POLITYKA ENERGETYCZNA – ENERGY POLICY JOURNAL

2025 ✦ Volume 28 ✦ Issue 1 ✦ 127–149

DOI: 10.33223/epj/199837

Payagda Misael Tarpaga[1], Mounaim Halim El Jalil[2], Ouadia Mouhat[3]

Enhancing climate resilience: comparative analysis of territorial strategies in Tangier, Andalusia, Tunis, and Marseille

Abstract: In recent years, many countries have adopted the decentralization of their national climate policies to the regional level in the form of Territorial Climate Plans (TCPs). The aim is to streamline the planning and implementation of adaptation and mitigation measures against the impacts of climate change (CC). This article presents a comparative analysis of TCPs in four Mediterranean regions exacerbated by CC, including Marseille, Andalusia, Tangier, and Tunis. Key performance indicators (KPIs), as well as mitigation and adaptation strategies extracted from national reports and other official sources, were the focus of this comparison. The comparison of KPIs revealed that 78% of GHG emissions came from European regions. In terms of carbon sequestration, European regions also outperformed. In terms of the energy transition, the share of renewable energies (RE) in the energy mix is highest in Andalusia, with 39%, followed by Tangiers, Marseille, and Tunis, with 36, 4, and 3%, respectively.

An analysis of measures and initiatives (M&I) shows a shared focus on promoting renewable energies and energy efficiency in the building and industry sectors via tax incentives. For

✉ Corresponding Author: Ouadia Mouhat; e-mail: ouadie.mouhat@gmail.com

[1] Civil and Environmental Engineering Laboratory, High School of Technology. Mohammed V University of Rabat, Morocco; ORCID iD: 0009-0008-4473-9356; e-mail: misael.tarpaga@research.emi.ac.ma

[2] Civil and Environmental Engineering Laboratory, High School of Technology. Mohammed V University of Rabat, Morocco; ORCID iD: 0000-0002-8922-6932; e-mail: mounaimhalim.eljalil@est.um5.ac.ma

[3] Mohammed V University, Morocco; ORCID iD: 0000-0003-4456-0897; e-mail: ouadie.mouhat@gmail.com

adaptation, regions focus on ecosystem restoration and coastal resilience. In conclusion, even if TCP alignment is strengthened, significant imbalances persist in GHG emissions. As such, this document is intended as an essential and valuable guide for decision-makers in drawing up and implementing their local climate plans. Focusing on KPIs as a guide to assessment could lead to effective management of local climate issues.

On the other hand, the strategic integration of fiscal incentives would promote local energy transition. Nature-based solutions could also emerge as crucial strategies for mitigating climate change and promoting the preservation of ecosystems. Moreover, mutual learning between regions could emerge as an effective strategy for strengthening measures and initiatives to combat climate challenges.

Keywords: Territorial Climate Plans (TCPs), Key Performance Indicators (KPIs), tax incentives, coastal resilience, ecosystem restoration

Introduction

At the United Nations Framework Convention on Climate Change (UNFCCC), a significant agreement was reached to combat climate change by limiting temperature rise to 1.5°C. The Conference of the Parties (COP-21) in Paris reinforced these actions for a sustainable, low-emission future, bringing all nations together in the fight against CC with significant financial support for emerging countries (Schmidt et al. 2024).

The countries that signed these agreements formulated climate policies (CPs) at the national level focused on two fundamental points: reducing GHG emissions (mitigation) and adapting to the consequences of CC to reduce vulnerability (Lesnikowski et al. 2016). On the one hand, the use of nature-based solutions (NBS) can be considered among the various CC adaptation management strategies (Kabisch et al. 2016). On the other hand, the promotion of renewable energies through fiscal incentives involving all energy sectors could play a crucial role in the most relevant CC mitigation efforts (Labandeira et al. 2019). In line with their international commitments and contexts, nations are formulating national and regional climate strategies. However, as the detailed TCPs are constantly evolving, they are challenging to implement. This study aims to shed light on regional climate policies (RCPs) in response to the agreements mentioned.

Indeed, the Mediterranean regions, which are major CO_2 emitters, are particularly hard hit by climate change. Because of their specific spatial and geographical features (proximity to the coast, high water demand, climate conducive to summer droughts, and extreme weather events such as heavy rainfall) and their growth, they are considered highly vulnerable areas. The natural environment of the Marseille region is particularly exposed to human activity, as evidenced by pollution thresholds being exceeded, the scarcity of quiet spaces, the retreat of agricultural areas, and the threat to certain species. Other signs appear only in times of crisis (droughts, fires, floods, submersions, industrial pollution) (Métropole Aix-Marseille-Provence 2020a). In

Andalusia, episodes of extreme drought and flooding raise environmental issues, while water resource management is becoming a central challenge (Climate Chance 2019). The Tangier and Tunis regions, meanwhile, face issues such as vulnerability to natural disasters, coastal erosion, water stress, biodiversity loss, and declining agricultural yields. Although these four regions share the same geographical area and suffer the same climatic impacts, their crisis management policies are similar. However, their strategies may vary due to their contexts, thus justifying the interest in such a comparison.

In the remainder of this document, in the first section, the RCPs adopted by these regions and their short-term objectives in terms of reducing GHG emissions will be presented. Then, in the second section, certain KPIs will be compared, notably carbon footprint, natural sequestration, and the share of renewable energies in the energy mix. Finally, in the last section, an analysis of strategies linked to carbon footprint improvement and adaptation to climate challenges, such as ecosystem restoration and coastal flood resilience, will be compared to measure the effectiveness of their NBS.

1. Methodology

This study covers four regions, including Marseille and Andalusia, located in the north of the Mediterranean, and Tangiers and Tunis in the south. As illustrated in Figure 1, the Marseille region is in the south of France, and the Andalusia region is in the south of Spain. The Tangiers region occupies the extreme northwest of Morocco, while the Tunis region occupies the extreme northeast of Tunisia. Grouped in pairs: Tangiers and Andalusia to the west, Marseille and Tunis to the east, each plays a crucial role in the economy of its respective country. In addition to international agreements, they are also bound by regional agreements, such as the Barcelona Convention, as well as other initiatives, such as the Water Action Strategy, the Mediterranean Financial Strategy, and the Water Strategy for the 5+5 National Dialogues (Touzi 2020).

Six main steps guided the approach based on climate policies. After determining the theme, the collection of relevant data was undertaken, using various databases to find national climate reports and related articles (Cooper et al. 2018). Official sources and scientific databases (Web of Science, Google Scholar, Scopus Indexed Journals, Elsevier Science Direct, Springer) provided these documents. “Regional climate policy,” “strategies,” “adaptation,” “mitigation,” “nature-based solution,” “coastal risks,” “Mediterranean,” “renewable energy,” “energy efficiency,” “climate indicators,” and “environmental tax” were among the keywords that were used. The collected KPI data were then harmonized by modifying the time references and the units of measurement. A comparative analysis of the KPIs was carried out using graphs. The ambition of the climate plans was assessed by comparing them to international targets, scientific recommendations, and best practices. A contextual analysis was also conducted to account for differences in capacity and national and regional constraints that could influence the results.

Finally, communicating results with stakeholders has fostered mutual learning, the identification of good practices, and continuous improvement of climate plans.

