

EU Mission on 'Climate-Neutral and Smart Cities' – Assessing Readiness to Join of 12 Greek Cities

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Abstract. Urbanization is currently perceived as a major challenge of the 3rd millennium, with severe repercussions in terms of Climate Change (CC) deterioration and related impacts. In fact, cities are deemed to be the 'source', but also the 'solution' to CC emergency. Such an ascertainment lies at the heart of the European Mission on 'Climate-Neutral and Smart Cities' that falls into the 2050 EU long term strategy towards climate neutrality; and seeks to improve urban sustainability and resilience by leveraging the concept of cities' nature- and technology-enabled climate neutrality. Along these lines, this paper delves into the preparedness or readiness of several Greek cities towards the directions set by the European Mission for Cities. Twelve cities – most thereof capitals of respective regional entities – already active, in one way or another, in the CO_2 reduction endeavor and smart initiatives realm, are explored in this respect. These are evaluated by means of Multicriteria Analysis (MCA), grounded on numerous Mission-oriented criteria, such as CO_2 emissions, participation in the Covenant of Mayors, waste management, deployment of digital infrastructure, smart city applications, governance schemes, etc. Results obtained uncover the diversified state and starting point of Greek cities investigated as to the EU Mission objectives.

Keywords: Urbanization · EU Mission on 'Climate-Neutral and Smart Cities' · Multicriteria analysis · Mission-oriented evaluation criteria · Greek cities

1 Introduction

Urbanization has dramatically escalated over the last few decades, while it is expected to further intensify by 2050 [1]. This ominous urban phenomenon lies among the megatrends of the new millennium [2], featuring resource-intensive pathways and putting at great risk sustainability objectives at the glocal (global/local) level. Urban areas, as engines of growth and prosperity, magnets for habitation, platforms of world's production and innovation, and hubs of government, commerce and transportation, are deemed to be the main source of numerous contemporary problems and overwhelming challenges [3, 4]. Pollution and Climate Change (CC) are the most significant among them, with cities being, at present, imprudent energy consumers (up to 80% of the world's energy is absorbed by cities) and responsible for about 75% CO_2 emissions globally [5], mainly due to transport and building needs.

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The noticeably accelerating urbanisation trends are anticipated to further affect pollution in a pretty harsh manner [6, 7] due to the increasing volume and intensity of urban functions that stem from the great mass of people, infrastructure, housing and economic activities piled up in cities. The same holds true for the aggravation of CC, owing to the growing levels of Green House Gases (GHG) cities emit, while delivering their services, either directly or indirectly [8, 9]. Both lead to the deterioration of urban living conditions with respect to the poor air quality, energy and water scarcity, land use change / soil sealing, waste overproduction, etc. [6]. At the same time, the rapidly expanding and, in many cases, unplanned urbanization patterns exert massive pressures on the environment, thereby giving prominence to urbanization's role as a key driver of environmental degradation and related impacts on the livelihood of both urban population and natural ecosystems [10–12]. In a bid to simultaneously support economic wellfare, social inclusion and environmental health – the so called "triple bottom line" [13] – urban systems seem to have a critical part as main contributors in the currently evolving *"triple planetary crisis"* – i.e., CC, pollution and biodiversity loss –, a crisis that marks a "code red" for humanity as a whole [14].

Taking into consideration urban systems' pivotal role in coping with the triple planetary crisis and its severe repercussions, cities' future pathways are currently placed at the heart of the global policy and the interdisciplinary planning discourse. This reflects the belief that cities can become avid proponents of sustainable development [15, 16]; and guides the endeavour towards crafting and implementing widely acceptable, innovative, sustainable and resilient future urban pathways and related policy paths that are capable of dealing with the key challenges of contemporary cities; and decreasing their footprint on the planet. Such an effort is largely driven by the conviction that the current urbanization surge appears to be related with two sides of the same coin, since it treats cities as both the source and the means for tackling the aforementioned triple crisis; and offers unprecedented opportunities for establishing sustainable, resilient, livable and climate-neutral future trajectories. These opportunities are currently 'translated' into specific goals by the policy community at the global, European but also national/regional/local level. Therefore, action is undertaken in these spatial contexts and visionary end states are articulated that aim at: motivating reduction of the urban ecological footprint in general and cities' contribution to CC in particular; and shaping the transition towards smart, resilient and climate-neutral cities.

The achievement of *climate neutrality* implies a drastic shift from purely sectoral or 'silo' policy-making approaches to holistic and integrated ones at the urban level [17, 18]. In addition, it calls for a nature-based and technology-enabled orientation, capable of addressing both mitigation and adaptation strategic pathways as two sides of an integral urban response [19, 20]. The former intends to achieve net zero GHG emissions by either reducing or developing trade-off mechanisms to offset remaining unavoidable emissions. The latter targets cities' adaptive capacity strengthening in order to establish resilience to various types of external crises, but also of internal, long-term, persisting trends.

The Mission of the European Commission on "Climate-Neutral and Smart Cities", which constitutes the core of this work, falls under such visionary policy directions. Within such a context, the question as to how prepared to join the climate neutrality

strategic vision Greek cities are, is raised. In an endeavor to provide solid answers to the above question, this paper attempts to explore the readiness of 12 Greek cities by use of multicriteria analysis and assessment of their current performance on the basis of several Mission-oriented evaluation criteria. The paper is structured as follows: Sect. 2 provides a succinct description of the idea of climate neutrality, which is perceived as a major strategic policy direction at the global and especially the European level; Sect. 3 delineates the adopted methodological approach; Sect. 4 roughly sketches the explored Greek cities, while it also presents the obtained results on their performance in respect to the EU Mission for cities direction. Finally, in Sect. 5 results are critically discussed and in Sect. 6 certain conclusions are drawn.

