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Enhancing Performance Management and Sustainable Development through e-government policies in Urban Areas
A System Dynamics Approach

Carmine Bianchi
Professor of Business
& Public Management
University of Palermo (Italy)
carmine.bianchi@unipa.it
bianchi.carmine@gmail.com

Diego Navarra
Research Fellow in Public
Management
University of Palermo (Italy)
d.d.navarra@gmail.com

ABSTRACT

This paper tackles a very controversial topic in the application of system dynamics for the evaluation of territorial policies and urban governance, in terms of sustainable development. The goal is to illustrate how system dynamics modeling can be used in territorial governance and e-government policy design as an innovative methodology to frame sustainable performance in urban areas.

A 'dynamic' performance management approach is proposed and applied to the specific field of study as an aid to support territorial analysis and planning, policy design and the assessment of policy outcomes. Topics such as renewable energy, efficiency, the design and exploitation of urban energy, water and waste management infrastructure and the alignment of different stakeholders provide relevant fields of study for the analysis of this paper. Specifically, we reflect upon the way in which insight system dynamics conceptual models, based on exemplary case-studies, can be used to outline performance drivers and end-result measures and link them with strategic resources in a feedback analysis. This approach fosters a common shared view among different policy makers and therefore may help them to highlight new ways to enable sustainable development in urban areas.

Introduction

Territorial governance concerns the policies, rules, processes and structures through which decisions are made about access to urban land and the use of its resources. It is an important element of the many complex challenges the world faces today including: sustainable development, adaptation and mitigation to climate change, rapid urbanization, growing food and energy insecurity, increased natural disasters, etc. (Navarra and van der Molen, 2012). Good territorial governance is typically seen to be supported by the development of e-government policies and systems at the state, regional and urban levels (Navarra, 2010, forthcoming).

E-government combines various information and communication technologies to connect government agencies and institutions, promotes the reorganization of governments' internal and external information flows, activities and functions in order to shift government's service delivery over the internet (Ciborra and Navarra, 2005). E-government is also expected to benefit the community by drawing together the public sector, civil society and international actors, as well as by improving consultation with, and participation by, all spheres of society and achieving a more transparent and participatory process of territorial governance and decision-making (Navarra and Cornford 2006, 2012; Navarra, 2010, forthcoming).

Sustainable development in metropolitan regions in Europe and around the world is generally measured in terms of both being part of a global economic network (i.e., for instance, in relation to the proliferation, spread and emergence of transnational corporations) and generating a strong public service making the urban territory more attractive to international knowledge, technology and innovation (Dicken, 2004; Castells and Cardoso, 2005). The former are considered building blocks of a sustainable innovative economy, a strategic resource in the urban territory, which is tightly related to public sector reforms. Such features are critical factors since the design and development of present and future e-government policies and systems is seen as the key locus of innovation in the public sector, in order to enable the enhancement of performance management in government organizations, and specifically in urban governance and sustainability (Navarra, 2009, 2011, forthcoming).

Implicit in this world-wide programme of e-government, found in countries of all levels of development, is a strong sense of managerialism, with e-government often seen as an essential part of a necessary process of reforming and reshaping management practices in the public sector, especially in projects and reforms which will establish accountability systems, increase transparency and reduce corruption (Navarra, 2010; Navarra and Cornford, 2012). Yet the evaluation of territorial governance policy on the performance of urban areas requires a more nuanced methodological approach. One where the contextualisation of the systemic geography of a city and its critical institutions (Burdett and Sudjic, 2008; Navarra, 2010) are considered in order to understand the nature of innovation dynamics in urban regions, in terms of sustainable development.

E-government policies and systems within the scope of this paper address sustainable development, innovation and economic growth in urban areas and the state's spatial development plans (including state infrastructure for water, energy and waste management), metropolitan and regional policies and other governmental interventions and activities such as in the environment, housing and energy efficiency. However, it can equally be of relevance for tourism, health care, education, crisis management, disaster management as well as for the participation and interaction with the citizens in the creation and re-creation of the city's landscape (also in the politics of urban planning).

Though urban studies are a tradition in the system dynamics (SD) literature (Forrester, 1969), to our knowledge, this is the first paper to propose a dynamic performance management system applied to territorial governance, e-government and sustainable development. The approach we use is based on insight conceptual models we have developed on an exemplary case study, to link territorial performance drivers and end-result measures in a feedback systems analysis.

