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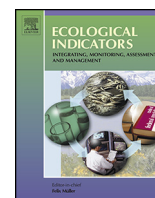
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Sustainability indicators: A tool to generate learning and adaptation in sustainable urban development



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ABSTRACT

The pursuit of sustainable development as an adaptive process of learning-by-doing may benefit from using sustainability indicators (SIs). Nevertheless, adaptive governance may demand more from SIs than what these indicators can currently deliver. In response, we identify three conditioning factors for SIs to indeed support processes of adaptive governance in pursuing urban sustainability. These conditions relate to the accessibility and understandability of SIs, their focus on policy performance and trend watching, and finally, whether they are being discussed both within and outside government authorities. We empirically provide further grounding for the relevance of these conditions and identify how they relate to existing practices working with SIs. We targeted six urban practices in four countries (Belgium, Denmark, the Netherlands and the USA) with advanced experience in sustainable development policies and SIs. These practices confirm the relevance of each condition and show evidence of how they might be operationalized in practice. However, confirmation and evidence are largely implicit and based on isolated examples. Hence, we conclude that there is a lack of explicit recognition and, in its wake, a lack of structured attempts at embedding SIs in urban governance for supporting processes of learning and policy adaptation.

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1. Introduction

This paper questions how sustainability indicators (SIs) might become effective tools in supporting adaptive governance. The paper understands the pursuit of sustainable development as an adaptive process of learning-by-doing, and subsequently argues that the role of SIs may be relevant in supporting this process. Rather than being mere tools to measure assumed 'degrees of sustainability', SIs can be important for informing processes of learning and adaptation. The paper proposes that SIs have the potential to be important tools in the governance of urban sustainability by helping planners and policymakers to learn about ongoing trends, successes and failures in their policies, and to respond to changing desires and priorities among their constituents.

The development of SIs began with the intention of showing progress in achieving sustainability ambitions and gaining an overview of the state of a city's environment (e.g., Hamilton and Atkinson, 1996). As such, SIs were directly linked to possibilities to operationalize and define sustainable development. After

being introduced into mainstream governance debates, sustainable development was first promoted as a long-term policy goal that allows the balancing of economic, social and environmental ambitions in a holistic strategy. In spite of this, the optimism that surrounded sustainable development during the early 1990s has faded somewhat. Even in the 1990s, sustainable development attracted criticism for being too vague and abstract to have a practical meaning (Richardson, 1997). Hence, sustainable development proved difficult to put into practice (Briassoulis, 1999; Jordan, 2008) and made the use of SIs in measuring the progress of sustainable development similarly problematic. Since then there has been a reframing of sustainable development. Instead of being considered as a static long-term goal to be pursued in a linear fashion, sustainable development was proposed as a more general direction for inspiring change via an adaptive process of learning-by-doing (Ahern, 2011; Carpenter et al., 2001; Folke et al., 2002; Walker and Holling 2004). Rather than defining the precise meaning of sustainable development, the phrase would instead provide a more general direction for evaluating and adjusting policies, plans and eventually, urban structures and functions.

Seeing sustainable development as a process of learning-by-doing resonates with debates on uncertainty and complexity that have found their way into planning and policy sciences (e.g., Connick and Innes 2003; De Roo and Silva, 2012; Innes and Booher

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2000). We tap into these debates by highlighting the complex and thus unpredictable processes of change that affect governance and its capacity to pursue societal ambitions (de Roo, 2012). Non-linearity and more general debates in the complexity sciences have helped policymakers to understand why the future cannot be fully controlled. These debates reveal that uncertainties are not just the result of a limited ability to fully grasp the many interrelated processes in society and our physical environment. Rather, the complexity sciences show us a world in a constant state of 'flux' where even complete knowledge would not result in clarity regarding the exact trajectories of change. The complexity sciences have forced planners and policy scientists to accept that, to a certain degree, governance will always have to be adaptive if it is to cope with these uncertain trajectories of change (e.g., de Roo and Porter, 2012; Folke et al., 2002).

Adaptive governance emphasizes a flexible, experimental and adaptive process of governance (Duit et al., 2010; Holling, 1978; Lee, 1999). As such, adaptive governance moves beyond a linear process of policy interventions intended to achieve predetermined policy objectives. Instead, the idea is for policies and their supportive regulatory or institutional frameworks to be continuously adapted to newly emerging knowledge or circumstances. Therefore, a central element within debates on adaptive governance is learning. This learning can follow not only from a keen monitoring of ongoing societal and physical developments, but also from evaluating the effects of common or experimental policy interventions. Having access to timely, relevant and clear information is an obvious requirement for such learning and thus for adaptive governance. Although we certainly acknowledge that adaptive governance moves far beyond a need for timely, relevant and clear information, here, we will specifically target this requirement while focusing on SIs.

The aim of this paper is to identify and empirically assess the conditions needed for SIs to support processes of adaptive governance in the pursuit of urban sustainability. Thus far, the literature has provided few specifications and little empirical grounding for how SIs might support adaptive governance. Therefore, the first step is to use existing academic work on SIs and adaptive governance to identify if and how SIs can be used to support adaptive governance for urban sustainability. Reflection on these academic debates has led to the identification of three key conditioning factors for SIs to indeed support processes of adaptive governance in the pursuit of urban sustainability (as explained in section two). Subsequently, the paper empirically assesses how a selection of existing cities and regions currently manage these conditioning factors with the goal of providing further grounding for the relevance of these conditions. In section three, the paper investigates six case studies in four countries where work on urban sustainability is relatively advanced: Belgium, Denmark, the Netherlands and the United States. Section four discusses the main results of the study. In section five, there is a reflection on the potential for SIs to inform processes of learning and adaptation. The paper then concludes by returning to the value of the previously identified conditioning factors.