2 Framing Climate Neutrality – An Issue of 'Glocal' Policy Concern

CC is currently recognized as a key driving force of global reach [21]. Thus, tackling CC and its ramifications is an issue of immense significance for humanity in general and a critical issue of global governance in particular. As such, overall reduction of GHG emissions and climate neutrality lie at the heart of the United Nations' Agenda 2030 for Sustainable Development. More specifically, this is reflected in SDG 13 (Fig. 1), which is dedicated to "Climate Action" and sheds light on the urgent need to undertake those vital steps that can support transition towards carbon neutrality. Further specialization of SDG 13 into sub-objectives highlights, inter alia, the: boosting of resilience and adaptive capacity of states and regions to climate-related hazards and natural disasters; integration of CC measures into national policies, strategies and planning processes; capacity building and awareness raising of population and institutions, etc. At present, a number of countries are taking mitigation and adaptation actions, targeting the reduction of their national emissions and promoting national and/or regional/local adaptation plans to address CC challenges.

Despite the critical importance of SDG 13 for confronting CC, several SDGs focus also on climate neutrality concerns, such as SDG 7 ('Affordable and Clean Energy'), SDG 9 ('Industry innovation and infrastructure'), SDG 10 ('Reduced inequalities'), SDG 12 ('Responsible production and consumption'), etc. Furthermore, SDG 11 ('Sustainable cities and communities') is of utmost significance, since it stresses the relevance of the local (urban) level and pertinent policies as key factors to the achievement of SDGs overall [22, 23]. SDG's 11 mission is to render cities and human settlements inclusive, safe, resilient and sustainable by addressing topics related to slums and vulnerable population to CC, planning of human settlements, CC mitigation and adaptation, and wealth / resilience of urban economies. Affordable and sustainable transport systems, inclusive and sustainable urbanization, battle against the adverse effects of natural disasters, reduction of cities' environmental impacts, and access to safe and inclusive green and public spaces, are included in the fundamental concerns of SDG 11, which are inextricably linked with climate neutrality dimensions.

Focusing on the European level, the *European Green Deal* (2019) is of substantial importance, as it is considered to be the medium whereby the European Union attempts to harmonize with United Nation's Agenda 2030 and the 17 SDGs; and put forward,

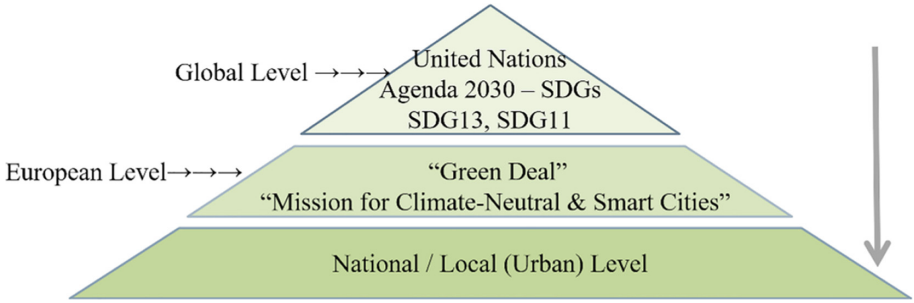

Fig. 1. Climate neutrality as a 'glocal effort' – From global to local (urban) level, Source: Own elaboration

in essence, a new growth strategy. This strategy promotes more sustainable pathways by serving the EU transition towards: a just and prosperous society; a resource-efficient and competitive economy, marked by the decoupling of economic growth from resource use; and a continent seeking to achieve climate neutrality first and foremost, i.e., no net GHG emissions by 2050 [24]. On the way to accomplishing climate neutrality, EU has committed to reduce net GHG emissions by at least 55% until 2030, compared to 1990 levels; and has set up a clear and coherent vision for climate neutrality by 2050. At the same time, Green Deal's strategic objectives are downscaled to the level of the member states by enforcing legislation updates and policy reforms as well as by monitoring their implementation. An ambitious EU strategy, targeting adaptation to CC, is also predicted in the Green Deal; while emphasis is placed on getting access to: data and instruments in support of integrating CC into risk management practices; smart energy infrastructure; and digital transformation, all three being grasped as critical 'vehicles' for reaching the Green Deal objectives [24].

In a bid to deal with the overwhelming challenges of the time, the EU has also put forward five *Missions* that aim at serving its policy priorities, with the Green Deal included. Missions have set quite ambitious goals and are planned to bring concrete results by 2030. For this reason, wide coalitions that are expected to establish the bridges among the research, policy and entrepreneurial communities as well as the European citizens, are provided for. This, in turn, implies that the goals of each Mission are meant to be accomplished by means of a portfolio of actions, incorporating research projects, policy measures or even legislative initiatives, in order to cooperatively attain a measurable goal.