The exemplary case study of Hammarby in Sweden was chosen because of its advanced programmes and achievements in the key areas of study of this paper, namely territorial governance, e-government, sustainable development and urban environmental performance.

Hence, how can territorial governance and e-government support the coordination of sustainable development policies across different urban organisations and stakeholders? How can we use SD to design a dynamic performance management system, which can: a) outline key performance drivers of sustainable development, and b) enhance a common shared view among policy makers about sustainable territorial performance (i.e. sustainable development and good urban governance)? What counter-intuitive behaviours can be identified in the case-study using an SD-based scenario analysis? We present 3 hypotheses as possible answers to our research questions:

- Hypothesis 1: a SD approach can be used to identify strategic resources, performance drivers and end-results and to design a dynamic performance management system model of key environmental processes with the greatest impact on the sustainable development of the urban territory.
- Hypothesis 2: an integrated e-government system allows the simultaneous consideration of the environment in budgets, excellent spatial planning, reporting and territorial policy development and monitoring.
- Hypothesis 3: among the counter-intuitive elements of the case-study which can be identified with a SD approach we hypothesize the capacity to transform general waste into environmentally sustainable electricity and a city brownfield in Stockholm into one of the world's most successful eco-villages.

The following section reviews the literature on territorial governance, e-government and sustainable development. Next we discuss the methodological considerations for the use of SD in the assessment of urban performance for sustainable development. Then we present the exemplary case-study of sustainable development, e-government and eco-cycle modelling in Sweden. Conclusions follow a discussion of the agenda for policy performance management in sustainable urban development.

Territorial Governance, E-Government and Sustainable Development

The global effects of climate change can no longer be reverted or even controlled, while efforts to avert it are growing weary. According to Grimmond (2007), globally the impact of cities on climate change at the regional and local scales is of greater magnitude than projected global scale climate change, which can have severe impacts on the planet and the human species. Addressing climate change is a key policy priority in Europe with both the Lisbon Agenda and the EU Strategy 2020 calling for measured and targeted improvements in urban environmental sustainability, emphasising specific methods and clear performance objectives. These include the rapid ratification of the Kyoto Protocol, which suggests that 12% of primary energy needs and 22% of gross electricity consumption would have to be from renewable energy sources. The introduction of the Energy Performance Building Directory in the European region, an energy taxation directive adopting environmental liabilities for building owners, stress the sustainable use of energy with a new regulatory framework. This mirrors the policy developments taking place at the global level. Therefore, one of the most important challenges faced by metropolitan regions and municipal governments is to identify and support dynamics leading to good territorial governance and sustainable development.

The rationale for the above is that urban and peri-urban areas hugely affect global climate change since they consume as much as 75% of commercial energy; generate as much as 80% of all waste and 60% of greenhouse gas emissions. Yet urban areas typically present for analysis highly differentiated institutional and political systems (Navarra, 2010). For instance, in order to develop and implement a policy to decrease the amount of greenhouse gasses emitted within a municipality, which is one of the key environmental policies in support of urban sustainability, detailed climate data and information can be very supportive (van der Molen, 2009). When developing climate policy at municipal scale it may even be argued that ‘high quality energy information’ is essential to sustain a good climate change policy at the regional and national levels as well.

van der Molen and Wubbe (2007) highlight the importance of urban e-government policies and systems when the public administration, private sector and citizens decide on issues where the spatial component is one of the determinants of decisions, such as when there is a need to access relevant spatial information, and could contribute in a meaningful way to the process of spatial decision making. Without these digital facilities, modern governments cannot understand the built environment of cities, manage land efficiently, utilize computer capacity to assist policy making, or retrieve significant value out of land. In the latter circumstances the value that can be considered important for good territorial governance would be safeguarding the reliability, availability, access and use of spatial information for the fulfilment of societal objectives and sustainable development. Within this context, an urban e-government system can be seen as a spatial information infrastructure that supports the management of land, spatial planning and territorial governance policy for the purpose of sustainable urban development. Data and information used in e-government can therefore be useful to facilitate governments in both their adaptive and mitigative climate policies (Van der Molen, 2009). Gathering and compiling such information, beyond the public sector policymaking and decision making processes, would encompass industrial activities, small and medium sized enterprises and many complex relationships between the political and the organisational systems in the public and private sectors (Bianchi, 2010).

