Climate change in the Tunisian cities: lessons learned and best practices

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Abstract
The aim of this policy paper 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. 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.

Keywords Climate change · Municipalities · Adaptation · Mitigation

1 Introduction

In the last few decades, the CO₂ levels were higher than at any time in the past 800,000 years (Lüthi et al. 2008). The decade 2010–2020 is considered the warmest decade on record during the past 150 years (Mann et al. 2016; Vitasse et al. 2018). According to NASA (2021), 2020 was the warmest year on record and saw a high decrease in global emissions due to the COVID-19 crisis. Major disruptions are observed all over the world due to effects of climate change and already “the climate emergency” is proclaimed in many countries and many cities.

Nowadays, more than half of the world’s population lives in urban areas. The activities in the urban areas are major contributors to climate change, accounting for
about 70% of CO₂ emissions (UN Habitat 2021). In the coming decades, millions of people in urban areas are likely to be affected by rising sea levels, increased precipitation, inland floods, more frequent and stronger cyclones and storms, and periods of more extreme weather events. Over 90% of all urban areas are coastal, putting most cities on the planet at risk of flooding from rising sea levels and severe storms (UCCRN 2018).

The Mediterranean is one of the regions of the world most affected by the effects of climate change. Mediterranean temperatures are increasing 20% faster than the global average (WWF 2021). Several analyses are made to identify the most vulnerable cities to climate change. Tapia et al. (2017) assessed the vulnerability of 571 European cities using a range of indicators from thematic areas such as human capital, governance and institutions, socio-economic conditions, the built environment and natural capital. According to this analysis, it is difficult to identify clear spatial patterns of vulnerability among European cities. The cities most vulnerable to all risks are more numerous in Central Europe, Estonia, parts of Germany, Latvia and Romania, but also scattered throughout Europe. According to the analysis made by Gu (2019), the majority of the riskiest cities in the world are located in East Asia, China, Taiwan, the Philippines and Japan, due to their degree of exposure to natural hazards. Many of these metropolitan areas are located on the coast and are threatened by floods, storms, earthquakes and other natural disasters.

Cities are at the forefront of the fight against climate change. They have a very important role in taking mitigation and adaptation actions to combat climate change. Several research show that cities have a huge opportunity for meeting the climate change adaptation and mitigation goals as well as to contribute to a sustainable development (Singh et al. 2021; Angelo and Wachsmuth 2020; Bai et al. 2018; Bazaz et al. 2018; Dulal 2017; Parnell 2016). There are several instruments, strategies and practices to enable cities to fight against climate change like integration of the climate adaptation actions in urban development (Friend et al. 2014; Singh et al. 2021), understanding the co-benefits and synergies of the adaptation and mitigation strategies to combat climate change (Sharifi 2021; Khosla and Bhardwaj 2019), or shifting to a more sustainable development of the cities (Angelo and Wachsmuth 2020). However, the focus of the actions on adaptation and mitigation is still unbalanced (Govindarajulu 2020; Dovie 2019; Papa et al. 2015). Often the adaptation plans are less advanced, while in many cities, even in the developed world, there are better institutional arrangements for mitigation actions (Hoppe et al. 2016; Landauer et al. 2019).

The literature on urban adaptation is increasing recently. Several studies are conducted to measure the potential of the cities and their barriers to implement adaptation strategies (Govindarajulu 2020; Bossio et al. 2019; Filho et al. 2019; Anguelovski et al. 2014). Some studies explore the effectiveness of the current adaptation actions (Doherty et al. 2016; Tyler et al. 2016) or the processes of adaptation planning and implementation (Kumar and Geneletti 2015). Studies show that comprehensive and sustainable adaptation can be enabled by effective political leadership, supportive funding and institutional processes, multi-stakeholder involvement and effective decision-making (Govindarajulu 2020; Chu 2018; Hughes and Sarzynski 2015; Friend et al. 2014). The adaptation actions at the local level can be enabled
also by non-government organizations (NGOs), which play an important role in climate policy (Ben Youssef 2021a).

Another important body of literature focuses on climate change mitigation in the cities (Holtz et al. 2018; Essl and Mauerhofer 2018; Ali et al. 2017; Peng and Bai 2018). The way of leading cities on climate change ambition through mitigation actions is not yet clear. Several studies have often critiqued the cities for not sufficiently being engaged in climate actions (Bansard et al. 2017; van der Heijden et al. 2019). While there are many practices that can help to mitigate climate change, new technologies are offering a huge potential in this matter (Ben Youssef 2020; Ben Youssef and Zeqiri 2022). Moreover, the change of behavioral consumption is important in this aspect (Ben Youssef 2021b).

This policy paper aims to characterize the current situation of Tunisian municipalities in matters of climate change policies and actions and understand the barriers and best practices. The interest of our paper is threefold. On the one hand, it provides information on the state of play taking into account the climate in local public policies in Tunisia and its degree of integration and assimilation by municipal councils. On the other hand, it examines the main obstacles to better consideration of the climate issue in Tunisian municipalities. Then, it collects a series of best practices useful for developing public policies at the local level.

The paper is organized as follows. Section 2 offers an overview of the context of Tunisia. Section 3 describes the methodology and data collection. Section 4 offers some descriptive statistics. Section 5 provides the best practices and main challenges to fight against climate change at the local level. Section 6 provides the main policy recommendations.

2 The context of Tunisia

Tunisia is a country which is exposed to the impacts of climate change. The effects of climate change are causing the problems of desertification, water scarcity and the degradation of natural resources. Population living in urban areas is increasing, where 69% of the current population resides in urban areas in Tunisia and is expected to reach 80% by 2050.