2. A role for SIs

SIs were developed during the 1990s with the ambition to "provide a solid basis for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems" (UN, 1992 p.346). This 'solid basis,' as Hamilton and Atkinson (1996) also explain, meant that indicators would show progress in achieving sustainability targets and inform decision-makers as well as the public about the current state of a city's or region's environment in a suitable and policy-relevant

manner. Nevertheless, the initial development of SIs remained predominantly expert-driven and focused largely on the technical design of indicators (e.g., Bossel 1999; Bell and Morse, 1999; Mitchell 1996; Spangenberg, 2002). The result was the production of standalone databases of SIs that often had no explicit link to local policies (e.g., Bell and Morse, 2001). Rather than being the desired 'solid basis,' SIs became marginalized for being too technical and largely irrelevant for use in urban governance (Pires, 2011).

The strong focus on the technical design of indicators led to several studies on SIs in the second half of the 1990s highlighting the need to link SIs and urban governance (Bell and Morse, 2001; Hezri, 2004, 2006; Lehtonen, 2012; Rosenström, 2006; The Pastille Consortium, 2002). A first logical step was to improve this link and to ensure that SIs were actually comprehensible and considered relevant by their envisioned users (Rosenström, 2006; Shields et al., 2002). Several studies subsequently emphasized that SIs should be directly connected to existing policies and the process of developing new policies. If SIs could provide information directly linked to such policies then they could potentially function as a relevant and useful basis for more effective decision-making and for reviews of policy performance (Bell and Morse 2001; Brugmann 1997; Singh et al., 2012). Other studies argued that SIs should not just be relevant and comprehensible for administrators and governmental parties, but should also inform alternative stakeholders and the general public on progress towards sustainable development objectives. This argument followed the idea that governments are increasingly forced to rely on the participation of multiple societal groups and stakeholders to make decisions (e.g., Jordan et al., 2000; Lemos and Agrawal 2006). SIs should therefore see all these groups and stakeholders as their potential users. If well-designed, the argument continued, SIs could even be tools to help engage stakeholders by providing policy relevant and expert-driven information for societal debates over policy agendas and objectives (Shields et al., 2002). The result, as Bauler (2012) states, is that "in order to become consistently influential, indicators need to be perceived simultaneously – consensually – by a group of policy actors as being legitimate, credible and salient" (p.40). Heink et al. (2015) explains legitimacy as meaning 'acceptability' or 'perceived fairness' and credibility as referring to the truthfulness of information, i.e. validity, consistency and quality of data. Therefore, well-designed SIs are not only constructed to be relevant or considered salient to stakeholders, but also to have legitimacy, be accepted as fair and to be considered credible and trustworthy. SIs can be made more salient and credible if they are presented with relevant information and a comprehensive explanation. Accessibility can also help to verify and enhance the perceived fairness and legitimacy of the indicators. This reasoning results in a first, and perhaps predictable, conditioning factor: if SIs are to be used to support learning in urban governance, then they should be accessible, comprehensible and considered relevant by both governmental and non-governmental parties.

2.1. Adaptive governance

The rise of debates on adaptive forms of governance urges us to move beyond this first and almost obvious condition factor. Underlying adaptive governance is the acceptance that change is not only inevitable but also only partially predictable. As Beck (2006) explains, surprises are inevitable in a world of continuous and non-linear change. To a certain extent we know that we can expect surprises, mostly because we have gained awareness of what we do not yet know, which Beck calls 'known unknowns'. However, we often lack awareness of the kind of surprises we might face, which Beck calls 'unknown unknowns'. Consequently, planners and policy scientists have come to accept that governance must always be

adaptive to a certain degree if it is to cope with these uncertainties (e.g., de Roo, 2012; Folke et al., 2002).

Adaptive governance means that policies and their supportive regulatory or institutional frameworks should be continuously adapted in light of newly emerging knowledge or circumstances. A first key strategy in implementing adaptive governance is to increase the ‘adaptive capacity’ of our policies, regulations and institutions. Adaptive capacity refers to the capability or potential of, in this case, governance systems to change their own characteristics or behaviors in the face of existing or future stresses put on the system (Pahl-Wostl, 2009). Adaptive capacity aims to avoid policies and regulations developed in the ‘here and now’ that create ‘path dependency’, i.e., where past choices frustrate future attempts to change course (e.g., Pahl-Wostl, 2009). A good example of path-dependency has been the construction of car-dependent urban districts. Such policy transforms an urban area into a low-density one, where there are long distances between lands with different functions of land-use. This makes alternatives to the car, such as biking or walking, problematic as they are compromised by long distances and public transport that is financially difficult in low-density districts. Hence, any shift away from the current reliance on cars is compromised by what cars made possible in the first place. In the face of path dependency, adding flexibility to policies, regulations and institutions becomes a strategy to increase the adaptive capacity of those policies and institutions (e.g., Gunderson and Holling 2002). However, simply ‘adding’ such flexibility will not be sufficient to create a truly adaptive policy.

To begin with a more reactive point of view, adaptive capacity involves the capacity to identify changing circumstances and respond to them. Hence, the literature on adaptive governance highlights the need to constantly monitor changes taking place in order to continuously allow for critical reflections on the assumptions underlying policies (e.g., Swanson et al., 2010; Walker et al., 2010, 2001; Walker and Marchau, 2003). After all, as McCray et al. (2010) explained, “Over time, things change. Science evolves, technology advances, and implementation costs migrate, so assumptions that were once reasonable can become much less supportable” (p.952). Hence, the idea is to have timely and clear information that allows policymakers to identify changes. SIs can play a key role in providing such information, but as this paper argues, not without being both policy-relevant *and* able to identify surprises. These two requirements do not occur naturally, however, which leads to a second conditioning factor.