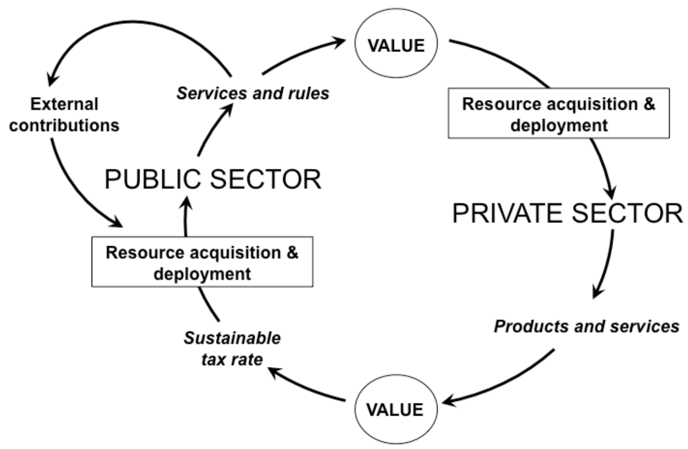

Figure 1: A systematic framework embodying both the public and private sector: value generation as a focus for assessing performance and a prerequisite for information flows in sustainable development policy.

Figure 1 shows public and private sectors dynamics, and how the rules underlying the survival and development of both sectors lie behind their own capability to generate value, to promote sustainable development. Figure 1 also shows how public sector performance does not only provide feedback under the form of taxes and financial contributions from the community receiving a given set of services, but also in terms of external contributions and, we would add, the same applies to information flows in sustainable development policies. So, the private sector feeds back to the public sector: public opinion is primarily affecting the political level, and income primarily affects the funds that the public administration will be able to raise through taxes and other sources to provide the administration level with resources to afford public expenditures.

This move can be associated to a growing interest of the society towards the improvement of public service quality, effectiveness and operational efficiency. This phenomenon is commonly referred as new public management (Navarra and Cornford, 2006). In the 1990s for instance, prior to large scale e-government systems, urban information systems were used to give a spatially detailed representation of the evolution of urban land-use patterns. Engelen et al. (1997) used this technique to represent urban land use dynamics to forecast climate change on a small island setting. Wu and Webster (1998) presented a model that also included user decisions to determine model outcomes. White's St Lucia model (White and Engelen, 1997), is an example of computer-based regional modelling of urban land-use dynamics and an attempt to use the standard non-spatial models of regional economics and demographics, as well as a simple model of environmental change for predicting the demand for future agricultural, residential, and commercial/industrial land uses (Deal, 2001).

These early models show a marked faith given to the use of relatively simple technologies of information and communication to simulate urban growth patterns, based on existing land uses and what was considered by the users to be the inherent suitability of a unit of land for each possible use. However, the former initiatives did not consider the underlying dynamics of the areas in which such patterns were simulated as well what could have been the roles of the public and private sectors in the process.

For instance, according to more recent studies, metropolitan urban areas in European regions, such as London, Paris, the Randstad region in The Netherlands, and Stockholm present a rather hybrid mix of managerial responsibility in urban governance (and information) shared between the public and the private sector (van der Bol, 2010). And this, we would add, happens increasingly via specific programmes of modernisation and informatisation of the public sector such as in e-government. However, recently the same argument has extended also to the possibility to foster sustainable economic development and the aversion of climate change through policy making and regulation, the promotion of investments, purchases and employment, and by implementing ambitious modernization programmes for the delivery of public services (i.e facilitating creative interaction between universities, scientists and researchers on the one hand and industry and commerce on the other driving technology transfer and innovation).

The mainstream discourse suggests that innovations in public administration can greatly contribute to increase cost efficiency and the effectiveness of policy implementation via public-private partnerships and related e-governance innovations. Examples of the latter include volunteered geographic information activities (e.g. Wikimapia, OpenStreetMap), public initiatives (e.g. Spatial Data Infrastructures, Geo-portals) and private projects (e.g. Google Earth, Microsoft Virtual Earth, and other 3D models). These initiatives are producing an overabundance of spatial data whereas until recently the main challenge in using urban e-government systems was the lack of spatial data availability. Such overabundance of spatial information has not yet been aptly put in use to increase the effectiveness of territorial governance and urban planning and for providing feedback for the development and performance assessment of territorial policies in diverse areas of urban governance for sustainable development (Navarra, forthcoming).

Likewise spatial information has not been widely used for the successful execution of public tasks, the coordination of government agencies and activities, information and services provision to citizens.

Yet there is no clear comprehensive or holistic methodology in place about how to enhance performance management, monitor and assess progress towards sustainable territorial performance in urban areas via the parallel improvements in public sector innovation and in the implementation of EU policies and guidelines (Navarra and van der Molen, 2012).

