste sorting and collection on the streets, including electrical device recycling.

Furthermore, in order to set a good example, the municipality will place recycling bins in all municipal buildings and facilities, encouraging the use of recycled paper in local government.

Table 49: Action 3.9.1 in numbers.

Duration	2023 - 2026
Total Implementation Cost (USD)	1,500,000
Annual Emission Reduction (tn CO_2)	1,532
Funding Source	Own funds
Net Present Value (NPV)	<<0

3.9.2. Waste Management

Raoued Municipality collects 108,000 tons of waste per year. The issue of solid waste has received a lot of attention in recent years, not only because of its environmental effects, but also because of its social and economic consequences. The Municipality is committed to working on reducing waste to be collected as the primary solution to reduce energy consumption for waste collection vehicles. It also intends to separate the biomass in order to produce bio-fertilizer. To treat the biomass and produce bio-fertilizer, biological treatment will be used. The 1.7 MW bio-fertilizer plant will convert bio organic waste into bio gas and fertilizer.

Short-term actions

The municipality will continue to raise public awareness about waste reduction, recycling, and separation. The plan is to use the pilot project's experience to expand it to the entire city.

Long-term actions

The municipality intends to separate the biomass in order to produce bio-fertilizer. To treat the biomass and produce bio-fertilizer, biological treatment will be used.

By converting bio organic waste to bio gas and fertilizer, the bio-fertilizer plant will save approximately 49,500 tn CO_{2eq} per year.

Furthermore, the municipality will separate the glass and sell it for recycling.

The total investment for the plant, which includes the costs for the 1.7 MWp biogas plant for bio fertilizer (purification and filling) and the solid waste separation plant, is 11,000,000 USD, with an operational cost of 1,850,000 USD. The estimated revenue from electricity and fertilizer production is $2,342,878 USD. In more detail, the income is calculated as follows:

Income from electricity=14,258 MWh * 71 USD/MWh= 1,012,318 USD

Income from fertilizer =45% (fertilizer production rate from biomass) * 70.4 tn of biomass daily * 300days of operation * 140 USD/tn of fertilizer= 1,330,560 USD

Table 50: Action 3.9.2 in numbers.

Duration	2023 - 2026
Total Implementation Cost (USD)	11,000,000
Annual Energy Production (MWh)	14,258
Annual Emission Reduction (tn CO_2)	49,500
Funding Source	Own funds
Net Present Value (NPV)	>0

3.10. Other Actions applying the WEF NEXUS approach

3.10.1. Soil-based agricultural innovations (soilless agriculture)

The Scope of the project

The project aims to strengthen the link between research, innovation and agricultural know-how in order to promote community resilience to climate change while focusing on the Nexus Energy – Water - Food. It draws on the experiences of community-based research and development and the opportunities offered by soil-based agricultural innovations (soilless agriculture).

The project will allow the establishment of local innovation network in Raoued proposing innovative solutions in water and food systems and strengthen the conditions for more resilient communities to climate change.

More specifically, this will be done through the establishment of an optimized aquaponics experimental pilot adapted to the local Tunisian climate and constraints. A group of research engineers will work on the experimentation/operationalization of a study developed by the GDA (end-of-study thesis) on an aquaponics experiment.

Experiments will be conducted to study the fish and crop species suitable for aquaponics in Tunisia in terms of growth, quality, effluents, temperature and nutrient balance. The prototyping work will also aim to optimize management practices and technologies in aquaponics, such as wastewater and solid waste treatment to protect the environment from pollution and pathogens.

Beyond simple technological experimentation, the project aims to set up a community training platform for the municipality of Raoued.

Beneficiaries:

The experimentation will take place with the participation of a group of young people and women selected in partnership with the municipality of Raoued. The GDA therefore aims to play the role of a platform of expertise at the service of the community and the municipality. The project will promote the Water - Energy - Food Nexus as a privileged partnership axis between the local authority (municipality) and the civil society (GDA Sidi Amor) to help them play the role of local aquaponics initiators in their respective communities. In addition, since above-ground farming can be a viable element of food production in Tunisia, the project beneficiaries will be supported to develop viable business models both on a small scale (urban aquaponics) and in the context of large-scale combinations of agri and aquaculture. Beneficiaries will be selected according to criteria related to their socioeconomic background, motivation, professional training, etc. The results will be disseminated to the public and the scientific community.
This partnership between local civil society, the municipality and scientific research could constitute a pilot model for all local governments in Tunisia and North Africa.