To improve the linkage between SIs and (urban) governance, SIs were considered most relevant if linked directly to existing policy agendas. While this can certainly help increase the relevance of SIs for existing governance agendas, such direct linkages can also reinforce processes of path dependency. SIs used solely in formalized policy review processes tend to focus only on the performance of existing policies and the challenges that these policies have identified. Learning can be amongst the outcomes, such as when reflecting on policy performance and whether existing assumptions about performance are justified. An example of this type of learning outcome would be in the use of indicators to establish whether a target for 20% of total energy consumption based on renewables has been met. If the performance is found to be 17% then the policies may still be seen as positive, although it may lead to the questioning of the existing assumptions about performance. There may have been intervening variables, the targets may have been too ambitious or there may have been an overestimation of the policy instruments used. Hence, it goes beyond simply measuring if targets are met (conformance) and instead assesses whether the policy interventions have contributed to the desired aims (performance) and thus, whether they or even the ambitions still ‘make sense’. Despite looking beyond mere conformance, SIs that are focused on policy reviews might not be able to grasp contextual developments

that were not part of existing policy agendas. Surprises, trends, contextual changes and unanticipated events might be identified, but such identification is not evident if it does not relate to existing policy agendas. For example, if the policies do not address the urban heat island effect then the indicators used may also be unable to capture whether this effect is getting worse and how it might affect related issues such as smog, health or biodiversity. Alternatively, imagine a policy seeking to reduce household energy use by improving insulation. If SIs only focus on the amount of houses insulated and the amount of heat consumed in houses, perhaps based on natural gas usage, other factors might be missed. After all, what if improved insulation triggers the increased use of air-conditioning, which depends on electricity use? It may well be that overall energy use does not decline and even increases. Measuring more than just the policy focus, such as overall household energy use or CO₂ emissions, is crucial to answer these questions and helps to reflect on how policies perform. In other words, focusing on existing policies alone may overlook processes of change and surprise elements that fall outside current policy targets (e.g., Walker et al., 2010; Walker and Marchau, 2003).

Increasing awareness of contextual changes may help to identify unexpected changes. Hence, the paper argues that SIs should focus on more than just formal policy review. SIs should instead take a broader perspective and continue to follow more general trends. This approach opens up more opportunities to enhance contextual awareness and thus identify surprises or intervening circumstances influencing policy performance. As Dahl (2012) also finds, responding to constantly changing conditions has prompted a need for SIs to help planners and policymakers capture the dynamics of ongoing changes and trends, and map the trajectories of important social and environmental developments. These ‘trends’ are described as movements in environmental, social and economic parameters, such as pollution levels, energy consumption, poverty, education, etc. (Dahl, 2012). SIs can help identify ‘trends’ that the policies need not directly address, but that do bear relevance in learning about the overall progress towards a more sustainable future.

SIs are connected to existing policies and this may mean that they also play an important role in avoiding a policy bias towards social or economic development. Environmental priorities tend to have a relatively ‘weak profile’ compared to more development-oriented priorities (e.g., Zuidema, 2011). They can be less tangible, as is the case for air pollution and stress from noise nuisance, or may have a long time horizon that can be difficult to balance with short term economic or welfare benefits. SIs can ideally help to maintain this balance by providing information on possible improved or degraded environmental conditions. In this regard, SIs could help to ensure that the ecological or environmental dimension remains a central element in policy. Giving first priority to ecological trends and having SIs connected to both short-term operational policies and long-term strategies can help planners and policymakers reflect on whether their policies do indeed lead to urban sustainability.

When taking a more proactive approach to the process of learning in adaptive governance, policy interventions can also be described as experiments triggering learning and debate (Ahern 2011; Carpenter et al., 2001; Folke et al., 2002; Walker and Holling 2004). Learning is thus not based only on a process of lessons taken from policy review, but is also drawn from the insights that are derived from experimental work. In Pahl-Wostl’s (2006) words, “dynamic hypotheses guide reasoning and structured argumentation” (p. 51). Adaptive governance therefore shifts the attention to the role of policy interventions as experiments to trigger an enhanced understanding of how planners and policymakers might better intervene given existing urban dynamics. Policy interventions are then also viewed as experiments for producing a better understanding of the issues faced and the policies that might help

alleviate them (Gunderson, 1999; Pahl-Wostl, 2006). The triangulation of various indicators is essential to enhance reflections on policy performance and trigger learning in the face of sustainable development, which is particularly important in such an experimental context. The result is that SIs should ideally address both the performance of established policies and related interventions, and sustainability trends more generally. This leads to a second conditioning factor for SIs to become tools for informing processes of learning and adaptation in urban governance: a focus on both policy performance and more general trends is advisable.

2.2. Learning as communicative practice

Learning itself is not a self-evident outcome of collecting timely, relevant and clear information, even if this information addresses both policy performance and more general trends or is based on experimental work. Learning depends on what Keen et al. (2005) describe as “a process of iterative reflection that occurs when we share our experiences, ideas and environments with others” (p. 9). It is through communicating and sharing information and interpretations among different groups in society that the processes of learning take place. Information in general and SIs in particular can be used for motivating dialog between different actors in order to negotiate an understanding of what the information actually means and how it relates to alternative local interests (Armitage et al., 2008; Reed et al., 2010). Analysis and discussion are needed to value information and translate it into local contexts to determine how a policy should be adjusted and adapted (Swanson et al., 2010).

The importance of communicating and sharing information shifts our focus to learning being embedded in a wider process of urban governance. This involves the ability of different authorities, experts, interest groups and the public to support learning processes. In other words, a process of cross-departmental debate within governments and the wider process of decision-making in urban governing, including non-governmental groups, must take place (Bevir, 2013; Jordan, 2008; Lemos and Agrawal, 2006; Murphy, 2000). Learning can be seen as a societal process resonating with the idea of social learning, which stresses the necessity of the social interactions of participants and their roles in negotiating common solutions that make sense under locally specific circumstances (Dlouhá et al., 2013; Wals, 2007). Learning processes therefore involve the processes of communication and discussion among different groups of stakeholders in order to recognize and understand the information delivered by the indicators. It is in the processes of sense making, interpreting and creating common understandings that the paper suggests SIs can become an important tool. In other words, SIs can be used as tools for providing a common language or benchmark for debate and can improve the factual basis of discussion and communication among stakeholders (Rosenström and Lyytimäki, 2006). If SIs are indeed to become tools for informing processes of learning and adaptation in urban governance, it is also advisable that they allow for usage outside of the confines of governmental institutions alone. The third condition factor therefore suggests that SIs should not only be used in the confines of formal government but also in wider societal debates.