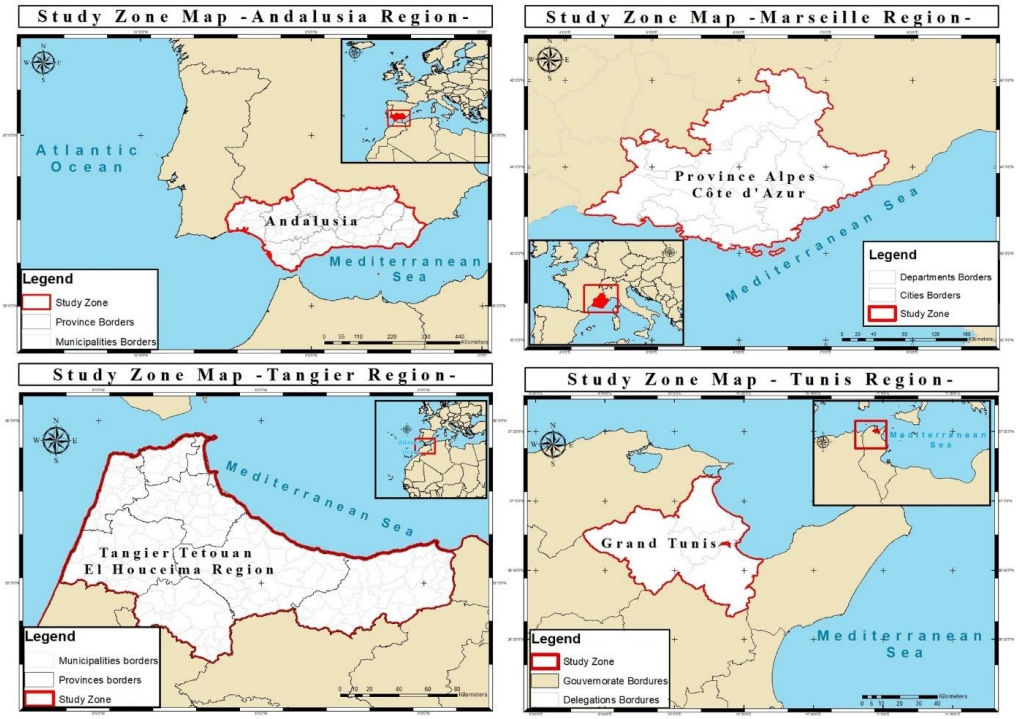

Fig. 1. Presentation of the regions covered by this study

Rys. 1. Prezentacja regionów objętych badaniem

2. Results

2.1. Regional climate action initiatives

In France, the first climate plan was set up as the Territorial Climate–Energy Plans (TCEP) in 2004, thus creating an operational framework for the CPs of local authorities with more than 50,000 inhabitants. The Aix-Marseille-Provence metropolitan area initiated its Metropolitan Climate-Air-Energy Plan (MCAEP) following deliberation by the metropolitan council, directing its efforts towards energy transition, air quality, and adaptation to CC, with particular attention to noise reduction. Through its efforts, the MCAEP aims to be a means of reducing emissions by 20% in 2030 compared to 2012 (Métropole Aix-Marseille-Provence 2020c). In Andalusia,

a Spanish autonomous region, the Andalusian Climate Action Plan 2007–2012 (ACAP), adopted in 2002, laid the foundations for the region's CPs. It remains central and is now integrated into the Andalusian Sustainable Development Strategy 2030, setting emission reduction targets of 39% in 2030 compared to 2005. The Andalusian CC Adaptation Program (ACCAP) aims to reduce territorial vulnerability to the negative impacts of CC while integrating adaptation measures into policy planning (Junta de Andalucía. Consejería de Medio Ambiente 2011). The territorial climate plan (TCP) of the Tangier region is part of the perspective of territorial convergence and alignment with the national plan to combat global warming (NPGW) at the local level, considering territorial specificities. Thus, its ambition is to reduce its GHG production by 31% in 2030 compared to 2016 (Ministère de l'Energie, des Mines et de l'Environnement 2020a). Following the ratification of the Paris Climate Agreement in 2016, Tunisia committed to developing its carbon-neutral and climate-resilient development strategy (CN&CRDS), thus integrating the low-carbon transition to achieve a 45% reduction in its emissions by 2030 compared to those of 2010 and the resilience of CC in policies, programs, and activities at different levels to improve long-term economic and social development (Ministère de l'Environnement and Gesellschaft für Internationale Zusammenarbeit 2022). As Tunisia has not decentralized its CP across the Tunis region, we will proceed with the determination of the data.

2.2. Key performance indicators

CC impacts both natural and urban environments, with serious consequences for their balance and ecosystems. To counteract these effects, the integration of NBS is proving promising, making it possible to both mitigate and adapt to CCs. These solutions also support the provision of ecosystem services. To assess the effectiveness of NBS in terms of benefits to populations and reduction of CC impacts, KPIs presented in table 1 are used, according to the SMART model (Specific, Measurable, Achievable, Realistic, and Time-bound) (Dumitru and Wendling 2021; Mosca et al. 2023). These SMART objectives facilitate the monitoring and evaluation of the progress made in the implementation of the CPs, making it possible to evaluate the effectiveness of the actions undertaken. Monitoring and evaluating these KPIs helps assess the performance of policies, strategies, plans, and actions, providing important data and information (Olkuski 2015). These can be used to guide and improve current and future management (Mäkinen et al. 2018; Pearce-Higgins et al. 2022).

It is crucial to note that the quality and availability of data can vary from country to country, influencing the accuracy of progress assessment. However, the adoption of specific KPIs and regular monitoring contribute to a better assessment of the progress made in the implementation of TCP. In this study, the KPIs compared are those that were available in all TCPs.

TABLE 1. KPIs and their measurable data that can be the subject of climate assessment and monitoring of the implementation of regional climate plans

TABELA 1. Kluczowe wskaźniki efektywności (KPI) i ich mierzalne dane, które mogą być przedmiotem oceny klimatu i monitorowania realizacji regionalnych planów klimatycznych

KPI	Measurable data	References
Carbon footprint (GHG emissions)	Emission [tCO_2/year]. Emission reduction compared to a baseline. Frequency of emissions in relation to GDP.	(Dumitru and Wendling 2021; Mosca et al. 2023; Pearce-Higgins et al. 2022)
Transition to Renewable Energy	% of RE in the national energy mix. RE installed capacity. RE production.	(Dumitru and Wendling 2021)
Energy Efficiency	Reduce energy consumption. Number of buildings that comply with energy efficiency standards. % of energy-efficient technologies.	(Dumitru and Wendling 2021; Mosca et al. 2023)
Sustainable transport development	Share of public transport. Number of electric vehicles on the road. Kilometers of bike lanes or public transport lanes.	(Dumitru and Wendling 2021)
Ecosystems and biodiversity	Area of primary forests or protected areas. Rate of deforestation or ecosystem degradation. Number of threatened or recovering species.	(Dumitru and Wendling 2021; Mosca et al. 2023; Pearce-Higgins et al. 2022)
Resilience to climate change	Investments in resilience infrastructure. Number of people benefiting from early warning systems. The number of adaptation projects completed.	(Dumitru and Wendling 2021)
Carbon Taxation	Amount of carbon tax. Number of economic sectors subject to carbon taxation. Amount of revenue generated by the carbon tax and their use for emission reduction measures.	(Dill 2023; Dumitru and Wendling 2021)
Carbon Capture and Storage (CCS)	CO_2 capture capacity [tCO_2/year]. CO_2 storage capacity [tCO_2/year]. Number of CCS projects completed.	(Dumitru and Wendling 2021; Mosca et al. 2023; Pearce-Higgins et al. 2022)
Reforestation and afforestation	New forested areas were created [ha or %]. % of trees planted remain after a certain period. CO_2 absorption capacity of new forested areas [tCO_2/year].	(Dumitru and Wendling 2021; Mosca et al. 2023; Pearce-Higgins et al. 2022)
Pricing of methane emissions	Tariffs applied to methane emissions. Reduction in methane emissions compared to a baseline [% or tCO_2.	(Dill 2023; Dumitru and Wendling 2021)
Ecosystem-based adaptation	Area of restored or protected ecosystems. Number of ecosystem adaptation projects carried out. Evaluating CC risk reduction through ecosystems.	(Dumitru and Wendling 2021; Mosca et al. 2023; Pearce-Higgins et al. 2022)

2.2.1. Carbon footprint

Carbon footprint refers to the calculation of the CC contribution from a consumption perspective. Given the global scale of climate challenges and the current globalized economy, it is relevant to examine GHG emissions related to individual consumption. This includes emissions generated by the production and consumption of imported goods and services. Carbon footprint can be assessed locally as well as in terms of per capita emissions, as shown in Figure 2.