Expected results:

Results (outcomes / outputs	Results description	Local partners
In depth study / research for the establishment of an aquaponics unit	In concrete terms, it is expected that with appropriate training, research work and support, a soilless culture unit (aquaponics) will be implemented as a replicable learning pilot adapted to the Tunisian climatic and agricultural specificities. This unit will constitute a technological prototype and the fruit of scientific research at the service of society.	Raoued Municipality, Technology and Scientific Research El Ghazala located in Raoued municipality, local NGOs
Aquaponics system installed		
Training beneficiaries in terms of soilless agriculture	The capacities building will nurture the spirit of innovation among young engineers/researchers and the entrepreneurial spirit of young people and women beneficiaries in Raoued. It will strengthen their self-esteem and enable them to develop projects that will provide them with a new source of income.	Raoued Municipality, Technology and Scientific Research El Ghazala located in Raoued municipality, local NGOs
Aquaponics System User Guide		
Development of a community training guide in soilless agriculture		
Integration of soilless agriculture as a component of a *community didactic circuit* Water - Energy - Food	The dissemination of the technology to young people and women and their active participation will enable the development of outgrower projects. Soilless agriculture is also an opportunity for healthy agricultural production. The GDA houses a start-up dedicated to traditional culinary knowledge as an incubator. Potential synergies are foreseen.	Raoued Municipality, Technology and Scientific Research El Ghazala located in Raoued municipality, local NGOs
Support to beneficiaries in order to develop a business model in the field of soilless agriculture	After a full year of training and mentoring, the beneficiaries, selected by the municipality will be encouraged to develop their start-up and sustainable local initiatives.	Raoued Municipality, Technology and Scientific Research El Ghazala located in Raoued municipality, local NGOs, national employment authorities

3.11. Actions' Overview

In the next Table 51, the complete list of the SECAP Actions is presented followed by the respective energy savings/production and the CO_2 reduction.

Table 51: Summary of the mitigation actions.

Action No.	Action	Emission Reductions (tn CO_2)
	Municipal Buildings and facilities	
3.2.1	Green procurement procedures for municipal buildings	2.7
3.2.2	Energy manager appointment in the municipality	1.6
3.2.3	Awareness raising activities for municipal employees	0.5
	Sub-total	**4.8**
	Public Lighting	
3.3.1	Street lighting upgrade	1,031
3.3.2	Astronomical timers	335
3.3.3	Green procurement procedures for future lighting equipment	794
	Sub-total	**2,160**
	Residential Sector	
3.4.1	Awareness raising activities for modification of the residents' consumption behavior and energy saving	9,030
3.4.2	Replacement of existing lamps with LEDs	3,444
3.4.3	Replacement of existing air-conditioners with more efficient ones	3,444
3.4.4	Building envelope improvement for the existing buildings	4,524
3.4.5	Installing 18 MW Photovoltaics on residential rooftops	15,107
3.4.6	Replacing existing water heaters with solar water heaters	14,361
	Sub-total	**49,910**
	Tertiary Sector	
3.5.1	5.1 MWp Photovoltaics on rooftops	4,305
3.5.2	Replacing existing water heaters with solar collectors	374
	Sub-total	**4,679**
	Industrial Sector	
3.6.1	Install photovoltaic systems in the industrial sector	2,849
	Sub-total	**2,849**
	Transportation Sector	
3.7.1	Carry out an audit of the municipality's fleet of vehicles and implement the actions recommended through a program contract	53.5
3.7.2	Train drivers in eco driving	40

3.7.3	Improve the process of car repair and purchasing new vehicles	26.7
3.7.4	Transfer of taxi stations and regulation of taxi traffic	322
3.7.5	Improve the city bus network	1,274
3.7.6	Raise public awareness of public transport	2,101
3.7.7	Improve and secure bike paths	7,969
3.7.8	Transfer all government departments and institutions to one complex near to the population centers in the city	5,359
3.7.9	Establishing central markets near dense residential areas	4,287
3.7.10	Promotion of using schools' buses rather than private cars	700
3.7.11	Replacing 5% of the existing Taxi vehicles with electric vehicles	1,714
3.7.12	Information events on the new vehicle technologies	996
	Sub-total	**24,842.2**
	Agricultural Sector	
3.8.1	Planting trees (increasing green areas)	8,640
	Sub-total	**8,640**
	Solid Waste Sector	
3.9.1	Promotion of Recycling	1,532
3.9.2	Waste Management	49,500
	Sub-total	**51,032**
	Total	**144,117**

To meet the 40% target, Raoued Municipality and the Government should make concerted efforts to strictly implement the SECAP and seek agreements and funds from national and international funding agencies.

4. Adaptation to climate change

1.1. Introduction on climate change impact

Tunisia is a signatory party of the 2015 Paris Agreement (PA) on climate change and as part of its Nationally Determined Contribution (NDC) for 2030, it has committed to reduce its greenhouse gas (GHG) emissions in all sectors (energy, industrial processes and product use, agriculture, forestry and other land uses, and waste). In this framework, Tunisia's NDC pledge is to reduce its carbon intensity by 45% by 2030, relative to 2010 levels, according to the most recent update, in order to reach the PA objectives.