At this point, the paper has outlined and described three conducting factors for using SIs to inform processes of learning and adaptation in urban governance. The result is that SIs must first be accessible and comprehensible for their users, either in terms of policy performance or sustainability trends (as summarized in Fig. 1). SIs should then ideally target existing policies to help reflect on policy performance as well as more general sustainability trends to further contextualize such reflections. Perceiving policy interventions as experiments that require the triangulation of indicators is an important process in stimulating learning. However, learning itself also necessitates a process of communicating and

sharing information between alternative governmental and non-governmental groups.

3. Study design

The next question to pose is whether the conducting factors identified are also recognized in urban practice. The focus here is on assessing the likelihood of SIs being used to inform processes of learning and adaptation in urban governance and whether the identified conducting factors also make sense in practice. Therefore, the empirical investigation aims to explore this further by comparing existing practices surrounding SIs in cities and urban regions with the condition factors identified.

The paper deliberately chose to study cities and regions that have more than three years of experience in using SIs. This choice allows the research to also analyze how SIs have influenced urban governance over time. The cities and regions were selected by focusing on countries that already have well-elaborated policies on pursuing sustainable development in urban areas. The majority of cases were chosen from the Netherlands (the municipalities of Rotterdam and Haarlemmermeer and the province of Overijssel) and Belgium (the Flemish City Monitor) for practical reasons of both language and distance. To avoid a specific political-administrative bias we also decided to study the Danish Green Cities initiative involving six very different Danish towns and cities (Alberton, Allerød, Ballerup, Herning, Kolding and Copenhagen) and, finally, one case in the United States (the San Francisco Sustainable Communities Index, or SCI). Diverse examples were deliberately identified to gain a wider understanding of alternative ways of using SIs in urban governance.

Two cases consisting of associations of cities that explicitly developed SIs together were chosen: the City Monitor in Flanders (thirteen cities) and the Green Cities initiative in Denmark (six cities). Both cases focused on comparing cities, which may trigger political influence and learning between cities. Three distinct cities that developed SIs in relation to their own policy agendas, and may therefore have a keener focus on policy performance, were also chosen: San Francisco, USA (840,000 inhabitants), Rotterdam, NL (620,000 inhabitants) and Haarlemmermeer, NL (150,000 inhabitants). To complete the study, one province was also chosen: Overijssel, NL (1.1 million inhabitants). The reason for choosing a province was because, in a Dutch or Flemish context, provinces also address issues such as traffic, biodiversity, water quality and energy that have direct influences on urban sustainability.

The empirical work began by analyzing relevant policy reports, websites, research reports and media reports related to the cases studied. Semi-structured interviews were then conducted with policy officers working on developing or using SIs in urban governance. These interviews were conducted face to face, by phone and by exchanging emails.

The focus was first on how the indicators were designed and presented. The main purpose was to assess whether the SIs were indeed accessible and easy to understand. The analysis specifically addressed online availability, the use of jargon, visualization techniques, reporting to the general public and media reports.

Second, the SIs were examined in terms of how they are used and positioned in urban governance debates with regards to their focus on either or both policy performance and general sustainability trends. On the one hand, the paper wanted to see how SIs were used to report on the performance of policies. We addressed how SIs were connected to either (or both) operational and strategic policies, and whether they were explicitly used for evaluating successes and failures of policy performance. In doing so, the means of reporting SIs, existing connections between SI databases and governmental practices, and whether SIs were also used in a wider

Condition 1 SIs are accessible and comprehensible	Condition 2 SIs are used for monitoring policy performance and trends	Condition 3 SIs are used for supporting discussion and communication
Representing sustainability trends	Monitoring sustainability trends	Understanding changes
Representing policy performance	Monitoring policy performance	Understanding policy performance

Fig. 1. Three proposed conditions for SIs to generate learning processes.

process of learning from more experimental policy interventions were addressed. On the other hand, the paper studied if and how SIs were used to keep track of more general trends not directly connected to policy agendas. As part of this, the paper also investigated if the knowledge gained is indeed used in a wider process of reflecting on policy agendas.

Finally, the paper investigated how SIs are used in the process of urban governance with a focus on their role in governmental and societal debates. We specifically searched for mechanisms used for supporting and facilitating political and societal debates based on SI data. We also aimed to identify projects, debates or policy processes in which a wider societal debate took place that was at least partly influenced by SIs.

4. SIs in practice

4.1. Design and presentation of SIs

The six cases studied all presented their SIs on websites designed specifically for SIs or in open access policy reports. Four chose to use a website for presenting their SIs, often with a user-friendly and interactive interface, e.g., Overijssel,¹ the City Monitor,² Green Cities,³ and the SCI (SF open data)⁴ In all these cases, more detailed information about distinct indicators is supported by various policy reports, or in the case of City Monitor, a fairly extensive explanation of the indicators and their intentions. These supportive reports and explanations not only help to identify existing governmental policies, but also provide more general overviews that help to interpret the data presented on websites. This help is especially needed in the cases of the City Monitor and SCI as they both have rather extensive lists of indicators that are sometimes presented in great detail. Although detail can be highly relevant in specific cases, it does not always ease the use of websites in relation to gaining a quick and clear overview of a specific trend or of the progress made in reaching policy objectives. In the case of Green Cities, specific cases are also identified where they are currently experimenting with new ambitions and policies. Search engines are also used to support users, such as in the case of the SCI. All four cases further support the user by categorizing their indicators in specific clusters, such as energy, nature, economy, crime, education, etc.

