Correlation of Weights in an Evaluation Model for Smart City Proficiency with Less Than 50,000 Inhabitants: A Greek City Case Study

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Abstract. New canny advancements are viewed as a vital factor in battling against environmental change and improving the sustainability in urban communities. A smart city is where administrations utilize progressed data and correspondence advances. According to literature, a smart city includes actions for 6 principle spaces: economy, environment, governance, living, mobility and people. The aim of the current study is to look at four alternative techniques for an all-encompassing smart city positioning model for urban areas with populace under 50,000 inhabitants, applicable in the context of Greece. Based on the European guidelines, 25 essential elements have been resolved and 68 indicators have been embraced for the improvement of the assessment model. The instance of Region of Elefsina is analyzed with these four techniques and a final model is recommended. The proposed model will assist urban communities with comparable qualities (under 50.000 inhabitants) assess their status in the field of "smart cities" to develop programs and strategies.

Keywords: Smart cities · Smart economy · Smart mobility · Smart governance · Smart environment · Smart living · Smart people · Smart city's footprint

1 Introduction

A city is the centre for all sustainable urban development strategies. Today, more than half of the world's population live in cities, and it is predicted that by 2050 urban areas will occupy 70% of the population [11]. Nowadays there has been observed a shift in a new city pattern based on smart targets instead of only sustainability goals. Smart city provides better urban services based on the use of advanced Information and Communication Technologies (ICT). Although the dominant part of the smart cities profile is the infrastructure, the involvement of people and citizens is, also, crucial [12].

As the exact definition of a smart city does not exist, the smart city concept contains several dimensions: Smart Economy, Smart Mobility, Smart Environment, Smart People, Smart Living and Smart Governance. These smart characteristics have been identified through a literature review: [2, 3, 6, 8, 10–12, 15]. Smart economy is driven

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by economic competiveness, entrepreneurship and innovation. Smart mobility refers to local accessibility, safe transport systems and availability of ICT [15]. The smart environment is related to the quality of environment, including the attractiveness of nature, lack of pollution and sustainable resource management. Smart people refers not only to the level of education of the citizens but, also, to the key role of people in developing a smart city. Smart living includes factors all around quality of life. Smart governance comprises aspects of political participation, public services and e-governance.

A smart city is a city well performing in these six smart characteristics [7]. In the literature, there are a few studies that have proposed ranking models to examine the performance of a smart city: Giffinger et al. [7] ranked 70 European smart cities by adopting a set of 74 indicators under the above analysed six dimensions. All the examined cities had population between 100,000 and 500,000 inhabitants and their data have been aggregated and standardized with z-transformation. Lazaroiu and Roscia [10] used z-transformation and fuzzy logic for evaluating 10 Italian cities, by adopting 18 crucial indicators. Alibegović and Šagovac [3] implement a ranking methodology for Croatian large cities by using indicators in strategic decision-making [12] developed an evaluation model of smart city performance specialized for China. The evaluation process has been carried out by applying entropy method and the multicriteria method, TOPSIS. Akande et al. [2] ranked 28 European capital cities on how smart and sustainable they are, by using 32 indicators. Their methodology has been based on hierarchical clustering and principal component analysis (PCA). Finally, Miloševic et al. [11] incorporated 35 key indicators for the assessment of Serbian smart cities. Their approach has been based on a hybrid fuzzy multicriteria decision making model.

In summary, all the above mentioned papers focused their research on metropolises with more than 100,000 inhabitants. Furthermore, their methodologies are based on multicriteria decision anlysis. So, it appears that there is no existing study examining smart city performance for cities with population less than 50,000 inhabitants. The aim of this study is to propose a holistic smart city ranking model, based on multicriteria analysis, for cities with population less than 50,000 inhabitants and, at the same time, recommend actions for improving the smart city performance. The majority of Greek municipalities cover this feature, as 95% of Greek municipalities have less than 50,000 inhabitants, and an evaluation process for smart cities' profile has not been carried out in Greek cities until now. A representative case study has been selected and so the proposed methodology has been implemented for Municipality of Elefsina.