The general objective of adaptation as per Tunisian NDC aims to «promote a Tunisia resilient to climate change, having significantly reduced vulnerabilities and strengthened the adaptive capacity of its ecosystems, its population, its economy, its territories, and having resolutely operated the necessary transformations, able to ensure a model of socio-economic development inclusive and sustainable and thus, can participate in the construction of a more resilient world". To achieve this objective, the adaptation component of the updated NDC is based on a «Resilience Star», designed as a framework to support Tunisian actors and their technical and financial partners, both public and private. In order to strengthen its resilience in all its different sectors, namely food, water, ecological, social, economic, territorial and health resilience, as well as resilience to natural disasters, the adaptation component of the NDC is based on both a paradigm shift and a cross-sectoral approach. The paradigm shift is based on a new way of acting in a more global and cross-cutting framework of adaptation that concerns all parts of the nation and its development. The implementation of the updated NDC is based on a prioritized action plan, with vertical actions that address specific sectoral issues and cross-cutting actions to better address cross-sectoral challenges. To this end, the sectoral actions affect the six most vulnerable sectors: water resources, agriculture, ecosystems, the coastline, health and tourism, while considering three new cross-cutting areas of intervention: gender, land use planning and natural disaster risk reduction.[2]

The updated version of the adaptation component of Tunisia's Nationally Determined Contribution (NDC) is based on a precise review of the exposure of national and sectoral vulnerabilities. This review is based on finer climate projections allowing a more robust downscaling to the level of territories. In addition, the update of the NDC integrates three new cross-cutting dimensions (gender, land use planning and natural disaster risk reduction) axes and measures aimed at limiting the impacts of climate change by 2050.

Several past and ongoing initiatives and projects included studies to assess the major impacts of climate change and develop adaptation strategies and plans in highly vulnerable sectors and ecosystems. These include in particular:

• A strategy related to the adaptation of the agricultural sector and ecosystems to climate change, elaborated with GIZ support (2007).
• Vulnerability assessment of water resources to climate change, with support from the Global Water Partnership (2016)
• Study of the environmental and socio-economic vulnerability of the Tunisian littoral in the face of an accelerated rise of sea levels (2008), Study of the vulnerability map of the Tunisian coastline to sea level rise due to climate change, with UNDP support (2012).
• Adaptation Strategy for health sector to climate change, with GIZ support (2010).
• Adaptation Strategy for the tourism sector to climate change, with GIZ support (2010).

[2] Updated NDC - TUNISIA https://unfccc.int/sites/default/files/NDC/2022-08/CDN%20-%20Updated%20-english%20version.pdf

• Study on an early warning system for the management of risks related to climate extremes and climate change in Tunisia, with GIZ support (2009).
• A portfolio of projects to cope with climate change in fragile sectors, with GIZ support.
• A strategy related to the adaptation of the littoral with UNDP support (2012).

1.2. Adaptation Needs and Priorities

Tunisia, as a middle-income country in North Africa, covers 164,000 km2 and has a 1,300 km coastline on the Mediterranean Seai. Its estimated population was 11.304 million in 2016. ii Two-thirds of the population and 80 percent of the country's economic activity is focused along the coast.

Tunisia's current climate varies considerably across the country. Hot, dry summers give way to mild, rainy winters in the north. In the center, a semi-arid climate results in modest rainfall and relatively high temperatures. The key climate vulnerabilities identified in Tunisia's First National Communication (2001) were largely framed in relation to sea level rise, rather than the impacts of temperature rise and changes in precipitation. Tunisia's coastal zone is particularly vulnerable to sea level rise.

Tunisia is expected to experience a significant increase in temperature by 2100. Temperatures are expected to increase at a greater rate in North Africa than anywhere else on the continent, with summer temperature increase exceeding 4°C by the end of the century (Christensen 2007). A general increase in the intensity of high-rainfall events is expected across Africa, and Tunisia, this will likely be offset by a greater decrease in the number of rain days. Finally, Tunisia can expect a rise in sea level of between 38cm and 55 cm by 2100 (Christensen, 2007)

The key climate vulnerabilities identified in Tunisia's First National Communication (2001) were largely framed in relation to sea level rise, rather than the impacts of temperature rise and changes in precipitation. A National Climate Change Strategy was developed in 2012, which outlined a vision and major climate change considerations in the Tunisian context.

The strategy highlighted spatial planning as one of the best ways for integrating adaptation in development planning, with the Land-Use Master Plan and Urban Development Plans being some of the best tools at national and local levels respectively.

Differences in Tunisia, like the rest of the Maghreb, are largely north-south environmental differences defined by sharply decreasing rainfall towards the south. Tunisia's landscape is mountainous in the northwest, where the eastern extension of the Atlas Mountains lies. To the south, a hot and dry central plain comprises a semi-arid area that merges into the Sahara Desert. Tunisia has a diverse, market-oriented, economy. However, it is facing an array of challenges following the 2011 Arab Spring revolution, with slow economic growth, chronic socio-economic challenges, and especially high levels of youth unemployment.

1.3. National Policies and Strategies

The country's First National Communication was prepared by the Ministry of Environment and Land Planning, and submitted in 2001. The Ministry of the Environment and Sustainable Development is in the process of completing Tunisia's Second National Communication. Other actions taken by Tunisia to address climate change adaptation include establishing a national committee on climate change in 1996. The committee is mandated to coordinate national action on climate change and participate in international climate negotiations[3].