Rotterdam and Haarlemmermeer have no distinct website to support the presentation of their indicators. Rotterdam provides a fairly complete overview in PDF format on a website for its Climate Initiative,⁵ where indicators are partly discussed in the text and partly presented in tables and graphs. Although this supports users in interpreting the data and linking trends to existing policy targets, the lack of a search engine or an easily accessible website does diminish the capacity of users to quickly find information. Haarlemmermeer has chosen to report specifically in yearly

reports. Although these are accessible online, finding them typically requires inside information regarding their website and policies or the use of common Internet search engines. Much like Rotterdam, data are presented in the general text and through the use of tables and graphs.

Jargon is usually avoided, although the reports of Rotterdam and Haarlemmermeer can be difficult for lay people to easily understand or use. This is especially problematic in the case of SCI where zip files that present data in shapefiles can be downloaded, but require specific software for geographical information systems (GIS). This makes their use by lay people impractical if not virtually impossible. Consequently, the SCI search engine seems to be useful only for experts. In all other cases the possible difficulties in browsing through the sometimes detailed information is counterbalanced with the use of tables to summarize outcomes and graphs to spot trends.

4.2. The focus of SIs: policies and trends

Explicit attempts to develop and use indicators to combine SIs to reflect on policy performance and trend watching were very limited. Nevertheless, all the cases did allow for such combinations to a certain extent, albeit in a more implicit sense. The differences between the different indicator systems, however, were large and thus showed significant variation in both the possibilities and mechanisms allowing for such combinations.

Rotterdam was the only example of a conscious choice to focus on both policy performance and general trends. Nevertheless, it was also evident that SIs in Rotterdam are mainly used for monitoring policy performance. The city annually reports on the policy performance of ten sustainability tasks related to the city's needs and its ambitions for sustainable development. Each of these tasks is translated into a set of indicators to measure progress. Some of the indicators are focused on measuring the number of new activities started, such as promoting green mobility and transport or recharging stations for electric vehicles. Other indicators focus on measuring progress towards clearly set objectives, such as the numbers of green vehicles, green kilometers travelled and liters of biofuels. This does carry the risk of creating the kind of 'path dependence' mentioned earlier, where the SIs are only designed to reflect on existing policy ambitions and to test if the assumed progress takes place. Rotterdam, however, also developed a 'transition monitor', which provides a more general view of whether the city is on the right track towards sustainability (Sustainable 2010–2014 Program Agency/City of Rotterdam, 2012). The 'transition monitor' is, in principle, exactly the kind of tool that can help contextualize the outcomes of specific policy related indicators and triangulation; however, it only monitors changes in CO₂ emissions in the mobility, industry, household, working and energy sectors. Although such a monitor does help to reflect on the effects of existing policies, it covers only a small part of what might be considered sustainable development. This can also be linked to Rotterdam's intention, which is to focus specifically on climate change mitigation and adaptation. In the meantime, Rotterdam does explicitly show awareness of the need for triangulation between indicators.

¹ <http://www.monitoroverijssel.nl/>

² <http://www.stadsmonitor.be/over-de-stadsmonitor>

³ <http://www.greencities.dk/>

⁴ <https://data.sfgov.org/>

⁵ <http://www.rotterdamclimateinitiative.nl/>

For example, the city noticed that CO₂ emission per KW/h shifted from the expected downward trend in 2012 to an upward movement. In searching for an explanation, Rotterdam found a reduced use of heat pumps. This subsequently led to closer investigations that discovered lower gas prices explained this reduced use.

Overijssel, Haarlemmermeer and Green cities are other cases that explicitly focus on policy performance. This focus on policy performance is most explicit in Overijssel, as a government administrator explained: *“Indicators have been linked to every level of the plans, from the highly normative strategic plan to the practical action plan. The politicians are cautious in spending budgets and also monitor in detail the progress of the action plans”*. In Overijssel,⁶ every practical target is reported on with regard to the degree to which it has already been met. This implies learning does take place. On the one hand, such learning can relate directly to the success or failure of policies as SIs are directly linked to them. To illustrate this, *“The agricultural area of Overijssel is highly important for keeping our regional economy going; therefore, indicators were set to watch over the quality of soil. After monitoring, we encountered disappointing results. In response, new policies were developed that were directly inspired by the reasons we identified for causing the disappointing results encountered”* (translation by authors). On the other hand, in focusing on more strategic policy ambitions, there is an implicit focus on wider trends. As discussed during the interviews, SIs are used to measure things as diverse as the percentage of green energy users, the perceived social cohesion, sustainable mobility and educational output, although these are not always directly translated into clear policy targets. As a result, SIs are used in ways that could allow them to be witnesses and responders to change and surprise. Although we could not identify clear examples in Overijssel, we did find examples in Haarlemmermeer that showed an even stronger focus on combining strategic and operational policies.

For Haarlemmermeer, the SIs have a clear double agenda in trying to *“measure how Haarlemmermeer scores on issues related to sustainability. (...) In addition, the monitoring system allows us to report on the results of our policies and programs and assess whether we are achieving our goals”*. Most of the indicators in Haarlemmermeer are linked to their strategic policies, which address the triple objectives of people, planet and profit (Gemeente Haarlemmermeer, 2012). As a consequence, the indicators used are also more general in nature and measure things such as the amount of CO₂ emissions (planet), the number of new companies (profit) or jobs created (people). More operational targets in Haarlemmermeer are defined in so-called innovation projects ranging from wind parks to new forms of asphalt, as well as raising environmental awareness among school children and building charging stations for electric cars. More detailed measurements are taken within the confines of individual projects. It is in reporting on both the progress made in these individual projects and performance on more strategic policy agendas that Haarlemmermeer may well triangulate and learn about new emerging trends or challenges. Although our interviews could not confirm explicit plans to do so, their yearly reports (e.g., Gemeente Haarlemmermeer, 2014) did show some evidence of this. For example, the reduced use of natural gas among households is discussed not just in relation to a project on improved insulation but also with regard to decreased gas use due to the economic downturn and related national trends, which Haarlemmermeer uses to reflect on its overall gas usage.