The remainder of this paper is structured as follows: Sect. 2 presents the methodology of the study as far as the weights of the model are concerned. Section 3 contains the analysis results for the performance of Municipality of Elefsina. Finally, Sect. 4 concludes the study including, also, future thoughts.

2 Research Methodology

The approach adopted in this research comprises of four steps. Firstly, the selected set of smart city indicators are presented. Secondly, the evaluation methodology is described. In the third step, a questionnaire is developed according to the selected indicators in order to determine their values and in the fourth step, the classes of a smart city footprint are presented.

2.1 Smart City Indicators

As smartness of a city is not easily measurable, a European or International agreement on smart city indicators does not exist [10]. The overall goal is to improve sustainability with the help of technology. It should meet the needs of the population and is composed of several smart characteristics that interact with each other [11].

According to literature each smart characteristic (Smart Economy, Smart Mobility, Smart Environment, Smart People, Smart Living and Smart Governance) is defined by a number of factors. Furthermore, each factor can be broken into relevant indicators, which reflect the most important aspects of every smart characteristic [7, 8]. The research team has identified 36 factors and 136 indicators through the literature review process.

In this study, the evaluation indicators have been selected by applying a hybrid research methodology including literature review and structured interviews. The significance of each candidate indicator is examined with the aid of local stakeholders. A questionnaire has been developed which is addressed to the municipalities, based on the European guidelines for smart cities. The selection of the factors and their indicators has been based on their applicability in cities with population less than 50,000 inhabitants. In total, 25 crucial factors have been selected and 68 indicators were elicited (Table 7, Appendix). These factors with their relevant indicators are based on the European trends for smart cities and the local needs.

2.2 Evaluation Process (Previous Model)

The problem has been modelled using multicriteria analysis [1]. The aim of multicriteria analysis is to solve complicated problems taking into consideration all the criteria that affect the decision process. In the current study, the criteria are the selected indicators.

All factors have their internal impact reclassified to a common scale so that it is necessary to determine each criteria's (indicator's) relative impact. Weight is assigned to the criteria-indicators to indicate its relative importance. Different weights could influence directly the results and it is necessary to obtain the rationality and veracity of criteria-indicators weights [9, 16].

The method of equal weights has been adopted in the proposed methodology. The criteria weight in equal weights method is defined as:

$$p_i = \frac{1}{n} i = 1, 2, \ldots, n, \ (n : indictors) \tag{1}$$

This method is very popular and is applied in many decision-making problems since Dawes and Corrigan argued that the obtained results are nearly as good as those optimal weighting methods [5].

All the values of the indicators have been normalised from 0 to 1, as the standardization of indicators is required, in order to compare them.

The ranking is obtained through the additive value model. The formula describing the additive value model is the following:

$$u(g) = \sum_{i=1}^{n} p_i u_i(g_i) \tag{2}$$

$$u_i(g_{i*}) = 0, u_i\left(g_i^*\right) = 1, i = 1, 2, \ldots, n \quad (3)$$

$$\sum_{i=1}^{n} p_i = 1 \quad (4)$$

$$p_i \geq 0 \, for \; i = 1, 2, \ldots, n \quad (5)$$

where g = (g1,…,gn) is the performance of each smart characteristic based on n indicators, $u_i(g_{i*})$ and $u_i(g_i^*)$ are the least and most preferable levels of indicator g_i, respectively, $u_i(g_i), i = 1, \ldots, n$ are non-decreasing marginal value functions of the performances $g_i, i = 1, \ldots, n$. p_i is the relative weight of the i^{th} function $u_i(g_i)$. Thus, for a candidate city α, $g(\alpha)$ and $u[g(\alpha)]$ represent the multicriteria vector of performances and the global value of the alternative solution (in case that there are more than one city to be compared and evaluated), respectively [4, 13, 14].

The results have been aggregated on all levels without further weighting [7, 10]. The aggregation has been done additive but divided through the number of values added.

2.3 Questionnaire for Previous Model

The development of the questionnaire is based on literature and the special features of Greek cities. Zong et al. [18] developed an evaluation indicator system of green and smart cities studying ten aspects: resource utilization, environmental governance and environmental quality, green and smart medical care, green and smart facilities, network security and citizens' experience. A similar questionnaire relative to the selected 68 indicators has been developed. It is addressed to the authorities, in order to answer the questions with their existing actions towards smart cities, and so the score for each factor and therefore for each smart characteristic has been calculated.