Climate change (along with sustainable development) has been identified as one of three main strategic pillars in Tunisia's Country Partnership Strategy (CPS) for 2010-2013, devised in collaboration with the World Bank.

Tunisia is currently involved in a number of regional adaptation projects, and small number of national projects- leading it to have a high level of programme based adaptation activity. The projects and programs currently underway reflect a mix of Agriculture and food security as dominant sectors. Other projects also address vulnerabilities in natural resource management, infrastructure, water, health, tourism, cities, forests, and costal zone management.

1.4. Proposed Adaptation Actions

Tunisia has taken important steps to plan for adaptation, with actions primarily focused at the sectoral level. The country has several sectoral adaptation plans and strategies that highlight the need to address climate risks and outline priority actions for key sensitive sectors (agriculture, tourism, coastal, health). These plans have started to build awareness among affected ministries and stakeholders. Currently, the Government of Tunisia wishes to further a cross-sectoral approach to adaptation planning and effectively guide choices for resilient development planning and investments that consider climate risks and integrate adaptation needs, both at central and local levels.

The aim of these actions is to characterize the current situation of Tunisian municipalities in matters of climate change policies and actions and to understand the barriers and best practices.

[3] http://www.changementsclimatiques.tn/latunisieetlescc_introduction.htm

By surveying municipalities in Tunisia, we were able to provide an overview of the Tunisian municipalities in matters of climate change actions and strategies, as well as finding the main barriers and best practices. First, we found that most Tunisian municipalities are facing different effects of climate change. Second, the majority of municipalities do not have a strategy for mitigation and adaptation of climate change at the local level. Third, the main barrier that municipalities face in investing in climate change actions is the lack of financial resources and funding. Four, we have identified some of the best climate change mitigation and adaptation practices of surveyed cities, which should be taken into consideration and implemented also by the other cities. The Government of Tunisia is aware of these challenges and has adopted a proactive policy of fighting climate change, via both mitigation and adaptation measures, as shown in its NDC.

The general objective of the proposed adaptive actions is to promote a Tunisia resilient to climate change, reduce vulnerabilities and strengthen the adaptive capacities of its ecosystems, its population, its economy, its territories, and operate the necessary transformations, to ensure a model of socio-economic development inclusive and sustainable.

Faced with more frequent and intense climate hazards, a resilient Tunisia must be able to ensure a renewed and shared economic growth can lead to progress, and create jobs for all, anticipate climate disturbances (sudden or slow), and combat the effects. To be achieved, this objective must be based on a comprehensive and cross-cutting framework for adaptation that concerns all aspects of the nation and its development.

The following actions address the municipality's adaptation needs for the benefit of the inhabitants, and to identify priority actions at the sectoral level that aim to maximize cross-sectoral co-benefits:

Improving Governance:

Tunisia has taken many steps to strengthen the institutional framework and improve climate governance in order to implement the Paris Agreement. Notably, within the Ministry of Local Affairs and the Environment, where the national focal point for the Paris Agreement is designated, the National Coordination Unit on Climate Change (UGPO-CC) was established by Decree No. 2018-263 of March 12, 2018, whose mission of coordinating climate action by public and private actors and measures taken to implement the NDC was specified, as was its central role in promoting the integration of climate change into all public policies and building capacity at the national and local levels.

Measure 1: Support the development of a 5-year work plan for the Adaptation Technical Consultative Committee at Raoued Municipality

Measure 2: Establish an Adaptation consultation and coordination mechanism with various stakeholders including civil society, private sector, gender experts and taking into consideration gender balance

Measure 3: Develop a communication strategy for increasing awareness and engagement of high level decision makers and stakeholders.

Measure 4: Develop a sustainable financing strategy for identified adaptation measures with identification of options for private sector investments.

Measure 5: Integrate lessons learned from the experience of Raoued municipality, develop a guideline for all municipalities and local authorities on how to integrate climate risks and adaptation in urban and local land -use planning and communication products for its dissemination.

Capacity building and technology transfer needs

If Tunisia is to meet their NDC targets and sustain climate action over the long term, six action will require the implementation of six accompanying measures referred to by the UNFCCC Secretariat and UNESCO as ACE. This term refers to the measures that to be taken under Article 6 of the UNFCCC and Article 12 of the Paris Agreement, and Agreement, and is closely linked to the Sustainable Development Goals (notably SDG targets 4.7 and 4.7 and 13.3):

• Education • Training • Public awareness • Public access to climate information • Public participation • International cooperation

Capacity building:

The roadmap has to be set up for the strengthening of the following aspects in particular:

Measure 1: Monitoring and reporting,

Measure 2: Education, awareness of the effects of climate change, and good adaptation practices,

Measure 3: Integration of climate change into development planning,

Measure 4: Management of genetic resources (collection, conservation, valorization),

Measure 5: Negotiations on climate change,

Measure 6: Drafting of climate financing requests,

Measure 7: Rehabilitation of local know-how and spin-offs,

Measure 8: Monitoring and sustainability of works,

Measure 9: Conflict management and mediation,

Measure 10: Strengthening the human and material resources of the various key institutions

Research and technology transfer:

National research priorities have clearly incorporated climate change adaptation and adaptation to climate change as well as the sectors considered as priorities at the level of the sustainable water resources management, biodiversity conservation and climate change, agriculture, coastal erosion and climate change, agriculture, coastal erosion and desertification, epidemics and diseases, development models and land use planning.