A Dynamic Performance Management approach to enhance sustainable development in urban areas.

According to Bianchi & Riverbank (2012) one possible avenue to enhance performance management in the public sector — which is the term used for the implementation of performance measurement as described by de Lancer Jules and Holzer (2001) – is the application of system dynamics, where modelling organizational systems and simulation techniques are used for understanding the behaviour of complex systems. The advantage of using this approach is placing performance measures into the broader context of the system, responding to the reality that even simple policy and process changes to impact specific outputs and outcomes are not likely to be that "simple" in organizations (Bianchi, Winch and Tomaselli, 2008). The main focus is on the wider system, and policy implications for each player can be taken by the light of the responses that the observed system's behaviour is likely to give, as a consequence of changes in its structure.

If one takes the point of view of each decision maker on behalf of whom a SD model is developed, such a perspective could be defined as 'external', since it does not primarily reflect the observation point from which each involved player perceives the system. In other words, an 'external' perspective primarily implies an analysis of the relevant system per se, rather than that of a specific decision maker (Bianchi, 2010). A critical tipping point in managing organizational and territorial (inter-institutional) performance is associated to the capability of policy makers to: a) identify those strategic resources which most determine the success in the environment (i.e. competitive and social systems) where an organization or different organizations operate; b) insure that the endowment of such resources is satisfactory over time; c) keep a proper balance between the different relevant strategic resources. SD can then be used to enrich performance management in local government, focusing specifically on how the development of conceptual and simulation models can foster a common shared view of the relevant system among stakeholders.

According to a dynamic performance management perspective, each strategic resource should provide the basis to sustain and foster others in the same system. For instance, both workers and equipment provide capacity, which affects perceived service quality. This affects territory attractiveness, which, in turn, influences population dynamics. A change in the population that a municipality must serve will affect workload and perhaps the stock of available financial resources, and eventually capacity and service. The feedback loops underlying the dynamics of the different strategic resources imply that the flows affecting such resources are measured over a time lag. Therefore, understanding how delays influence strategic resources and achieved results becomes a key-issue to manage performance in dynamic complex systems.

Another key-issue suggested by a dynamic performance management view is the need to adopt a broad enough perspective in order to understand the driving forces affecting achieved results. This implies that the number and range of stakeholders involved in making decisions influencing strategic resource dynamics — and, therefore, the relevant system's performance — are often located in several organizational units and institutions in a given territorial area. Such implication is particularly relevant when performance management concerns the outcomes generated by public policies and the sustainability of performance indicators is measured not only in the long term, but also in the short-run.

Figure 2 illustrates how the *end-results* provide an endogenous source in an organization to the accumulation and depletion processes affecting strategic resources. In fact, they can be modelled as *in-* or *out-*flows, which change over a given time span the corresponding stocks of strategic resources, as a result of actions implemented by decision makers. End-results that most synthetically measure the overall organizational performance are flows affecting the accumulation of corresponding strategic resources that cannot be purchased. These are: 1) resources generated by management routines, and 2) financial resources (Bianchi, 2012).

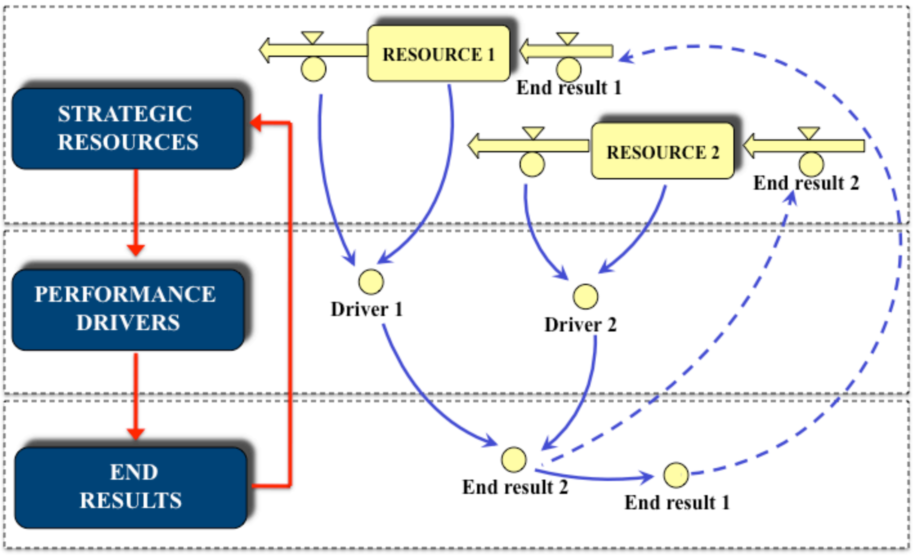

Figure 2: A dynamic performance management view.