2.4 Questionnaire for Weights in New Model

A questionnaire is used in this case to collect measurable data that can be statistically processed, regarding the indicators of the "Smart Cities" evaluation model. According to the basic principles of using questionnaires in research, a series of individuals, called "sample", answer the same set of questions, which are asked in the same predefined order. The main advantages of the questionnaires over the other data collection methods are their flexibility and adaptability to the questions asked in the sample, the analysis and processing of their data is standardized and does not pose a risk of subjective judgment of the researcher, it is the least method and finally has lower implementation costs compared to other methods.

This questionnaire is a closed-ended questionnaire (or structured questionnaire), i.e. with specific, precise questions aimed at obtaining clear answers in order to collect quantitative data. The questionnaire is divided into a total of eight parts. The first part gives the context in which the research is conducted and then the respondent is asked for his Demographic Data. In the second part, a general definition is given regarding the "Smart Cities" through which the six central Pillars emerge. They are asked to fill in their preferences, while the participant is given the possibility of multiple choices. In the third to the eighth part, the questionnaire is structured on the same pattern. Each part is the unit for each of the six central Pillars. As already mentioned, each Pillar is divided into certain Sectors and they in turn are divided into certain Indices. Therefore, in each part the participant is first asked to choose his preferences first between the Sectors of each Pillar and then between the Indices of each Sector. In all the above cases, multiple choices are possible.

Based on the model used, in the pilot sample of 30 people where the confidence interval was set to the test and a satisfactory percentage of 95%, the probability of finding a problem is 0.10 or 10% [19].

Taking into account standard research practices [20] regarding the reliability of results on general issues (eg. non-laboratory measurements where high accuracy of sample results is required), an error margin of 5% and a confidence interval of 95% are taken into account. Given this, the minimum sample size from which safe conclusions can be drawn regardless of population size is 385 people.

2.5 SIMOS Method

The original Simos method [13] consists of the following three steps, concerning the interaction with the decision maker (DM) and the collection of information:

1. The DM is given a set of cards with the name of one criterion on each (n cards, each corresponding to a specific criterion of a family F). A number of white cards are also provided to the DM.
2. The DM is asked to rank the cards/criteria from the least to the most important, by arranging them in an ascending order. If multiple criteria have the same importance, she/he should build a subset by holding the corresponding cards together with a clip.
3. The DM is finally asked to introduce white cards between two successive cards (or subsets of ex aequo criteria) if she/he deems that the difference between them is more extensive. The greater the difference between the weights of the criteria (or the subsets of criteria), the greater the number of white cards that should be placed between them. Specifically, if u denotes the difference in the value between two successive criteria cards, then one white card means a difference of two times u, two white cards mean a difference of three times u, etc.

The information provided by the DM is utilized by the Simos method for the determination of the weights, according to the following algorithm: i. ranking of the subsets of ex aequo from the least important to the most important, considering also the white cards, ii. assignment of a position to each criterion/card and to each white card, iii. calculation of the non-normalized weights, and iv. determination of the normalized weights.

The least qualified card is given Position 1, while the most qualified one receives Position n. The non-normalized weight of each rank/subset is determined by dividing the sum of positions of a rank, by the total number of criteria belonging to it. The non-normalized weights are then divided by the total sum of positions of the criteria in each rank (excluding the white cards), in order to normalize them. The obtained values are rounded off to the lower or higher nearest integer value.

2.6 SIMOS 2 Method Alteration

The Alterated SIMOS method, consists of the following three steps:

1. The DM is given a set of cards with the name of one criterion on each (n cards, each corresponding to a specific criterion of a family F). A number of white cards are also provided to the DM.
2. The DM is asked to rank the cards/criteria from the least to the most important, by arranging them in an ascending order. At this point, if multiple criteria have a 5% difference we considered that they do not have a significant difference and we ranked them together.
3. The DM is finally asked to introduce white cards between two successive cards (or subsets of ex aequo criteria) if she/he deems that the difference between them is more extensive. The greater the difference between the weights of the criteria (or the subsets of criteria), the greater the number of white cards that should be placed between them. Specifically, if u denotes the difference in the value between two successive criteria cards, then one white card means a difference of two times u, two white cards mean a difference of three times u, etc.