Indeed, Tunisia is an associated partner in the EU research program (Horizon 2020) and has demonstrated the capacity and expertise of its research structures to mobilize to mobilize the necessary funding and participate in a framework of scientific excellence.

The development of scientific research in the field of adaptation to climate change is a key pillar in the climate change is an essential pillar in the different stages of the adaptation process. It requires a holistic, multidisciplinary approach that considers the different nexuses and integrates global and local thematic models. All of this in a framework of RRI (responsible research and innovation) that involves several actors. In order to consolidate the national effort and consider the global nature of climate change, Tunisia will want to mobilize international cooperation to finance:

Measure 1: The development of integrated models for the study of vulnerability with dynamic mapping and dynamic mapping and vulnerability trajectories well traced and applied to sectors, territories or production processes (integrated and adapted system of monitoring and monitoring and modeling system). The objective is to reduce the existing uncertainties in the analysis of the impact of climate change and to create tools for integrated quantitative assessment of risks and vulnerability. This will allow the design of adaptive management tools and to select appropriate measures, technologies and practices;

Measure 2: The development of digital innovation in the areas of adaptation;

Measure 3: The scaling up of innovative solutions through PPPs.

Technology Transfer

Programs will be necessary to allow Tunisia to access the main technological innovation niches related to the low-carbon transition, as well as the know-how and the appropriate industrial means to ensure the sustainability of its contribution.

The priority technologies selected are:

- Conservation agriculture and payment for environmental services for the agricultural sector.
- The implementation of a smart water system and an early warning system for the water sector.
- The strengthening of the information and decision support system (SIAD) and coastal zone management for the coastal and marine sector.

Ecological Resilience

Measure 1: Stocktake and compile available information on climate change impacts, vulnerability and adaptation; assess gaps and needs related to creating an enabling environment to effectively integrate adaptation needs in development planning.

Measure 2: Conduct a study of socio -economic vulnerabilities for the entire Tunisian territory, with data analysed at the municipality level.

Measure 3: *Food Resilience:* improve the efficiency of green water by promoting rainfed and irrigated agriculture resilient to the effects of climate change (cultivation practices, seeds, ...)

Measure 4: *Water Resilience*- Improve the quantitative and qualitative management of conventional water resources in the face of climate change impacts.

Cross-Cutting Issue of Adaptation

Measure 1: Endorse the national policy on gender mainstreaming and the fight against climate change

Strengthen women's economic empowerment in the face of climate change impacts.

Measure 2: Support the inclusion of gender issues and women's participation among political leaders

and public affairs managers.

Measure 3: Develop a GIS -based interactive Decision Support Tool to enable municipal decision-makers to visualize impacts of climate change on their localities and elements of adaptation choices.

Territorial Resilience

Measure 1: Integrate vulnerability and risks related to climate change into territorial planning processes.

Measure 2: Legal frameworks for land use planning that are sensitive to climate change, in particular by explicitly introducing the fight against climate change as a principle in the new Land Use and Urban Planning Code)

Measure 3: Update the planning approach to integrate climate change (establishment of a methodological toolbox that integrates climate change and land use planning for the preparation and development of five-year plans)

Measure 4: Establish a monitoring and evaluation system for the impacts of climate change (take advantage of the creation of the ODT to make it a reference institution for the M&E of phenomena related to climate change)

Measure 5: Consideration of a climate risk budget in territorial planning (define and introduce new provisions in the future regulations that codify the new organic law on the budget to provide guidance on the integration of adaptation needs in sectoral and local budgets).

Coastal Areas and Fisheries

The Tunisian coast has a total length of 2,290 km, distributed as follows: 1,280 km of continental coastline, 450 km of island coastline and 560 km of lagoons. The three main types of fishing encountered in Tunisia are trawling, lamp fishing and inshore fishing. The main marine production area is located in the governorates of Sousse, Monastir and Nabeul, while the production of continental aquaculture, is mainly located in the governorate of Béja. Fishery production has steadily increased since the 1990s, reaching a total production of 118,000 tons in 2012, with an annual growth rate of 2.6% between 1996 and 2012.

Tunisian coasts are subject to the continuous action of physical hazards (current, swells, tide, etc.) which can be amplified by sea level rise (SLR) induced by climate change. A progressive retreat of the coastline is therefore expected.

Measure 1: Produce and share information, knowledge and know-how to improve the resilience of the coastal sector to the effects of climate change and natural disasters.

Measure 2: Develop and integrate innovative processes, methods and tools that integrate climate change and natural disaster risks into planning in the coastal sector.