Since the Tunisian revolution of 2011, the Ministry of Local Affairs and Environment, the responsible entity at the national level, and municipalities have been engaged in an ongoing process which intends to transition from centralized decision-making to an increased functionality at the local level. Local authorities, by their proximity to citizens, are considered the primary institutions responsible for environmental actions and are supposed to be the most effective actors in the fight against climate change. In Tunisia, there is the organic law of local authorities (Code des Collectivités Locales, JORT law no.29 of May 9, 2018, hereinafter CCL) which determines the roles and responsibilities of municipalities in terms of environmental preservation, cleanliness and sustainable development.

However, in 2021, the decentralization process has not been completed and the support it receives at the national level can be considered uneven. The level of engagement between ministries and local authorities is inadequate and there is a
disassociation between policy intentions and the operational level. The inertia of a highly centralized system does not compel the municipality to take a proactive role. Weaknesses across planning, financing and operations affect the formulation and implementation of projects across sectors. Municipal staff with higher education do not represent more than 11%. When available, the potential of technology is underutilized, and skilled people are overloaded.

Central government provides general information and guidance on climate change effects that are most likely to have a significant impact at a regional, national or sector level. This allows the local governments to access the information needed to take action to mitigate and to adapt to climate change. The local governments are responsible for adapting and mitigating climate change and are considered as the most effective level for making decisions about local climate actions and natural hazards.

Tunisia is committed to the global process of combating climate change and respecting sustainability in its economic development model. Several international conventions and agreements are adopted today as a normative framework to move countries towards sustainable development. The first framework is that of the International Convention for the Fight against Climate Change (UNFCCC) to which Tunisia has been a signatory since 1994. Then, the 2030 Agenda was adopted in 2015 by the United Nations. The Paris Climate Agreement was made at the COP 21 in Paris in 2015. In its updated NDC, Tunisia has committed itself through an ambitious objective of reducing its carbon intensity by 45% by 2030 (NDC of Tunisia, 2021). Local climate action is one of the priority projects.

The importance of the integration of climate change risks, adaptation and mitigation needs into local development plans and urban plans is one of the priorities of Tunisia’s NDC. As Tunisian cities are experiencing very rapid growth, it appears that at least 50% of GHG emissions take place within urban perimeters, through industrial activities and inter-municipal transport, as well as sources from the building sector. Even though many initiatives are underway relating to projects for adaptation to climate change and having a strong impact on the resilience of communities and on social inclusion in Tunisia, most of them remain at the pilot or prototype stage.

The need for local governance on climate change is demonstrated also with the fact that municipalities in Tunisia have different bioclimates, which need specific action varying from one municipality to another. Therefore, the extreme climatic events are experienced differently in municipalities in Tunisia (floods in Nabeul, forest fires in Aïn Draham or Boukarnine, marine intrusion in Radès, loss of coastline in Bizerte, Djerba, etc.). The preoccupations related to the effects of climate change and the new direction of national climate strategies towards greater involvement of the local level leads to the consideration that ultimately, all municipalities should have skills in this area.

Some funds are available at the local level and not at the central level. For instance, the projects funded by international climate funds. We can mention here the local-level project financed by the Global Environment Fund for protection of the Marine and Coastal Resources of the Gulf of Gabes. Another example is the project financed by the Adaptation Fund for contributing to the eradication of poverty.
in the Kairouan by empowering the rural poor to adapt to climate change through environmental management and sustainable livelihoods.

Adaptation policies need to be settled with local communities at the local level, by taking into consideration a participatory approach. Planning methods can help build appropriate local-level institutions, which can enable the recognition of communities’ potential to organize themselves and identify appropriate planning tools. Local-level institutions can support community action through a climate compatible development partnership.

3 Methodology

The aim of this policy paper is to characterize the current situation of Tunisian municipalities in matters of climate change policies and actions and understand the barriers and best practices. We have surveyed 68 municipalities in Tunisia. The various municipalities in terms of size, spatial location, area covered, urbanization and rurality are represented. Our approach covered municipalities with more than 637,568 inhabitants (Tunis) and municipalities of 1,824 inhabitants (Menzel Salem), as it is shown in Table 1.

A review of the literature on the available instruments was carried out and allowed us to develop the questionnaire that best adapts to the Tunisian context. Cognitive tests were then carried out for the validation of the questionnaire before embarking on its large-scale administration. At the same time, we engaged in a series of interviews with numerous presidents of city councils and councilors with knowledge of the climate issue. This “qualitative” work is not fully taken into account in this version of the paper. We should mention that this is exploratory research.

Data were collected through a questionnaire developed by the author. The questionnaire was prepared in English and translated into French and Arabic. It was distributed face-to-face with relevant people in the Tunisian municipalities.

The survey questions covered the following areas: (a) general information about the municipality; (b) perception of the municipality for climate change; (c) climate change adaptation measures; (d) climate change mitigation measures and (f) climate strategic framework at the local level.

4 Descriptive statistics

The effects of climate change are being felt more and more in Tunisian municipalities, but the actions taken to fight against climate change are still far from being adequate and proportionate to the climate threat. Even if several initiatives are taken, this has not been enough to adapt and mitigate the effects of climate change in Tunisia.