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2.7 The Footprint of a Smart City

The aim of the proposed approach is for each city to be able to rank itself. The proposed footprint of a smart city includes 9 classes, from I to H (Fig. 1). The range of scores in the higher classes is smaller than the range in the lower classes. As a result, the candidate city is obligated to implement more actions towards smart cities strategy when it is in the lower classes. The classification is elicited by aggregating the score from each separate Smart Characteristic. The result is aggregated on all levels by using equal weights and the method of additive value model (Model 1), Questionnaire, Simos Method and Simos 2 Method Alteration (Table 1).

3 The Case of Municipality of Elefsina

The municipality of Elefsina is in West Attica, Greece, situated about 18 km northwest from the centre of Athens. The municipality Elefsina was formed at the 2011 local government reform by the merger of the following two former municipalities that became municipal units: Elefsina and Magoula. The municipality has an area of 36.589 km^2, the municipal unit 18.455 km^2 and a population of 29.902. Elefsina is a major industrial centre, at least 40% of the industrial activity of the country is concentrated there, with the largest oil refinery in Greece. On 11 November 2016 Elefsina was named the European Capital of Culture for 2021 (Wikipedia).

3.1 Smart City Performance Across 6 Different Characteristics

The aim of this step is to record all the actions, fulfilling the requirements of each indicator, that Municipality of Elefsina has, already, implemented towards the smart city concept. The necessary information has been collected from the developed questionnaire and the individual interviews, addressed to the responsible Departments of the Municipality (Department of revenues, IT Department, Department of Economics, Department of Transparency Programming and Department of Environment). All the answers have been matched with the selected indicators and their values have been normalized from 0 to 1. The total score for each smart characteristic is calculated following the additive value model. Based on these data, the evaluation process has indicated the following results:

Smart Economy: The indicators in the group of smart economy measure the performance of productivity, innovation, entrepreneurship and the integration with international markets. The total score in this smart characteristic is 0.224 using Model 1, 0.245 using questionnaire, 0.310 using SIMOS Method and finally 0.313 using SIMOS 2 Method (Table 1).

Smart Environment: Indicators in the group of smart environment addresses the issues related to the energy saving in public buildings, ecological awareness, sustainable resource management, air pollution and attraction of natural conditions. Municipality of Elefsina has already implement some actions in this direction and the total score in the field is 0.171 using Model 1, 0.425 using questionnaire, 0.432 using SIMOS Method and finally 0.438 using SIMOS 2 Method (Table 1).

Smart Governance: The indicators in the group of smart governance are associated with transparency in governance: municipality expenditure, e-government online availability, political strategies and perspectives and participation in decision making. In this field municipality of Elefsina has its higher score, 0.409 using Model 1, 0.448 using questionnaire, 0.511 using SIMOS Method and finally 0.519 using SIMOS 2 Method (Table 1).

Smart Living: Smart Living improves the quality of life and it is measured by the following indicators: educational and cultural facilities, individual safety and health conditions. The total score in this Characteristic is 0.268 using Model 1, 0.261 using questionnaire, 0.295 using SIMOS Method and finally 0.299 using SIMOS 2 Method (Table 1).

Smart Mobility: Smart Mobility indicators refer to local accessibility, touristic attractivity, availability of ICT infrastructure, public database and in general sustainable, innovative and safe transport systems. Here the score is very low, 0.194 using Model 1, 0.169 using questionnaire, 0.131 using SIMOS Method and finally 0.135 using SIMOS 2 Method (Table 1).

Smart People: Lifelong learning, level of qualification and participation in public life are the indicators that determine the Characteristic of "Smart People". The score is, also, high in comparison to the other fields, 0.310 using Model 1, 0.314 using questionnaire, 0.323 using SIMOS Method and finally 0.313 using SIMOS 2 Method (Table 1).

