A climate mitigation action index at the local scale: Methodology and case study

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Abstract

This paper presents a novel climate mitigation action index to evaluate various aspects linked to the implementation of Sustainable Energy Action Plans (SEAP), which define the carbon dioxide emission reduction targets and outline the key actions to achieve these at the municipal level.

A SEAP Implementation Index (SII) is developed and applied to study climate change mitigation actions implemented by 102 Municipalities belonging to the Metropolitan City of Milan (Italy) in the framework of the Covenant of Mayors (CoM). The SII is composed of six categories and 16 sub-indicators and results in a final score ranging from 1 to 10. The average rating obtained in the case study area is 4.2, and only eleven Municipalities achieved an evaluation higher than 6. The sensitivity analysis shows the index robustness against variations in the applied weight factors.

The population engagement and the management of the initiative, neglected by many Municipalities mostly due to the lack of funding and personnel, are identified as the most critical aspects. Despite the massive participation in the CoM, no quantitative analysis of the SEAPs implementation has been proposed until now and this study shows some severe shortcomings in their application.

Keywords

Climate change; mitigation; local authorities; Covenant of Mayors; SEAP Implementation Index (SII).

1 INTRODUCTION

1.1 Cities and the climate change challenge

In the framework of the Paris Agreement and its bottom-up nature, which requires strong and coordinated commitments from a variety of different actors (Solecki et al., 2018), urban areas are regarded as key players for the implementation of mitigation and adaptation policies needed to reach its objectives (Castán Broto, 2017; Rosenzweig et al., 2010; Mi et al., 2019). The involvement of various levels and types of governance will be even more important in pursuing 1.5°C-consistent pathways (Fuhr et al., 2018; Amundsen et al., 2018). Climate change mitigation is closely connected to urban sustainable development because of its links to urbanization, ecosystems, air pollution and extreme events (Mi et al., 2019) but it is necessary to explore how different environmental policies will interact in the long term (Pasimeni et al., 2014).

Even if local administrations are often considered in the best position to leverage collective behaviors and contribute to shifting the energy consumption towards more sustainable solutions (Fudge e Peters, 2009; Heidrich et al., 2016), the idea that cities can lead the fight against climate change is often commended (Mulugetta et al., 2010) and many authors highlight several limits on the effectiveness of local climate policies. Most of the world's local governments have only little responsibilities in key sectors with relevance to climate change and often lack the resources necessary to carry out climate policies in their communities with continuity (Fuhr et al., 2018). According to other authors (Brooks, 2017; Jabareen, 2015), the contribution of cities to climate change mitigation has been overestimated, because the wider use of renewables and the transportation-related carbon dioxide (CO_2) emission reductions are mainly the results of national energy policies and improved national fuel-efficiency standards, while are only marginally due to the direct intervention of local authorities. The modalities, rationale and effectiveness of cities engagement in climate policies is currently under debate (Bertoldi et al., 2018; De Gregorio Hurtado et al., 2015; Heidrich et al., 2016; Kona et al., 2018), and the effect of national or international policies on the local level has not yet been fully investigated. Indeed, the success of local climate policy depends not only on a small group of leading cities taking action, but also on the willingness of others to follow their example and on the introduction of binding standards for those cities that would otherwise not undertake their own initiatives (Kern, 2019). Reckien et al. (2018) demonstrated how city size, national legislation and international networks could influence the implementation of local climate plans. Still, transnational climate governance initiatives (such as the Covenant of Mayors, ICLEI, C-40 and 100 Resilient

Cities) seem to have low effectiveness and cannot thus be expected to fill the mitigation gap between the 2°C target and the aggregate effect of Nationally Determined Contributions (Michaelowa and Michaelowa, 2017; Roelfsema et al., 2018).
Currently, little assessment and monitoring activity concerning the actual implementation of climate mitigation policies at the local level has been carried out, and limited formal quantitative indices are available. Relying on the implementation of a novel index for the evaluation of Sustainable Energy Action Plans (SEAP), the purpose of this study is to find evidence of the shortcomings of local climate mitigation at the local level, in order to suggest future directions towards the 2030 commitments.

1.2 Covenant of Mayors and Sustainable Energy Action Plan

The Covenant of Mayors (CoM) is a voluntary initiative launched by the European Commission in 2008 to involve local authorities in the implementation of the EU targets for climate change mitigation (EC, 2008). Cities within the initiative pledged actions to reduce GHG emissions, rising energy efficiency and increasing the use of renewable energy sources in their areas. The CoM renewed itself in 2015 by merging with Mayors Adapt and becoming the Covenant of Mayors for Climate & Energy. The success of the CoM has been beyond expectations: by 2017 the initiative had become global gathering over 7,700 local and regional authorities across 53 countries. Italy and Spain have been the most enthusiastic participants, accounting for, respectively, around 4,600 and 1,800 signatories (Covenant of Mayors, 2019).
In order to translate their political commitment into practical measures and projects, Covenant signatories are expected to submit, within a year from the signing of the CoM, a Sustainable Energy Action Plan (SEAP) defining the CO_2 emission reduction target and outlining the key actions they plan to undertake to reach it. The SEAP submission marks the beginning of a long-term process with cities committed to periodically report for evaluation, monitoring and verification purposes. Signatories have to report on the implementation progress of their plans every two years through an "Action Report" and are expected to submit an "Implementation Report" (or "Full Report") every four years, which includes an updated CO_2 Monitoring Emission Inventory (MEI).
According to Rivas et al. (2015), the main strengths of the CoM are the vast signatories' community and the chance of building a network to work together, sharing experiences and best practices. The main advantages for participants are the availability of know-how, thanks to a dedicated help desk service and the support of Covenant Coordinators, and the facilitated access to funding, available to signatories through specific financial instruments at European and national levels (Covenant of Mayors, 2019). Nevertheless, as the mentioned help desk service is managed for free, it cannot provide operative support on the SEAP implementation. The actual availability of funds is questionable too, due to the complexity of application procedures which results in a restriction of the Municipalities' participation, especially for small cities. Moreover, local authorities often show limited investment and financial capacity, mainly because of the constraints of the European Stability Pact. Hence, it is not surprising finding out that many Municipalities have faced great difficulties in implementing the SEAP, especially when considering small towns where the availability of financial resources and personnel is limited. Despite being initially drafted for large cities, the vast majority of adhering cities count less than 50,000 inhabitants, thus influencing the overall initiative effectiveness. In many cases, Municipalities signed the CoM without ever translating this commitment into concrete actions: more than 1,500 signatories are currently inactive and labeled as "on hold" for not meeting their planned deadlines as described in their political commitments (Covenant of Mayors, 2017).
The evaluation of the initiative effectiveness is made problematic by the lack of an adequate number of monitoring reports including a Monitoring Emission Inventory. By September 2016, only 315 of the 1,779 local authorities that should have handed in one of these reports had done so, i.e. 6% of the signatories that had submitted a SEAP (Kona et al., 2017). Furthermore, there is no detailed external check of the Monitoring reports, or a formal peer-review process on the emissions reductions declared. No quantitative analysis of the various aspects of SEAP implementation has been proposed. To overcome these shortcomings and to better understand the level of implementation of the CoM initiative, this paper proposes a SEAP Implementation Index (SII) considering all the relevant aspects

related to the management and effectiveness of the initiative. The index has then been applied to the 102 Municipalities of the Metropolitan City of Milan that are active partners of the CoM.

2 METHODOLOGY

2.1 SEAP Implementation Index (SII) structure

The SII structure proposed in the present paper has been ideated taking into account an index proposed at a different level, used to keep track of countries' efforts in tackling climate change. The Climate Change Performance Index (CCPI), developed in 2005 by Germanwatch, Climate Action Network and NewClimate Institute (Burck et al., 2017), evaluates and compares, based on standardized criteria, the climate protection performance of 56 countries and the EU that, together, are responsible for nearly 90% of global greenhouse gas emissions. 80% of the CCPI evaluation is based on objective indicators of emissions, renewable energy and energy use, while 20% of the index results are built upon national and international climate policies, assessed by about 300 experts from the respective countries. No similar index has yet been proposed for the municipal level, although the need to track climate change mitigation actions actually undertaken at the local level is gaining relevance.

The proposed SII is composed of 16 indicators, classified in six categories: SEAP quality, online information, involvement, governance, implementation effort and performance. Each of these categories is defined by two or three sub-indicators associated with a different weight according to their relative importance. The results for each category, expressed in tenths, are obtained as a weighted average of the indicator scores (Equation 1); then, another weighted average combines these results in the final score (Equation 2), as shown in the following formulas:

$$C_i = \sum_j I_{ij} * w_{ij} \quad (1)$$

$$SII = \sum_i C_i * W_i \quad (2)$$

$C_i =$ score for category i, with i ranging from 1 to 6

$I_{ij} =$ score for indicator j in category i, with j ranging from 1 to 2 or 3 depending on the category

$w_{ij} =$ weight for indicator j in category i, with $\sum_j w_{ij} = 1$

$SII =$ SEAP Implementation Index

$W_i =$ weight for category i, with $\sum_i W_i = 1$

Table 1 shows the composition of the proposed index and the weights assigned to each category; all the indicators and the related scoring scales are detailed in the following paragraphs. The scores assigned to each indicator are listed in Table 2, details are given in the Supplementary Material.

The overall score scale ranges from 0 to 10 and can be summarized in five possible assessments: very low (0-2), low (2-4), intermediate (4-6), good (6-8) and very good (8-10) SEAP implementation.