Figure 1 shows that all of the municipalities surveyed have faced some sort of climate change effects in their perimeters over the past 5 years. 78% of the municipalities surveyed had experienced a heat wave in the past five years. Then, a majority of municipalities (59%) have observed a degradation of the water
| Municipality       | Population | Municipality       | Population | Municipality       | Population |
|-------------------|------------|-------------------|------------|-------------------|------------|
| Tunis             | 637,568    | Le Kef            | 60,876     | El Ksar           | 25,607     |
| Sfax              | 280,566    | Sakiet Ezzit      | 60,224     | Jilma             | 24,732     |
| Sousse            | 221,715    | Mahdia            | 55,458     | Moularès          | 22,798     |
| Bizerte           | 167,759    | Ksar Hellal       | 54,533     | Nefta             | 21,731     |
| Soukra            | 129,693    | Ghardimaou        | 50,793     | Degache           | 21,590     |
| Kairouan          | 117,903    | La Goulette       | 45,711     | El Guettar        | 20,137     |
| Ariana            | 114,486    | Zarzis            | 45,223     | El Hachachna      | 18,797     |
| Gafsa             | 111,170    | Siliana           | 44,736     | Le Sers           | 17,787     |
| Sidi Hassine      | 109,672    | Bou Salem         | 43,997     | Carthage          | 17,010     |
| Médenine          | 102,700    | Hammam Sousse     | 42,691     | Kerkennah         | 15,501     |
| Jendouba          | 100,085    | Regueb            | 41,823     | El Ksour          | 15,215     |
| Gabès             | 99,426     | Agareb            | 40,943     | Bennane–Bodheur   | 14,258     |
| Moknine           | 96,606     | Gremda            | 40,862     | Ksibet el–Médiouni| 13,082     |
| Monastir          | 93,306     | Soliman           | 37,749     | Sayada            | 12,962     |
| La Marsa          | 92,987     | El Fahs           | 34,456     | Khniss            | 11,229     |
| M’saken           | 84,295     | Tabarka           | 33,942     | Haidra            | 9,762      |
| Douar Hicher      | 84,090     | Sisseb-Driat      | 33,257     | El Maâmoura       | 9,708      |
| Djerba–Houmt Souk| 83,470     | Bir El Hafey      | 29,889     | Chott Meriem      | 7,294      |
| Sidi Bouzid       | 81,004     | Haffouz           | 27,110     | Sidi Bou Said     | 7,206      |
| Nabeul            | 73,128     | Mdihilla          | 26,976     | Touiref           | 6,184      |
| Le Bardo          | 71,961     | Redeyef           | 26,976     | Bohra             | 6,168      |
| Radès             | 70,388     | Kalâat el-Andalous| 26,796     | Menzel Salem      | 1,824      |
| Djerba–Midoun     | 63,528     | El Haouaria       | 25,995     |                   |            |
| **Total**         | **4,339,104**|                  |            |                   |            |

**Table 1** Sample of 68 municipalities

**Fig. 1** Climate change events in Tunisian municipalities over the past five years
table linked to climate change over the past five years. This is followed by floods (51%) and episodes of drought (50%). During the last five years, climate change has been perceptible by Tunisian municipalities and its multiple manifestations clearly identified.

Most Tunisian municipalities are on the front line when it comes to the perceptible effects of climate change. Thus, adaptation measures, sometimes urgent, are necessary and put in place without being taken into account as such in national programs. For coastal cities, marine erosion and the loss of coastline have become almost unquestionably a reality. For the cities of the south, the preservation of the oases and the fight against desertification are at the heart of their actions. Across Tunisia, the scarcity of water implies greater participation by municipalities in solving this problem. Thus, adaptation policies—through adequate land use planning—are local policies in which cities should play a major role.

The issue of mitigating the effects of climate change at the local level is important. For the moment, this issue remains strictly linked to controlling energy expenditure, setting up renewable energy projects and controlling transport. Actions in the field of construction and building remain very weak in Tunisia. The same goes for mobility. Our field survey revealed important trends that need to be taken into account in future action plans and strategies at the national level.

As it is shown in Fig. 2, in terms of adaptation to climate change, 88% of municipalities surveyed have no strategy. Only 12% of municipalities surveyed say they have an adaptation strategy. This axis is fundamental for tackling climate change. While a group of leaders pull away and seem to begin to define a strategic framework of actions, the vast majority have no strategic thinking for adaptation to climate change. This leads to setting up differentiated actions and including the

![Fig. 2 The situation of municipalities in terms of adaptation and mitigation to climate change](image-url)
local adaptation plan at the heart of the strategic thinking of municipalities as in Local Development Plans or Cities Development Strategies (CDS).

Regarding mitigation, only 21% of the municipalities surveyed state that they have put in place a strategy and measures to mitigate GHG emissions. These strategies mainly concern energy control and public lighting. The mitigation project seems to be a priority for the next decade. It concerns both the consolidation of actions carried out by the municipalities involved and the training of municipalities without an action plan until now.

Figure 3 shows that funding and financial resources are cited as the main obstacles facing the development of a climate change adaptation strategy at the local level at more than 84%. Adaptation and mitigation strategies are not meant to remain at the document stage, they have to be put on the ground and for that we need the means. However, the current budgets of municipalities are too low to assume new expenditure items. In addition, the staff of municipalities in general is under supervision. Adapting and mitigating the effects of climate change requires dedicated staff and municipalities are missing this staff at the moment.

In terms of adaptation, as it is indicated in Fig. 4, the main measures taken at the level of cities concern the fight against floods, the fight against heat waves and the degradation of the water table. Measures are almost non-existent for the loss of biodiversity where special work is necessary. The same is true for forest fires where the summer of 2021 has shown their capacity to endanger certain local economies.

Figure 5 shows that the budget allocated to climate actions has been declared declining over the past five years by 53% of municipalities surveyed. In 32% of cases, this budget increased in the same proportions as the budget (the relative share remained stable). On the other hand, in 15% of cases, municipalities increased their budget allocated to climate by a greater proportion than the increase in the overall
The budgets of the municipalities in Tunisia are so low (4% of the total budget). This also makes the budget for climate action to be very low and as results indicate the majority of the surveyed municipalities claim to have decreased their budget. The available resources for municipalities are not entirely mobilized and this restricts their activities in fighting climate change.

However, several projects are implemented at the local level and funded by important international funds, particularly for mitigation of climate change. The
fundings provided by international organizations and funds are supporting the development of the actions at the local level and putting them at the forefront of fighting climate change.