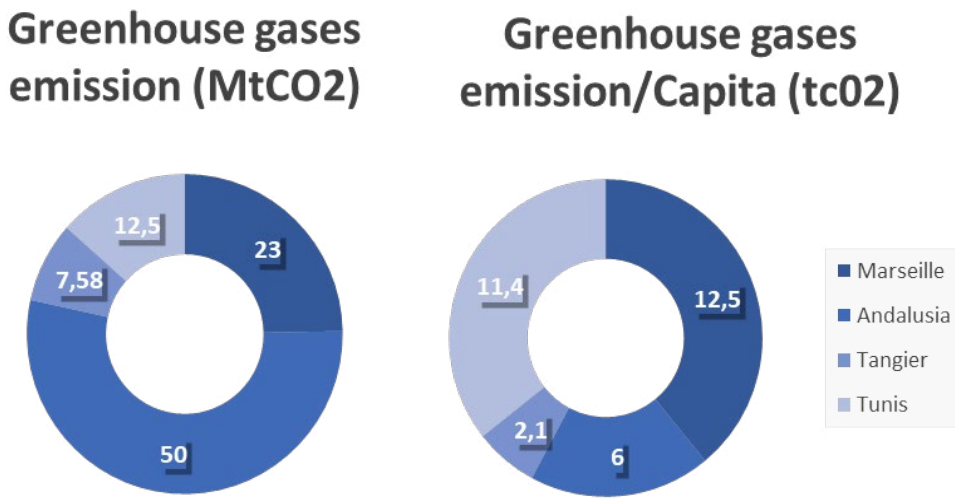

Fig. 2. Local carbon footprint and carbon footprint per capita of regions in 2016

Rys. 2. Lokalny ślad węglowy i ślad węglowy na mieszkańca regionów w 2016 r.

A diagnosis of the GHG emissions of the Marseille territory estimates a total of 23 $MtCO_2$ emitted between 2014 and 2015, which could also be applicable to 2016, the equivalent of an emission of 12.5t/capita (Métropole Aix-Marseille-Provence 2020a). In Andalusia, the GHG emission balance quantified about 50 $MtCO_2$, or 6 t/capita, in 2016 (Climate chance 2019). In the Tangier region, GHG emissions were estimated at 7,58 $MtCO_2$ in 2016, or 2,1 t/capita (Ministère de l'Energie, des Mines et de l'Environnement 2020b). Moreover, in Tunisia, GHG emissions were 37.2 $MtCO_2$ in 2015 and 36.3 $MtCO_2$ in 2016. About 50% of these emissions occur in urban areas (Ministère de l'Environnement and Gesellschaft für Internationale Zusammenarbeit 2022; United Nations Framework Convention on Climate Change 2022). The Tunis region, which generates the largest share of wealth (34.3%), concentrates a significant share of national activities (Hurpeau et al. 2019). Emissions from the region could be estimated at 12.5 $MtCO_2$, or 11.4 tCO_2/capita for the year 2016.

2.2.2. CO_2 absorption capacity of local vegetation

The capacity of the regions' vegetation to assimilate carbon is an essential complementary aspect in reducing GHG emissions. It plays a crucial role in improving the carbon footprint and aiming, in particular, at carbon neutrality. It is important to note that the area has significant carbon storage potential thanks to the presence of forests, wooded grassland, wetlands, and artificial grassland.

In the Marseille region, the estimated natural sequestration capacity of vegetation was 29.1 $MtCO_2$ (Métropole Aix-Marseille-Provence 2020a). According to (Muñoz-Rojas et al. 2011), the CO_2 storage potential of the Andalusian Forest estate was estimated at 156.08 $MtCO_2$, which is assumed to remain unchanged. The Tangier region, for its part, has a carbon assimilation capacity estimated at 2 $MtCO_2$ in 2016 (Ministère de l'Energie, des Mines et de l'Environnement 2020b). In Tunisia, the forestry sector had an assimilation capacity of 14 $MtCO_2$ in 2012. By simulating forest assimilation based on available or extrapolated activity data, a net assimilation of 2.6 $MtCO_2$ was observed in 2016 (Ministère de l'Environnement and Gesellschaft für Internationale Zusammenarbeit 2022). According to the General Directorate of Forests, the Tunis region represents 3.5% of the national forest potential, the equivalent of an assimilation estimated at 0.1 $MtCO_2$.

2.2.3. Transition to renewable energy

The transition to RE is of paramount importance in the fight against CC and the search for more sustainable and less GHG-emitting energy sources (Honegger et al. 2021). RE, such as solar, wind, hydro, geothermal, and marine energies, are considered alternatives to non-renewable energy sources, such as fossil fuels

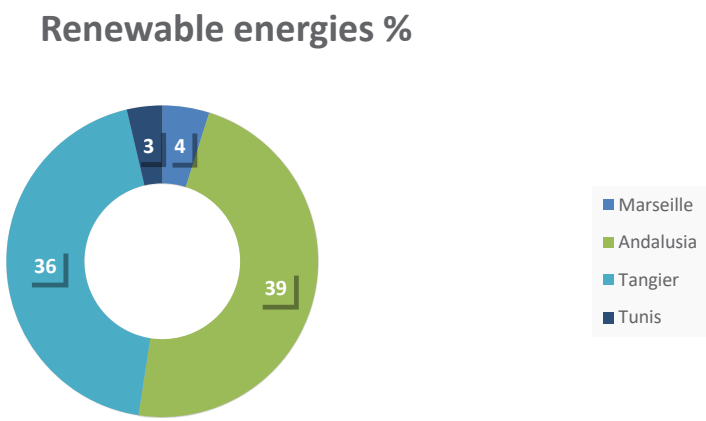

Fig. 3. Percentage of renewable energies in the energy mix of regions

Rys. 3. Procentowy udział energii odnawialnej w miksie energetycznym regionów

As illustrated in Figure 3, in 2015, RE production in the Marseille region represented 2,721 gigawatt-hour or 4% of the region's energy mix (Métropole Aix-Marseille-Provence 2020c). The Andalusian region was aware of the importance of its GHG emissions and had measures to reduce them. In 2017, RE accounted for 39% of the region's energy mix (Climate chance 2019; Agencia Andaluza De La Energia 2020). In the Tangier region, the contribution of RE to energy production was estimated at 36% in 2016 (Ministère de l'Energie, des Mines et de l'Environnement 2020b). In 2017, the installed capacity of RE in Tunis represented 3% of the total capacity, or 311 megawatts (Jammali and Liouane 2017).

2.3. Measures and initiatives for improving the carbon footprint, ecosystem restoration and resilience of coastal areas

As mentioned in the introduction, CC can be managed by two distinct approaches: mitigation and adaptation. CC mitigation involves measures to reduce the human contribution to this phenomenon by limiting GHG emissions (Hurlimann et al. 2021; IPCC 2014b). On the other hand, adaptation to CC involves taking action to adapt to new climate conditions by implementing appropriate strategies and harnessing the potential benefits of these changes (IPCC 2022, 2014a). These two approaches need to be addressed separately because of their differences in terms of implementation in time and space (Locatelli et al. 2016). Recent research from the (IPCC 2022) warns the global community of the need to halve GHG emissions within this decade and dramatically accelerate adaptation action to avoid further impacts. Various studies highlight the urgency of CC adaptation to complement mitigation efforts (Dellmuth and Gustafsson 2021). Unlike mitigation, research on climate change adaptation is constantly changing as new problem areas arise (Ginbo et al. 2021; Singh et al. 2022; Yang et al. 2020). Lesnikowski et al. (2021) note that there is still a dearth of research on the implementation challenges associated with different levels of government adaptation to climate change (CC).

The TCPs focus on reducing greenhouse gas emissions. These include promoting RE through financial incentives, enforcing strict standards to improve EE in buildings, and encouraging environmentally friendly industrial practices. As a reflection of the coordinated efforts for sustainable energy, the tax incentives of the various regions are shown in Table 2 and are intended to promote the switch to RE. In addition to the tax incentives for RE, measures for EE, both in the residential sector presented in Table 3 and in the industrial sector presented in Table 4, have been the subject of strategies adopted by the TCPs for the reduction of their emissions. The measures adopted in each region reflect the ongoing commitment to EE, thus contributing to energy and environmental sustainability.