Figure 2 also highlights that *performance drivers* are a measure of factors on which to act in order to affect the final performance. They can be measured in relative terms, i.e. as a ratio between organizational or territorial (inter-institutional) performance perceived by the community or specific groups of service users and a benchmark, or target. Such denominator must be gauged in relation to either perceived past performance, or users' expectations, or even competitors' (e.g. other territories) performance. For instance, if related to an end-result such as the number of new business initiatives undertaken in a urban area in a given time span, corresponding performance drivers could be associated to the (financial and socio-political) perceived stability of a region, and to the perceived transparency and promptness of the public sector (e.g., in terms of authorization protocols or supply of various services, such as those related to security, transportation, social assistance, housing).

In order to affect such drivers in the desired direction, each decision maker must build up, preserve and deploy a proper endowment of tangible and intangible strategic resources systemically linked each other.

The growth of a single organization and of a territorial community (like a urban area) embracing different institutions can be sustainable if the rate at which end-results change the endowment of corresponding strategic resources is balanced. This implies that each institutional decision maker is able to increase the mix of strategic resources and that this increase is not obtained by reducing the endowment of the wider strategic resources in the territory.

Methodological considerations for the use of System Dynamics modelling in the management of Urban Performance

Climate change is a global phenomenon. Although it will be important to attempt to model its effects in different urban areas around the world, we can identify four scales of spatial quality which may be used in system dynamics to model the effects of climate change in different areas around the world.

These are: 1) nations within the international system; 2) regions within a country; 3) cities within a region, and 4) intra-urban structure (Wilson, 2010). Here we address the methodological considerations for the application of SD for the assessment of sustainability in urban performance with regards to the two former dimensions. The goal is to demonstrate how SD modelling can be used in territorial governance and e-government as an innovative methodology to frame sustainable performance in urban areas, as an aid to support territorial analysis and planning, policy design and the assessment of policy outcomes.

Earlier SD studies have been developed to map the dynamic complexity related to e-government policies (Black, Cresswell and Luna, 2002; Gil-Garcia and Martinez-Moyano, 2005; Gil-Garcia and Pardo, 2006). SD has also been used to explore the core capabilities of local governments as key-factors to exploit the benefits of digital government (Luna-Reyes, Gil-Garcia and Ramirez-Hernandez, 2011). It has also been applied to model stakeholders behaviour, learning, knowledge management, inter-institutional dynamics and citizens trust in e-government policy initiatives (Gil-Garcia and Martinez-Moyano, 2007; Luna-Reyes, Cresswell and Richardson, 2004; Luna-Reyes, Andersen and Pardo, 2007; Martinez-Moyano and Gil-Garcia, 2004; Martinez-Moyano, et al. 2007).

The government of a territory faces dynamic complexity, mostly implying: 1) different (public and private) stakeholders playing a key-role in affecting a territory's performance; 2) difficulties for each player to detect the performance of the territory as a key determinant of its own performance; 3) misperceptions about the drivers and related strategic resources affecting the territory's end-results; 4) inconsistencies in understanding and managing the accumulation and draining processes affecting the territory's tangible and intangible strategic resources; 5) poor identification of delays and non-linear relationships between factors affecting performance; 6) flaws in policy-making, which often disregard framing trade-offs in time and space; 7) poor coordination among stakeholders in setting policies and understanding the causes of emerging problems.

Such dynamic complexity factors justify the use of SD as an approach to frame territorial performance processes, and to improve decision makers' mental models and policy design. In the context of this paper SD provides a supporting methodology to the address the above methodological considerations for the development of a territorial strategy, an urban performance management model and a dynamic monitoring system when it is not immediately possible to understand *ex ante* the causes of phenomena, where it is problematic to conduct an evaluation of the possible future outcomes of decisions taken today. Especially when the decisions taken by a single organisation affect other areas of interdependency with other organisations and stakeholders in the same or other cultural, local, regional or national systems. SD in this case would help decision makers to develop a common shared analytical view of the horizontal relationships between phenomena and of their interdependencies and evolution over time. An SD based analysis does not disregard the elicitation of the decision areas that each player is in charge of, and does not focus only on possible responsibility overlaps, but also on unattributed roles, inconsistencies, conflicts and ambiguities in decision-making processes, and their consequences on the governance, management and performance of the observed territory.