The Green Cities initiative stays close to the example of Haarlemmermeer by also having indicators linked to more strategic policies and having distinct projects in cities where progress is monitored by focusing on specific targets. For example, on the topic of ‘green

transportation’ the share of people cycling or using public transportation is used as an indicator to reflect on the strategic ambition for all cities to have a 25% share of people using green transportation by 2020. Indicators focus on distances commuted within the city by both car and bike, although there is also a specific indicator only used for reporting on a project in the city of Ballerup regarding the lending of electric bikes. The initiative shows added value compared to other cases in its focus on benchmarking. Not only are all strategically oriented indicators presented by continuously comparing cities on eight selected topics, i.e., energy, nature, air, noise, materials, soil and groundwater, and the two interdisciplinary fields of planning and anchoring; but the cities also meet regularly at the level of both administrators and politicians. These meetings provide them with an arena to discuss progress, differences in successes between cities, and the success or failure of specific projects. Benchmarking, combined with frequent debates among cities, is thus also a mechanism to allow for reflection on progress towards sustainability. Nevertheless, reflexive learning based on comparing indicators to trends and policy performance is facilitated only by this more implicit process of debate.

In the cases of the Flemish City Monitor and the SCI, indicators are not explicitly linked to governmental policies. The SCI also generates a more general picture. It was initially created as a tool for developing and evaluating land use plans and only later became a more general sustainability index for the city. Despite its potential and ambition to become a supporting tool for policy making and monitoring, its link with the process of policy making remains ill-defined. In regard to land use planning, as explained by our respondent, the SCI does play an important role: *“We still continue to use the indicators to do a baseline area analysis for specific development projects, so as to inform the Planning Department about key things to consider in their plan”*. Nevertheless, the SCI is rarely used as a monitoring system, even in supporting land use planning, which undermines its potential as a tool to support learning processes. This is different from the City Monitor. Although, as our respondent in Kortrijk explained, *“The City Monitor is used to tell us how ‘healthy’ the city is”*, this knowledge also plays a role in policy practice. As our respondent in Ghent explained, *“The City Monitor may indicate the extent to which targets are met (degree of goal achievement). It may constitute an important source of data for evaluating if the environment indicators correspond to the evaluation questions”*. The City Monitor was also explicitly developed with the help of over one hundred experts from participating cities with the intention of creating a more general source of information for social, administrative and political debates. This is supported by the Flemish regional government’s frequent reports on the status of its 13 core cities. The City Monitor is therefore not an isolated and hidden database and, consequently, does provide input to administrators and politicians. In doing so, it also provides input for agenda setting as explained by our respondent from the city of Ghent: *“They help to make the issues that are emergent and necessary to handle visible”*. However, reflexive learning based on comparing indicators to trends and policy performance is again facilitated through reporting by the Flemish government and local debates, not by an explicit intent or mechanism.

To summarize, the need for SIs to reflect on policy performance and trend watching is not explicitly recognized in most of the cases studied. Nevertheless, in most cases that relevant mechanisms do exist show an implicit awareness and response to this need. Most notable is the combination of a focus of SIs targeting more strategic and long-term policies with those targeting more operational policies. Another mechanism was the focus on individual projects (Haarlemmermeer) and cases (Green Cities) that are action-oriented (comparing and testing their projects and cases in an experimental fashion) and function within a frame of more long-term policies monitored by indicators. What seems to be largely

⁶ The indicators and tasks are listed at <http://jaarverslag.monitoroverijssel.nl/>

missing is a structured approach in which the monitoring of trends and triangulation of indicators, to engage in learning processes and debate assumptions, underlies more strategic ambitions.

4.3. *The focus of SIs: communication and debate*

Several interesting attempts at embedding the use of SIs within a wider context of societal debates within urban governance were found. However, not all cities and regions made this attempt explicitly. The monitor Overijssel was originally created as a tool to support communication within the government. This is clearly illustrated by its focus on policy performance and its direct link with governmental budgets. As such, the SIs mostly play a role in providing substantive support for governmental decision-making. Similarly, the SCI in San Francisco is still largely used to perform baseline area analyses for specific development projects within government-led land use development. Its reliance on specialized data formats such as shapefiles for GIS software also limits its potential for use by organizations or citizens lacking such software.

Alternatively, the Flemish City Monitor partly relies on being used within a political and social realm. It is supported by frequent press releases and is also featured in Flemish media. The City Monitor tends to be used mostly in the discussion of topics that also feature in political debates and, as such, provides arguments for either agenda setting or reflection on past policies. While this allows the City Monitor to play a role in wider social debates, its relatively implicit link with existing policies makes it susceptible to ad hoc use based on more accidental media attention and undermines its role in supporting a continuous and structured attempt at learning.

The three remaining cases show a more structured attempt at embedding SIs within a wider societal and governance debate. A first mechanism for this is found in Haarlemmermeer, where the development of a 'Global Sustainability Center' means engaging research institutes, other governments and local businesses. The center is intended to stimulate education, networking and the exchange of knowledge and best practices on sustainability issues both nationally and globally. The center consists of several local initiatives and networks that foster innovation and entrepreneurship in sustainable development. Haarlemmermeer is also quite conscious of its role in wider civil society, not just in reporting on policy progress but also in helping to implement policies. In its 'Strategic Communication Agenda' (Gemeente Haarlemmermeer, 2012), the municipality suggests that it wants to "use communication more consciously as a strategic instrument", where "the communication should follow logically from policy priorities" (p.74). Although clearly recognizing the role of individual stakeholders and wider civil society in pursuing sustainable development, Haarlemmermeer does not explicitly use SIs themselves as tools for engaging these actors. Rather, SIs merely play a supporting role in being open for use and easily accessible. Haarlemmermeer therefore depends on local initiatives, projects and its sustainability center to create an environment of learning and innovation for sustainable development.