5 Best practices and main challenges to fight climate change

This section provides the best innovative practices in matter of mitigation and adaptation to climate change and main challenges to fight against climate change at the local level in Tunisia.

5.1 Innovative practices in the matter of climate change at the local level

Our survey shows that most of the cities do not have mitigation or adaptation strategies. They have taken some isolated initiatives, but there is an absence of the implementation of climate strategic frameworks and action plans. Some of the cities have implemented the city development strategy and action plans to fight climate change. City development strategies have been carried out for 9 pilot cities: Medenine, Beja, Gabès, Jendouba, Kairouan, M’saken, Sidi Bouzid, La Soukra and Tataouine. City development strategies help the strengthening and disseminating strategic urban planning initiatives, enabling municipalities to support their efforts to strengthen their power, capacities and leadership. While many city development strategies contain a climate and environment component, they are still weakly based on in-depth analysis of vulnerabilities and without reference to national adaptation and mitigation policies. However, 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.

5.1.1 Inter-communality in the service of the climate: development of an intercommunal climate plan for the island of Djerba

The climate plan is a regional sustainable development project, the purpose of which is the fight against climate change and the adaptation of the territory. It aims at both adaptation and climate mitigation. Its objective is to reduce climate risks and ecosystem imbalance. It highlights the importance of systematizing a sustainable development approach and identifying projects compatible with the fragility of the island. Indeed, the island of Djerba is committed to a climate plan that brings together the three municipalities. Inter-communal rapprochement makes it possible to consider relevant actions on the scale of the territory and with a rationing of means. At the same time, the master plan for the sensitive area of Djerba is the bearer of a development project which proposes to fundamentally revise current policies and practices. The central idea of this strategy is to return to a fundamental rule which is the application of the law and its respect. The
master plan is drawn up using a local participatory approach. Its objective is to put the island on the path of sustainable development.

5.1.2 Progressive engagement in mitigation actions through pro-climate energy actions

There are several mitigation actions taken by cities in Tunisia. However, one of the most noticeable advances in recent years at the municipal level concerns the multiplication of initiatives for the realization of an energy transition. Many municipalities have committed themselves to low-energy public lighting, the equipment of photovoltaic stations, the control of the car fleet and the associated energy consumption. These initiatives are numerous and those cited are only illustrations.

First, several cities have benefited from specific support from the ACTE program, such as Bizerte, Douz, Hammam-Lif, Kairouan, Medenine, Nabeul, and Sfax. They have drawn up action plans for the energy transition. After the development of the action plans, a prioritization and identification approach for Quick Win was adopted. Several actions due to this support are developed: the installation of the mini-solar power plants in Bizerte; implementation of strategic plans for soft mobility to promote soft modes of travel in Douz; replacement of sodium light points by LED lamps and implementation of a remote lighting management system in Hammam-Lif; construction of a high energy efficiency building in Medenine; improvement of the municipality’s car fleet through the acquisition of electric waste collection machines in Nabeul; and implementation of a geographic information system (GIS) in Sfax.

Second, the implementation of the data-driven energy approach at the local level. The creation of an energy consumption dashboard (TBGE) in the city of Sousse is a first concrete step in the implementation of a data-driven approach to the municipality. The activity is innovative and builds a complementarity between energy management and geographic information systems.

Third, the development of a carbon footprint approach in the cities. In the city of Sfax, is developed a carbon footprint tool, which has a triple concern: first to reduce the energy bill of the municipality of Sfax, then to reduce the consumption of fossil energies and the substitution by gas and renewable energies including solar, finally to contribute to the reduction of pollution due to greenhouse gases including CO₂.

Fourth, installation of photovoltaic stations in the cities. The city of Nabel has installed photovoltaic stations to power the municipality building and public lighting nearby. The objective of this initiative is to put the city of Nabeul in a position to realize, replicate autonomously and demonstrate to other neighboring cities photovoltaic solutions for the supply of electricity to public buildings and urban lighting and wastewater treatment stations.

Fifth, the implementation of remote smart lighting as a tool for the development of the smart cities. In Ras Jebel is implemented the smart lighting management, which consists of the remote management of an LED lighting network combined with a remote management platform. This solution will improve the lighting of public roads and generate a reduction in energy consumption of more than 75% in the municipality of Ras Jebel in Tunisia. In addition, it is a modular solution that can
manage an unlimited number of objects and applications (waste management, traffic, parking, pollution measurement) without additional deployment or subscription costs, making it an ideal tool for the development of the Smart City.

Sixth, the implementation of the sustainable energy action plans. Sousse and Sfax have developed their Sustainable Energy Action Plan (SEAP). The municipality of Sousse and Sfax committed to reducing its emissions by 20% compared to trend emissions in 2020. To achieve this objective, an action plan to reduce GHG emissions has been developed.

### 5.1.3 Innovative practices in matter of adaptation to climate change

The actions and policies to climate change adaptation in Tunisia are absent. While urbanization is increasing and effects of climate change are becoming more severe, the climate change adaptation actions remain still weak. The lack of the financial resources and the adaptation strategy at the local level are a barrier for future actions. However, we have identified some of the best practices developed by Tunisian cities in matter of climate change adaptation.

First, the creation of disaster risk management rooms to cope with extreme events. There are two disaster risk management rooms in Tunisia, one in Ain Draham and the other one in Tataouine. This practice helps to strengthen the local skills of the city in disaster management (forest fires, snowstorms, landslides). The case of the floods experienced in September 2018\(^1\) showed that the task of intervention and response is more effective given the existence of early warning systems, strategies and response plans. The establishment of an early warning system will also facilitate decision-making for the municipality, more efficiently and quickly.