Among the five EU Missions, the present work places its attention on the one seeking to achieve "Climate neutral and smart cities" (henceforth 'Cities' Mission'). This is justified by the fact that Cities' Mission and cities' exceptional role in achieving climate neutrality by 2050, as set by the Green Deal, are tightly intertwined. The significance of the abovementioned role lies in the very nature of cities, considering that these account for more than 70% of global CO_2 emissions [25]. That said, the goal of the EU Mission for Cities is to steer their *climate mitigation efforts* by accelerating green and digital transformation, among others. In doing so, it is supposed to deliver 100 climate-neutral and smart cities by 2030. These will act as pilots and laboratories of innovative and

social experimentation, paving thus the way for the rest of the European cities that will follow till 2050. In order to gain one position among the first 100 pilot cities, candidates should satisfy certain criteria (e.g., population size). Furthermore, they should fill out an extended questionnaire that seeks information on: city's vision; current level of emissions; current policies, highlighting climate ambition, actions up to now and existing sectoral or cross-sectoral plans (energy, transport, waste management, etc.) relevant to CC mitigation and GHG reduction; participation in city networks; priorities for abating GHG emissions; partnerships and networking; capital needs and investment strategies; etc. Delving into the necessary requirements for this first selection round of cities by the European Commission has guided the formulation of evaluation criteria for assessing preparedness of 12 Greek cities to join the Cities' Mission, which is actually the primary subject of the following sections.

At the national level, Greece has launched several initiatives for tackling CC, such as the: National and regional strategies for CC [21], actions towards CC awareness raising, National Energy and Climate Plan (NECP) targeting the fulfillment of specific climate and energy objectives by 2030 and 2050, Climate Law, etc. Adhering to the national strategic directions, numerous plans – at the urban level – are conducted, such as Sustainable Urban Development Plans, Sustainable Energy Action Plans (SEAPs), Sustainable Urban Mobility Plans (SUMPs), etc.

3 Methodological Approach

The methodological approach, as presented below, aims at establishing a solid framework for assessing cities' readiness or preparedness to step into the ambitious EU Cities' Mission; and is implemented in the context of 12, unbiasedly selected, Greek urban environments.

3.1 The Steps of the Methodological Approach

The methodological approach consists of two distinct stages, namely (Fig. 2):

- The *development stage*, which aims at picking a number of Greek cities that can potentially fulfill the prerequisites to join the Cities' Mission. In this respect, two specific selection criteria are set: i) population size larger than 50,000 inhabitants; and ii) spatial balance, implying an even coverage across the various Greek regional entities. The output of this stage is a sample of 12 candidate cities, best complying with the aforementioned preselection criteria. These are then subjected to a more in-depth exploration at the evaluation/prioritization stage.
- The *evaluation/prioritization stage*, which represents the core of the Mission-oriented assessment process of the 12 preselected cities. Towards this end, the REGIME multi-criteria evaluation method is used. The adopted procedure starts with the demarcation and definition of the evaluation problem, as previously defined. Then, a range of evaluation criteria – stemming from the directions given by the EU Mission at the stage of preselecting the 100 pilot cities that are supposed to achieve its goals by 2030 – are set. Afterwards, an exhaustive exploration of the finally selected cities' current state, that incorporates all those dimensions sketched by the evaluation criteria, is

taking place. Based on the cities' thoroughly examined profile and their performance as to the evaluation criteria, the impact matrix – the main input to the evaluation process – is constructed. This is accompanied by the criteria weights that reflect the diversifying importance attached to each single criterion. In the case of this work, equal weights are assigned to all criteria, taking for granted that cities' performance should be measured along all the dimensions introduced by the evaluation criteria, i.e., they all play a crucial role in meeting Mission's objectives. Finally, the impact matrix and criteria weights are used as input to REGIME multicriteria method in order to identify the prioritization of selected cities on the basis of their performance as to the defined criteria.

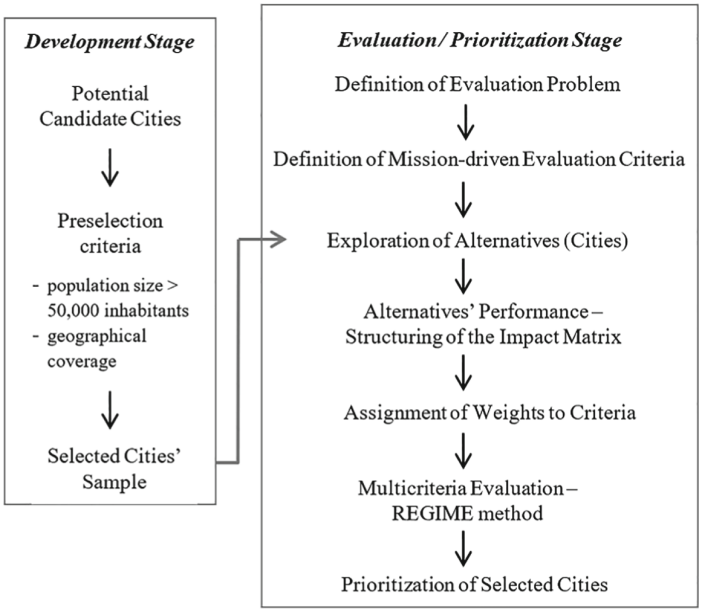

Fig. 2. Steps of the methodological framework, Source: own elaboration

3.2 The REGIME Multicriteria Evaluation Method

REGIME is a discrete multicriteria method, used to evaluate both projects and policies [26, 27]. The advantage of the method lies in its capacity to deal with *mixed data* (quantitative and qualitative) as to the effects and criteria priorities considered in the evaluation problem.