Rotterdam also has an active strategy to encourage wider public debate on its sustainable development ambitions and progress (Program on Sustainability and Climate change/City of Rotterdam, n.d.). The city achieves this by targeting people with information markets, campaigns and by developing telephone apps, contests, etc. The results of their monitoring are also featured annually on their website and are regularly referred to in press releases. In terms of actual policy making, Rotterdam relies on the so-called 'Rotterdam Climate Initiative', which includes many companies, investors, knowledge and research institutions, and societal institutions. It is also within this framework that monitoring results are discussed with the goal of keeping pressure on agreements made between parties, adjusting policies, and setting new targets

and agreements (Sustainable 2010–2014 Programme Agency/City of Rotterdam, 2012). As one of our respondents indicated, data from monitoring is also actively discussed within the context of the climate initiative. The associated interpretation, triangulation and judgement are the result of both a wider process of sense making and additional studies to explain surprising outcomes. For example, late 2013 showed a rapid and unexpected increase in the number of electric vehicles purchased by households. It triggered further debate that swiftly resulted in an unconfirmed but likely conclusion: the expiration of national subsidies on the first of January 2014. Another good example is the inclusion of research partners who informed Rotterdam that existing indicators on air quality (concentrations of particulate matter 10 and nitrogen oxide) might not be adequate from a health perspective. In response, Rotterdam is now investigating whether it can also focus on elementary carbon (EC) as an indicator.

The Green Cities initiative can already be considered a platform for knowledge sharing both among its city members and with the wider urban society. This goes beyond mere benchmarking and press features. On the one hand, participating cities actively engage in discussions to learn from each other. For example, the cities of Allerød, Ballerup and Kolding have shared their experiences regarding the reduction of CO₂ emissions. One of the cases from Allerød is a project called "together on energy renovation" where citizens can share their experiences in energy retrofitting to learn from each other. In using indicators to reflect on this project, the cities jointly identified possibilities for future action, not just in Allerød but also in Ballerup and Kolding. The indicators are therefore not only used to reflect on policy performance, but have also triggered the exchange of knowledge and practices. In addition to this practical example, the initiative organizes an annual conference focused on current and relevant themes regarding the environment and climate change. It is not simply a conference to report on progress made; it also promotes the active exchange of knowledge and experiences to adjust existing policy agendas. On the other hand, Green Cities also tries to reach the wider urban society. The cities created activities to encourage the involvement of citizens and businesses. For example, the Agenda Center established by Albertslund organizes citizen-oriented activities such as campaigns and personal advice to help citizens save energy and water as well as to take care of public green spaces and nature. Another example is in Allerød, where citizens and business are involved in the co-design of strategies, action plans and specific projects for the environment. However, the role of SIs again seems more modest: they are intended simply as a knowledge base for the various conferences, debates and projects cited. Nevertheless, SIs do provide important triggers for debates and projects and hence cannot be isolated from the more extensive exchange of knowledge taking place within the initiative.

We can conclude that SIs are typically used to support debates in urban governance rather than being the main tools to trigger such debates in the first place. This is in itself not particularly surprising, nor does it have to be a problem. SIs may not necessarily raise the interest of media, businesses or civil society. Only in more ad hoc cases, as the case of the City Monitor illustrates, might such interest exist. However, institutional frameworks such as the sustainability center (Haarlemmermeer), the Rotterdam Climate Initiative, and the conferences of the Green Cities initiatives also provide ample ground for facilitating debates. Although they do have a tendency to be confined mostly to an 'in-crowd' of governments, research institutes, politicians and businesses. To reach citizens, however, projects and campaigns such as in Haarlemmermeer and Green Cities seem crucial.

Table 1
How SIs meet conditions for facilitating learning processes.

Cases	Condition 1 Accessible and comprehensible	Condition 2 Monitor policies and learn trends	Condition 3 Communicate and debate
Overijssel (NL)	Online interface with explanation, representing policy performance	Mostly focus on policy performance and (to some degree) triangulating based on the mixture of strategic and operational indicators	Hold regular meetings and reporting
Rotterdam (NL)	Separate report, representing policy performance	Focus on policy performance and learn trends by 'transition monitor'	Provide information, markets and campaigns
Haarlemmermeer (NL)	Separate report, representing policy performance	Focus on policy performance, triangulating based on the mixture of strategic and operational indicators and experimenting through initiative projects	Create "Global sustainability center"
SCI (US)	Online interface with graphic presentation, representing general trends	No explicit link to policy performance and learning is dependent on users	Provide information
Green Cities (DK)	Online interface with cases and examples, representing policy performance	Focus on policy performance, triangulating based on 1) the mixture of strategic and operational indicators, 2) experimentation, and 3) benchmarking and comparing cases	Create knowledge sharing platform
City Monitor (BE)	Online interface with graphic and explanation, representing general trends	No explicit link to policy performance and learning is optionally applied by individual city	Create frequent press releases

5. Reflections on the three conditions

The first condition identified is straightforward and implies that indicators should be accessible and comprehensible to both policy and societal actors. Clearly, the use of well-categorized online fora with search engines is the most common tool used, followed by well-illustrated reports that are also available online (see [Table 1 condition 1](#)). In most cases, these tools were found to make the use of SIs easy even for lay people. Furthermore, given the SIs' clearly identifiable sources, legitimacy was not found to be under dispute. In some cases, however, discovering information was either difficult (Haarlemmermeer) or using the information required expert software and expert knowledge (SCI). The digital age offers attractive formats to reach a wide and diverse audience. Still, without ensuring that digitally available information can be easily located, shown on screen and interpreted, SIs run the risk of remaining expert-driven or even isolated databases.