Second, the development of a participatory approach for biodiversity conservation. The municipality of Soliman in collaboration with local civil society actors carried out the “FLORAWETS” project whose objective is to contribute to the conservation of wetland biodiversity through the preservation and enhancement of plant species in “Sebkhet Soliman”. It aims to involve all stakeholders and consolidate existing resources and skills to promote participatory and sustainable management of natural resources.

Third, safeguarding the flora and diversity of plants through a nursery. To safeguard the flora and diversity of plants, the municipality of Tabarka has created a nursery for the specificities of the region. It aims to plant the regions burned after the forest fires and to encourage citizens to the problem of greening the city. Other cities have similar plans and are looking to launch massive tree planting campaigns to limit the effects of heat waves and create shady areas in the city.

Fourth, actions to limit the loss of coastline. The city of Soliman has developed some actions and works to protect the coastline of Soliman against coastal erosion. Plunging spikes, riprap riders at the beaches of Sidi El Jahmi and Soliman beach, windbreaks for the rehabilitation and fixing of the dunes as well as the reloading

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\(^1\) The evaluation for the floods in Nabeul in 2018 indicates economic losses for approximately USD 106 million.
beaches by bringing sand are the main actions. Recently, a project is underway to protect the Bizerte Corniche from marine erosion. It aims to renovate and protect the retaining wall and the pavement of the cornice damaged following a violent storm in November 2019.

Fifth, development of programs for the oasis ecosystem management. There are several cities that have developed oasis ecosystem management programs: Tameghza, Chebika, Midès, El Guettar, Noueil and Zarat. These programs aim to intervene and preserve the environment and biodiversity and to ensure better management of resources in several oases in Tozeur, Kebili, Gafsa and Gabès. Oasis ecosystem management is a good practice for adaptation to climate change effects.

5.2 Training of key stakeholders in matter of climate change

Different programs are developed for training the key stakeholders at the local level regarding the CO₂ effects and harmful effects of climate change. However, these training programs are being developed under the framework of different projects. One example is the ACTE-MEA project for all municipalities as part of a partnership between ANME, the Local Authorities Loans and Support Fund (CPSCL) and the General Directorate of Public and Local Authorities (DGCPL), which aims to strengthen the capacity of Tunisian municipalities.

Other programs in the matter of adaptation (Littoral, water, agriculture, etc.). For instance, the project for social innovation in the agriculture sector aims on capacity building of women at the local level in Tunisia that works in the agriculture sector and how to cope with the effects of climate change. Another example is the municipal reinforcement investment project, which aims at the institutional strengthening of municipalities and ministries of interior and finance, including the creation of a training directorate within the ministry of interior to manage a training program for municipalities and regional councils, and the provision of training and studies supporting the reform of local taxation.

Besides the projects, the government has put in place also the national education strategy for sustainable development. This enables formal education at the level of teaching programs; increases the awareness and animation for sustainable development outside the formal education system (clubs for children and youth); and information for sustainable development that can be accessed by everyone.

However, the development of the programs for the training of officials in matter of climate change adaptation and mitigation is not still at the desirable level. Strong efforts are made but there is still work to be done to be able to increase awareness of the harmful effects of climate change.

5.3 The challenges of integrating climate into local policies

We found several challenges that cities face in integrating climate into climate policies.

First, the lack of climate change culture. Climate change is not a priority for city councils. The contribution of municipalities to climate action is low and mechanisms
to combat climate change at the local level are absent. Urban dwellers and policymakers have not yet assimilated the culture of fighting climate change.

Second, the absence of climate change data and local decision support tools. Local authorities in Tunisia do not hold data on the environment and climate change. The lack of a strategy for collecting data on climate change, the lack of available information and the weakness of actions in favor of sustainable development impact the level of awareness and relevance of projects on climate change.

Third, the lack of training and knowledge on climate change. Although cities are directly affected by climate change, policymakers and decision-makers do not have a thorough knowledge of climate change. The majority of city councilors and civil servants have not participated in training on climate change issues at the local level, allowing them to be sensitized to the key concepts, tools and methodologies available.

Fourth, the absence of a local governance framework promoting climate change as a cross-cutting theme. The absence of a governance framework makes the initiatives launched by some municipalities ineffective. It can also affect the quality of decisions made by local governments, create investment uncertainty, increase the costs of providing local public services, reduce the availability of resources used by the community, or require more resilient local infrastructure.

Fifth, the lack of support and expertise for strategic planning on climate change. Decision-makers insist on the importance of climate change support in order to be able to manage environmental and climate issues. Technical and financial support is very important to equip decision-makers to develop strategic and operational planning. Tunisia faces little expertise and support for climate change at the local level.

Sixth, municipal budgets that are too limited and do not allow municipalities to play a more important role in climate policies. The sum of the budgets of all Tunisian municipalities does not exceed 4% of the State budget. In the absence of resources, it is difficult to cope with climate change and put in place ambitious policies without substantial external assistance. The municipalities’ own financial resources do not allow strategic and operational planning for the fight against climate change. They are limited and assigned for the management of everyday life.

6 Conclusions and policy recommendations

This paper attempted to characterize the current situation of Tunisian municipalities in matters of climate change policies and actions and understand the barriers and best practices. Tunisia, as a developing country, is facing huge needs in matters of adaptation and mitigation at the local level. The country has signed the Paris agreement and is part of the Convention of UNFCCC. The country has adopted a long-term national strategy (LTS-RCC, 2050) and a new NDC in 2021 where local action is considered as a key component. Our paper presents a series of recommendations both for the municipalities, the Ministry of Environment and the Tunisian government in general. The lessons learnt are easily generalized to similar development countries and to MENA region countries which are facing similar challenges. These managerial and economic policy recommendations could be taken into account in
the country’s strategic documents (CDN, NAP, SNBC-RCC) but also serve for technical and financial partners in the definition and conduct of future climate projects.