Table 1 – Components of the SII and their relative weights

Categories (C_i)	Category weights (W_i)	Indicators (I_{ij})	Indicator weights (w_{ij})
1. SEAP quality	0.2	1.1 Data quality	0.5
		1.2 SEAP level of detail	0.3
		1.3 Diversification of areas of intervention	0.2
2. Online information	0.1	2.1 Official documentation availability	0.3
		2.2 Information on CoM and SEAP	0.3
		2.3 Information accessibility	0.4
3. Involvement	0.1	3.1 Number of events organized	0.5
		3.2 Typologies of target groups covered	0.5
4. Governance	0.2	4.1 Target ambition	0.2
		4.2 Deadlines compliance	0.4
		4.3 Involved personnel	0.4
5. Implementation effort	0.2	5.1 Per capita expenditure	0.5
		5.2 Ongoing actions	0.5
6. Performance	0.2	6.1 Emission reduction goal completion	0.3
		6.2 Completed actions	0.3
		6.3 Emissions reductions due to completed actions	0.4

Table 2 – Scores assigned to each indicator

Online information	
Scores	**Documentation availability**
1	complete
0.5	lacking
0	none
Scores	**Info on CoM and SEAP**
1	thorough
0.5	incomplete
0	none
Scores	**Information accessibility**
1	very high
0.8	high
0.6	intermediate
0.4	low
0.2	very low
0	none

Involvement	
Scores	**N. events / 10,000 inhab.**
1	more than 12
0.8	from 9 to 12
0.6	from 6 to 9
0.4	from 3 to 6
0.2	less than 3
0	none
Scores	**Recipients covered**
1	all 4 typologies
0.75	3 typologies
0.5	2 typologies
0.25	1 typology
0	none

Governance	
Scores	**Target ambition**
3	>20% (absolute)
2	20% (abs.) or >20% (per capita)
1	20% (per capita)
0	lower than the minimum required
Scores	**Deadline compliance**
5	deadlines met
4	delay 1 year
3	delay 1-2 year
2	delay 2-3 year
1	delay 2-3 year
0	delay > 4 year
Scores	**Personnel allocated**
2	sufficient
1	insufficient
0	no personnel

Implementation effort	
Scores	**Per capita expenses**
5	> 50 €/year
4	30-50 €/year
3	20-30 €/year
2	10-20 €/year
1	< 10 €/year
0	no funds
Scores	**Ongoing actions**
5	> 80%
4	60-80%
3	40-60%
2	20-40%
1	0-20%
0	0%

Performance	
Scores	**Target achievement**
5	> 80%
4	60-80%
3	40-60%
2	20-40%
1	0-20%
0	< 0%
Scores	**Completed actions**
5	> 50%
4	35-50%
3	20-35%
2	10-20%
1	0-10%
0	no complete actions
Scores	**SEAP impact on emission trend**
5	> 80%
4	60-80%
3	40-60%
2	20-40%
1	0-20%
0	0%
Scores	**SEAP impact on target**
5	> 80%
4	60-80%
3	40-60%
2	20-40%
1	0-20%
0	0%

2.1.1 SEAP quality

To evaluate this category, all of the 102 SEAPs have been analyzed for the following criteria:

- Data quality: quality of the data used to draw the Baseline Emission Inventory (BEI), considering their source and accuracy (regional or local data) or their level of disaggregation.
- SEAP level of detail: level of detail of the SEAP document (i.e., geographic and socio-economic context, existing regulatory framework, long term goals and vision, methodology adopted for the emission inventory, in-depth description of the planned actions, budget and foreseen financing sources, staff and structures assigned to the initiative managing, planned monitoring method). The originality of the document was also taken into consideration to verify that the contents were problem specific and not simply copied from the work of others.
- Diversification of areas of intervention: number of areas of intervention involved among those suggested by the European guidelines (buildings, equipment and facilities; transport; non-ETS industry; local electricity production; local heating/cooling generation; urban and land use planning; citizens and stakeholder involvement; public procurement).

2.1.2 Online information

To evaluate the indicators in this category, research on the institutional websites was carried out for each of the 102 Municipalities in the sample.

- Official documentation availability: availability, on the municipal website or in its profile page on the CoM website, of the official Covenant documentation, i.e. SEAP and monitoring reports.
- Information on CoM and SEAP: availability, on the municipal website, of general information about the Covenant of Mayors initiative and the SEAP.
- Information accessibility: effort made in identifying the information mentioned above. The search was carried out on the municipal websites and then extended to internet results.

2.1.3 Involvement

This category analyses the signatories' commitment to engaging the population, including kick-off meetings with citizens and stakeholders to draft the SEAP as well as all activities organized to promote awareness and train the staff. The indicator scores for this category are based on the answers to the survey, integrated with the results of a search in the events/news section of the municipal websites. This allowed the evaluation of all the 102 Municipalities in the sample, even when they did not take part in the survey.

- Number of events organized: it consists of the average number of events organized per year since the entry in the Covenant. The scores vary according to the size of the Municipality considered.
- Typologies of target groups covered: it evaluates the diversification of the communication and training activities organized, checking the involvement of all four typologies of recipients considered: municipal employees, operators in the energy sector, citizens and students.

2.1.4 Governance

The scores for the first two indicators in this category are based on information included in the SEAPs. On the other hand, the scores concerning the personnel allocated depend on the answers to the survey, therefore limiting the evaluation only to 41 Municipalities. Although some of the analyzed SEAPs included organizational provisions, this kind of information was neglected since it could not provide evidence of the staff allocated.

- Target ambition: ambition in defining the CO_2 emission reduction target with respect to the minimum required by the CoM, defined either as "absolute reduction" or "per capita reduction".
- Deadline compliance: whether the deadlines for the submission of the SEAP (1 year after joining the Covenant) and of the monitoring reports (every 2 years after the SEAP publication) have been met. In case of noncompliance, it computes the overall delay in the document's submission as of December 2017.
- Personnel allocated: the amount of personnel allocated to the managing of the initiative in terms of "full-time workers equivalent", by measuring both the number of staff and the share of their working time dedicated to SEAP related activities. The scores vary according to the dimension of the Municipality considered.

2.1.5 Implementation effort

This analysis is based on the publicly available results from the "Action Reports", thus limiting the analysis to 69 Municipalities among the 73 in the sample that reached the monitoring phase. Most data on the monitoring phase come from the information that signatories individually decided to publish on their profile page on the CoM website rather than from the reports, which are rarely available. Moreover, it must be noted that only some Signatories made budgetary information available to the public: accordingly, only 44 SEAPs could be evaluated against their economic component, whereas a null score was applied to the others. For Municipalities with more than one monitoring report, the assessment of the indicators was based on the latest available figures.

- Per capita expenses: yearly average of the per capita costs for implementation of the actions.
- Ongoing actions: share of measures that are already underway, including both ongoing and completed actions.

2.1.6 Performance

The evaluation of this category proved to be problematic. An adequate assessment of two out of three indicators required the availability of an "Implementation Report" featuring the Monitoring Emission Inventory (MEI): however, this was only available for 23 Municipalities, placing a serious constraint to the overall analysis. Accordingly, it was decided to introduce a further indicator to replace the two abovementioned ones in case MEI results were not available. Such additional indicator is designed to measure the distance to the goal without comparing current emissions to the baseline. Adding this indicator allowed to raise the total number of Municipalities evaluated to 69, namely those that provided the necessary monitoring data.

- Emission reduction goal achievement: percentage of completion of the emission reduction target, comparing the per capita reductions obtained with respect to the BEI to the 2020 goal.
- Completed actions: share of completed actions over the total number of actions planned.
- Emission reductions due to completed actions: SEAP impact on the per capita emissions reductions with respect to the BEI, computed as the share of the recorded reductions directly ascribable to the completed actions.
- Emission reduction goal completion due to completed actions: SEAP influence on the scheduled per capita emission reductions, by computing the share of the reductions linked to the completed actions with respect to the reductions to be achieved by 2020 (additional indicator).

2.2 Study area

The developed index is applied to 134 Municipalities that compose the Metropolitan City of Milan (MCM). 107 out of the 134 Municipalities signed the CoM, but 5 of them never submitted a SEAP and are now considered "on hold". Among the 102 Municipalities with a SEAP, 73 have submitted an Action Report and only 31 have reached a complete Monitoring Report (Figure 1). More details about the classification in size classes of the Municipalities are provided in the Supplementary Material (Table SM1).

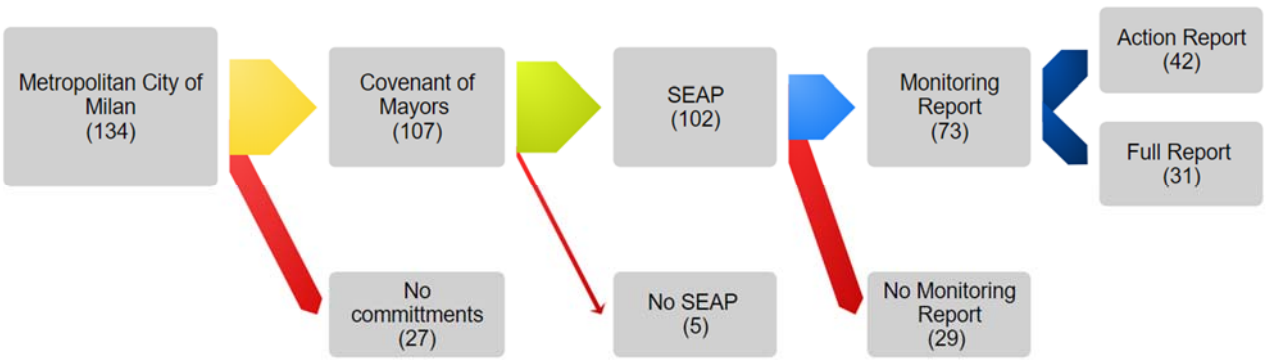

Figure 1 – CoM implementation phases carried out by the 134 Municipalities in the Metropolitan City of Milan

2.3 Data sources: online websites

Online websites represent the first type of data sources used in this study: institutional websites of each local authority; official CoM website, where each signatory has its own page (Covenant of Mayors, 2017); Fondazione Cariplo website, collecting data on Municipalities financed through the call "Sostenibilità energetica" in 2010 (Fondazione Cariplo, 2017). By putting together the documentation available on each of these platforms, it was possible to obtain all the SEAPs presented by the signatories in the sample.

Only 16 monitoring reports were available on the web, seven of which are fully complete reports including a MEI. For this reason, most of the following analyses requiring monitoring data have been developed based on the information published by signatories on their pages on the CoM website. When it was possible to find the complete documentation, the data shown on the signatories' profile page were compared to the contents of the official reports, resulting in mostly coherent information. However, it is important to note that each administration can choose which data to publish on their page: because of this, for instance, it was not always possible to gather information on the funds allocated to implement the planned measures.

2.4 Data sources: direct survey among the Municipalities

An original survey composed of 45 questions (available in the Supplementary Material) on the activities undertaken related to the SEAP was developed and sent to all the 134 Municipalities with an official invitation by the MCM. The survey was open online from 12/10/2017 until 31/01/2018 and 55 Municipalities answered, representing 41% of the municipalities in the MCM and 68% of its total population. Among the 102 partners of the CoM, the answer rate only reached up to 42%.

3 RESULTS AND DISCUSSION

3.1 Category results

The following paragraphs display the score distributions for each category for the study area, also represented in Figure 2. The percentages shown in the graph are computed over the 102 Municipalities in the sample for SEAP quality, Online information, Engagement and Governance; for the remaining two categories, they are computed over the 69 Municipalities providing monitoring data. The results obtained by each Municipality have been mapped and are available in details in Messori (2018).