The Mediterranean region is a particularly vulnerable area (Mariotti et al. 2015), where expected warming rates exceed the global average of 25% for global warming and 40% for summer warming (Cramer et al. 2018). Based on regional climate models and various documented studies, it is possible to conclude that in this area, recent anthropogenic environmental changes have

TABLE 2. Tax incentive measures and initiatives on renewable energy as a mitigation strategy

TABELA 2. Środki i inicjatywy zachęt podatkowych w zakresie energii odnawialnej jako strategii łagodzenia

Region	Marseille	Andalusia	Tangier	Tunis
Measures and Initiatives	✦ Tax advantages for energy renovation and RE. ✦ Reduced property tax for green buildings. ✦ Reduced VAT for renewable equipment. ✦ Government financial support for green projects. ✦ Carbon emissions taxation.	✦ Tax relief for renewable energy projects. ✦ Tax exemptions for equipment related to RE. ✦ Tax credits for RE projects. ✦ Reduction of the installation costs of RE. ✦ Tariff reduction for green electricity. ✦ Advantageous financing for RE projects. ✦ Land availability for solar farms	✦ Offering financial incentives (grants, tax, credits, and preferential loans) for energy-efficient technologies. ✦ Reduction of energy costs for local authorities supplied with RE. ✦ Reduce energy bills for households using RE. ✦ Support for solar photovoltaic energy through regulations, subsidies, credits. ✦ Reduction in the cost of importing RE.	✦ Exemption from customs duties and taxes on equipment related to RE. ✦ Decrease in VAT on equipment related to RE. ✦ Tax advantages for investments in RE. ✦ Preferential feed-in tariffs for renewable electricity. ✦ Grants for RE projects. ✦ Financing and tax credits for RE projects. ✦ Income tax reductions for investments in RE.
References	(Métropole Aix-Marseille-Provence 2020b; Chabrol and Grasland 2016).	(Moudene and Ridouane 2024; Agencia Andaluza De La Energia 2020)	(Kafi and Elbayed 2023; Moudene et al. 2023)	(Barthel and Verdeil 2013; Benalouache 2013)

TABLE 3. Tax incentives measures and initiatives for energy efficiency in the residential sector as a mitigation strategy

TABELA 3. Środki i inicjatywy zachęt podatkowych na rzecz efektywności energetycznej w sektorze mieszkaniowym jako strategia łagodzenia

Region	Marseille	Andalusia	Tangier	Tunis
Measures and Initiatives	✦ Develop a code of good practice for environmentally friendly construction. ✦ Supervise the energy renovation of private homes. ✦ Facilitate municipalities access to EE expertise. ✦ Assist municipalities in their energy renovation projects. ✦ Support efficient municipal energy management. ✦ Promote responsible lighting for sustainability. ✦ Develop heating and cooling networks in social housing. ✦ Strengthen heating networks in social housing. ✦ Improve indoor air quality. ✦ Stimulate the use of local wood in the construction and renovation of metropolitan properties.	✦ Optimize the thermal performance of buildings. ✦ Combine natural and artificial light in lightweight architecture. ✦ Find innovative climate solutions. ✦ Produce energy for personal use from RE. ✦ Increase the efficiency of public facilities and buildings. ✦ Optimize building energy systems.	✦ Promote energy-efficient household appliances, ✦ Promote energy-saving lamps and low-voltage photovoltaic systems in homes. ✦ Encourage the use of residential solar water heaters.	✦ Encourage energy audits followed by EE investments. Promote cogeneration/ trigeneration. ✦ Promote the ISO 50001 energy management system. ✦ Deploy EE measurements in buildings, including lighting, air conditioning, technical management, and solar thermal systems. ✦ Install solar photovoltaic systems for self-generation of electricity in low- and medium-voltage buildings. ✦ Approve green construction, efficient lighting and EE appliances.
References	(Métropole Aix-Marseille-Provence 2020b)	(Agencia Andaluza De La Energia 2020; Ibañez Iralde et al. 2021; Collado and Díaz 2017)	(Ministère de l'Energie, des Mines et de l'Environnement 2020b)	(Ministère de l'Environnement and Gesellschaft für Internationale Zusammenarbeit 2022)

TABLE 4. Tax incentives measures and initiatives for energy efficiency in the industrial sector as a mitigation strategy

TABELA 4. Środki i inicjatywy zachęt podatkowych na rzecz efektywności energetycznej w sektorze przemysłowym jako strategia łagodzenia

Region	Marseille	Andalusia	Tangier	Tunis
Measures and Initiatives	✦ Encourage energy audits of companies. ✦ Optimize manufacturing processes through technologies and practices. ✦ Recycle thermal energy from industrial processes. ✦ Raise awareness and train industrial staff on EE. ✦ Establish EE regulations and standards. ✦ Create a shared energy council for businesses. ✦ Label low-carbon emissions.	✦ Encourage energy audits of companies. ✦ Certify industries for EE. ✦ Promote the best clean techniques (cogeneration, heat recovery, renewable energy). ✦ Raise awareness of EE among industrial staff. ✦ Support R&D for sustainable industrial technologies. ✦ Establish EE standards. ✦ Work with the private sector to improve EE. ✦ Support innovation in EE solutions. ✦ Set up regular monitoring and evaluation systems.	✦ Encourage energy audits of companies. ✦ Establish strict EE standards for the industry. ✦ Raise awareness of EE among industrial companies through training. ✦ Promote cogeneration for electricity and heat production. ✦ Implement energy management systems to monitor and optimize industrial consumption. ✦ Establish public-private partnerships for EE and cogeneration projects. ✦ Encourage clean technologies. Subsidize R&D for new technologies. ✦ Create an energy certification system for industry. ✦ Introduce monitoring and reporting of EE progress.	✦ Encourage industrial energy audits. ✦ Establish EE standards for industry. ✦ Promote cogeneration/ trigeneration. ✦ Foster collaboration between the public and private sectors to improve EE. ✦ Support R&D in innovative energy technologies. ✦ Raise awareness and train companies on EE.
References	(Métropole Aix-Marseille-Provence 2020b)	(Agencia Andaluza De La Energia 2020; Collado and Díaz 2017)	(Ministère de l'Energie, des Mines et de l'Environnement 2020b, 2020c)	(Ministère de l'Environnement and Gesellschaft für Internationale Zusammenarbeit 2022)

generated a CC whose evolution results in high temperatures and an increase in the frequency of heat waves. Precipitation is becoming scarcer with changing spatial distribution, while extreme weather events, such as droughts, floods, and storms, are becoming more frequent. Sea levels are also rising (MedECC 2020). These mutations only exacerbate the pre-existing environmental problems facing the region (Cramer et al. 2018; Torres-Bagur et al. 2019), thus contributing to the worsening of environmental damage. In addition, biodiversity is threatened by CC, which has become the leading emerging cause of species loss at an alarming rate. Studies have shown a significant link between large-scale species dynamics and various climate events (Manes et al. 2021; Ortiz et al. 2021). At the same time, the coastal ecosystem is on the brink of deterioration (Perera et al. 2018; Phillips 2018).

Immediate attention to TCPs through the required strategic measures for ecosystem restoration, summarized in Table 5, and coastal zone adaptation in Table 6, could increase the chances of countering the devastating effects generated by these factors. These strategies aim to strengthen resilience by setting up early warning systems, improving flood protection infrastructure, managing natural resources sustainably, raising public awareness of climate issues, and encouraging sustainable behaviors, but also by making use of NBS.

3. Discussion

This comparative study of TCPs in the Mediterranean coastal regions, including Marseille and Andalusia to the north and Tangier and Tunis to the south, achieved several objectives. First, it identified existing local policies developed to respond to climate assessments, as well as the objectives of those policies. Second, it compared different KPIs, such as GHG emissions, natural carbon sequestration capacity, and renewable energy production. Finally, it analyzed corporate measures and initiatives (M&I) to reduce GHG emissions through tax incentives and energy efficiency improvements in the residential and industrial sectors, as well as corporate (M&I) to adapt to CC challenges, including ecosystem restoration and coastal zone resilience to marine flooding.

The analysis highlighted similarities in the formulation of local CPs but also highlighted a significant imbalance in GHG emissions between the northern and southern regions of the Mediterranean basin. Emissions from European regions are higher than those from African regions, and this disparity can be explained by the more significant industrial development of European regions compared with African regions.

In terms of carbon storage capacity, the vast forest areas of European regions stand out for their promising results, attributable to their diverse plant biodiversity. According to Muñoz-Rojas et al. (2011), the very high absorption capacity of Andalusian forests, which stands out from that of other regions, can be explained by changes in plant land use favored by afforestation and agricultural intensification. They also point out that coniferous forests and olive groves are the main contributors to these remarkable results.