Through the SD method, it is possible to carry out a structure-and-behaviour analysis (Richardson, 1986; 1995), based on which the reinforcing loops underlying growth can be identified and fostered by proper development policies. Also, reinforcing loops can be associated to corresponding balancing loops, which provide a source of limit to the growth of the investigated system. By promptly detecting and counteracting balancing loops, decision makers can foster sustainable development. Bagheri and Hjorth (2007) called *viability loops* the key elements in these critical balancing mechanisms, which rely on the development and flow of information, knowledge and/or communication to keep the system in balance. Thus, to ensure that a system is meeting the sustainability requirements, we should look for the viability loops and keep them healthy to prevent exponential growth or decline due to reinforcing loops. Hence we outline the pillars of sustainable development in urban areas based on an international best practice (i.e. the critical elements in a balancing system able to reinforce sustainable urban development dynamics), and then we highlight a useful set of metrics to measure progress towards urban sustainability.

A system of *viability loops* for the management of urban performance known as the Amsterdam Sustainability Index (ASI) has been developed by the city of Amsterdam, although without a direct contribution from a SD approach. Please refer to Figure 3 displaying the index indicators used the city of Amsterdam.

Pillars	Indicator	Indicator specified	Source
General indicators	CO_2 emissions per inhabitant	Annual CO_2 emissions in tonnes of CO_2 per inhabitant	Amsterdam Department for Research and Statistics
	NO_x emissions per inhabitant	Average concentration NO_2 + average concentration NO, data from ten measuring stations	Amsterdam Health Department
Climate and Energy	Energy use (households) per inhabitant	Annual energy use inhabitants in GJ per inhabitant.	Liander, grid company
	Sustainable energy production per inhabitant (inverse)	Annual sustainable energy production in GJ per inhabitant	Amsterdam Climate and Energy Bureau
Sustainable Mobility and Air Quality	Bicycle share in modal split (inverse)	Percentage of bicycles in total movements of bicycles + mopeds + motorbikes + cars on the Singelgracht	Amsterdam Department of Transport and Infrastructure
	Share clean trucks and lorries (inverse)	Percentage of trucks and lorries with Euro 4 or cleaner engine	TNO, research institute
Sustainable Innovative Economy	Attractiveness of Amsterdam for new companies	Ranking in European Cities Monitor (ECM)	Cushman & Wakefield
	Energy use per added value	Use of electricity and natural gas in MJ per euro added value.	Liander, TNO and Amsterdam Department for Research and Statistics
Materials and Consumers	Amount of residual household waste per inhabitant	Residual waste from households in kg per inhabitant	Amsterdam Waste and Energy Company
	Liveability indicator (inverse)	Value between 1 and 10 given by inhabitants when asked: "How satisfied are you with your own neighbourhood?"	Amsterdam Department for Research and Statistics

Figure 3: The Amsterdam Sustainability Index

(Source: http://www.sustainablecities2012.com/images/uploads/documents/SC2012.pdf)

According to the ASI, urban sustainability is measured through: a) energy savings achieved by locally produced sustainable energy and the efficient use of fossil fuels, which reduce also CO2 emissions within the city; b) mobility and air quality (Amsterdam is expected to be an accessible city on condition that the transport system is sustainable); c) sustainable innovative economy (inter-national companies choose Amsterdam because doing sustainable business in Amsterdam is worthwhile); d) materials and consumers: Amsterdam is a liveable city where citizens and companies use raw materials in an effective way, live and act in a sustainable way and where the municipal organisation itself demonstrates this approach. Low emissions energy systems, the harvesting of rainwater and clean water supply and sewage are just as important.

It should also be noted that, although the ASI provides and interesting benchmarking to measure the progress towards sustainability in an urban area, in Europe climate change related pressures will also affect rural environments and natural habitats driven also by human land use requirements, pollution and resource exploitation in urban areas. Progress towards urban sustainability (or the lack of it) could have severe impacts well beyond urban areas and not only as a consequence of deceasing water volume, higher temperatures and higher-intensity rainfall. Hence, the role of national and municipal policies should not be underestimated. As part of counter-intuitive behaviours which may be observed from territorial governance policies emphasising sustainable development, we could notice the promotion of ecological high-tech jobs (with the consequential increase in overall employment rate), the redevelopment of brownfields, the diversity and ecological quality of services, access to low emissions public transport, pedestrian and bicycle systems and incentives for the construction of innovative house types and energy systems which can improve urban sustainability.