The application of the method is based on two kinds of input data, namely the [28]:

- evaluation (impact) matrix, composed of elements e_{ij} that measure the effect of each alternative i (12 preselected Greek cities in this case), $I = 1, 2, \ldots, I$ on every evaluation criterion j, $j = 1, 2, \ldots, J$;

- set of political weights that provide information on the relative importance of criteria to be considered in the evaluation context.

Each value e_{ij} with i = 1, 2, … I (set of alternatives) and j = 1, 2,…, J (set of evaluation criteria), represents the score of alternative i as to the criterion j, but also a short of ranking order of alternative i in respect to the criterion j. Therefore, it can be asserted that if $e_{ij} > e_{i'j}$, then the choice option i is preferable for the evaluation criterion j, compared to I' [29].

REGIME method is founded on a pairwise comparison of all alternatives. It is worth highlighting that the comparison of every set of alternatives is not influenced by the presence and effects of other alternatives, while the potential ranking order of a certain alternative is conditioned by the remaining ones [30].

The development of REGIME method is based on the 'regime' concept. Therefore, the relation $s_{ii'j} = e_{ij} - e_{i'j}$ is defined. In the case of quantitative information, a certain magnitude of $s_{ii'j}$ of the 'regime' is determined. However, when information is of ordinal (qualitative) type, only the sign of the 'regime' matters and not its magnitude. The relation $\sigma_{ii'j} = \text{sign}\, s_{ii'j} = +$ implies that alternative i is better than i′ as regards criterion j, whereas the relation $\sigma_{ii'j} = \text{sign}\, s_{ii'j} =$ - entails that alternative i is worse than i′ as to criterion j. By carrying out comparisons between alternatives i and i′ for all j = 1, 2, …, J judgement criteria, a Jx1 regime vector $r_{ii'}$ can be constructed, which is translated into the Eq. 1 [29]:

$$r_{ii'} = (\sigma_{ii'1}, \sigma_{ii'2}, \ldots \sigma_{ii'J})^T, \quad \forall\, i, i', i' \neq I \tag{1}$$

This vector reflects a certain degree of dominance of alternative i over i′ for the unweighted effects of all J criteria [29].

For all I(I −1) pairwise comparisons, I(I − 1) regime vectors are created, which can be combined into the J × I(I − 1) regime matrix R that has the following form [30]:

$$R = \{r12\, r13 \ldots r1I, \ldots\ldots rI1\, rI2 \ldots rI(I-1)\} \tag{2}$$

Additional information on the relative importance of the set of evaluation criteria is needed. Such information is usually provided by preference weights that are attached to the criteria.

In case of ordinal data, the weights are represented by means of rank orders w_j (j = 1, 2, .., J) in a weight vector of the following form [30]:

$$w = (w_1, w_2, \ldots w_j)^T \tag{3}$$

if $w_j > w_{j'}$, criterion j is perceived as more important than j′ [29].

These are considered as a rank order representation of the cardinal weights:

$$\underline{w}^* = (\underline{w}_1^*, \underline{w}_2^*, \ldots \underline{w}_j^*)^T \text{ with } \max \underline{w}_j^* > 0, \text{ for every } j = 1, 2, \ldots J \tag{4}$$

The ordinal ranking of weights is supposed to be consistent with the quantitative information, incorporated in the unknown cardinal vector w*, that is [30]:

$$\text{if } w_j > W_{j'} \rightarrow w_j^* > w_{j'}^* \tag{5}$$

Then the weighted dominance of alternative i with regard to i′ can be represented by the following stochastic expression [30]:

$$v'_{ii} = \sum_{j=1}^{J} \sigma_{ii'j} w_j^* \tag{6}$$

If $v'_{ii} > 0$, alternative i is dominant with respect to i′. But w_i^* is not known. What is known is only the ordinal value w_j, which is assumed to be consistent with w_j*. Therefore, a certain probability can be introduced for the dominance of alternative i with regard to i′:

$$P_{ii'} = \text{prob}\,(v_{ii'} > 0) \tag{7}$$

Then the probability of alternative i to rank higher than the rest of the alternatives can be calculated by the following formula [30]:

$$P_i = [1/(I-1)] \sum_{i \neq i'} P_{ii'} \tag{8}$$

where P_i is the average probability that alternative i ranks higher than any other alternative [30]. Ranking order of P_i's is then defining the ranking of respective alternative options.

Application of the REGIME method is accomplished by use of the DEFINITE (DEcisions on a FINITE set of alternatives) software.

4 Prioritizing Mission's Readiness of 12 Greek Cities –Implementation and Results

In a bid to explore Greek cities' readiness regarding the objectives of the European Cities' Mission, 12 candidates were finally selected. The aim of such an effort focuses on looking into initiatives and actions already in place that are in alignment with the scope of the Mission's vision.

A profusion of Greek cities was inspected. As already mentioned, these cities should fulfill the requirements of a minimum population of 50,000 inhabitants and their even distribution across the Greek territories. Therefore, the spatial dimension is seriously taken into account in order to attain – to the best possible extent – the equal dispersion of Greek cities of varying population size – large, medium and small. Moreover, it is pretty critical that chosen cities should represent different geomorphological contexts, i.e., located in the coastal or inland part of the country.

Out of the examined potential candidates, 12 cities are finally selected for further exploration (Fig. 3), including the two largest cities of the Greek state, Athens and Thessaloniki. The picked cities share numerous commonalities such as: they have crafted a vision with respect to sustainability and a long-term planning towards its attainment; they have already implemented various environmentally-friendly measures; they have deployed adequate ICT infrastructure and related applications for serving urban functions; they have embraced participatory approaches and governance schemes at the stage of designing policy actions; and they range from frontrunners to less-experienced in the ICT field.