First, most of the cities and municipalities will need to put in place and strengthen the strategic settings for combating climate change at the local level. The vast majority of municipalities do not have a strategic framework and action plans to combat climate change. For most municipalities, there is no climate change governance plan or strategy. Therefore, establishing a strategic framework for climate change for municipalities is fundamental for effective action, monitoring and evaluation, for good governance and transparency. One of the key weaknesses found in our study is the lack of a strategic vision (with a holistic approach of climate change in the cities). There is an urgency to improve the strategies and to adopt a clear methodology for considering both mitigation and adaptation policies at the local level. One possible approach and best practices found is the generalization of the PAAEDCs approach to a large part of Tunisian municipalities. The approach taken by the PAAEDC could serve as an example for the rest of the municipalities. The strategies are adapted according to each municipality. Capitalization on the methodology and approach of the AECAP project is highly recommended. Other strategies are possible, but the merit of the latter is its availability and adaptation to municipalities of different sizes and geographical locations. A scale-up and expansion of the project to reach about fifty municipalities by 2025 is strongly recommended as a first step. The obligation to have a climate plan could be considered by 2030. One could mention that this approach is already adopted in other Mediterranean cities.

Second, promoting the emergence of a group of municipalities that are champions of the “low-carbon strategy”. Most of the countries, like Tunisia’s national low-carbon strategy (SNBC 2050), should adapt their national strategy to the local context. Municipalities must participate in this structural transformation and contribute to the achievement of the national low-carbon strategy by 2050. For the moment, there is a group of leading municipalities that are able to implement this trajectory by starting by establishing their carbon footprint and engaging their municipalities in a comprehensive decarbonization strategy. The target municipalities need to be equipped with climate information systems. Currently, only 9% of the municipalities surveyed say they have communication plans on climate change and 11% say they are in the process of developing a plan. This means that citizens have little awareness and access to climate information. Municipalities must collect environmental

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2 PAAEDC: a methodology for integrating climate into a local strategic framework. As part of the Climamed project, 100 Mediterranean cities are engaged in the preparation of action plans for access to sustainable energy and the climate PAAEDCs. The PAAEDCs is a document approved by the city council. The Covenant of Mayors for the Mediterranean (CdM Med) is created to support local authorities in strategic and operational planning and the implementation of sustainable climate and energy policies. The work relating to the planning of priority actions at the local level and the development of planning guides at the local level represents a tool of great interest to improve actions and initiatives related to climate change adaptation and reduction of climate change. Today, 10 Tunisian municipalities are involved in the Clim-Med project and have set up ambitious action plans. This initiative truly offers local climate plans for municipalities and a strategic framework for action that will be consolidated over time. The logistical and financial support of Clima-Med enables the mobilization of stakeholders from the municipalities concerned.
Third, cities will need to transform their energy and transport sector as key drivers for structural change for mitigation. Most of the municipalities will need to intensify renewable energy and energy efficiency programs in municipalities and advancing the transport and mobility of people to mitigate climate change. At present, 64% of the municipalities surveyed in Tunisia, do not have a plan for renewable energies. Switching to renewable energy should be a priority. The implementation of renewable energy strategies in municipalities will make it possible both to meet the growing demand for urban energy and to reduce emissions. The government’s stated goal of multiplying by 10 the installed capacity of renewable energies by 2030 cannot be achieved without greater involvement of local authorities. At the same time, the current situation in Tunisia is characterized by a strong tendency for people to use private cars. Therefore, mobility is a dimension of great importance for mitigating climate change at the local level. Investing in public transport, using electric mobility, investing in soft mobility should be a major challenge for Tunisian municipalities in the coming years. The carrying out of travel and mobility studies are fundamental in large municipalities to define short-term strategies.

Fourth, cities need to set adaptation strategies targeting water resources management, resilience to extreme events and protecting biodiversity in municipalities (protect forests, green spaces, fauna and flora, coastlines, wetlands, etc.). Municipalities must ensure the resilience of existing water resources and think about water supply and sanitation infrastructure. This would help protect water quality and quantity and minimize the risk of flood damage and water scarcity. Biodiversity preservation actions are almost non-existent in the sample of our municipalities surveyed. Key strategies for biodiversity conservation should include environmental education, afforestation plans, partnerships between universities and the public sector, involving all ecosystem actors in decision-making, in order to increase awareness and importance of preserving urban biodiversity and the establishment of special protection areas. Several extreme events (heat waves, floods, water table degradation) have been observed in Tunisia in the last ten years. 79% of municipalities reported having declared a heat wave in recent years. Building organizational and management capacities (crisis management units, early warning systems), resilient infrastructures (modification of components and standards) and having a change in spatial planning and especially a better allocation of land in peri-urban perimeters are emergencies for most municipalities.

Fifth, increase of the participation and the involvement of local communities in the implementation of climate change adaptation and mitigation strategies at the local level. Climate change adaptation and mitigation strategies should be at the local level. However, in Tunisia, only a small number of municipalities have developed a strategy and implemented measures to adapt to climate change (11% of the municipalities surveyed) and mitigation measures (11% of the municipalities surveyed). Therefore, work at the municipal level on climate change should be intensified. This requires greater consultation and involvement on the part of MALEv and central public authorities in the implementation of these strategies and in the
implementation of national awareness-raising programs. There is a lack of trust and effectiveness in the relations between municipalities and organizations responsible for the environment and climate change. Some central authorities are highly considered ineffective by 69% of municipalities, while the Ministry of Local Affairs and Environment comes first for positive judgments on its effectiveness with 59%. On this basis, these institutions and organizations should change the way they work and cooperate with municipalities.