TABLE 5. Measures and initiatives for ecosystem restoration as an adaptation strategy

TABELA 5. Środki i inicjatywy na rzecz odbudowy ekosystemów jako strategia adaptacyjna

Region	Marseille	Andalusia	Tangier	Tunis
Measures and initiatives	✦ Create a Metropolitan Atlas of Biodiversity. ✦ Study the ecological corridors of the territory. ✦ Develop NBS. Create a metropolitan network of low-light areas to reduce light pollution and protect nocturnal biodiversity. ✦ Promote nature in urban areas, by raising public awareness of its benefits. ✦ Integrate urban nature into the planning and administration of spaces. ✦ Reinforce the importance of trees in urban areas. ✦ Integrate a landscape component into RE and transport projects. ✦ Optimize the management, conservation, and enhancement of the metropolitan urban forest. ✦ Integrate water in urban areas to refresh the city.	✦ Promote territorial cohesion through development measures, including the creation of ecological corridors. ✦ Encourage research on biodiversity and its link with CC and integrate it into funded projects. ✦ Promote good management practices, including biodiversity protection and CC adaptation. ✦ Preserve and rehabilitate fragile ecosystems. -Develop strategies to control invasive alien species. ✦ Combat the fragmentation of ecosystems and protected areas. ✦ Identify new areas to expand habitats and ecosystems. ✦ Promote research on dispersal and regeneration of species. ✦ Restore, conserve, and enhance biodiversity in areas subject to natural constraints.	✦ Deepen understanding of key ecosystems and their benefits to local communities. ✦ Encourage the economic enhancement of biodiversity and ecosystem services in the region. ✦ Examine the links between the root causes of biodiversity degradation and the imperatives for change to achieve the sustainable development goals.	✦ Restore the health of fragile coastal ecosystems by combating pollution and biodiversity loss. ✦ Update and implement project management plans for the preservation of certain environments. ✦ Develop technical and feasibility studies for national sites already identified. ✦ Actively strengthen the natural capital of coastal ecosystems and promote recognition of their services.
References	(Métropole Aix-Marseille-Provence 2020b; Ministère de la Transition Ecologique et Solidaire 2018)	(Junta de Andalucía. Consejería de Medio Ambiente 2011)	(Ministère de l'Energie, des Mines et de l'Environnement 2021a, 2021b;)	(Ministère de l'Environnement and Gesellschaft für Internationale Zusammenarbeit 2022)

Table 6. Measures and initiatives for the resilience of coastal areas to marine flooding as an adaptation strategy

Tabela 6. Środki i inicjatywy na rzecz odporności obszarów przybrzeżnych na powodzie morskie jako strategia adaptacyjna

Region	Marseille	Andalusia	Tangier	Tunis
Measures and initiatives	✦ Observe the rise of the sea level with a designed system (SONEL). ✦ Strengthen coastal surveillance with SONEL and wave generators. ✦ Deepen the understanding of climate impacts. Forecast changes in coastal events related to sea level rise. ✦ Integrate sea level rise into coastal management. ✦ Adapt prevention strategies to coastal risks. ✦ Create an adaptation guide for protective works. ✦ Develop specific technical approaches for the adaptation of structures to sea level rise.	✦ Review and assess risks. ✦ Establish regular monitoring of the coastline with alerts and evacuation plans. ✦ Nourish beaches and dune systems. ✦ Create artificial beaches and dunes. ✦ Preserve and rehabilitate wetlands and salt marshes. Build new protective structures (dikes, seaside walks). ✦ Adapt existing infrastructure to current standards and regulations. ✦ Introduce appropriate insurance premiums. ✦ Reorganize existing structures, even in estuaries. Purchase necessary land. ✦ Change land use. ✦ Encourage inland wetlands and salt marshes and create new intertidal zones. ✦ Strengthen skills and raise awareness. ✦ Support research and development. ✦ Assess the benefits of ecosystem services. ✦ Move and protect coastal areas. Plan for unified coastal zone management.	✦ Carry out repairs on damaged infrastructure and improve those already in place, including the demolition and reconstruction of some, such as dikes, jetties, spurs and breakwaters. ✦ Realign the coastline. Restore beaches. ✦ Stabilize and revegetate coastal dunes. ✦ Establish a database of vulnerable areas. ✦ Set up operational alert systems. ✦ Harmonize coastal risk management policies and strategies at the local level. ✦ Develop a framework for action to reduce urban vulnerabilities. ✦ Strengthen the capacity of local communities to respond to disasters. ✦ Streamline participatory local planning processes.	✦ Develop a monitoring system to anticipate extreme events and floods, issuing early warnings to the populations concerned. ✦ Combat coastal erosion and implement a coastal protection program. ✦ Integrate the consequences of CC into the National Spatial Planning Scheme. ✦ Include CC-adapted urban planning in local plans. ✦ Build and strengthen infrastructure (dikes, dams, and reforestation systems) to protect inhabited areas. ✦ Promote practices to reduce coastal erosion. ✦ Inform the local communities about flood risks and educate them on adaptive measures and in implementing solutions.
References	(Galliot 2013 ; Pietrapertosa et al. 2023; Ministère de la Transition Ecologique et Solidaire 2018)	(Junta de Andalucía. Consejería de Medio Ambiente 2011; Losada et al. 2019)	(Ministère de l'Energie, des Mines et de l'Environnement 2021a, 2021b; Agharroud et al. 2023)	(Agence de Protection et d'Aménagement du Littoral 2020; Ministère de l'Environnement and Gesellschaft für Internationale Zusammenarbeit 2022)

The examination of energy sources also reveals significant disparities. The proportion of RE contribution in the regions of Andalusia and Tangier is higher than in Marseille and Tunis. The preferred energy sources in southern regions mainly include hydroelectricity, photovoltaics, and wind power (Agencia Andaluza De La Energia 2020; Ministry of Energy, Mines and the Environment 2020b; Jammali and Liouane 2017), while in the north, in addition to using the same sources, biomass and thermodynamics are also exploited (Métropole Aix-Marseille-Provence 2020c; Climate Chance 2019). This testifies to The European Union's energy policy, in which energy security and protection of the natural environment remain a priority (Wojtkowska-Łodej 2015; Skoczkowski and Bielecki 2016). According to Climate Chance (2019), Andalusia stands out as the national leader in RE due to its high share. However, even if renewables control emissions in Tangier, Marseille, and Tunis, they should still increase their use of these sources to reduce their emissions.

On the other hand, it is important to note that, despite different local contexts, the M&I implemented for the energy transition with the aim of reducing emissions have many similarities. Indeed, worrying trends in CO_2 emissions between these different regions have forced local policymakers to implement other environmentally friendly measures. These measures aim to limit environmental degradation and promote the adoption of renewable energies via one of the most effective approaches seriously considered by governments, such as the environmental tax. This tax comes in various forms depending on the economic context considered, which may include taxes on energy, transport, pollution, and extraction, with the aim of forcing individuals and companies to adopt environmentally friendly practices (Azhgaliyeva et al. 2023; Nchofoung et al. 2023). As for the M&I adopted for CC adaptation, it depends on the level of development and resilience of each region (Rogers et al. 2023). For example, the northern regions have put in place measures adapted to their level of development. There are, however, some similarities in terms of resilience to marine flooding. Coastal regions are distinguished by their diversity in terms of planning, geomorphology, and biodiversity, thus requiring a wider range of adaptation measures, whether preventive or curative. TCPs have identified suitable solutions for risk areas that consider coastal risk analysis. These solutions incorporate robust infrastructure, such as dikes, jetties, spurs, and breakwaters, to protect coastal roads and sensitive areas. They also include NBS, such as preserving beaches through methods such as feeding, stabilizing, and rehabilitating coastal dunes. In addition, the TCPs advocate the establishment of warning and information systems, as well as the education of local populations to promote their adaptation to coastal risks and strengthen their resilience to these events.

On the other hand, some M&I undertaken in the northern regions for energy transition, coastal flood resilience, and ecosystem restoration could serve as examples and be applied in the southern regions due to their potential to improve climate performance. These measures include the suspension or partial exemption of property taxes for buildings equipped with renewable energy sources, the development of sustainable construction and renovation charters and carbon taxation, as well as the creation of dark zone networks to reduce light pollution and preserve nocturnal biodiversity, or the use of permeable sidewalks and the restoration of coastal dunes to strengthen flood resilience. To do this, they could draw inspiration from the example

of Andalusia to develop their forest area by promoting the afforestation of species with high absorption potential and by intensifying their sustainable agricultural practices.