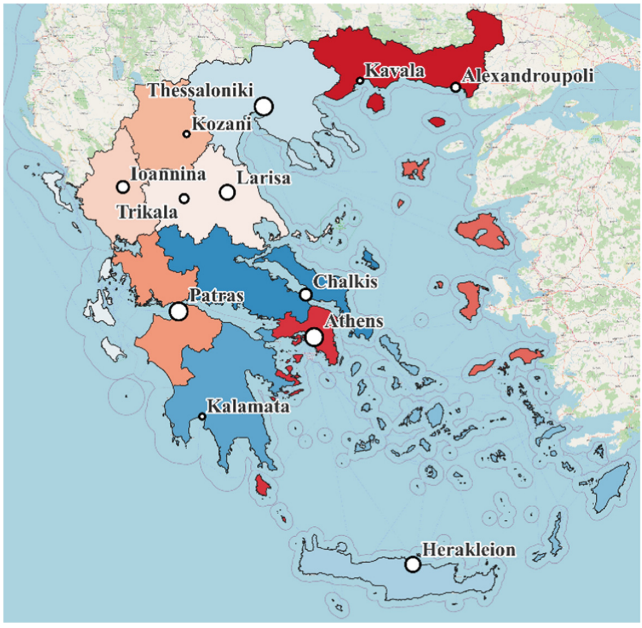

Fig. 3. Spatial distribution of the selected cities across the Greek state, Source: Own elaboration

Figure 3 illustrates the spatial dispersion of the 12 chosen cities, while Table 1 presents the population and type of each one. A brief description of the selected cities is provided the following section.

4.1 The 12 Greek Cities Case Studies

Municipality of Athens is the capital of Greece, a historic city of myths and monuments, characterized by an enduring entrepreneurial spirit that seizes the benefits of digital economy. The city is very active in undertaking action towards CC mitigation, and participates in several pertinent initiatives/networks, such as the Covenant of Mayors and the Compact of Mayors for CO_2 reduction/reporting; Civitas for sustainable mobility; Eurocities for exchange of good practices and cooperation; 100 Resilient Cities for establishing smart and resilient cities; and C40 cities, a global network of mayors that fights

against climate crisis. Despite the absence of a Sustainable Energy Action Plan (SEAP), the municipality is determined to decrease CO_2 levels by 40% until 2030; while it also has a Sustainable Urban Mobility Plan (SUMP), a Sustainable Urban Development Plan, etc.; and a number of ICT-enabled applications for serving urban functions (parking, free Wi-Fi, electronic governance, green entrepreneurship, etc.).

Table 1. Population size and type of the selected cities' sample

Municipality	Population Size	Type
1. Athens	664,046	Inland, in plain land
2. Alexandroupoli	72,959	Coastal
3. Herakleion-Crete	173,993	Coastal
4. Thessaloniki	322,240	Coastal
5. Ioannina	112,486	Inland, lake city, in mountainous land
6. Kavala	70,501	Mix of coastal, plain and mountainous parts
7. Kalamata	69,849	Coastal
8. Kozani	71,388	Inland, mix of plain and mountainous parts
9. Larisa	162,591	Inland, in plain land
10. Patras	213,984	Coastal, in plain land
11. Trikala	81,355	Inland, river city, in plain land
12. Chalkis	102,223	Mix of coastal, plain and mountainous parts

Municipality of Alexandroupoli is a member of the Compact of Mayors, while it implements its own SEAP, a waste management plan 2021–25, and a Sustainable Urban Development Plan. It fosters sustainable mobility; it participates in European-funded projects related to sustainable cities; while it is deemed to be a pioneer in the energy sector through the deployment of numerous Renewable Energy applications (photovoltaic, geothermal energy applications, LED lighting, biomass, electric charging stations, etc.).

Municipality of Herakleion-Crete is among the protagonists of the Greek smart cities and possesses a high-quality, advanced, digital infrastructure. The municipality is very active in European-funded projects that target various dimensions of sustainable cities; while it is also a member of various initiatives/networks, such as CIVITAS and Eurocities. In addition, the municipality has drawn up a local waste management plan, a Sustainable Development Strategy, as well as a Resilience Strategy.

Municipality of Thessaloniki – the second largest Greek city, home to the country's second most prominent export and transit port and a gateway to the Balkans – is an active member of initiatives/networks, such as the Covenant of Mayors, Civitas, Eurocities and 100 Resilient Cities. The municipality is engaged in European-funded projects, dedicated to sustainable cities. It has already a SEAP in place, while governance schemes and related platforms are also established, aiming at creating an inclusive and interconnected city through data provision and strengthening of digital innovations for citizens' engagement in decision-making. Furthermore, the municipality has at its disposal a wide

spectrum of ICT-enabled applications that fall into the six dimensions of a smart city, as expressed by [31].

Municipality of Ioannina, the capital of the Region of Epirus, at the crossroad of the Via Egnatia ancient road that connects Europe with Asia, is already a member of the Covenant of Mayors and the 100 Intelligent Cities' Challenge European Initiative, which seeks to achieve ICT-enabled, smart, just and sustainable cities. The municipality partakes in European-funded projects, pertinent to various sustainable city dimensions; while it has already developed action plans for sustainable mobility, sustainable urban development, sustainable energy, waste management, etc. Ioannina possesses an adequate ICT infrastructure, which hosts a number of ICT-enabled applications – public participation platforms as well – for serving citizens' needs.