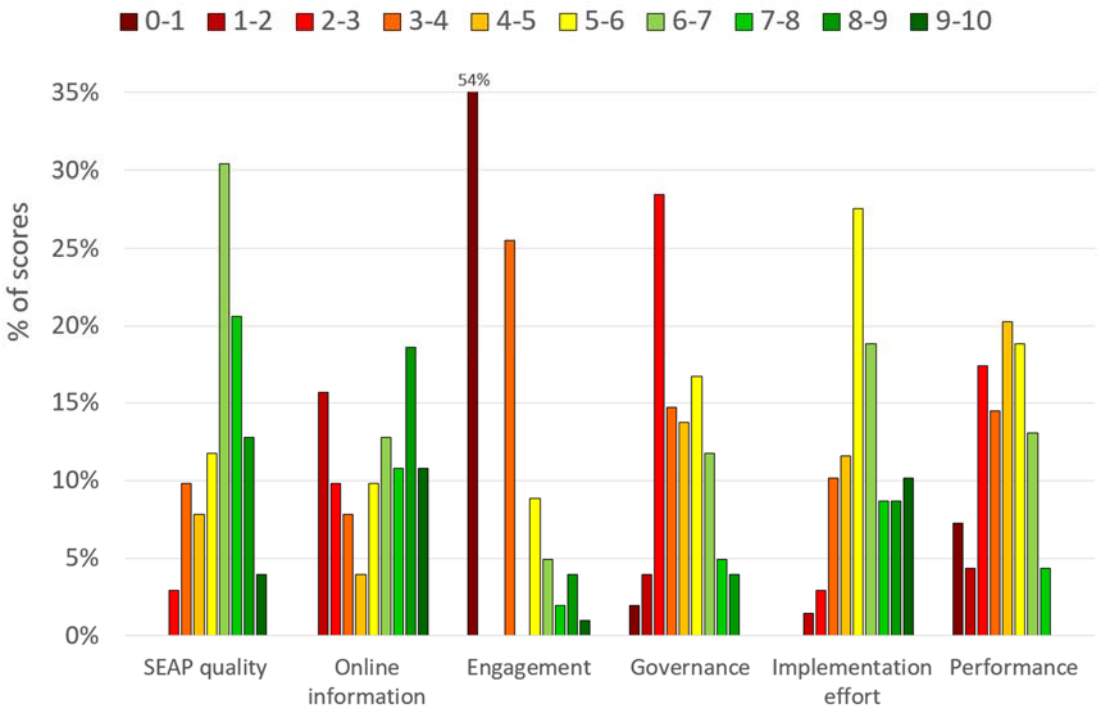

Figure 2 – Scores distribution for each of the 6 categories in the SII

3.1.1 SEAP quality

The scores for the SEAP quality have been the best among all the considered categories: 68% of the Municipalities managed to reach "good" (6-8) or "very good" results (8-10). However, none of the signatories obtained the maximum score available: despite most of the documents being well structured and containing most of the information required, their lack of originality prevented them from receiving a score of 10.

3.1.2 Online information

The availability of online information was the only other category that could reach a high percentage (53%) of scores above 6. However, 26 signatories obtained results between 1 and 2, since it was impossible to find any information about their participation in the initiative, if not by accessing directly to the Covenant website. None of the Municipalities was given a null mark though, since a minimum level of documentation was always available through the CoM website. Online information often proved to be of good quality, allowing various Municipalities to obtain high scores.

3.1.3 Involvement

The issue of population participation has been completely ignored by most Municipalities, leading to a very high share (54%) of null scores. Most of the remaining results ranged between 3 and 4; only 12% of the signatories obtained marks above 6. However, it must be noted that these data come from two different sources: Signatories who did not take part in the survey usually achieved lower scores since searches on the municipal websites only provided limited information.

3.1.4 Governance

Concerning the management of the initiative, most scores ranged between 2 and 3 even if 21% of the Municipalities managed to obtain results above 6. The criterion on the target ambition obtained particularly positive results, with 50% of the Municipalities achieving the maximum score. The evaluation of the personnel indicator lowered the overall results for this category, although data on personnel were not always available: the 59 signatories that did not provide such information obtained a null score. Nonetheless, Governance results were not great even considering only the 41 Municipalities with complete data: 42% of them scored between 4 and 6, proving that results would not have been too different even taking into account the missing data.

3.1.5 Implementation effort

Among the 69 Municipalities that reached the monitoring phase, 46% obtained scores higher than 6. The ongoing actions indicator leads to very good evaluations (4 or 5 over 5) for 74% of the signatories, while the evaluation of the per capita costs generally obtained lower scores. As already discussed, some Municipalities did not make their expenses data available on the CoM website which implied, since it was not possible to access the monitoring reports directly, the assignment of a null score for 25 of them for this particular criterion. However, 73% of the 44 Municipalities with complete data obtained scores above 6, which means that the lack of expenses data had a big impact on the results.

3.1.6 Performance

The 69 signatories that submitted at least one monitoring report obtained a varied range of results for the performance category, although only 14 Municipalities could reach scores above 6. The indicator about the emission reductions goal completion showed the best results, since 52% of the 23 Municipalities with a MEI scored between 4 and 5 over a total of 5 points. These signatories state to have already achieved more than 60% of their 2020 reduction target, share that in some cases seems even to have exceeded 100%, suggesting reductions even higher than those scheduled.

On the other hand, it was possible to conclude that SEAP-related actions had a weak direct impact on emission trends. In most cases (74%), such actions were only responsible for less than 20% of the observed emissions reductions, suggesting the influence of other drivers at a higher level and scale, such as the financial crisis affecting Italy since 2007. As registered in the National Inventory Report on Greenhouse Gas Emissions and Removals (ISPRA, 2018), Italy's GHG emissions significantly decreased after 2005 mainly due to a general decrease in consumption (e.g., fossil fuels) and in industrial activities, with inevitable consequences at the local level too.

3.2 Overall results

Overall, 11 of the 102 Covenant signatories within the Metropolitan City of Milan (10%) have obtained a good evaluation for the SEAP implementation, resulting in scores above 6 (Figure 3). Most Municipalities (49%) scored between 4 and 6, while the remaining 41 earned very low scores. The average score is 4.2 points over 10.

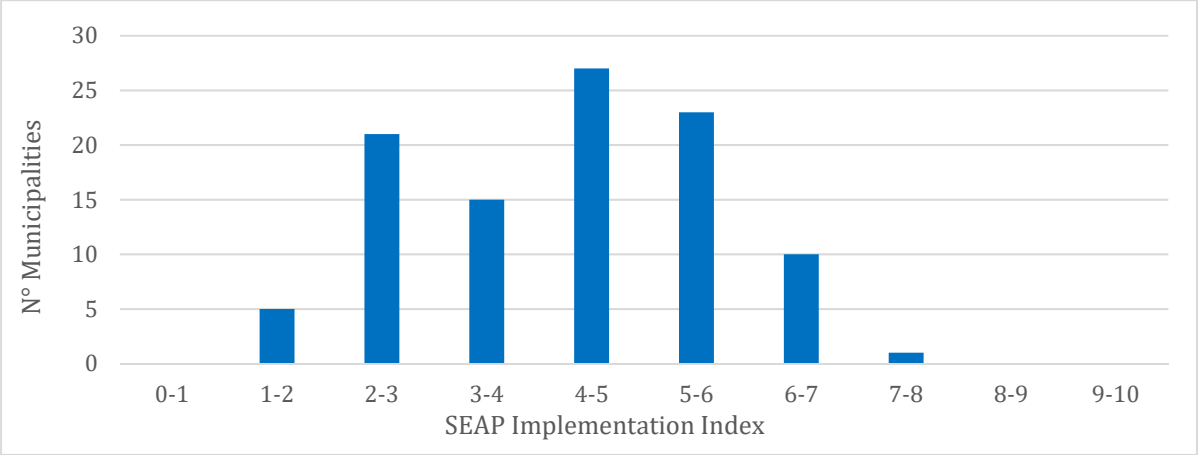

Figure 3 – SII scores distribution for the 102 Municipalities within the sample.

These results can be explained as follows: the evaluations were positive when gauging the intentions declared in the SEAP or the availability of online information, but they dropped as soon as the criteria shifted to assessing the quality of the initiative management or its actual performances (Table 3). The implementation effort category could obtain an average score above 5, resulting from a high share of ongoing action. However, most of these actions have not been completed and the reductions directly linked to the SEAP have been low, resulting in poor performance scores. The involvement, with an average score of only 2.3, has fared the worst among the considered categories; the governance also faced serious difficulties, especially associated with the personnel.

Table 3 – Average scores obtained by the Municipalities for each category, subdividing the sample into three groups

Categories	Complete sample average scores (102 Municipalities)	Monitoring sample average scores (69 Municipalities)	SEAP sample average scores (33 Municipalities)
SEAP quality	6.4	6.4	5.9
Online information	5.7	5.9	5.3
Involvement	2.3	2.6	1.6
Governance	4.1	4.4	3.6
Implementation effort	5.6	5.6	-
Performance	3.8	3.8	-
SEAP Implementation Index	**4.2**	**4.9**	**2.6**

The 102 signatories can be subdivided into two main groups according to the stage reached in the implementation of the initiative: those that only submitted the SEAP and those that handed in at least an Action report.

The 33 Municipalities that did not reach the monitoring phase (or did not provide their monitoring data) could only be subject to a partial evaluation: the absence of a score for the last two categories led to a maximum potential score of 6. Furthermore, the especially poor scores achieved for the governance and involvement categories led to even lower results: the overall mean score for these Municipalities is 2.6, only 15% of them managed to reach a score above 4.

As shown in the thematic map available in the Supplementary Material (Figure SM1), the Municipalities that achieved the worst overall scores are mostly concentrated South-West of Milan, i.e. the area with the lowest population density. This result is probably due to bigger issues faced by smaller local authorities in gathering the necessary resources to implement the planned actions, as demonstrated by very low scores in the governance and actualization categories.

3.3 Sensitivity analysis

A sensitivity analysis was carried out in order to verify the stability of the scores obtained for each category and to identify the most significant elements in defining the results. Full information on the applied methodology is available in the Supplementary Material.