Prevailing approaches of planning and strategy making, which traditionally deal with the states of systems in terms of fixed goals, fail to acknowledge the nature of sustainable development processes. Therefore to overcome the myopic view of relying on a handful of performance indicators to facilitate change, preliminary SD models can be sketched to map the structure of sustainable viability loops and to capture and communicate an understanding of behaviour driving process changes over time to a variety of stakeholders in a dynamic performance management model. The underlying principle is that if process structure determines system behaviour, and system behaviour determines the performance of stakeholders and organisations, then the key to developing sustainable strategies to maximize performance is acknowledging the relationship between processes and behaviours and managing the leverage points of the investigated system (Bianchi & Riverbank, 2012).

The case study: sustainable development, E-government and Eco-Cycle Modelling in Sweden

We now describe the case study of Hammarby (CABE, 2013), a district of Stockholm in Sweden, including how specific territorial governance policies, e-government systems and dynamic performance measures were used to promote urban development and environmental sustainability. Our goal is to show how a systems approach can help public officials move to good territorial governance and performance and identify several possibilities of how SD can be used to improve territorial performance in terms of sustainable development.

This case study demonstrates the potential of sustainable development policy and eco-cycle modelling in the dynamic performance assessment of the interaction between different urban processing systems (i.e. sewage, energy and waste processing infrastructure) in Hammarby Sweden. Hammarby is an admirable example of urban transformation. Formerly a run-down part of town in Stockholm’s industrial area affected by heavy pollution problems, it become an environmental role model in less than a decade. The city council developed the eco-cycle model to integrate environmental results with strategic planning. An ambitious programme to recycle all waste or waste water to turn into renewable energy was introduced to efficiently use the resources required by households (fig. 4).

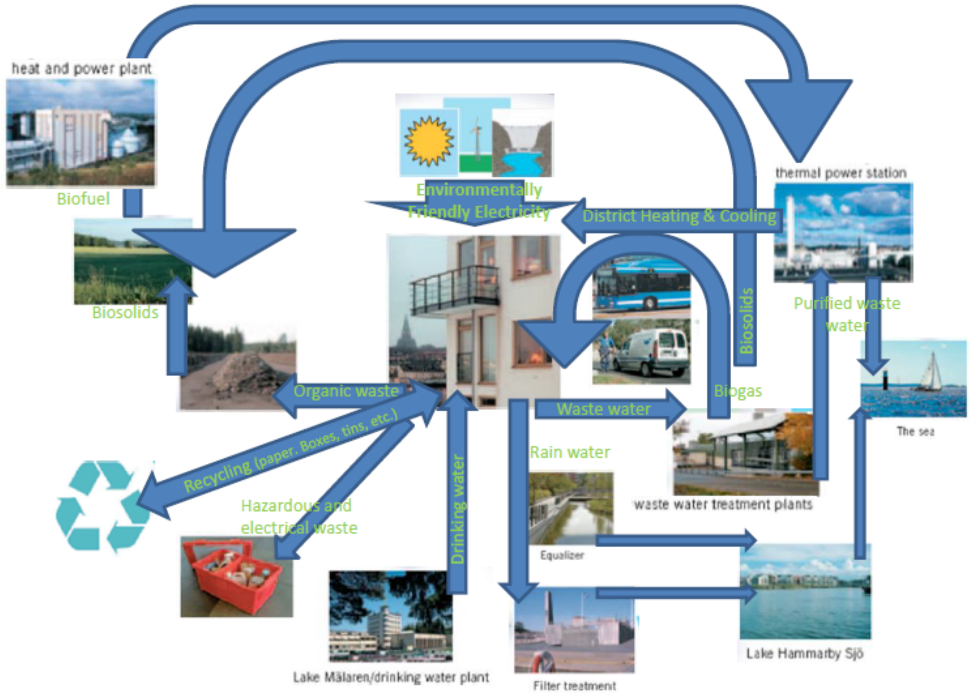

Figure 4: Hammarby's territorial management model.