Economic Resilience

Measure 1: Modernize information management, facilitate access to and sharing of knowledge and forecast risks related to climate change

Measure 2: Increase the resilience of economic sectors, including tourism and its subsectors, of their actors and rationalize the use of resources.

Climate-related Natural Disaster Resilience

Measure 1: Develop integrated and multi-level governance of DRR

Measure 2: Implement Early Warning Systems (EWS)

Measure 3: Strengthen, raise awareness, and share knowledge on risks

Measure 4: Undertake integrated multi -hazard risk assessment in Raoued municipality.

1.5. 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 the Table below, while those applicable for Raoued have been identified.

Table 52: Climate Hazard Types.

General Climate Hazard Types	Applicable for Raoued region
Extreme heat	√
Extreme cold	
Landslides	√
Storms	√
Droughts	√
Sea level rise	√
Floods	√
Extreme precipitation	√
Forest fires	√
Ice and snow	

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 (Coastal areas, 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.

Raoued Municipality has filled in Table 82 below, in order to conduct the vulnerability analysis, based on sources such as the Future Cities Adaptation Compass Tool and UNFCCC.

Table 53: Suggested template for the 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. • Spread of vector born and infectious diseases. • Altered allergic pattern. • 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
		Storms	• Casualties and deaths	All people living or working in the area
		Sea level rise	• Damages and causalities • Injuries and deaths • Water-borne diseases • Asthma and respiratory allergies	All people living or working in the area mainly in the coastal area especially Fishermen.
		Droughts	• Asthma and cardiovascular diseases. • Accumulation of trace elements.	All people living or working in the area
		Floods	• Injuries and deaths. • Water-borne diseases. • Asthma and respiratory allergies.	All people living or working in the area
		Extreme Precipitation	• The spread of insects and diseases such as malaria.	All people living or working in the area
		Forest fires	• Choking occurrence and poisoning. • Death.	All people living or working in the area

Infrastructure	Transport	Extreme heat	• Road network damages. • Change in behavior patterns. • Air quality problems. • Higher maintenance costs.	Roads, public transport, people mobility
		Landslides	• Damages • Mobility difficulties in afflicted areas	Roads, public transport, people mobility
		Droughts	• Difficult transport of bulk material	Waterways, water management
		Storms	• Damages • Mobility difficulties in afflicted areas	• Roads, rail roads, public transport, people mobility
		Sea level rise	• Damages • Mobility difficulties in afflicted areas	• Roads, rail roads, public transport, people mobility
		Floods	• Damages • Mobility difficulties in afflicted areas	Roads, public transport, people mobility
		Extreme Precipitation	• Damages. • Road sliding.	Roads, public transport
		Forest fires	• No effect	No effect
	Energy	Extreme heat	• Altered electricity peaks/demand • Damages • Cooling problems • Reduction of efficiency yield from conventional power plants and distribution grid • Higher maintenance costs	Conventional power plants, electricity providers and consumers
		Landslides	• Damages • Operational difficulties	All facilities in the electricity generation (including RES such as PVs), as well as the electricity transmission and distribution grid
		Storms	• Damages and losses	All facilities in the electricity generation and distribution grid in the affected areas
		Sea level rise	• Higher maintenance cost • Damages	All facilities in the electricity generation

			• Operational difficulties	and distribution grid in the affected areas
		Droughts	• Energy supply and demand patterns' shift • Higher maintenance costs • Cooling problems	Conventional and renewable energy facilities (PVs, etc.)
		Floods	• Damages • Operational difficulties	All facilities in the electricity generation, transmission and distribution grid in the affected areas
		Extreme Precipitation	• Higher maintenance costs. • Network outage.	Electrical network.
		Forest fires	• Network outage.	Electrical network.
	Water	Extreme heat	• Higher water demand • Water quality issues • Higher maintenance costs	Public health, water infrastructures
		Landslides	• Damages • Water quality issues	Public health, water infrastructures
		Storms	• Water management issues • Water quality issues	Public health, water infrastructures
		Sea level Rise	• Water management issues • Damages • Water quality issues • Higher maintenance costs • Increased salinity of underground water	Public health, water infrastructures
		Droughts	• Water scarcity • Water quality issues • Higher maintenance costs	Public health, water infrastructures
		Floods	• Water quality issues • Water management issues • Damages • Higher maintenance costs	Public health, water infrastructures
		Extreme Precipitation	• Extreme mismatches between water supply and demand. • Reduce the groundwater supply.	Water resources.
		Forest fires	• No effect	No effect
	Social	Extreme heat	• Higher electricity demand to cover cooling needs	Hospitals, schools, public places,