The results obtained show that the most sensitive category to changes in the weights of its indicators is the implementation effort. The strong variations in the results are caused by the differences in performance in its two indicators; indeed, Municipalities have high shares of planned actions already underway, while showing very low scores for the expenses incurred for their implementation. As for the other categories, this study has found that the weights for individual indicators have a lesser influence on the final evaluation.

The stability of the overall scores was also verified by changing the categories' relative weights. These variations led only to negligible shifts in the results: the average variation coefficient registered for each Municipality amounts to 13%; the average overall score is only slightly changing, and its average value is 4.17 with a variation coefficient of 7%.

In Figure 4, each Municipality is described by its overall score and the 5- and 95-percentile of the alternative distributions studied in the sensitivity analysis. As can be gathered by the graph, the combined effect of weights variations on both indicators and categories does not change significantly the relative ranking of the Municipalities or the overall poor results obtained within the study area.

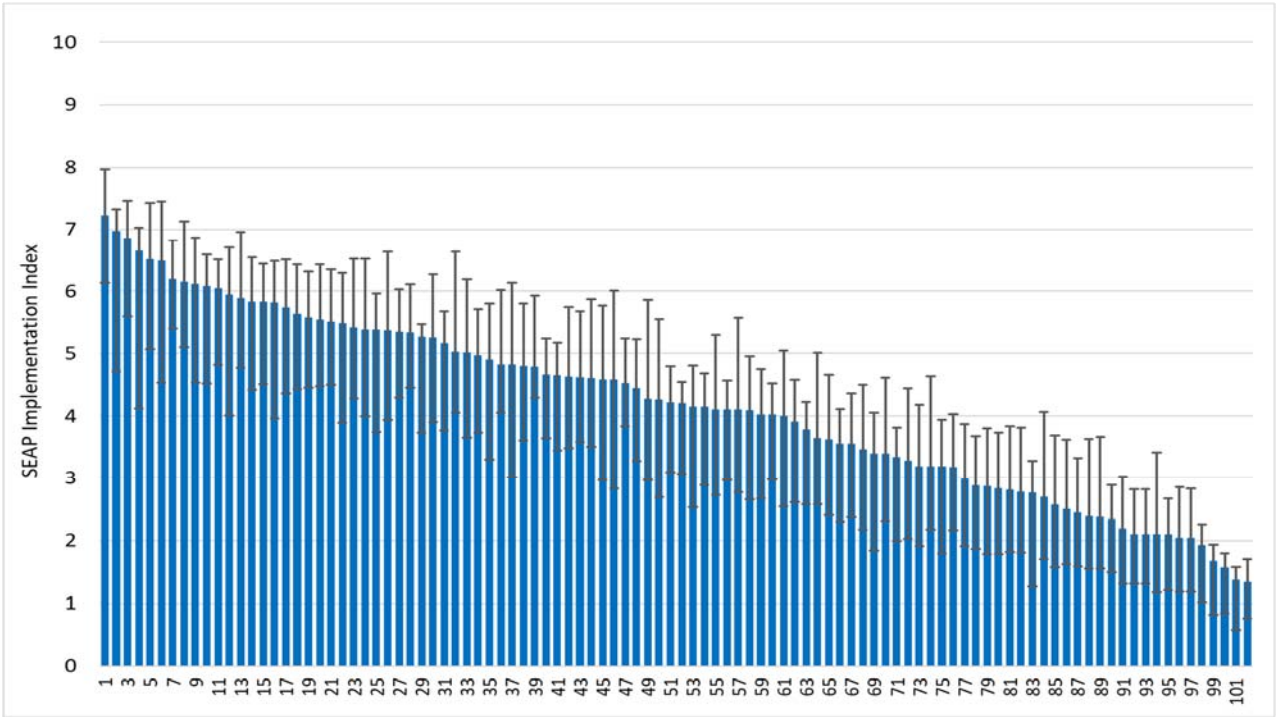

Figure 4 – SII results for the 102 Municipalities sampled. The whiskers represent the score 5th and 95th percentile, obtained with all the considered sets of weights. Municipality names are available in Table SM2

4 CONCLUSIONS AND POLICY IMPLICATIONS

The proposed novel index provides a comprehensive evaluation of the implementation level of climate actions at the Municipality level, quantifying the amount of effort and the effectiveness of the actions undertaken within the framework of the Covenant of Mayor.

Despite the high willingness and the massive number of signatories, the application of the SII to the case of the Municipalities in the Metropolitan City of Milan has shown serious shortcomings in the actual implementation of the initiative. The execution of the planned actions is shown to be hindered by the lack of the necessary financial and human resources assigned to the initiative; the management and the population involvement resulted to be lacking as well.

The terms of the commitments undertaken by the Municipalities under study will be achieved in most cases, but mainly thanks to external drivers rather than to the action of local administrations: indeed, the results obtained in the Performance category show how CO_2 emission reductions due to SEAP-related actions have generally been negligible compared to the overall ones recorded in Italy in many sectors and mainly due to the economic crisis and the consequent drop in consumption (i.e. -18.5% decrease in fuel consumption in the transport sector from 2007 onwards, ISPRA, 2018).

In general, this study has found a lack of funding and personnel as the main issues preventing the achievement of concrete results. Building upon such results, general recommendations for climate research directions and governance programs to support local action can be drawn, particularly in order to meditate on the future 2030 commitments to be adopted by local administrations in the framework of the renewed Global Covenant of Mayors for Climate and Energy. Firstly, promoting policy programmes and funding schemes to encourage shared governance is essential to achieve effective multi-stakeholder civic engagement: continuous monitoring and the tangible presence by municipalities on-site, developing new tools for communicating climate challenges to citizens and co-producing shared solutions though public-private-people partnerships, could overcome the current approach to climate planning intended as a merely technical and office-work operation with scares out-reach to the public.

Secondly, strictly concerning climate governance instruments, new modalities for cooperation and aggregation of local administrations and their respective actions should be developed; for instance, the submission of a joint Sustainable Energy and Climate Action Plan (SECAP) at the Metropolitan level represents an option that saw broad consensus in the initial survey: most respondents stated to be interested in this possibility, with 31% being “highly interested”. For instance, the Metropolitan City of Milan could take on the role of planning supervisor, mainly taking care of the following: formulating the strategic guidelines, defining the 2030 targets based on a metropolitan BEI and, finally, drafting a SECAP based on the voluntary contributions set by each Municipality. Unified planning would facilitate the stability and continuity of long-term actions, as it would reduce the influence of political changes occurring to the many administrations involved.

In the above-mentioned new framework, each Municipality could adopt a more focused approach: first of all by financing part of the human resources needed to draft the joint SECAP and by carrying out the monitoring phase, which would allow to share the costs and to cut the ineffective practice of recurring to external consultancies, which often prevented the building of in-house expertise and mined the continuity of the planning, especially in the technical offices of smaller administrations. Secondly, once freed from the time-consuming tasks linked to the bureaucratic procedures to participate in the Covenant, collect data and monitor the results, Municipalities could finally focus on the concrete implementation of the strategic actions concerted with the Metropolitan City, taking advantage of territorial affinities, starting inter-municipal cooperation and replicating good practices.

Further studies might want to apply the SII to a wider spectrum of cities, from different countries and with different socio-economic backgrounds, in order to compare the results, verify whether the most common issues are the same and devise a shared strategy to overcome them.

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SUPPLEMENTARY MATERIAL AVAILABLE

A climate mitigation action index at the local scale: methodology and case study

SUPPLEMENTARY MATERIAL

Summary

1. Survey to the Municipalities

The following survey collects information on the climate actions ongoing at the local scale in the Municipalities under investigation and is part of the "Cambiamenti climatici e territorio" project, launched by the Metropolitan City of Milan with the support of Fondazione Cariplo.
The text has been translated from the original language (Italian).

Municipality of: ……
Respondent's name: ……
Sector/Area: ……
Respondent's role: ……
Phone number: ……
Email address: ……

1. Covenant of Mayors

1.1 Is the Municipality a Covenant of Mayors partner? Yes / No

1.2 If not: why did it not take part in the initiative?

- □ Unaware of the initiative
- □ Lack of interest
- □ Lack of personnel to manage it
- □ Lack of funding
- □ Would be interested in taking part
- □ Other ……

Go to point 3

1.3 If the Municipality is a Covenant signatory, has the SEAP been approved by the City Council? Yes / No

1.4 If the SEAP has been approved by the City Council: Go to point 2

1.5 If the SEAP has not been approved by the City Council:

1.5.1 Is the SEAP being drafted? Yes / No

1.5.2 If not, why has it not yet been drafted?

- □ Lack of personnel to manage it
- □ Lack of funding
- □ Lack of external expertise
- □ Other ……

1.5.3 Would you be interested in a collaboration with other Municipalities in the framework of a joint SEAP? Yes / No

1.5.4 Insert here any other relevant information.

……
……
……

Go to point 3

2. SEAP

2.1 When has the SEAP been approved by the City Council? ..../..../....

2.2 How many internal staff members were involved in the drafting of the SEAP?

0 1 2 3 4 5 or more

2.3 Has the SEAP been drafted with the help of external expertise? Yes / No

2.4 If so, how was the consultancy funded?

- □ Internal funds
- □ CARIPLO funds

□ Calls for tender
□ Other ……

2.5 Are adaptation policies (e.g. actions designed to reduce the negative impacts linked to different rainfall patterns or heat waves) included in the SEAP? Yes / No

2.6 Has the Municipality joined "Mayors Adapt"? Yes / No

2.7 Would the Municipality be interested in renewing its commitments in the framework of the Covenant of Mayors for Climate and Energy, which sets targets to 2030 and requires the integration of adaptation policies alongside the mitigation ones? Yes/No

2.8 Have dissemination and training activities on climate change topics and/or rational energy usage been carried out after the SEAP approval? Yes / No

2.9 If so, select the recipients involved and the number of events organized so far for each category:

□ Municipal employees: ……
□ Citizens: ……
□ Schools: ……
□ Operators in the energy field: ……

2.10 How many people are working on the SEAP?

0 1 2 3 4 5 or more

2.11 How much of their working time is devoted, on average, to the SEAP?

□ Less than 10%
□ 10 – 30%
□ 30 – 50%
□ 50 – 70%
□ 70 – 90%
□ More than 90%

2.12 Define the amount of funding allocated to the SEAP so far for the implementation of the planned measures.

□ Less than 1,000,000 €
□ 1,000,000 – 5,000,000 €
□ 5,000,000 – 10,000,000 €
□ More than 10,000,000 €

2.13 Which portion of such amount has already been spent?

Less than 25% 25–50% 50–75% More than 75%

2.14 Has a monitoring report been presented? Yes / No

2.15 If not, why it has not yet been drafted?

□ Lack of personnel
□ Difficulty in obtaining the necessary data
□ Lack of external expertise
□ Political issues
□ The deadline for its presentation has not passed yet
□ Other ……

2.16 If a monitoring report has been drafted:

2.16.1 When has it been sent to the European Commission? (If more than one report has been submitted, please insert the delivery date of each one of them) ..../..../....