Sixth, investing in new technologies to move to green and smart cities. The implementation of “green” digitalization, supporting innovation and the transition to a more sustainable economy and smart cities is a necessity in Tunisian municipalities. Smart cities can also help reduce greenhouse gas emissions. The main obstacle that municipalities face in implementing climate actions is the lack of funding. Therefore, the promotion of ecological taxation should be a great opportunity for sustainable municipalities. Municipalities should set up an operating theater for the prevention and management of natural disasters, similar to the rooms installed in the cities of Aïn Draham and Tataouine. Several municipalities are located in areas prone to flooding and vulnerable to natural disasters. It is, therefore, important to provide municipalities with a room and a strategy to combat natural disasters to intervene in time and coordinate interventions with other competent authorities.

6.1 Limitations and extension of the work

Despite the important findings from this initial research, one needs to mention three limitations to be challenged in the future and will lead us to extend this exploratory research.

First, cities are located in different geographic areas. They are not facing the same climatic events. While some cities are located in the desert, others are in the mountains or in the front of the sea. Since then, we need to make a distinction in our interpretation of the results depending on the location of the cities. Moreover, specific studies for specific ecosystems are needed to better refine the policies. This is particularly true for the mountain region, the “oasis” (desert region) and the Sahel (seafront cities). Our study has provided a “rough” picture of cities’ climate policies in Tunisia and a more refined picture will be provided in the next studies.

Second, our sample needs to be extended to allow us to make a quantitative analysis. While the sample includes about 40% of the total population of Tunisia, it contains some limitations since we still have 280 cities to survey. We plan to extend our research to cover at least 200 municipalities in the future in order to make a solid quantitative analysis and to better understand the current situation and the main obstacles for setting climate policies at the local level in Tunisia.

Third, most of the municipalities and cities are not well equipped with information systems as regards the climatic variables. However, other institutes—like the Tunisian Meteorology Institute or the National Forestry Institute—have important climatic variables that can be used in quantitative research. We plan to extend our
research by enriching our database with other data from other sources in order to provide a better explanation of the climate action at the local level in Tunisia.

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References

Ali G, Pumijumnong N, Cui S (2017) Decarbonization action plans using hybrid modeling for a low-carbon society: the case of bangkok metropolitan area. J Clean Prod 168:940–951
Angelo H, Wachsmuth D (2020) Why does everyone think cities can save the planet? Urban Studies (edinburgh, Scotland) 57(11):2201–2221. https://doi.org/10.1177/0042098020919081
Anguelovski I, Chu E, Carmin J (2014) Variations in approaches to urban climate adaptation: experiences and experimentation from the global South. Global Environ Change 27:156–167. https://doi.org/10.1016/j.gloenvcha.2014.05.010
Bai X, Dawson RJ, Urge-Vorsatz D, Delgado GC, Salisu Barau A, Dhakal S, Dodman D, Leonardsen L, Masson-Delmotte V, Roberts DC, Schultz S (2018) Six research priorities for cities and climate change. Nature 555(7694):23–25. https://doi.org/10.1038/d41586-018-02409-z
Bansard JS, Pattberg PH, Widerberg O (2017) Cities to the rescue? assessing the performance of transnational municipal networks in global climate governance. Intern Environ Agreem Polit Law Econ 17(2):229–246. https://doi.org/10.1007/s10784-016-9318-9
Bazaz A, Bertoldi P, Buckeridge M, Cartwright A, de Coninck H, Engelbrecht F, Jacob D, Hourcade JC, Klaus I, de Kleijne K, Lwasa S, Markgraf C, Newman P, Revi A, Rogelj J, Schultz S, Shindell D, Singh C, Solecki W, Steg L, Waisman H (2018) Summary for urban policymaker. What the IPCC special report on 1.5 °C means for cities. IHHS Indian Institute for Human Settlements, India
Ben Youssef A (2020) How can industry 4.0 contribute to combatting climate change? Revue d’économie industrielle 169:161–193. https://doi.org/10.4000/rei.8911
Ben Youssef A (2021a) The role of NGOs in climate policies: the case of Tunisia. Economic Research Forum. Working Paper No. 1519
Ben Youssef A (2021b) The triple climatic dividend of COVID-19. Energy transition, climate change, and COVID-19. Springer International Publishing, Cham, pp 107–118
Ben Youssef A, Zeqiri A (2022) Hospitality industry 4.0 and climate change. Circ Econ Sustain. https://doi.org/10.1007/s43615-021-00141-x
Bossio C, Ford J, Labbé D (2019) Adaptive capacity in urban areas of developing countries. Clim Change 157(2):279–297. https://doi.org/10.1007/s10584-019-02534-2
Chu EK (2018) Urban climate adaptation and the reshaping of state–society relations: the politics of community knowledge and mobilisation in indore, India. Urban Studies (edinburgh, Scotland) 55(8):1766–1782. https://doi.org/10.1177/0042098016686509
Doherty M, Klima K, Hellmann JJ (2016) Climate change in the urban environment: advancing, measuring and achieving resiliency. Environ Sci Policy 66:310–313. https://doi.org/10.1016/j.envsci.2016.09.001
Dovie DBK (2019) Case for equity between Paris climate agreement’s co-benefits and adaptation. Sci Total Environ 656:732–739. https://doi.org/10.1016/j.scitotenv.2018.11.333
Dulal HB (2017) Making cities resilient to climate change: identifying “win-win” interventions. Local Environ 22(1):106–125. https://doi.org/10.1080/13549839.2016.1168790
Essl I, Mauerhofer V (2018) Opportunities for mutual implementation of nature conservation and climate change policies: a multilevel case study based on local stakeholder perceptions. J Clean Prod 183:898–907. https://doi.org/10.1016/j.jclepro.2018.01.210
Filho WL, Balogun A-L, Olayide OE, Azeiteiro UM, Ayal DY, Muñoz PDC, Nagy GJ, Bynoe P, Oguge O, Yannick Toamukum N, Saroar M, Li C (2019) Assessing the impacts of climate change in cities
and their adaptive capacity: towards transformative approaches to climate change adaptation and poverty reduction in urban areas in a set of developing countries. Sci Total Environ 692:1175–1190. https://doi.org/10.1016/j.scitotenv.2019.07.227