Municipality of Kavala is a member of the Civitas network, 100 Intelligent Cities' Challenge, and Digital Cities Challenge, i.e., European Commission's initiative in support of cities' digital transformation. It is also active in partnerships and coalitions through European-funded projects; while it has crafted strategies and action plans for digital transformation, sustainable urban development and sustainable energy. The latter is accomplished via several city interventions (school energy upgrades, pedestrian networks, etc.). Moreover, various interventions that pursue governance upgrading and strengthening of interaction between the local administration and the citizens are implemented. Along these lines, a participatory GIS platform for coastal zone management is also established.

Municipality of Kalamata is a member of the Covenant of Mayors and has launched many initiatives related to sustainability and CC adaptation, including renewable energy, LED lighting, urban renewal and pedestrian network, bicycle network, waste management, etc. The municipality has already a SEAP, a SUMP, a Sustainable Urban Development Plan and a local waste management plan in place. Furthermore, the development of a resilience plan and the 'Citizens' observatory' – citizens' communication with municipal services and delivery of emergency messages from local government to citizens (G2C) – are in progress.

Municipality of Kozani, the most prominent lignite hub in Greece for more than five decades, is a member of the: Covenant of Mayors; WHO European Healthy Cities Network (raises health issues in the urban agenda); Civitas network**;** Energy Cities (targets interaction and exchange of good practices for cities' just and sustainable energy transition in the climate neutrality era). The municipality has already applied a SEAP, a SUMP, a strategic plan for shifting into the smart city paradigm, and a Sustainable Urban Development Plan; while a range of smart city applications for serving citizens' needs are deployed.

Municipality of Larisa, located at the most fertile and productive agricultural plain of Greece, is a member of the Covenant of Mayors; Civitas network; UNESCO Global Network of Learning Cities (intends to upgrade long-life learning and digital skills of labour force); Major Cities of Europe – IT Users Group (aims at exchanging ICT-oriented knowledge and good practices in various sectors); River/Cities (promotes interaction among cultural, environmental and political actors for pursuing sustainable development objectives of urban waterfronts); ICLEI-Local Governments for Sustainability (encourages cooperation and cooperative learning of cities committed to sustainable urban development). The municipality of Larisa has also implemented a SEAP, a SUMP and a local waste management plan; while a number of smart applications are at citizens' disposal for satisfying their everyday needs.

Municipality of Patras is one of the largest Greek ports, with intense commercial and passenger activity and connects the Greek mainland with the western European countries and the Ionian Islands. Patras is a member of the Covenant of Mayors; the B-40 Balkan Cities Network (supports cooperation among cities that seek to localize the New Urban Agenda and other international agreements and plans, particularly the SDGs); and the Digital Cities Challenge. The municipality has also developed a SEAP, a strategic plan for sustainable urban development and a local waste management plan. With the assistance of an upgraded ICT infrastructure, a range of digital applications are in place for managing parking, environmental quality, citizens' interaction with municipal services, etc.

Municipality of Trikala, the first Greek smart city, lies at the heart of the country's mainland. It is deeply engaged in cities' networking, and a valuable member of the Covenant of Mayors; Civitas network; and CitiesNet (the first Greek digital community); while it is very active in European-funded projects and serves as a test-bed for numerous digital innovations (e.g., driverless buses). The city has also implemented a SEAP, a SUMP, a sustainable urban development plan, a local waste management plan, installation of two electric vehicle charging stations, etc. The advanced and constantly upgrading ICT infrastructure has allowed Trikala to emerge as one of the most dynamic medium-sized cities in Europe and a pioneer in a wide spectrum of ICT-enabled applications.

Finally, *Municipality of Chalkis*, a distinguished port of the Region of Central Greece, is a member of the Covenant of Mayors and has mapped out a SUMP, a local waste management plan and a strategic plan towards a sustainable and smart city. Its improved ICT infrastructure has offered city the chance to develop plenty of ICT-enabled applications for the benefit of its citizens.

4.2 Multicriteria Analysis and Results

The selection of the evaluation criteria for assessing the 12 selected cities' preparedness or readiness to join the Mission's vision is guided by the directions provided by the Mission at the stage of picking the 100 pilot cities. More specifically, the chosen evaluation criteria – both quantitative and qualitative – their measurement units and directions are presented in Table 2.

The *impact matrix* (Fig. 4), that features the evaluation problem under consideration, is constructed on the basis of the evaluation criteria and the performance (scores) of

the selected cities (alternatives) in respect of each single evaluation criterion. Figure 4 provides all the necessary data used as main input to the DEFINITE software, which incorporates the REGIME multicriteria model, among others. Additionally, in this case, equal weights are assigned to all evaluation criteria, implying that each one should be met to the greatest possible degree, since none of them takes precedence.

Taking into consideration the constructed impact matrix, as this is presented in Fig. 4, and treating all 13 evaluation criteria as equal (assignment of equal weights), the results obtained by the application of the REGIME multicriteria evaluation method are displayed in Fig. 5.