2.16.2 Has a Monitoring Emission Inventory (MEI) been drafted? Yes / No

2.16.3 If so, which year has been considered as the reference for the MEI? .....

2.17 Is a monitoring report being drafted? Yes / No

3. Public buildings sector

3.1 Have interventions or municipal regulations been promoted to reduce the energy consumption of public buildings?

□ Yes, for both existing and new-build buildings
□ For newly-built buildings only
□ For existing buildings only
□ No

3.2 Which types of interventions have been conducted in the buildings sector?
□ No intervention
□ On public building shields
□ On heating systems
□ On cooling systems
□ Other……

3.3 How many public buildings have been subjected to energy requalification?
……..

3.4 Have "social housing" projects been drafted including energy efficiency interventions aimed at improving poor conditions, reducing heating expenses and thus defaulting cases? Yes / No

3.5 Are interventions on public heritage expected? Yes / No

3.6 Have funds been allocated to implement indicated measures? Yes / No

3.7 Have incentive mechanisms been used?
□ No
□ Regional calls for tender
□ Energy Efficiency Titles – TEE ("White Certificates")
□ Thermal Account ("Conto Termico")
□ Other ……

3.8 Indicate the funding source, if available
……..

3.9 Indicate the amount of funds invested, if available
……..

4. Private buildings sector

4.1 Have interventions or municipal regulations been promoted to reduce energy consumption of private buildings? Yes / No
□ 4.2 Which interventions have been realized to promote energy saving for heating appliances in the private sector? No interventions
□ Opening of information points
□ Synergies with other municipalities
□ Information campaign on incentive mechanisms
□ Support to privates on mandatory requirements from existing laws
□ Enhancement of grid/district heating system.
□ Other ……

5. Transport sector

5.1 Have measures to reduce transport emissions been promoted? Which ones?
□ No
□ Replacement of municipal vehicles with traditional fueling
□ Promotion of private vehicles renewal
□ Improvement of public transports
□ Promotion of cycle-pedestrian mobility
□ Development of shared mobility (i.e. bike / car sharing)
□ Set up a limited traffic area
□ Other ……

6. Energy sector

6.1 Have renewable energy systems been installed on public buildings?

- □ No
- □ Photovoltaics
- □ Solar thermal
- □ Geothermal energy (i.e. heat pumps)
- □ Biomass
- □ Other ……

6.2 Is there a grid/district heating system in the municipality? Yes / No

6.3 Has the municipality appointed an Energy Manager? Yes / No

6.4 If yes, in which year was he/she appointed? .... / .... / ....

7. Final remarks

7.1 Which were the major difficulties you encountered while writing the SEAP and in the subsequent achievement of the objectives?

- □ Lack of internal staff
- □ Skills of internal staff
- □ Lack of external consultancies
- □ Lack of funding
- □ Other ……

7.2 How useful was the support of the Province of Milan as a "Covenant Coordinator"?

Very little 1 2 3 4 5 Very useful

7.3 How interested would you be in creating a single, joint, SEAP for each of the homogeneous areas of the Metropolitan City of Milan? This option entails the collective development of the SEAP by the municipalities belonging to each area, resulting in a single inventory of emissions and in a set of actions to be implemented both individually and collectively. Such cooperation between local authorities would make it possible to manage problems related to the lack of funding and personnel, as well as ensuring better results which are not influenced by municipal boundaries.

Very little 1 2 3 4 5 Very interested

7.4 Would you be willing to provide, at a later stage, quantitative data on the interventions carried out in your municipality? Yes / No

7.5 Enter any other suggestions.

……
……
……

2. Scoring scales for SEAP Implmentation Index indicators

2.1 SEAP quality

Data quality: the scores range between 0 and 5 and depend on the evaluation given to each of the following characteristics: data source, data accuracy (regional or local data) and their level of disaggregation.

SEAP level of detail: the scores range between 0 and 5, the evaluation depends on how many of the following nine aspects have been addressed in the SEAP and with what level of detail: geographic and socioeconomic context, existing regulatory framework, long term goals and vision, adopted methodology for the emission inventory, in-depth description of the planned actions, budget and foreseen financing sources for the investments, staff and structures assigned to the initiative managing, planned monitoring method and SEAP originality.

Diversification of areas of intervention: the score scale goes from 0 to 5, 5 is given when the planned measures cover all the sectors suggested by the European guidelines (buildings, equipment and facilities; transport; non-ETS industry; local electricity production; local heating/cooling generation; urban and land use planning; citizens and stakeholders involvement; public procurement), 0 is given instead when less than three areas of intervention have been involved.

2.2 Online information

Official documentation availability: the score scale goes from 0 to 2: 2 is given when all the relevant documents are available, 1 when the documentation is only partially available (lack of monitoring report) and 0 when no documentation can be found.

Information on CoM and SEAP: the scores can range from 0 to 2, where 2 means thorough information, 1 means incomplete information and 0 indicates the lack of any information.

Information accessibility: the score scale ranges between 0 and 5, 5 means very high accessibility of the information while 0 points out the lack of any information.

2.3 Involvement

Number of events organized: the score scale ranges between 0 and 2, 0 if no events have been organized from the entry in the Covenant, 2 if the Municipality organized on average more than 1 event per year. For Municipalities with more than 20,000 inhabitants, the maximum score was given when the average number of events organized per year was higher than two.

Recipients covered: the scoring scale ranges from 0 to 4, depending on how many of the 4 typologies of recipients (municipal employees, operators in the energy sector, citizens and students) have been involved in the events. A score of 0 is given to Municipalities who did not organize communication activities, while the maximum score is reserved for those who organized specific events for all the possible recipients.

2.4 Governance

Target ambition: the scores range from 0 to 3, 0 means that the SEAP does not comply to the minimum required by the Covenant (i.e. a 20% cut by 2020 in comparison to the baseline year) 1 in case of a 20% per capita reduction target, 2 indicates a per capita objective higher than 20% or a 20% reduction in absolute terms, while the maximum score was given to absolute reduction targets higher than 20%.

Deadlines compliance: the score scale ranges between 0 and 5 depending on the overall delay in the submissions of documents, as of December 2017. A 0 indicates over four years of cumulated delay while a 5 means that all the relevant documents have been submitted by the established deadlines.

Personnel allocated: the scores range on a scale from 0 to 2, 0 means that the Municipality does not have the personnel for the managing of the initiative, 1 means that the appointed personnel is inadequate and 2 means that the allocated personnel is sufficient for a good management of the initiative. The amount of personnel deemed sufficient depends on the size of the Municipality: one employee, even if not completely dedicated to the SEAP, is enough for towns with less than 10,000 inhabitants, Municipalities with less than 50,000 inhabitants should have at least a full-time worker, cities with less than 100,000 inhabitants should have at least two full-time employees and even bigger cities should have a least three.

2.5 Implementation effort

Per capita expenses: the score scale ranges between 0 and 5, 0 means that no funds have been allocated to the implementation of the planned measures, 5 means that per capita expenses exceeded 50€/year.

Ongoing actions: the scores range from 0 to 5, 0 means that none of the planned actions have been implemented while the maximum score implies that more than 80% of the planned measures are already underway.

2.6 Performance

Target achievement: the score scale goes from 0 to 5, the minimum score means that in recent years the per capita emissions have risen instead of decreasing, while 5 means that more of the 80% of the goal has been already achieved.

Completed actions: the score scale goes from 0 to 5, where 0 means that none of the planned actions have been completed, while the maximum score means that more than the 50% of the actions have been finalized.

SEAP impact on emission trend: the scoring scale ranges from 0 to 5, 0 means that the completed actions could not counter the registered emissions increase while the maximum score indicates that more than 80% of the obtained reductions are directly linked to the completed actions.

SEAP impact on target: the scores range from 0 to 5, 0 means that the completed actions hold no weight in the achieving of the 2020 objective while a score of 5 means that completed actions account for more than 80% of the final objective.

3. SEAP Implementation Index results

Following a brief analysis of the study area, this section provides the SII results for each Municipality, ordered according to their scores and illustrated in a thematic map.

Table SM1 – Municipalities classification in size classes.

Size [inhabitants]	Metropolitan City of Milan		Municipalities partners of the CoM	
	N° Municipalities	Population	N° Municipalities	Population
< 1,000	1 (1%)	685 (0%)	-	-
1,000 – 10,000	73 (54%)	409,078 (13%)	53 (52%)	299,011 (11%)
10,000 – 50,000	55 (41%)	1,188,372 (37%)	44 (43%)	888,538 (32%)
50,000 – 250,000	4 (3%)	268,507 (8%)	4 (4%)	268,507 (10%)
> 250,000	1 (1%)	1,351,562 (42%)	1 (1%)	1,351,562 (48%)
Total	134	3,218,204	102	2,807,618

Table SM2 – SEAP Implementation Index results for each of the 102 Municipality.