			• Changes in behavior patterns, e.g. living outdoors • Burdening of the health care facilities due to the increased number of patients in hospitals	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 • Burdening of the health care facilities due to the increased number of patients in hospitals	Hospitals, schools, public places, municipal facilities, athletic facilities
		Storms	• Damages in social facilities in afflicted areas • Burdening of the health care facilities due to the increased number of patients in hospitals	Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities
		Sea level rise	• Impacts on public spaces (e.g. loss of beaches) • Damages on coastal facilities	Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities
		Extreme Precepetation	• Damages in social facilities	Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities
		Forest fires	• Damages in social facilities	Hospitals, schools, public places, municipal facilities/infrastructure, athletic facilities
Bui	Building stock and	Extreme heat	• Concrete's damages • Increased cooling demands	All building infrastructure

	material		• Higher maintenance costs • Urban heat island effect	
		Storms	• Damages • Higher maintenance costs	All building infrastructure
		Sea level rise	• Sinkholes collapse • Extensive damages • Flooding at the city level of all building infrastructure	All building infrastructure
		Landslides	• Extensive damages	All building infrastructure in afflicted areas
		Droughts	• Higher water demand	All building infrastructure
		Floods	• Damages • Higher maintenance costs	All building infrastructure in afflicted areas
		Extreme Precipitation	• Partial destruction of infrastructures	All building infrastructure
		Forest fires	• Fire in buildings.	All building infrastructure
Economy	Tourism	Extreme heat	• Increased demand for cooling • Lower touristic flows during the impacted seasons • Higher water demand	Tourists, tourist infrastructure, tourist related economy
		Landslides	• Lower touristic flows • Damages in touristic infrastructure	Tourists, tourist infrastructure, tourist related economy
		Droughts	• Increased pressure on water resources, escalating water scarcity issues • Increased water supply costs	Tourists, tourist infrastructure
		Storms	• Damages in touristic infrastructure and related costs for repairs	Tourists, tourist infrastructure, tourist related economy
		Sea level rise	• Damages in touristic infrastructure, which are located at coastal areas	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
		Forest fires	• Destruction of tourist facilities. • Lower touristic flows	Tourists, tourist infrastructure, tourist related economy
	Agriculture	Extreme heat	• Changes in growth cycle • Damages / loss of harvest • Livestock loss and impacts on health • Lower crop yields	Farmers, food industry, consumers
		Landslides	• Damages / loss of harvest in afflicted areas / loss of livestock • Potential property loss in afflicted areas • Loss of soil resources	Farmers, food industry, consumers
		Droughts	• Damages / loss of harvest • Lower crop yields • Livestock loss and impacts on health • Land degradation	Farmers, food industry, consumers
		Floods	• Damages / loss of harvest in afflicted areas / loss of livestock	Farmers, food industry, consumers
		Storms	• Damages / loss of harvest in afflicted areas / loss of livestock	Farmers, food industry, consumers
		Sea level Rise	• Damages / loss of harvest in coastal areas • Increased water salinity will result in existing crops' long-term destruction • Loss of fertile grounds near coastal areas and especially the deltas	Farmers, food industry, consumers
		Extreme Precipitation	• Destruction of food crops.	Food industry
		Forest fires	• Lower crop yields.	Farmers, food industry

Table 54: Suggested template for the risk assessment

	Receptors	Weather Sensitivity	Future Risk	Impact
Population	Public Health	Extreme heat	• Increased number of deaths • Reinforcement of heat stress • Increased infectious diseases • Altered allergic patterns • Chronic respiratory diseases • Vector Born Diseases (VBD) • Skin diseases Melanoma and sunburn	Medium
		Sea level Rise	• Increased incidents of asthma and pneumonia • Increased water-borne diseases • Limitations to the healthcare access	High
		Storms	• Limitations to the healthcare access • Increased numbers of injuries and deaths	High
		Landslides	• Increased number of injuries and deaths • More respiratory problems	Medium
		Droughts	• Increased allergic incidents • Decreased air quality • More respiratory problems • Consumption and use of unsafe (contaminated) water for drinking due to water scarcity • Malnutrition • Food shortages	Medium

		Floods	• Limitations to the healthcare access • Increased numbers of injuries and deaths • 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
		Forest fires	• Increased number of injuries and deaths - More respiratory problems.	High
Infrastructure	Transport	Extreme heat	• Damages on road network • Modification of transport frequency and means • Air quality problems • Higher maintenance costs	Medium
		Landslides	• Damages on road network • Modification of transport frequency and means • Higher maintenance costs	Medium
		Sea level Rise	• Damages	High
		Storms	• Damages • Mobility problems	High
		Droughts	• Difficult transport of bulk material	Medium
		Floods	• Damages • Mobility problems	High
		Extreme Precipitation	• Damages on road network • Modification of transport frequency and means	High

			• Higher maintenance costs	
		Forest fires	• Difficult transport of bulk material.	Low
	Energy	Extreme heat	• Blackouts and inability to cover demand load • Damages, especially in the thermal power plants	High
		Landslides	• Damages in the transmission and distribution grid • Damages in any power generating plants, including RES (PVs) in afflicted areas	Medium
		Droughts	• Blackouts and inability to cover demand load • Higher maintenance costs • Cooling problems in power plants	Medium
		Sea level Rise	• Damages	Medium
		Storms	• Damages / Failures in the production facilities and distribution grid / power cuts	Medium
		Floods	• Damages / power cuts	Medium
		Extreme Precipitation	• Damages in the transmission and distribution grid • Damages in any power.	High
		Forest fires	• Damages in the transmission and distribution grid • Damages in any power generating plants, including RES (PVs) in afflicted areas	High
	Water	Extreme heat	• Water scarcity • Water quality issues	High
		Landslides	• Water scarcity due to infrastructure damages	Medium