Table 2. Evaluation criteria for assessing/prioritizing the selected cities, Source: Own elaboration

Evaluation Criteria	Type	Measurement Unit	Direction*
K1 – Population size	quantitative	Ratio scale (thous. of inh/s)	Benefit
K2 – Total CO_2 emissions	quantitative	Ratio scale (tons)	Cost
K3 – Implementation of Action Plan for Sustainable Energy and Climate	qualitative	Binary scale (yes/no)	Benefit
K4 – Accession to the Covenant of Mayors	qualitative	Binary scale (yes/no)	Benefit
K5 – Current policies for mitigating and adapting to climate change	qualitative	Ordinal Scale**	Benefit
K6 – Implementation of waste management plan	qualitative	Binary scale (yes/no)	Benefit
K7 – Level of digital infrastructure deployment	qualitative	Ordinal Scale	Benefit
K8 – Implementation of Sustainable Mobility Plan	qualitative	Binary scale (yes/no)	Benefit
K9 – Deployment of smart city applications	qualitative	Ordinal Scale	Benefit
K10 – Projects – Cooperative spirit / Participation in national / international city networks	qualitative	Ordinal Scale	Benefit
K11 – Adoption of participatory processes in city management	qualitative	Ordinal Scale	Benefit
K12 – Governance level	qualitative	Ordinal Scale	Benefit
K13 – Implementation of strategic plan for sustainable development	qualitative	Binary scale (yes/no)	Benefit

* Type of criterion – benefit/cost: the higher the value of criterion the better (benefit) or worse (cost) the alternatives' performance with respect to the specific criterion.

** Ordinal scale in REGIME: i) rating performance from 1 (very good) to 5 (very bad) with intermediate values 2 (good), 3 (neutral) and 4 (bad).

	Athens	Alexan-droupoli	Hera-kleion	Thessa-loniki	Ioannina	Kala-mata	Kavala	Kozani	Larisa	Patras	Trikala	Chalkis
Evalua-tion Criteria	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12
K1	664046	72959	173993	322240	112486	70501	69849	71388	162591	81355	213984	102223
K2	5069040	435250	880034	2494215	552427	327371	395170	469182	773309	452216	1064886	543006
K3	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
K4	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
K5	1	2	3	3	3	2	3	1	3	3	2	2
K6	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
K7	1	4	1	3	3	3	3	3	3	4	1	3
K8	yes	yes	yes	no	yes	yes	yes	yes	yes	yes	yes	yes
K9	2	3	2	2	3	3	4	3	4	3	1	4
K10	1	4	1	1	2	2	3	2	2	4	1	5
K11	3	3	3	3	3	2	2	2	4	4	2	3
K12	4	3	2	1	3	2	2	2	1	3	2	4
K13	yes	yes	yes	no	yes	yes	yes	yes	no	no	yes	no

Fig. 4. Spatial Impact matrix of the evaluation case study, Source: Own elaboration

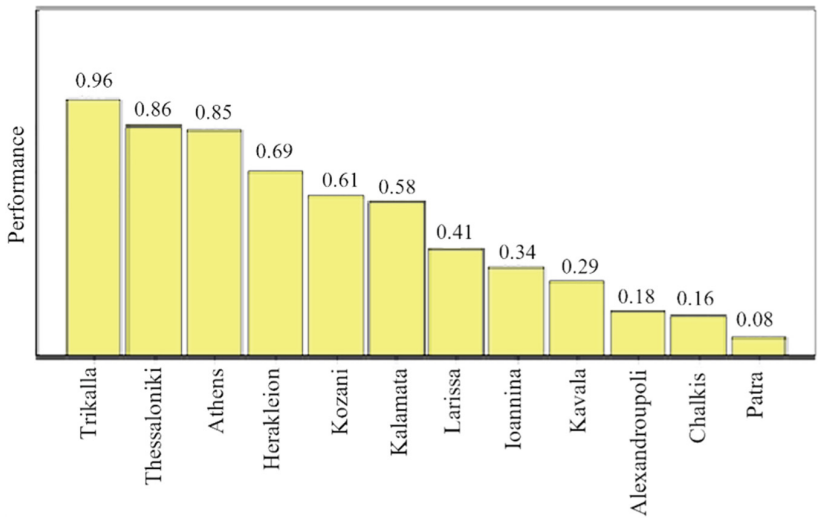

Fig. 5. Prioritization of cities' preparedness with regard to EU Cities' Mission objectives, as emerging from the REGIME multicriteria method, Source: Own elaboration

5 Discussion

The assessment of the 12 inspected Greek cities regarding the alignment of their current state and policy directions with the key objectives of the EU Cities' Mission, carried out in this work, ends up with certain diversifying outcomes. The reason behind this is related to the different city contexts explored in terms of: distinct locational attributes (coastal vs inland, port vs non-port city, plain vs mountainous terrain, etc.); position in the urban network hierarchy and role in the Greek economic system (metropolitan areas of Athens

and Thessaloniki vs regional peripheral centers); economic profile (e.g., Kozani as an energy hub of national importance vs Larisa as an agricultural pole); population size; pursued sustainability objectives, starting point and visionary end state; achievements related to the implementation of specific policy pathways; extraversion and interaction by means of being part of various networks/institutions, etc., with specific focus on contemporary city challenges (e.g., Civitas network, Covenant of Mayors, CitiesNet, Energy Cities, etc.).

Considering all the above-mentioned distinct attributes of the explored Greek cities, their prioritization – on the basis of their preparedness to harmonize with the Cities' Mission objectives – leads to the following classification.