Rank	Municipality	SII score
1	Gorgonzola	7.2
2	Gaggiano	7.0
3	Carugate	6.9
4	Cologno Monzese	6.7
5	Gessate	6.5
6	Rho	6.5
7	Vaprio d'Adda	6.2
8	Bareggio	6.1
9	Turbigo	6.1
10	Bellinzago Lombardo	6.1
11	Cesano Boscone	6.0
12	Inzago	5.9
13	Cinisello Balsamo	5.9
14	Paullo	5.8
15	Boffalora sopra Ticino	5.8
16	Liscate	5.8
17	Dresano	5.7
18	Pozzo d'Adda	5.6
19	Locate di Triulzi	5.6
20	Melzo	5.5
21	Trezzano Rosa	5.5
22	Pessano con Bornago	5.5
23	Morimondo	5.4

Rank	Municipality	SII score
24	Grezzago	5.4
25	Vanzago	5.4
26	Milano	5.4
27	Pioltello	5.3
28	Garbagnate Milanese	5.3
29	Pozzuolo Martesana	5.3
30	Basiano	5.3
31	Trezzo sull'Adda	5.2
32	Cormano	5.0
33	Masate	5.0
34	Cassano d'Adda	5.0
35	Vignate	4.9
36	Dairago	4.8
37	Pregnana Milanese	4.8
38	Corbetta	4.8
39	Abbiategrasso	4.8
40	Busto Garolfo	4.7
41	Canegrate	4.7
42	Cambiago	4.6
43	Bollate	4.6
44	Baranzate	4.6
45	Marcallo con Casone	4.6
46	Lainate	4.6

Rank	Municipality	SII score
47	Settala	4.5
48	Cuggiono	4.5
49	Cesate	4.3
50	Pero	4.3
51	Senago	4.2
52	Rescaldina	4.2
53	San Donato Milanese	4.2
54	Cernusco sul Naviglio	4.2
55	Vanzaghello	4.1
56	Arluno	4.1
57	Magnago	4.1
58	Truccazzano	4.1
59	Cerro al Lambro	4.0
60	San Giorgio su Legnano	4.0
61	Arese	4.0
62	Trezzano sul Naviglio	3.9
63	Ossona	3.8
64	Settimo Milanese	3.6
65	Motta Visconti	3.6
66	Melegnano	3.6
67	Sesto San Giovanni	3.6
68	Zibido San Giacomo	3.5
69	Cornaredo	3.4
70	Pieve Emanuele	3.4
71	Corsico	3.3
72	Arconate	3.3
73	Robecchetto con Induno	3.2
74	Cassina de' Pecchi	3.2

Rank	Municipality	SII score
75	Villa Cortese	3.2
76	Solaro	3.2
77	Nerviano	3.0
78	Assago	2.9
79	Peschiera Borromeo	2.9
80	Legnano	2.8
81	Buscate	2.8
82	Cerro Maggiore	2.8
83	Lacchiarella	2.8
84	Colturano	2.7
85	Bussero	2.6
86	Novate Milanese	2.5
87	Calvignasco	2.4
88	Magenta	2.4
89	Sedriano	2.4
90	Albairate	2.3
91	Santo Stefano Ticino	2.2
92	Bubbiano	2.1
93	Ozzero	2.1
94	Besate	2.1
95	Bernate Ticino	2.1
96	Casarile	2.0
97	Vizzolo Predabissi	2.0
98	Vimodrone	1.9
99	Rosate	1.7
100	Casorezzo	1.6
101	Cisliano	1.4
102	Cassinetta di Lugagnano	1.3

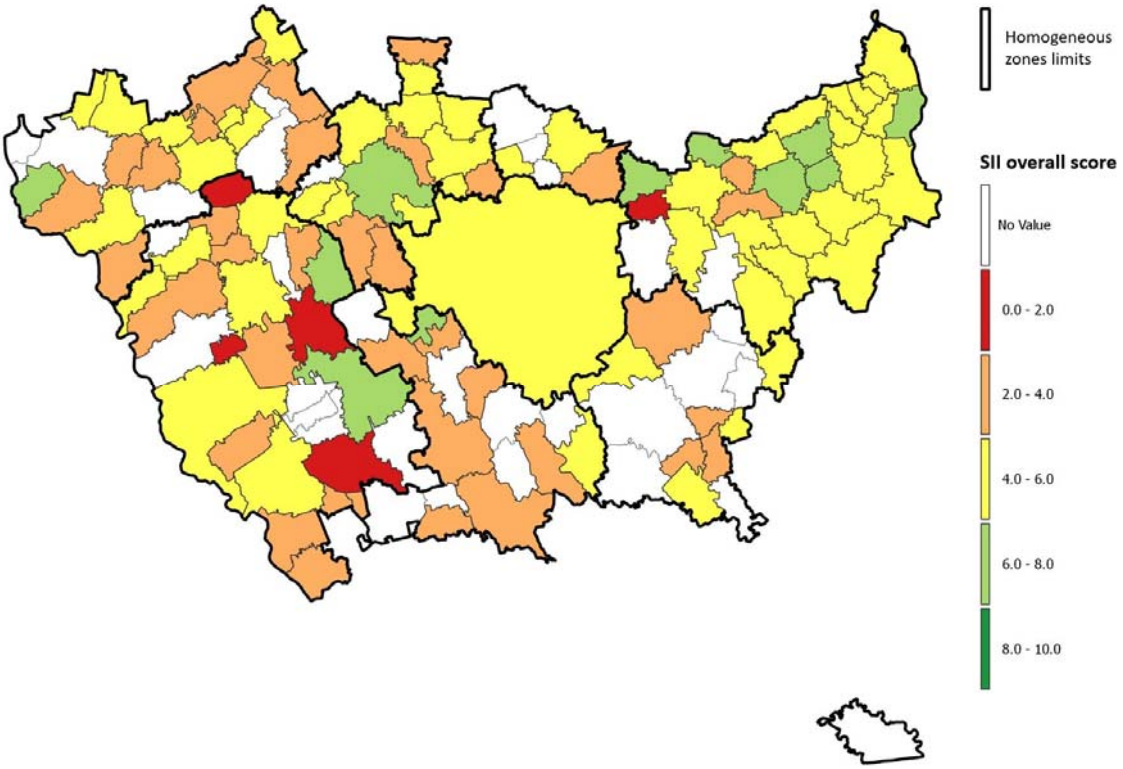

Figure SM1 – Thematic map of the scores obtained with the SII by the Municipalities in the Metropolitan City of Milan.

4. Sensitivity analysis methodology

Contrary to what is usually done in this kind of analysis, it was not possible to change only one parameter at a time: all the weights had to vary simultaneously to ensure their sum remained equal to one. For this reason, each category was associated to several sets of weights, each built by increasing the base weight of one of the criterions by 0.1, 0.2 or 0.3 and by applying a corresponding reduction to the weights of the remaining indicators. The sets were named after the indicator gaining relevance and associated to a +, a ++ or a +++ depending on the variation applied to the base weight. When not used as the starting set, a further case was added (stated as "uniform") attributing the same weight to all the category's indicators. Afterwards, the stability of the overall SII scores was verified by changing the categories' relative weights. The latter analysis was carried out applying the same method previously described, with the only difference that each category's weight could be incremented by 0.2 at most.

Table SM3 – Sets of weights for the "SEAP quality" category.

	SEAP quality		
	Data quality	SEAP level of detail	Diversification of areas of intervention
base	0.50	0.30	0.20
uniform	0.33	0.33	0.33
1.1data+	0.60	0.25	0.15
1.1data++	0.70	0.20	0.10
1.1data+++	0.80	0.15	0.05
1.2det+	0.45	0.40	0.15
1.2det++	0.40	0.50	0.10
1.2det+++	0.35	0.60	0.05
1.3div+	0.45	0.25	0.30
1.3div++	0.40	0.20	0.40
1.3div+++	0.35	0.15	0.50

Table SM4 – Sets of weights for the "Online information" category.

	Online information		
	Official documentation availability	Information on CoM and SEAP	Information accessibility
base	0.30	0.30	0.40
uniform	0.33	0.33	0.33
2.1doc+	0.40	0.25	0.35
2.1doc++	0.50	0.20	0.30
2.1doc+++	0.60	0.15	0.25
2.2info+	0.25	0.40	0.35
2.2info++	0.20	0.50	0.30
2.2info+++	0.15	0.60	0.25
2.3acc+	0.25	0.25	0.50
2.3acc++	0.20	0.20	0.60
2.3acc+++	0.15	0.15	0.70

Table SM5 – Sets of weights for the "Involvement" category.

	Involvement	
	Number of events organized	Typologies of target groups covered
base	0.50	0.50
3.1events+	0.60	0.40
3.1events++	0.70	0.30
3.1events+++	0.80	0.20
3.2typol+	0.40	0.60
3.2 typol ++	0.30	0.70
3.2 typol +++	0.20	0.80

Table SM6 – Sets of weights for the "Governance" category.

	Governance		
	Target ambition	Deadlines compliance	Involved personnel
base	0.20	0.40	0.40
uniform	0.33	0.33	0.33
4.1target+	0.30	0.35	0.35
4.1target++	0.40	0.30	0.30
4.1target+++	0.50	0.25	0.25
4.2deadline+	0.15	0.50	0.35
4.2deadline++	0.10	0.60	0.30
4.2deadline+++	0.05	0.70	0.25
4.3pers+	0.15	0.35	0.50
4.3pers++	0.10	0.30	0.60
4.3pers+++	0.05	0.25	0.70

Table SM7 – Sets of weights for the "Implementation effort" category.

	Implementation effort	
	Per capita expenditure	Ongoing actions
base	0.50	0.50
5.1exp+	0.60	0.40
5.1exp++	0.70	0.30
5.1exp+++	0.80	0.20
5.2actions+	0.40	0.60
5.2actions++	0.30	0.70
5.2actions+++	0.20	0.80

Table SM8 – Sets of weights for the "Performance" category.

	Performance		
	Emission reduction goal completion	Completed actions	Emissions reductions due to completed actions
base	0.30	0.30	0.40
uniform	0.33	0.33	0.33
6.1goal+	0.40	0.25	0.35
6.1goal++	0.50	0.20	0.30
6.1goal+++	0.60	0.15	0.25
6.2compl+	0.25	0.40	0.35
6.2compl++	0.20	0.50	0.30
6.2compl+++	0.15	0.60	0.25
6.3reduct+	0.30	0.20	0.50
6.3reduct++	0.20	0.20	0.60
6.3reduct+++	0.15	0.15	0.70

Table SM9 – Set of weights for the "Performance" category in its alternative version.

	Alternative performance	
	Completed actions	Emissions reduction goal completion due to completed actions
base	0.50	0.50
6.2compl+	0.60	0.40
6.2compl++	0.70	0.30
6.2compl+++	0.80	0.20
6.4reductbis+	0.40	0.60
6.4reductbis++	0.30	0.70
6.4reductbis+++	0.20	0.80

Table SM10 – Sets of weights for the sensitivity analysis on the overall index.