The second condition highlights the need for SIs to move beyond a single-minded focus on existing policies (see [Table 1 condition 2](#)). This condition seeks to avoid the risk of a path dependent development of SIs towards reinforcing the focus of existing policy agendas and the risk of overlooking important trends or contextual changes. To avoid these risks it is important to ensure that SIs also attempt to capture ongoing trends and developments related to sustainability. Triangulation across indicators and reflection on policy performance can subsequently become means to create a more enhanced reflection on policy efforts. Most of the cases studied implicitly recognize this need and thus confirm the relevance of this condition. Triangulation was encountered in Rotterdam and Haarlemmermeer, while Rotterdam even attempted to explicitly combine a focus on policy performance with a wider 'transition monitor' (although it focused only on CO₂). The most common strategy supporting SIs in moving beyond a single-minded focus on existing policies was the implicit choice to relate SIs to operational policies and strategic policies. This strategy was chosen in Overijssel, Haarlemmermeer and the Green Cities. SIs were partly linked to operational policies with the intent to evaluate policy performance. These SIs were supported by SIs used to reflect on the general and long term perspective of strategic policies. This also forced SIs to

address some relevant ongoing trends and developments related to sustainability. Whilst an implicit recognition of combining a focus on policy performance with that of 'trend watching' was identified, we must also conclude that an explicit structure or mechanism to do so was not identified by this paper. It was noted that cities were also using individual projects to experiment with new policies and initiatives. This was visible in Green Cities and Haarlemmermeer; these experimental projects also helped to reflect on existing policies and also used SIs to measure their impact.

Finally, the need to extend the debate on SIs beyond formal governmental organizations was also recognized by several of the cities and projects studied (see [Table 1 condition 3](#)). Rotterdam, Haarlemmermeer and the Green Cities in particular have created specific fora, project groups, workshops, conferences and centers to conduct outreach, while the City Monitor is often used more to support for such activities. On the one hand, this seems to confirm the relevance of SIs for galvanizing public support. On the other hand, most of the examples encountered seem to use SIs more implicitly. The focus is more on engaging various societal groups to develop and alter policies and projects, with SIs merely being one of many tools used in such debates. This is also an important lesson to highlight: SIs are not the central elements in accommodating processes of learning and inspiring policy adaptations. Instead they are supportive tools that form part of a wider institutional configuration supporting learning and policy adaptations.

6. Conclusions: SIs as a tool for learning?

There should be no doubt that degrees of learning and adaptation are natural in any process of governing. Therefore, the distinction between adaptive governance and other forms of governing is not that degrees of learning and adaptation occur. Instead, adaptive governance points towards a structural attempt to create institutions and policies that actively promote learning, flexibility and adaptiveness. It is in this context of adaptive governance that the paper sought to position SIs. More specifically, the paper aimed to assess how pursuing sustainable development as an adaptive process of learning-by-doing can benefit from the use of SIs.

Our main conclusion is that SIs do have the potential to support adaptive processes of learning-by-doing on the path towards sustainable development, but also that unlocking this potential requires active management. This active management should start with avoiding the risk of SIs becoming largely isolated databases separated from governance practices. Preventing SIs from functioning as isolated databases, and instead having them more closely connected to one another, is not only making SIs easily accessible and understandable, but also opening them up to the wider urban society. In our empirical inquiry we saw that digital tools made it relatively easy for SIs to indeed be accessible and understandable to a large variety of stakeholders. But even in the more advanced practices that we studied, not all SIs were so easy to access or interpret. If cities are to make SIs accessible and understandable, it is advisable to develop well-categorized online databases that are supported by search engines, maps, illustrations and explanatory reports.

In the meantime, SIs should not be predominantly directed at the practice of administrators and experts but also of alternative stakeholders. Our cases suggest SIs still seem to be used and developed largely by administrators, which implies that SIs only provide limited input into political and societal debates. We found ample evidence of cities engaging in societal discussions on progressing towards sustainable development approaches, such as through online platforms, conferences or workshops, marketing campaigns, media press releases and learning centers. Although SIs did play a role in these discussions, they were far from being central. If we are to increase the use of SIs as input for learning then the role of SIs in these societal discussions should be explicated and supported by active promotion and management. Press releases, presentations and easily understandable reports are among the possible tools to use. Nevertheless, practice also urges us to reconsider the degree to which SIs might become central elements in accommodating processes of social learning and policy adaptations. They might not be sufficiently useful or attractive for political and societal debates. Rather than treating them as central elements, it might be better to ask how we can position them as tools in a wider institutional configuration supporting learning and policy adaptations.

Unlocking the potential of SIs to support adaptive governance also implies active management to look beyond existing policy agendas. SIs that only focus on measuring policy performance might well overlook ongoing trends and developments. We found only limited evidence in practice that such active management takes place. Nevertheless, we did encounter more implicit attempts to foster learning based on SIs and to then adaptively respond to this learning. First, experimentation in specific projects takes place where SIs are used to help identify successes and failure. Secondly, some cities and regions use processes of triangulation to interpret data provided by SIs. Finally, three out of six cities and regions also combine more strategic policy agendas with more operational policy agendas. SIs that aim to measure the progress of strategic policy agendas might also focus more on ongoing trends and developments, especially if they are more abstract and long term. Despite these good examples, the main conclusion remains that active management for using SIs remains limited. Rather, most of these attempts to foster learning based on SIs seem to be tailored to specific local practices and urgencies. The risk is thus to overlook long term trends that can be used as a baseline set of information for benchmarking and warnings. There is much to gain if cities would actively pursue a structured approach that combines trend watching, triangulation, experimentation and policy performance measuring.

The sample of six cities and regions studied is not representative. Neither is this sample sufficient to provide a definite answer upon how SIs are and can be used to support adaptive governance. Nevertheless, we did choose to study only cases in countries considered relatively advanced in sustainable urban governance and SIs.

This means that it is unlikely that a great number of more advanced or positive examples will be found in other countries: widespread and explicit usage of SIs as supporting tools for adaptive governance seems all but likely. Furthermore, the cases we studied suggest that the conditions identified do make sense for not only being tools to analyze practice, but also to help inform practice. Implicitly, most of these conditions did receive attention in how the cities and regions tried to develop and use SIs. SIs were also regarded as tools to help adapt policies and learning-by-doing. However, there is an absence of an explicit recognition of structured attempts at embedding SIs in urban governance for supporting processes of learning and policy adaptation. It is in making the implicit explicit that we suggest the conditions we opted for might be of assistance for using SIs as tools to support adaptive governance.

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