Friend R, Jarvie J, Reed SO, Sutarto R, Thinphanga P, Toan VC (2014) Mainstreaming urban climate resilience into policy and planning; reflections from Asia. Urban Climate 7:6–19. https://doi.org/10.1016/j.uclim.2013.08.001

Govindarajulu D (2020) Strengthening institutional and financial mechanisms for building urban resilience in India. Intern J Disaster Risk Reduc 47(101549):101549. https://doi.org/10.1016/j.ijdr.2020.101549

Grafakos S, Trigg K, Landauer M, Chelleri L, Dhakal S (2019) Analytical framework to evaluate the level of integration of climate adaptation and mitigation in cities. Clim Change 154(1–2):87–106. https://doi.org/10.1007/s10584-019-02394-w

Gu D (2019) Exposure and vulnerability to natural disasters for world’s United Nations-Department of Economic and social affairs Technical Paper No. 2019/4

Holtz G, Xia-Bauer C, Roelfes M, Schüle R, Vallentin D, Martens L (2018) Competences of local and regional urban governance actors to support low-carbon transitions: development of a framework and its application to a case-study. J Clean Prod 177:846–856. https://doi.org/10.1016/j.jclepro.2017.12.137

Hoppe T, van der Vegt A, Stegmaier P (2016) Presenting a framework to analyze local climate policy and action in small and medium-sized cities. Sustainability 8(9):847. https://doi.org/10.3390/su8090847

Hughes S, Sarzynski A (2015) Building capacity for climate change adaptation in urban areas: editors’ introduction. Urban Climate 14:1–3. https://doi.org/10.1016/j.uclim.2015.07.002

Khosla R, Bhardwaj A (2019) Urbanization in the time of climate change: examining the response of Indian cities. Wiley Interdiscip Rev Clim Change 10(1):e560. https://doi.org/10.1002/wcc.560

Kumar P, Geneletti D (2015) How are climate change concerns addressed by spatial plans? an evaluation framework, and an application to Indian cities. Land Use Policy 42:210–226. https://doi.org/10.1016/j.landusepol.2014.07.016

Landauer M, Juholo S, Klein J (2019) The role of scale in integrating climate change adaptation and mitigation in cities. J Environ Plan Manage 62(5):741–765. https://doi.org/10.1080/09640568.2018.1430022

Lüthi D, Le Floch M, Bereiter B et al (2008) High-resolution carbon dioxide concentration record 650,000–800,000 years before present. Nature 453(7193):379–382. https://doi.org/10.1038/nature06949

Mann ME, Rahmstorf S, Steinman BA, Tingley M, Miller SK (2016) The likelihood of recent record warmth. Sci Rep 6(1):19831. https://doi.org/10.1038/srep19831

NASA. (2021). 2020 Tied for warmest year on record, NASA analysis shows. https://www.nasa.gov/press-release/2020-tied-for-warmest-year-on-record-nasa-analysis-shows (Accessed on 25 Dec 2021)

Papa R, Galderisi A, Vigo Majello MC, Saretta E (2015) European cities dealing with climate issues: ideas and tools for a better framing of current practices. J Land Use Mobil Environ. https://doi.org/10.6092/1970-9870/3658

Parnell S (2016) Defining a global urban development agenda. World Dev 78:529–540. https://doi.org/10.1016/j.worlddev.2015.10.028

Singh C, Madhavan M, Arvind J, Bazaz A (2021) Climate change adaptation in Indian cities: a review of existing actions and spaces for triple wins. Urban Climate 36(100783):100783. https://doi.org/10.1016/j.uclim.2021.100783

Tapia C, Abajo B, Feliu E, Mendizabal M, Martinez JA, Fernández JG, Laburu T, Lejarazu A (2017) Profiling urban vulnerabilities to climate change: an indicator-based vulnerability assessment for European cities. Ecol Ind 78:142–155. https://doi.org/10.1016/j.ecolind.2017.02.040

Tyler S, Nugraha E, Nguyen HK, Van Nguyen N, Sari AD, Thinphanga P, Tran TT, Verma SS (2016) Indicators of urban climate resilience: a contextual approach. Environ Sci Policy 66:420–426. https://doi.org/10.1016/j.envsci.2016.08.004
UCCRN-Urban climate change research network (2018) The future that we do not want. How climate change could impact the world’s greatest cities. https://www.c40.org/wp-content/uploads/2021/08/1789_Future_We_Dont_Want_Report_1.4_hi-res_120618.original.pdf (Accessed on 23 Dec 2021)

UN habitat (2021). Climate change and cities. https://unhabitat.org/sites/default/files/2021/03/Cities%20IPCC%20Proceedings%20FINAL%20for%20Email-S.pdf (Accessed on 22 Dec 2021)

van der Heijden J, Patterson J, Juhola S, Wolfram M (2019) Special section: advancing the role of cities in climate governance—promise, limits, politics. J Environ Plan Manage 62(3):365–373. https://doi.org/10.1080/09640568.2018.1513832

Vitasse Y, Signarbieux C, Fu YH (2018) Global warming leads to more uniform spring phenology across elevations. Proc Natl Acad Sci USA 115(5):1004–1008. https://doi.org/10.1073/pnas.1717342115

WWF (2021) The climate change effect in the Mediterranean. Six stories from an overheating sea. https://www.wwf.fr/sites/default/files/doc-2021-06/20210607_Rapport_The-Climate-Change-Effect-In-The-Mediterranean-Six-stories-from-an-overheating-sea_WWF-min.pdf (Accessed on 25 Dec 2021)

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