	SEAP Implementation Index					
	SEAP quality	Online info	Involvement	Governance	Implementation effort	Performance
base	0.20	0.10	0.10	0.20	0.20	0.20
uniform	0.17	0.17	0.17	0.17	0.17	0.17
1SEAP+	0.30	0.08	0.08	0.18	0.18	0.18
1SEAP++	0.40	0.06	0.06	0.16	0.16	0.16
2online+	0.18	0.20	0.08	0.18	0.18	0.18
2online++	0.16	0.30	0.06	0.16	0.16	0.16
3involvem+	0.18	0.08	0.20	0.18	0.18	0.18
3involvem++	0.16	0.06	0.30	0.16	0.16	0.16
4govern+	0.18	0.08	0.08	0.30	0.18	0.18
4govern++	0.16	0.06	0.06	0.40	0.16	0.16
5implem+	0.18	0.08	0.08	0.18	0.30	0.18
5implem++	0.16	0.06	0.06	0.16	0.40	0.16
6perform+	0.18	0.08	0.08	0.18	0.18	0.30
6perform++	0.16	0.06	0.06	0.16	0.16	0.40

To compute the overall variability of final results, given by the combination of the variations of the weight for both the indicators and the categories, we decided to focus only on the most significant combinations instead of testing all of them. To do so, the sets of weights for each indicator that would lead to the best and worse mean scores were selected for each category, as shown in the following table. The final evaluations have been obtained by using the weights for the categories that were already selected for the sensitivity analysis, for each of the three possible configurations of weights for the indicators (standard, max and min).

Table SM11 – Sets of weights leading to the best and worst final results.

Categories	Indicators	Indicators' weights		
		Base	Best	Worst
SEAP quality	Data quality	0.5	0.8	0.3
	SEAP level of detail	0.3	0.2	0.3
	Diversification of areas of intervention	0.2	0.1	0.3
Online information	Official documentation availability	0.3	0.6	0.2
	Information on CoM and SEAP	0.3	0.2	0.2
	Information accessibility	0.4	0.3	0.7
Involvement	Number of events organized	0.5	0.8	0.2
	Typologies of target groups covered	0.5	0.2	0.8
Governance	Target ambition	0.2	0.5	0.1
	Deadline compliance	0.4	0.3	0.3
	Involved personnel	0.4	0.3	0.7
Implementation effort	Per capita expenditure	0.5	0.2	0.8
	Ongoing actions	0.5	0.8	0.2
Performance	Emission reduction goal completion	0.3	0.6	0.2
	Completed actions	0.3	0.2	0.2
	Emissions reductions due to completed actions	0.4	0.3	0.7

5. Sensitivity analysis results

This section provides the results of the sensitivity analysis by showing the variations in the results when using different sets of weights.

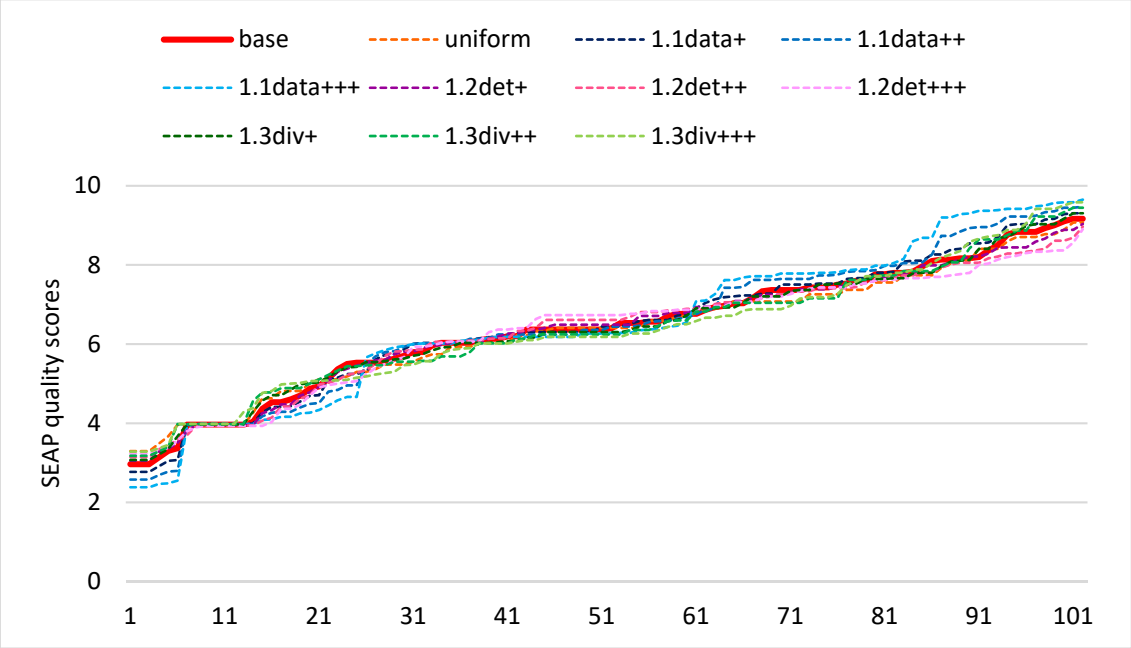

Figure SM2 – "SEAP quality" scores variations for the 102 Municipalities considered.

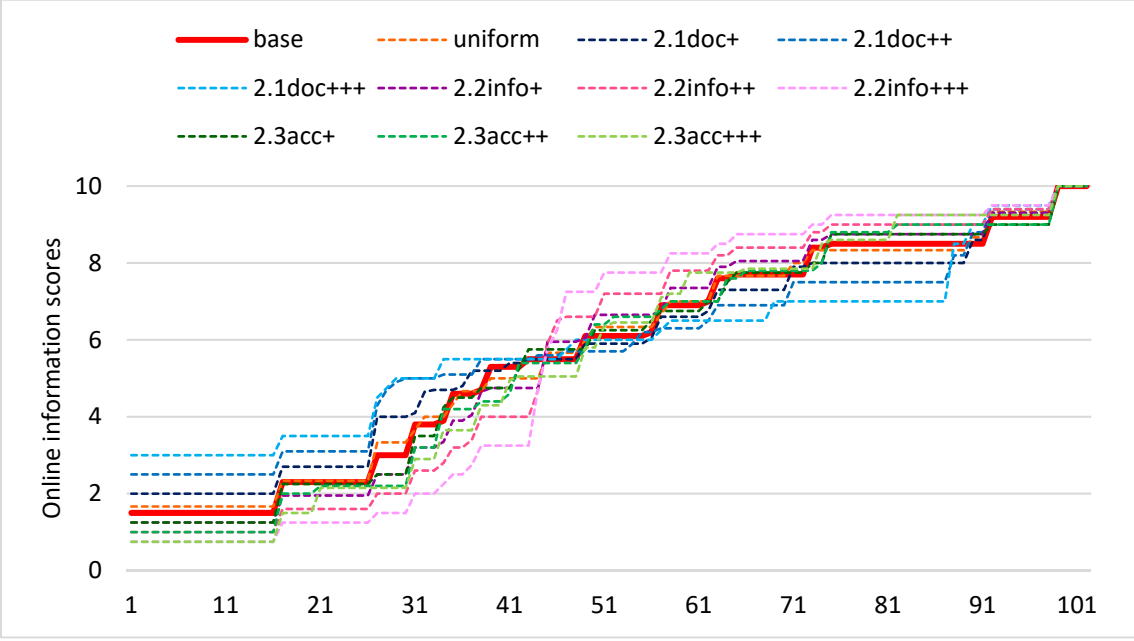

Figure SM3 – "Online information" scores variations for the 102 Municipalities considered.

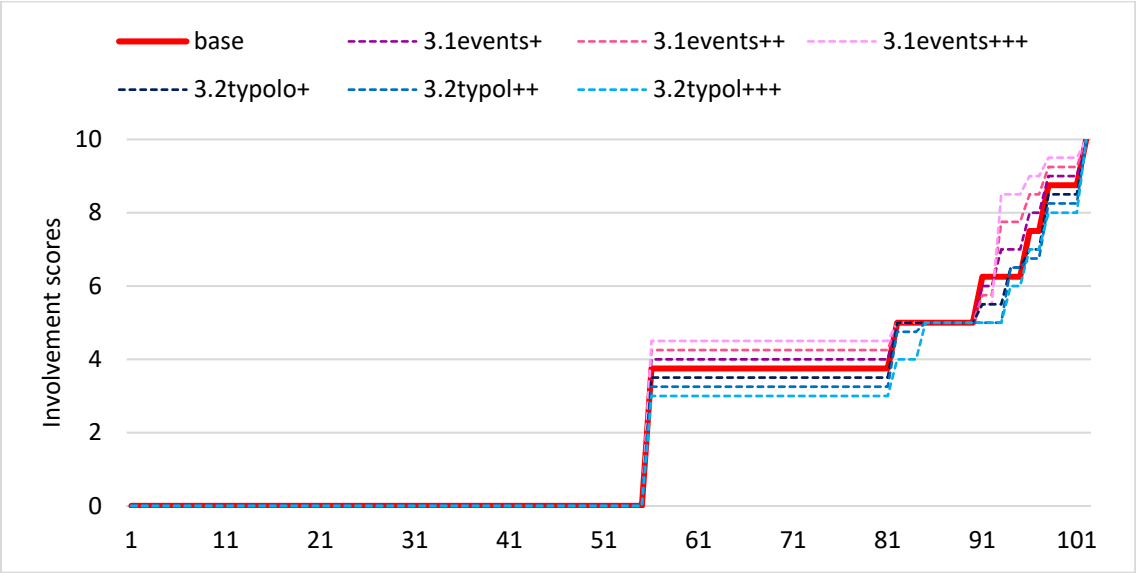

Figure SM4 – "Involvement" scores variations for the 102 Municipalities considered.

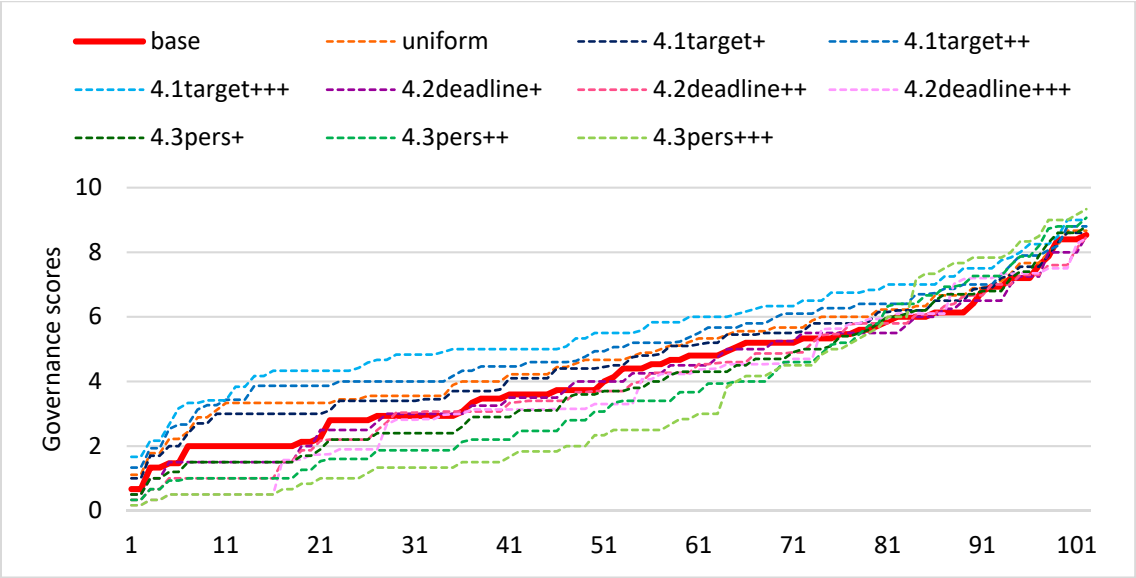

Figure SM5 – "Governance" scores variations for the 102 Municipalities considered.