			• Water quality issues due to infrastructure damages	
		Sea level Rise	• Increased underground water salinity • Water management issues • Damages • Water quality issues • Higher maintenance costs	Medium
		Storms	• Increased damages and related maintenance costs • Water management issues	Medium
		Droughts	• Water scarcity • Water quality issues	Medium
		Floods	• Increased damages and related maintenance costs • Water management issues • Water quality issues	Low
		Extreme Precipitation	• Water scarcity • Water quality issues	Medium
		Forest fires	• No expected risks	No expected risks
	Social	Extreme heat	• Increased needs for air conditioned public spaces	Medium
		Landslides	• Damages • Mobility problems • 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 • Inability to cover the water demand • Difficulties in the operation of certain facilities due to lack of	Medium

			water (e.g. swimming pools)	
		Sea level Rise	• Potential damages in the coastal area facilities • Loss of coastal public spaces (beaches etc.)	High
		Storms	• Damages • Increased maintenance costs	High
		Floods	• Damages • Increased maintenance costs • 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
		Forest fires	• Increased needs for protected places.	High
Built Environment	Building stock and material	Extreme heat	• Concrete's damages • Increased cooling demands • Higher maintenance costs • Urban heat island effect	Low
		Landslides	• Damages	Low
		Droughts	• Higher water demand	Medium
		Sea level Rise	• Sinkholes collapse • Extensive damages and loss of property • Impact on coastal zone economy	Medium
		Storms	• Damages • Increased maintenance costs	Medium
		Floods	• Damages • Increased maintenance costs	Medium
		Extreme Precipitation	• Concrete's damages. • Infrastructure Damages	Medium

		Forest fires	• Damages	High
Economy	Tourism	Extreme heat	• Change of the tourism season – lower touristic flows • Reduction of the tourism related economy	Medium
		Landslides	• Potential damage to touristic infrastructures and sites	Low
		Droughts	• Increased water supply costs • Potential increase of indirect costs for the tourists (infrastructure related) and reduction of touristic flows	Low
		Sea level Rise	• Damages and even complete destruction of touristic infrastructure, nearby coastal areas and deltas	Medium
		Storms	• Damages to touristic facilities	Medium
		Floods	• Damages to touristic facilities • Potential effects on the touristic flows, in areas with flooding history	High
		Extreme Precipitation	• Change of the tourism season – lower touristic flows • Reduction of the tourism related economy	Medium
		Forest fires	• Reduce the touristic flows	Medium
	Agriculture	Extreme heat	• Changes in growth cycle • Damages / loss of harvest • Livestock loss and impacts on health	High

			• Lower crop yields • Increased fire risks	
		Landslides	• Damages/ loss of harvest • Loss of soil and reduction of cultivated lands	Medium
		Droughts	• Damages / loss of harvest • Lower crop yields • Livestock loss and impacts on health • Land degradation • Increased fire risks	High
		Sea level Rise	• Damages / loss of harvest in areas near delta, sea etc. • Increased water salinity will result in existing crops' long-term destruction.	High
		Storms	• Damages/ loss of harvest in afflicted areas • Surface soil erosion	High
		Floods	• Damages/ loss of harvest in afflicted areas • Livestock loss • Surface soil erosion	High
		Extreme Precipitation	• Damages/ loss of harvest. • Loss of soil and reduction of cultivated lands	High
		Forest fires	• Damages/ loss of harvest.	High
Biodiversity	Coastal zone ecosystems	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
		Sea level Rise	• Loss of specific species (fish, etc.) • Soil erosion • Water salinization	Medium

		Storms	• Soil erosion	Medium
		Floods	• Soil erosion	High
		Extreme Precipitation	• Destruction of agricultural lands	Low
		Forest fires	• Reduce the green zones	Medium

3. Appendices

3.1 Appendix A (Public and Private Transportation)

	%	traffic in Fathi Zuhair street (vehicle/day)[11]	Average distance (km)[9]	Lit/km @50 km/hr	Liter/day	Diesel (Liter/year)	Gasoline (Liter/year)	MWh/yr
Passenger cars	86%	32,794	30	0.125	121,702		36,510,505	354,882
Two wheels	4%	1,525	30	0.047	2,133		639,773	6,219
Heavy Good vehicles	4%	1,525	30	0.267	12,117	3,635,074		36,351
Public transport group taxis	5%	1,907	30	0.125	7,076		2,122,704	20,633
Public transport others	1%	381	30	0.267	3,029	908,769		9,088
Total	100%	38,133	30			4,543,843	39,272,982	427,172

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