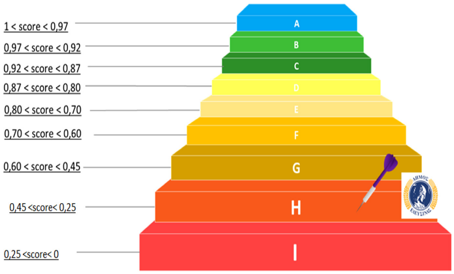

Fig. 1. Municipality Elefsina's smart footprint [1].

3.2 Overall Performance for Municipality Elefsina

Figure 1 gives the overall smartness of Municipality Elefsina for all the Characteristics and Fig. 1 shows its smart footprint. It is classified in level H (aggregated total score 0.265 using Model 1, 0.314 using questionnaire, 0.373 using SIMOS Method and finally 0.364 using SIMOS 2 Method (Table 2).

Therefore, its overall smart city performance is poor. The aggregate scores from all the Characteristics are low, even under 0.5, with a slight promotion of smart governance and smart people among the rest ones. The domains of smart environment and smart mobility have the lowest scores. It is obvious that the authorities are working towards the direction of smart cities, but more effort is needed. In that direction, a set of indicative actions will be recommended in order to improve their smart footprint.

3.3 Percentage Change Among the Four Methods

The Percentage Change Calculator (% change calculator) will quantify the change from one number to another and express the change as an increase or decrease. The formula describing the percentage change is the following:

$$\frac{(V_2 - V_1)}{|V_1|} \times 100 \tag{6}$$

Where Percentage change equals the change in value divided by the absolute value of the original value (V1), multiplied by 100.

Table 1. Weights and scores for Municipality of Elefsina using all four methods.

	Model 1		Questionnaire		SIMOS		SIMOS 2	
Characteristics/ Factors	**Weights**	**Scores**	**Weights**	**Scores**	**Weights**	**Scores**	**Weights**	**Scores**
I) Smart Economy	**0.17**	**0.224**	**0.1595**	**0.245**	**0.0952**	**0.310**	**0.0952**	**0.313**
Innovation	0.25	0.100	0.3237	0.104	0.4872	0.113	0.4557	0.112
Entrepreneurship	0.25	0.094	0.2358	0.117	0.1538	0.139	0.1646	0.138
Productivity	0.25	0.700	0.2616	0.700	0.3333	0.700	0.3417	0.700
Integration with International Markets	0.25	0	0.1789	0	0.2570	0	0.380	0
II) Smart Environment	**0.17**	**0.185**	**0.1808**	**0.425**	**0.2857**	**0.432**	**0.2619**	**0.438**
Attraction of Natural Conditions	0.20	0	0.1922	0	0.1918	0	0.1849	0
Air Pollution Integrated index	0.20	0.286	0.1798	0.600	0.1370	0.610	0.1370	0.600
Sustainable Resource Management	0.20	0.240	0.2146	0.496	0.2329	0.605	0.2466	0.598
Ecological Awareness	0.20	0.400	0.2400	0.400	0.3150	0.400	0.2945	0.400
Energy Saving in Public Buldings	0.20	0	0.1734	0.660	0.1233	0.66	0.1370	0.660
III) Smart Governance	**0.17**	**0.409**	**0.1646**	**0.448**	**0.1905**	**0.511**	**0.1905**	**0.519**
Participation in Decision Making	0.25	0.710	0.3192	0.693	0.4565	0.694	0.4778	0.698
Political Strategies & Perspectives	0.25	0.643	0.2256	0.676	0.1522	0.738	0.1444	0.736
E-Government online availability	0.25	0.285	0.2847	0.262	0.3478	0.235	0.3444	0.229
Municipality Expenditure	0.25	0	0.1705	0	0.4350	0	0.3340	0
IV) Smart Living	**0.17**	**0.268**	**0.1775**	**0.261**	**0.2381**	**0.295**	**0.2619**	**0.299**
Cultural Facilities	0.25	0.020	0.2086	0.018	0.1714	0.014	0.1471	0.014
Health Conditions	0.25	0.550	0.3104	0.629	0.3571	0.763	0.3603	0.748
Individual Safety	0.25	0	0.2293	0	0.2144	0	0.2279	0
Educational Facilities	0.25	0.500	0.2517	0.248	0.2571	0.077	0.2647	0.105
V) Smart Mobility	**0.17**	**0.194**	**0.1549**	**0.169**	**0.0476**	**0.131**	**0.0952**	**0.135**
Touristic Attractivity	0.20	0.429	0.1696	0.430	0.9620	0.043	0.762	0.430
Local Accessibility	0.20	0.066	0.2779	0.070	0.4615	0.079	0.4667	0.075
Availability of ICT Infrastructure	0.20	0.473	0.1882	0.409	0.1539	0.345	0.1905	0.351
Sustainable, Innovative & Safe Transport Systems	0.20	0	0.2019	0	0.2115	0	0.1905	0
Public Database	0.20	0	0.1624	0	0.7690	0	0.7610	0
VI) Smart People	**0.17**	**0.310**	**0.1627**	**0.314**	**0.1429**	**0.323**	**0.0952**	**0.313**
Participation in Public Life	0.34	0.600	0.3864	0.600	0.4889	0.600	0.4574	0.600
Level of Qualification	0.34	0.330	0.2295	0.367	0.6670	0.442	0.852	0.448
Affinity to Lifelong Learning	0.34	0	0.3841	0	0.4444	0	0.4574	0