Conclusion and outlook

Decentralization of national CPs at the regional level has proven to be an effective strategy to combat CC and achieve results that are in line with the objectives established by the experts. Our study focused on a comparative analysis of the climate plans of four Mediterranean coastal regions. These regions, renowned for their economic dynamism and geostrategic importance, play a central role in the economics of their respective nations, and marked trends in population growth reinforce their attractiveness. Localized climate plans provide the flexibility to adapt mitigation and adaptation strategies to the specifications of each region. Investigations revealed a significant trend. While many efforts are focused on mitigation, adaptation, or a combination of both, limited attention has been paid to local climate plans. Ironically, these plans are the cornerstone of mitigation and adaptation measures and initiatives, as presented in various studies. In addition, the existing literature often suffers from a lack of transparency regarding the methodologies used in the implementation of local climate policies. This in-depth study aims to fill this critical gap by providing a comprehensive analysis of local climate plans, accompanied by a detailed presentation of their implementation methods. In summary, this article aspires to become an essential guide for climate change decision-makers when developing and implementing their local climate plans.

Looking to the future, the results highlight the importance of valuing local climate planning within the broader climate action discourse. We advocate for further decentralization of CPs at the regional level while insisting on the imperative of a rigorous methodology and transparency in their application. As these Mediterranean regions face multiple challenges due to CC, we encourage the formation of collaborative partnerships, the sharing of best practices, and the emergence of innovative solutions to ensure a sustainable and resilient future collectively.

The Authors have no conflicts of interest to declare.

References

Agence de Protection et d'Aménagement du Littoral 2020. National Strategy for Integrated Coastal Zone Management in Tunisia and two Coastal Development Programs for the sites of Ghar el Melh and Djerba (*Stratégie Nationale de Gestion Intégrée des Zones Côtières en Tunisie et de deux Programmes d'Aménagement Côtiers pour les sites de Ghar el Melh et Djerba*). [Online] http://www.apal.nat.tn/site_web/annonces/GIZC_dec_2020_final.pdf [Accessed: 2024-11-25] (*in French*).

Agencia Andaluza De La Energia (AAE) 2020. Andalusian Energy Strategy 2020 (*Estrategia Energética Andalucía 2020*). [Online] https://www.agenciaandaluzadelaenergia.es/sites/default/files/Documentos/estrategia-andalucia-2020.pdf [Accessed: 2024-12-05] (*in Spanish*).

Agharroud et al. 2023 – Agharroud, K., Puddu, M., Ivčević, A., Satta, A., Kolker, A.S. and Snoussi, M. 2023. Climate risk assessment of the Tangier-Tetouan-Al Hoceima coastal Region (Morocco). *Frontiers in Marine Science* 10, DOI: 10.3389/fmars.2023.1176350.

Azhgaliyeva et al. 2023 – Azhgaliyeva, D., Beirne, J. and Mishra, R. 2023. What matters for private invest-ment in renewable energy? *Climate Policy* 23(1), pp. 71–87, DOI: 10.1080/14693062.2022.2069664

Barthel, P.-A. and Verdeil, E. 2013. Arab cities, sustainable cities? Issues, circulations and testing of new urban policies (*Villes arabes, villes durables ? Enjeux, circulations et mise a l'épreuve de nouvelles politiques urbaines*). *Environnement Urbain/Urban Environment* 7. [Online] https://journals.openedition.org/eue/324 [Accessed: 2024-12-05] (*in French*).

Benalouache, N. 2013. A test of Tunisian energy policies: diffusion and territorialization of the domestic use of solar energy in urban areas (*Une mise à l'épreuve des politiques énergétiques tunisiennes: Diffusions et territorialisation de l'usage domestique de l'énergie solaire en milieu urbain*). *Environnement Urbain/Urban Environment* 7 [Online] https://journals.openedition.org/eue/425 [Accessed: 2024-12-05] (*in French*).

Chabrol, M. and Grasland, L. 2016. Local taxation of renewable energy, an uncertain leverage of local development (*Fiscalité locale des énergies renouvelables, un levier incertain de développement local* (*France*)). Cybergeo, DOI: 10.4000/cybergeo.27488 (*in French*).

Climate chance 2019. 2019 Review of Territorial Climate Action: Climate Chance for Non-State Climate Action (*Bilan 2019 de l'action climat des territoires: Climate Chance de l'action climat non-étatique*) (138). Cahier des territoires (*in French*).

Collado, R.R. and Díaz, M.T.S. 2017. Analysis of energy end-use efficiency policy in Spain. *Energy Policy* 101, pp. 436–446, DOI: 10.1016/j.enpol.2016.10.041.

Cooper et al. 2018 – Cooper, C., Booth, A., Varley-Campbell, J., Britten, N. and Garside, R. 2018. Defining the process to literature searching in systematic reviews: A literature review of guidance and supporting studies. *BMC Medical Research Methodology* 18(1), DOI: 10.1186/s12874-018-0545-3.

Cramer et al. 2018 – Cramer, W., Guiot, J., Fader, M., Garrabou, J., Gattuso, J.-P., Iglesias, A., Lange, M. A., Lionello, P., Llasat, M.C., Paz, S., Peñuelas, J., Snoussi, M., Toreti, A., Tsimplis, M.N. and Xoplaki, E. 2018. Climate change and interconnected risks to sustainable development in the Mediterranean. *Nature Climate Change* 8(11), pp. 972–980, DOI: 10.1038/s41558-018-0299-2.

Dellmuth, L.M. and Gustafsson, M.-T. 2021. Global adaptation governance: How intergovernmental organizations mainstream climate change adaptation. *Climate Policy* 21(7), pp. 868–883, DOI: 10.1080/14693062.2021.1927661.

Dill, H. 2023. Carbon pricing initiatives and green bonds: Are they contributing to the transition to a low-carbon economy? *Climate Policy* 24(4), pp. 529–544, DOI: 10.1080/14693062.2023.2210107.

Dumitru, A. and Wendling, L. 2021. Evaluating the impact of nature-based solutions: A handbook for practitioners. European Commission EC. [Online] https://cris.vtt.fi/en/publications/evaluating-the-impact-of-nature-based-solutions-a-handbook-for-pr [Accessed: 2024-11-25].

Galliot, M. 2013. The national plan for adaptation to climate change (*Le plan national d'adaptation au changement climatique*). *Bulletin de l'association de géographes français. Géographies* 90(1), DOI: 10.4000/bagf.1366 (*in French*).

Ginbo et al. 2021 – Ginbo, T., Di Corato, L. and Hoffmann, R. 2021. Investing in climate change adaptation and mitigation: A methodological review of real-options studies. *Ambio* 50(1), pp. 229–241, DOI: 10.1007/s13280-020-01342-8.

Hurlimann et al. 2021 – Hurlimann, A., Moosavi, S. and Browne, G.R. 2021. Urban planning policy must do more to integrate climate change adaptation and mitigation actions. *Land Use Policy* 101, DOI: 10.1016/j.landusepol.2020.105188.

Hurpeau et al. 2019 – Hurpeau, B., Khedhaouria, S. and Salah, K. 2019. Development of the first regional GDPs in Tunisia (*Élaboration des premiers PIB régionaux en Tunisie*). *Statéco* 113. [Online] https://dial.ird.fr/wp-content/uploads/2021/12/STATECO-N%C2%B0113-12_article-4.pdf [Accessed: 2025-01-10] (*in French*).

Ibañez Iralde et al. 2021 – Ibañez Iralde, N.S., Pascual, J. and Salom, J. 2021. Energy retrofit of residential building clusters. A literature review of crossover recommended measures, policies instruments and allocated funds in Spain. *Energy and Buildings* 252, DOI: 10.1016/j.enbuild.2021.111409.

IPCC 2014a. Climate change 2014: Impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Cambridge University Press.

IPCC 2014b. Climate change 2014: Mitigation of climate change. Cambridge University Press.

IPCC 2022. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change 2022: Impacts, Adaptation, and Vulnerability. Cambridge University Press.

Jammali, D. and Liouane, N. 2017. Energies Renouvelables, Efficacité Energétique Et Croissance Verte En Tunisie. *International Journal of Scientific Research*.

Junta de Andalucía. Consejería de Medio Ambiente 2011. Programa Andaluz de daptación al cambio climático (Plan Andaluz de Acción Por El Clima. Programa de Adaptación). [Online] https://www.juntadeandalucia.es/export/drupaljda/programa_adaptacion_clima.pdf [Accessed: 2024-12-04] (*in French*).

Kafi, S. and Elbayed, H. 2023. The promotion of renewable energies in Morocco as a lever for the attractiveness of foreign direct investments: An empirical analysis (*La promotion des énergies renouvelables au Maroc comme levier de l'attractivité des investissements direct étrangers: Une analyse empirique*). *Revue Française d'Economie et de Gestion* 4(10). [Online] https://www.revuefreg.fr/index.php/home/article/view/1310 [Accessed: 2024-12-04] (*in French*).