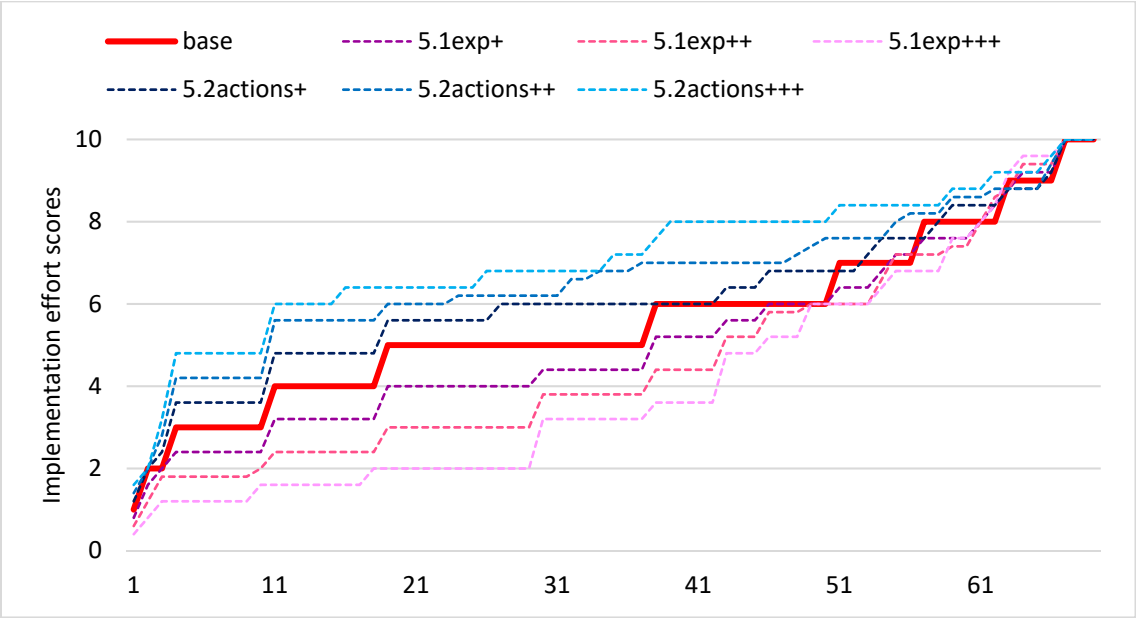

Figure SM6 – "Implementation effort" scores variations for the 69 Municipalities with a MEI.

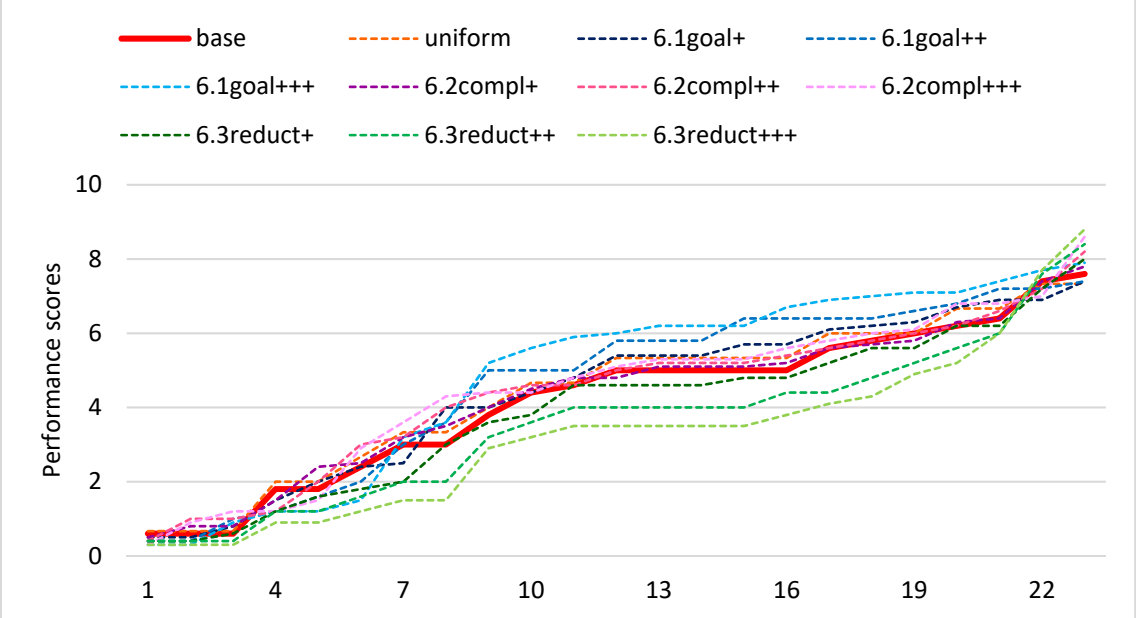

Figure SM7 – "Performance" scores variations for the 23 Municipalities with a MEI.

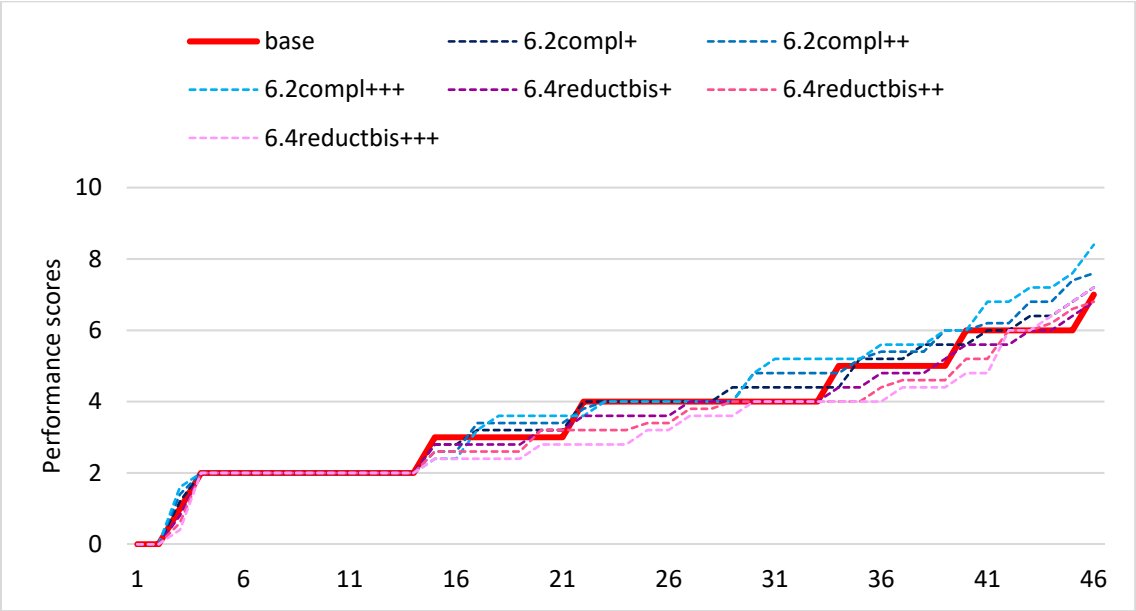

Figure SM8 – Scores variations for the "Performance" category in its alternative form, for the 46 Municipalities without a MEI.

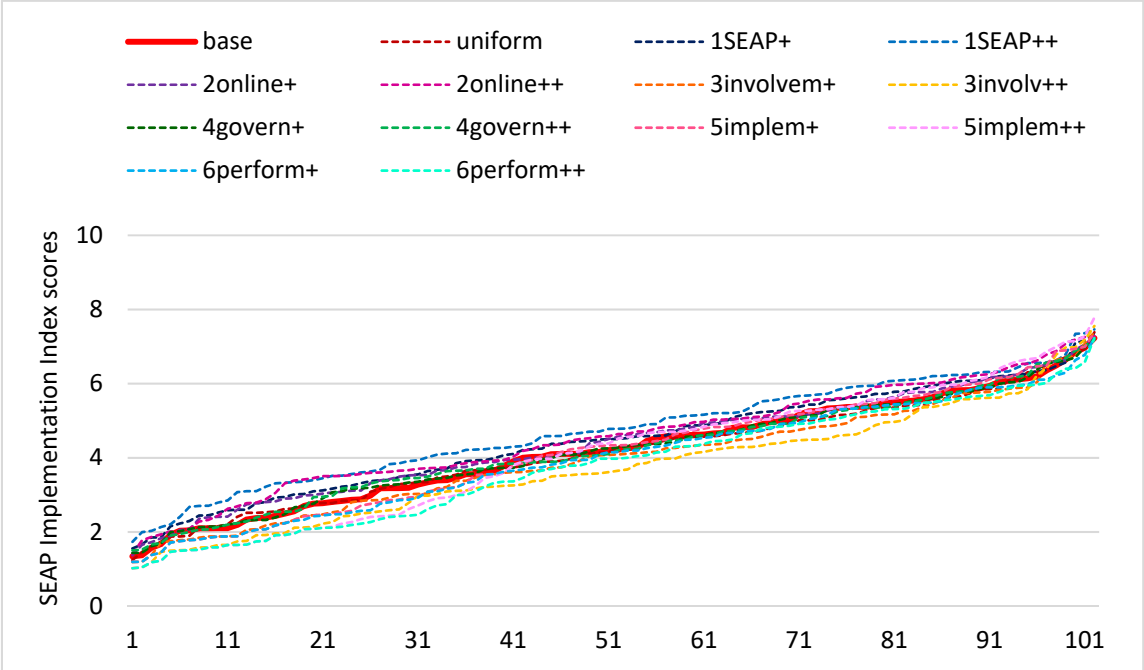

Figure SM9 –SEAP Implementation Index scores variations for the 102 Municipalities within the sample