Table 2. Elefsina's score and ranking.

	Model 1	**Questionnaire**	**SIMOS**	**SIMOS 2**
City Score	0,265	0,314	0,373	0,364
City Ranking	H	H	H	H

By using the original value the one from Model 1 the results are the following (Table 3):

Table 3. Original value model 1.

Percentage Change to MODEL 1	Model 1	Questionnaire	SIMOS	SIMOS 2
Smart Economy	0,224	9,37	38,48	39,92
Smart Environment	0,185	129,62	133,43	136,46
Smart Governance	0,409	9,47	24,86	26,69
Smart Living	0,268	-2,31	10,15	11,83
Smart Mobility	0,194	-12,58	-32,53	-30,48
Smart People	0,310	1,95	4,13	0,83
City	0,265	18,42	40,77	37,50

By using the original value the one from Questionnaire the results are the following (Table 4):

Table 4. Original value questionnaire.

Percentage Change to Questionnaire	Model 1	Questionnaire	SIMOS	SIMOS 2
Smart Economy	-8,564	0,245	26,618	27,937
Smart Environment	-56,451	0,425	1,657	2,978
Smart Governance	-8,652	0,448	14,057	15,726
Smart Living	2,363	0,261	12,757	14,474
Smart Mobility	14,395	0,169	-22,817	-20,473
Smart People	-1,912	0,316	2,142	-1,097
City	-15,557	0,314	18,872	16,106

By using the original value the one from SIMOS Method the results are the following (Table 5):

Table 5. Original value simos method.

Percentage Change to SIMOS	Model 1	Questionnaire	SIMOS	SIMOS 2
Smart Economy	-27,786	-21,022	0,310	1,041
Smart Environment	-57,160	-1,630	0,432	1,300
Smart Governance	-19,910	-12,324	0,511	1,464
Smart Living	-9,218	-11,314	0,295	1,523
Smart Mobility	48,213	29,562	0,131	3,037
Smart People	-3,970	-2,098	0,323	-3,172
City	-28,963	-15,876	0,373	-2,327

Finally, by using the original value the one from SIMOS2 Method Alteration the results are the following (Table 6):

Table 6. Original value Simos 2 method alteration.

Percentage Change to SIMOS 2	Model 1	Questionnaire	SIMOS	SIMOS 2
Smart Economy	-28,530	-21,836	-1,030	0,313
Smart Environment	-57,710	-2,892	-1,283	0,438
Smart Governance	-21,065	-13,589	-1,442	0,519
Smart Living	-10,580	-12,644	-1,500	0,299
Smart Mobility	43,844	25,743	-2,948	0,135
Smart People	-0,824	1,110	3,276	0,313

4 Conclusions

Cities are examined as a piece of the answer for a considerable lot of the present financial social and ecological issues [2]. The smart city represents the future challenge. A viable all-encompassing assessment model on the presentation of a smart city is of most extreme significance. In contrast to past examinations, this study endeavors to assess small smart cities with regards to Greece. In this article, a keen city positioning model has been proposed for urban communities with under 50,000 inhabitants, including 25 factors and 68 indicators, and the contextual analysis concerned a Greek city, Region of Elefsina. The selected indicators fall into the most critical areas for the assessment of a small smart city.