Labandeira et al. 2019 – Labandeira, X., Labeaga, J.M. and López-Otero, X. 2019. New Green Tax Reforms: Ex-Ante Assessments for Spain. *Sustainability* 11(20), DOI: 10.3390/su11205640.

Lesnikowski et al. 2021 – Lesnikowski, A., Biesbroek, R., Ford, J.D. and Berrang-Ford, L. 2021. Policy implementation styles and local governments: The case of climate change adaptation. *Environmental Politics* 30(5), pp. 753–790, DOI: 10.1080/09644016.2020.1814045.

Lesnikowski et al. 2016 – Lesnikowski, A., Ford, J., Biesbroek, R., Berrang-Ford, L. and Heymann, S.J. 2016. National-level progress on adaptation. *Nature Climate Change* 6(3), pp. 261–264, DOI: 10.1038/nclimate2863.

Locatelli et al. 2016 – Locatelli, B., Fedele, G., Fayolle, V. and Baglee, A. 2016. Synergies between adaptation and mitigation in climate change finance. *International Journal of Climate Change Strategies and Management* 8(1), pp. 112–128, DOI: 10.1108/IJCCSM-07-2014-0088.

Losada et al. 2019 – Losada, I.J., Toimil, A., Muñoz, A., Garcia-Fletcher, A.P. and Diaz-Simal, P. 2019. A planning strategy for the adaptation of coastal areas to climate change: The Spanish case. *Ocean & Coastal Management* 182, DOI: 10.1016/j.ocecoaman.2019.104983.

Mäkinen et al. 2018 – Mäkinen, K., Prutsch, A., Karali, E., Leitner, M., Völler, S., Lyytimäki, J., Pringle, P. and Vanneuville, W. 2018. Indicators for adaptation to climate change at national level–Lessons from emerging practice in Europe. *ETC/CCA Technical Paper* 3, DOI: 10.25424/CMCC/CLIMATE_CHANGE_ADAPTATION_INDICATORS_2018.

Manes et al. 2021 – Manes, S., Costello, M.J., Beckett, H., Debnath, A., Devenish-Nelson, E., Grey, K.-A., Jenkins, R., Khan, T.M., Kiessling, W., Krause, C., Maharaj, S.S., Midgley, G.F., Price, J., Talukdar, G. and Vale, M.M. 2021. Endemism increases species' climate change risk in areas of global biodiversity importance. *Biological Conservation* 257, DOI: 10.1016/j.biocon.2021.109070.

Mariotti et al. 2015 – Mariotti, A., Pan, Y., Zeng, N. and Alessandri, A. 2015. Long-term climate change in the Mediterranean region in the midst of decadal variability. *Climate Dynamics* 44(5–6), pp. 1437––1456, DOI: 10.1007/s00382-015-2487-3.

MedECC 2020. *Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future*. First Mediterranean Assessment Report (Version 1). Zenodo, DOI: 10.5281/ZENODO.7224821.

Métropole Aix-Marseille-Provence 2020a. Plan Climat Air Energie 2021–2027: *Diagnostic et état initial de l'environnement*. [Online] https://ampmetropole.fr/missions/strategie-environnementale/plan-climat-air-energie/ [Accessed: 2024-11-25] (*in French*).

Métropole Aix-Marseille-Provence. 2020b. Plan Climat Air Energie 2021–2027: *Plan d'action*. [Online] https://ampmetropole.fr/missions/strategie-environnementale/plan-climat-air-energie/ [Accessed: 2024-11-25] (*in French*).

Métropole Aix-Marseille-Provence MAMP. 2020c. Plan Climat Air Energie 2021–2027: *Stratégie Climat Air Energie Métropolitain.* [Online] https://ampmetropole.fr/missions/strategie-environnementale/plan-climat-air-energie/ [Accessed: 2024-11-25] (*in French*).

Ministère de la Transition Ecologique et Solidaire. 2018. *Le plan national d'adaptation au chanchement climatique 2*. [Online] https://www.ecologie.gouv.fr/sites/default/files/2018.12.20_PNACC2.pdf [Accessed: 2024-11-25] (*in French*).

Ministère de l'Energie, des Mines et de l'Environnement. Département de l'environnement. 2020a. Elaboration d'un plan climat territorial pour la région de Tanger-Tétouan-al Hoceima. Mission 1: Diagnostic « situation territoriale face au changement climatique » (stcc) de la région Tanger-Tétouan-al Hoceima (Etude d'élaboration de Plans Climat Territoriaux Pour 6 Régions Du Royaume Du Maroc.). [Online] https://www.uae.ma/website/sites/default/files/Pr%C3%A9sentation%20atelier%20PCT%20-%20Mission%202.pdf [Accessed: 2024-11-25] (*in French*).

Ministère de l'Energie, des Mines et de l'Environnement. Département de l'environnement. 2020b. Elaboration d'un plan climat territorial pour la région de Tanger-Tétouan-al Hoceima. Mission 2: Analyse tendancielle des émissions des GES au niveau régional et sectoriel et élaboration d'un Plan d'Atténuation (Etude d'élaboration de Plans Climat Territoriaux Pour 6 Régions Du Royaume Du Maroc). [Online] https://www.uae.ma/website/sites/default/files/Pr%C3%A9sentation%20atelier%20PCT%20-%20Mission%202.pdf [Accessed: 2024-11-25] (*in French*).

Ministère de l'énergie, des mines et de l'environnement. 2020c. Stratégie nationale de l'efficacité énergétique à l'horizon 2030 (*in French*).

Ministère de l'Energie, des Mines et de l'Environnement. Département de l'environnement. 2021a. Elaboration d'un plan climat territorial pour la région de Tanger-Tétouan-al Hoceima. Mission 3: Conception et élaboration d'un plan d'adaptation prioritaire (Etude d'élaboration de Plans Climat Territoriaux Pour 6 Régions Du Royaume Du Maroc). [Online] https://www.uae.ma/website/sites/default/files/Pr%C3%A9sentation%20atelier%20PCT%20-%20Mission%203_compressed.pdf [Accessed: 2024-11-25] (*in French*).

Ministère de l'Energie, des Mines et de l'Environnement. Département de l'environnement. 2021b. Elaboration d'un plan climat territorial pour la région de Tanger-Tétouan-al Hoceima. Mission 4: Plan de sensibilisation et d'information de la région de Tanger-Tétouan-al Hoceima (Etude d'élaboration de Plans Climat Territoriaux Pour 6 Régions Du Royaume Du Maroc). [Online] https://www.uae.ma/website/sites/default/files/Pr%C3%A9sentation%20atelier%20PCT%20-%20Mission%203_compressed.pdf [Accessed: 2024-11-25] (*in French*).

Ministère de l'Environnement and Gesellschaft für Internationale Zusammenarbeit 2022. Stratégie nationale bas carbone et résiliente aux changements climatiques horizon 2050. [Online] https://unfccc.int/sites/default/files/resource/Strat%C3%A9gie%20de%20d%C3%A9veloppement%20

neutre%20en%20carbone%20et%20r%C3%A9silient%20-%20Tunisie.pdf [Accessed: 2024-11-25] (*in French*).

Mosca et al. 2023 – Mosca, F., Canepa, M. and Perini, K. 2023. Strategies for adaptation to and mitigation of climate change: Key performance indicators to assess nature-based solutions performances. *Urban Climate* 49, DOI: 10.1016/j.uclim.2023.101580.

Moudene et al. 2023 – Moudene, K., El-Oud, R., Ejbari, R. and Amedjar, A. 2023. Renewable Energy and Economic Growth in Morocco. *Journal of Human Resource and Sustainability Studies* 11(2), pp. 401–413, DOI: 10.4236/jhrss.2023.112023.

Moudene, K. and Ridouane, E. 2024. Investment Determinants and Their Impact on Renewable Energy Development: International Experiences. *International Uni-Scientific Research Journal* 5, pp. 130––145, DOI: 10.59271/s45515.024.2345.17.

Muñoz-Rojas et al. 2011 – Muñoz-Rojas, M., De La Rosa, D., Zavala, L.M., Jordán, A. and Anaya-Romero, M. 2011. Changes in land cover and vegetation carbon stocks in Andalusia, Southern Spain (1956–2007). *Science of The Total Environment* 409(14), pp. 2796–2806, DOI: 10.1016/j.scitotenv.2011.04.009.