The city of *Trikala* ranks first by a wide margin. Trikala – the first Greek smart city since 2008, awarded in 2009, 2010 and 2011 by the Intelligent Community Forum (ICF) [32] – exhibits intense degree of extraversion and networking, and broad partnerships in innovative EU-funded projects; as well as extended ICT infrastructure and relevant smart applications. This is coupled with the city's policy interventions in critical fields, such as energy, transport, waste management, governance and citizens' online engagement. Thus, Trikala appears as a fertile ground for paving the Cities' Mission pathway in the Greek territory, and falls under the group of frontrunner cities, at least for the Greek standards.

The two metropolitan areas of Greece, *Athens and Thessaloniki*, rank second, at a distance from the first (Trikala). Their performance with respect to Cities' Mission objectives appears to be very close, exhibiting, however, certain differences as to the: CC mitigation efforts, state of digital infrastructure, smart city applications for citizens' engagement, and implementation of sustainable development plans. Nevertheless, the large population size of these cities may have a stronger impact in terms of climate neutrality.

Herakleion, Kozani and *Kalamata* are classified in the third group, with Herakleion holding the reins, while the rest two cities exhibit similar performance, with slight difference from Herakleion (Fig. 5). Despite their relatively close hierarchical positions, these three cities are diversified on the basis of several attributes. Herakleion is a coastal city, the economic and administrative center of the Region of Crete, a beacon in smart city development, and a remarkable tourism hub. Kozani is an inland city, with a prominent role as the country's most significant energy hub, but a victim of the national energy decarbonization strategy at the same time. Finally, Kalamata is a regional agricultural urban settlement, a port city of minor importance, and an immature tourism destination that also lags behind in terms of smart city developments. However, all three of them seem to be oriented towards or to have in progress ICT- and non-ICT-enabled policies in critical – for Cities' Mission objectives – fields for achieving sustainability and climate neutrality. Thus, they are perceived as potentially early candidates for Cities' Mission.

Comparable performance is detected among the cities of *Larisa, Ioannina* and *Kavala* that comprise the fourth group. All three constitute important regional poles of Greece, with diversifying roles, namely: Larisa is the agricultural center of the Region of Thessaly and a city that is taking steps towards the implementation of critical for the Mission policy fields; Ioannina is the economic, administrative and research center of the Region of Epirus – one of the poorest regions in the EU – and a city that sets up policy efforts

in the direction of sustainable and just future development; Kavala is a regional port city that has acquired noticeable importance in the emerging energy landscape and the energy routes of Greece and Europe as a whole.

Finally, the last group consists of the cities of *Alexandroupoli, Chalkis* and *Patras.* Despite their substantial role in the Greek economy – Alexandroupoli as a rising energy hub in liquified natural gas (LNG) routes and a border of the EU, Chalkis as a satellite city of the metropolitan area of Athens, and Patras as a vital commercial and passenger port – they seem to be really weak in terms of the climate neutrality goal set by EU Cities' Mission.

6 Conclusions

Seeking to attain sustainability and climate neutrality of future cities is currently perceived to be an absolute necessity, considering their ecological footprint on the planet. This view has been transformed into a global concern, articulated through the Agenda 2030, but also the EU Cities' Mission that aims at supporting European cities to reach this visionary end state by tackling the CC challenges and promoting a digital 'metamorphosis'. The EU Mission is formulated as a two-step approach. Initially, 100 cities that will serve as hubs of technological, social and managerial innovation in order to reach the desired climate neutrality end state by 2030, are selected. Afterwards, these 100 frontrunners will establish a pool of good practices, concrete solutions and evidence-based results for feeding the effort of the rest of the European cities towards meeting City Mission's objectives by 2050.

The first step is already complete, and has ended up with a plethora of candidate cities (377 cities) that immediately responded to the European Commission's call. Candidates originate from all EU Member States as well as nine associated or potentially associated countries; and demonstrate remarkable diversity, a critical factor for featuring multiple trajectories that will lead to climate neutrality by 2030, on the basis of different city profiles; and will inform policy efforts and strategies of the rest of the EU cities during their climate neutral journey by 2050. Out of the 362 eligible cities, the first 100 are picked, with six Greek cities falling among them (a number that is considered a great success for Greece), namely: *Athens, Ioannina, Kalamata, Kozani, Thessaloniki* and *Trikala* (in alphabetical order).

The finally selected cities – the result of a multicriteria evaluation process of candidate cities by the Commission (including political and even geographical distribution criteria) – seem to be quite close to the ones obtained in the context of the present work. In fact, selected cities by the Commission incorporate: *Trikala* (the city ranks first in the evaluation of this work), *Athens* and *Thessaloniki* (second best group of cities regarding their performance), *Kozani* and *Kalamata* (third best performing group) and *Ioannina* (fourth best performing group). The slight discrepancy observed between the Commission's final choice and the one of this work as to cities' rating – i.e., selection of Ioannina instead of Herakleion – seems to be well justified considering that the final selection should incorporate – inter alia – cities that exhibit a diversified degree of maturity concerning their climate neutrality performance. That said, Herakleion is left aside, giving

thus way to Ioannina, as a city marked by a relatively slow pace towards achieving climate neutrality and digital transformation and as part of one of the poorest regions in the EU.

Ultimately, the multicriteria evaluation exercise conducted in this work seems to be quite fruitful; and may be pretty useful at the national level for: identifying cities' weaknesses in climate neutrality pathways, setting political priorities for treating such weaknesses, and motivating cities to improve their position in the climate neutrality hierarchy.

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