The multicriteria method, Additive Value Model, and the questionnaire for weights have been selected for the evaluation process. The combination of these two methods simplified and summarized a complex concept into a manageable form. The smart footprint of a city is introduced as a result of the evaluation process.

Although it seems that Municipality of Elefsina has already taken small steps towards the smart cities, its overall score is very poor. It is remarkable its low score on smart environment, as the development of actions for improving the local environmental conditions should be a prime objective of the authorities.

It was observed that the smart environment assumes a vital part in the inhabitants, since statistically it had the greatest change contrasted with the first model. Also important to mention is that in none of the 4 methods did the city change the ranking category, which means that the results in all 4 cases were very close to each other and thus to our previous model.

The contribution of the research is indicated by two areas: the proposed evaluation methodology for small smart cities and the implemented case study for a Greek city. Future research could focus on testing the methodology in more than one case studies, its holistic application will be improved. The presented model could be further enhanced with the evaluation of more Greek cities and the ranking of their results using multi-criteria analysis. Furthermore, the comparison with other cities will enable the share of experience and effective actions could be formulated for the development of smart city in the whole country.

Appendix

The proposed model includes 25 crucial factors and 68 relative indicators, shown in Table 7:

Table 7. The selected factors and their indicators.

Factors	Indicators
I) Smart economy	
Innovation	Public Expenditure on R&D
	Funded projects
Entrepreneurship	New businesses registered
	Promotion of digital adoption
	Entrepreneurship Programs
Productivity	Unemployment rate
Integration with international markets	Research grants funded by international projects
II) Smart environment	
Attraction of natural conditions	Green space
Air pollution integrated index	CO_2 emissions
	Air Pollutants

(*continued*)

Table 7. (*continued*)

Factors	Indicators
Sustainable resource management	Waste separation and disposal
	Annual thermal energy consumption
	Street lighting
	Electricity consumption
	Renewable resources
	Intelligent management of waste and recycling products
	Smart resource management
Ecological Awareness	Ecological consciousness
Energy Saving in Public Buildings	Public Schools
	Town hall and office buildings
	Museums/Theatres
	Sports Facilities
	Library
III) Smart governance	
Participation in decision-making	City representatives per inhabitant
	Political activity of inhabitants
	Share of female city representatives
Political strategies & perspectives	Communication of economic and community development to the outside world
	Strategies for economic & social development
E-Government on-line availability	Employment services
	Online Payments
	Social services
	Public cultural and sporting activities
	Services for disabled people
	Safeguard system
	Public Health
	Urban management
	Public security
	E-commerce
Municipality expenditure	Bridging the digital divide

(*continued*)

Table 7. (*continued*)

Factors	Indicators
IV) Smart living	
Cultural facilities	Theatres/Cinemas
	Culturally active citizens
	Technologies for cultural facilities
	Museums and historic monuments
	Public Libraries
Health conditions	Public care facilities
	Doctors
Individual safety	Safety at playgrounds
	Safety at sport facilities
	Safety at parks
	Safety at pools and beaches
	Safety at public buildings
Educational facilities	Public lessons
	Quality of educational system
V) Smart mobility	
Touristic attractivity	Municipality's site
Local accessibility	Availability of public transport
	Quality of public transport
	Cycle paths
Availability of ICT infrastructure	Internet facilities
	Wireless networks
Sustainable, innovative and safe transport systems	Green mobility share
	Use of economical cars
Public Database	Urban infrastructure database
	Urban economy and society database
VI) Smart people	
Participation in public life	Voters
Level of Qualification	Computer skills
	Foreign language lessons
	After school study
Affinity to lifelong learning	Book loans

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