Nchofoung et al. 2023 – Nchofoung, T.N., Fotio, H.K. and Miamo, C.W. 2023. Green taxation and renewable energy technologies adoption: A global evidence. *Renewable Energy Focus* 44, pp. 334–343, DOI: 10.1016/j.ref.2023.01.010.

Olkuski, T. 2015. CO_2 emission allowance trading in the European Union and its impact on combating climate change (*Wpływ handlu uprawnieniami do emisji CO_2 w Unii Europejskiej na przeciwdziałanie zmianom klimatu*). *Polityka Energetyczna – Energy Policy Journal* 18(3), pp. 87–98 (*in Polish*).

Ortiz et al. 2021 – Ortiz, A.M.D., Outhwaite, C.L., Dalin, C. and Newbold, T. 2021. A review of the interactions between biodiversity, agriculture, climate change, and international trade: Research and policy priorities. *One Earth* 4(1), pp. 88–101, DOI: 10.1016/j.oneear.2020.12.008.

Pearce-Higgins et al. 2022 – Pearce-Higgins, J.W., Antão, L.H., Bates, R.E., Bowgen, K.M., Bradshaw, C.D., Duffield, S.J., Ffoulkes, C., Franco, A.M.A., Geschke, J., Gregory, R.D., Harley, M.J., Hodgson, J.A., Jenkins, R.L.M., Kapos, V., Maltby, K.M., Watts, O., Willis, S.G. and Morecroft, M.D. 2022. A framework for climate change adaptation indicators for the natural environment. *Ecological Indicators* 136, DOI: 10.1016/j.ecolind.2022.108690.

Perera et al. 2018 – Perera, K.A.R.S., De Silva, K.H.W.L. and Amarasinghe, M.D. 2018. Potential impact of predicted sea level rise on carbon sink function of mangrove ecosystems with special reference to Negombo estuary, Sri Lanka. *Global and Planetary Change* 161, pp. 162–171, DOI: 10.1016/j.gloplacha.2017.12.016.

Phillips, J.D. 2018. Environmental gradients and complexity in coastal landscape response to sea level rise. *CATENA* 169, pp. 107–118, DOI: 10.1016/j.catena.2018.05.036.

Pietrapertosa et al. 2023 – Pietrapertosa, F., Olazabal, M., Simoes, S.G., Salvia, M., Fokaides, P.A., Ioannou, B.I., Viguié, V., Spyridaki, N.-A., De Gregorio Hurtado, S., Geneletti, D., Heidrich, O., Tardieu, L., Feliu, E., Rižnar, K., Matosović, M., Balzan, M.V., Flamos, A., Šel, N.B. and Reckien, D. 2023. Adaptation to climate change in cities of Mediterranean Europe. *Cities* 140, DOI: 10.1016/j.cities.2023.104452.

Rogers et al. 2023 – Rogers, N.J.L., Adams, V.M. and Byrne, J.A. 2023. Factors affecting the mainstreaming of climate change adaptation in municipal policy and practice: A systematic review. *Climate Policy* 23(10), pp. 1327–1344, DOI: 10.1080/14693062.2023.2208098.

Schmidt et al. 2024 – Schmidt, L., Apergi, M., Eicke, L. and Weko, S. 2024. Who believes in green growth? Strategic framing and technology leadership in the UNFCCC negotiations. *Climate Policy* 24(2), pp. 177–192, DOI: 10.1080/14693062.2023.2248061.

Singh et al. 2022 – Singh, C., Iyer, S., New, M.G., Few, R., Kuchimanchi, B., Segnon, A.C. and Morchain, D. 2022. Interrogating 'effectiveness' in climate change adaptation: 11 guiding principles for adaptation research and practice. *Climate and Development* 14(7), pp. 650–664, DOI: 10.1080/17565529.2021.1964937 .

Skoczkowski, T. and Bielecki, S. 2016. Energy effectiveness – formal and political conditions for its development in Poland and the European Union (*Efektywność energetyczna – polityczno-formalne uwarunkowania rozwoju w Polsce i Unii Europejskiej*). *Polityka Energetyczna – Energy Policy Journal* 19(1), pp. 5–20 (*in Polish*).

Torres-Bagur et al. 2019 – Torres-Bagur, M., Ribas, P.A. and Vila-Subirós, J. 2019. Perceptions of climate change and water availability in the Mediterranean tourist sector: A case study of the Muga River basin (Girona, Spain). *International Journal of Climate Change Strategies and Management* 11(4), pp. 552–569, DOI: 10.1108/IJCCSM-10-2018-0070.

Touzi, D.S. 2020. Plan National Sècheresse Tunisie.

United Nations Framework Convention on Climate Change. 2022. Tunisia. Biennial update report (BUR). BUR 3. [Online] https://unfccc.int/sites/default/files/resource/BUR%203%20Tunisia-%20version%2028%20D%C3%A9cembre%202022.pdf [Accessed: 2024-11-25].

Wojtkowska-Łodej, G. 2015. Climate and energy policy of the European Union – the challenges for the future of the Polish economy. *Polityka Energetyczna – Energy Policy Journal* 18(1), pp. 15–25 (*in Polish*).

Yang et al. 2020 – Yang, Y., Liu, B., Wang, P., Chen, W. and Smith, T.M. 2020. Toward sustainable climate change adaptation. *Journal of Industrial Ecology* 24(2), pp. 318–330, DOI: 10.1111/jiec.12984.

Payagda Misael Tarpaga, Mounaim Halim El Jalil, Ouadia Mouhat

Wzmocnienie odporności na zmiany klimatu: analiza porównawcza strategii terytorialnych w Tangerze, Andaluzji, Tunisie i Marsylii

Streszczenie

W ostatnich latach wiele krajów przyjęło decentralizację krajowych polityk klimatycznych na poziomie regionalnym w formie terytorialnych planów klimatycznych (*Territorial Climate Plans* – TCP). Ich celem jest usprawnienie planowania i wdrażania środków adaptacyjnych i łagodzących skutki zmian klimatu (CC). Niniejszy artykuł przedstawia analizę porównawczą TCP w czterech regionach śródziemnomorskich dotkniętych skutkami zmian klimatu, w tym w Marsylii, Andaluzji, Tangerze i Tunisie. Porównanie to koncentrowało się na kluczowych wskaźnikach wydajności (KPI), a także strategiach łagodzenia i adaptacji wyodrębnionych z raportów krajowych i innych oficjalnych źródeł. Porównanie wskaźników KPI wykazało, że 78% emisji gazów cieplarnianych pochodzi z regionów europejskich. Pod względem sekwestracji dwutlenku węgla regiony europejskie również osiągnęły lepsze wyniki. Jeśli chodzi o transformację ener-

getyczną, udział energii odnawialnej (OZE) w koszyku energetycznym jest najwyższy w Andaluzji (39%), a następnie w Tangerze, Marsylii i Tunisie (odpowiednio 36, 4 i 3%).

Analiza środków i inicjatyw (M&I) pokazuje wspólny nacisk na promowanie odnawialnych źródeł energii i efektywności energetycznej w sektorze budowlanym i przemysłowym poprzez zachęty podatkowe. Jeśli chodzi o adaptację, regiony koncentrują się na odbudowie ekosystemów i odporności wybrzeży. Podsumowując, nawet jeśli dostosowanie TCP zostanie wzmocnione, utrzyma się znaczna nierównowaga w zakresie emisji gazów cieplarnianych. W związku z tym niniejszy dokument ma być istotnym i cennym przewodnikiem dla decydentów przy opracowywaniu i wdrażaniu lokalnych planów klimatycznych.

Z drugiej strony, strategiczna integracja zachęt fiskalnych promowałaby lokalną transformację energetyczną. Rozwiązania oparte na przyrodzie mogą również okazać się kluczowymi strategiami łagodzenia zmian klimatu i promowania ochrony ekosystemów. Co więcej, wzajemne uczenie się między regionami może okazać się skuteczną strategią wzmacniania środków i inicjatyw mających na celu walkę z wyzwaniami klimatycznymi.

Słowa kluczowe: terytorialne plany klimatyczne (TCP), kluczowe wskaźniki efektywności (KPI), zachęty podatkowe, odporność wybrzeży, odbudowa ekosystemów