Solid waste is disposed into a vacuum-based underground collection system, which separates it into organic, recyclable and other forms. Organic waste, biosolids are converted into biofuels and combustible garbage is burned to supply electricity and hot water with the use of heat and power plants and thermal power stations. Nitrogen and phosphorous are retained in the highest possible percentage to be used as fertilisers for local agricultural activities. The use of recycled water and waste for the environmentally friendly production of electricity affects not only the consequential reduction in waste and pollution, but counter-intuitively the process of conversion of sewage and waste transforms them into strategic resources for the production of environmentally friendly electricity. Not only the net end result has been environmental quality along the dimensions of the reduction in air, water and land pollution, but such an integrated planning process has been introduced at the territorial scale of the entire urban area and as a role model for the planning of new urban areas in Sweden. It has also been exported to the United Kingdom, Russia and China.

The initial success of the Hammarby model to bring forward the priorities of integration of urban sustainability, information and communication technology and energy efficiency led to the recent establishment in 2011 of a Minister for Information Technology and Energy within the Ministry of Enterprise, Energy and Communication. Coordinating various former individual policy makers and institutions, the ministry is a notable example of how territorial governance and e-government can support the coordination of sustainable development policies across different urban organisations and stakeholders.

A preliminary territorial dynamic performance management model is presented in figure 5.

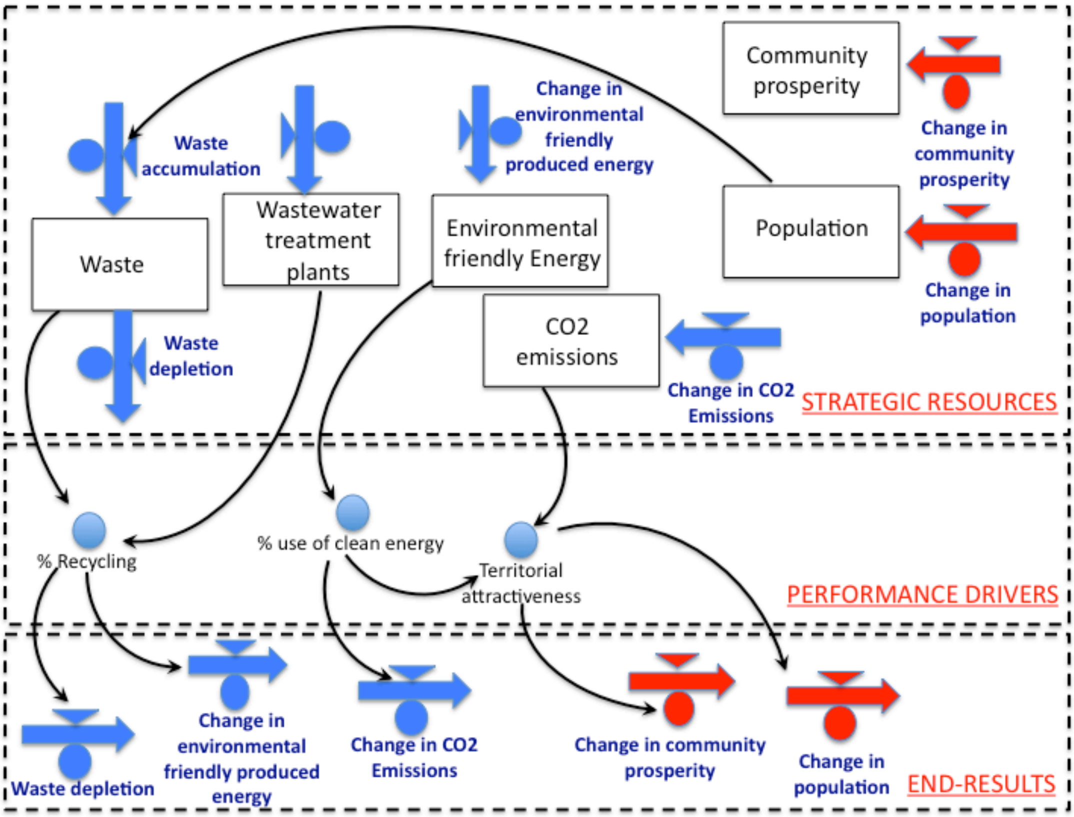

Figure 5: A SD insight model portraying Hammarby's territorial performance

The figure shows how the outcome indicators to take into account in order to monitor the effectiveness of adopted territorial policies in the investigated case-study, can be referred to two different sequential levels. On the one side, waste depletion and the change in environmental friendly produced energy are specific end-results for the project. They allow decision makers to affect waste accumulation and the stock of environmental friendly produced energy. Such end-results are affected by the recycling % (i.e. the ratio between recycled and total waste). Such driver is, in turn, affected by the investments in wastewater treatment plants (strategic resource) and by the stock of waste.

Figure 5 also shows how the stock of environmental friendly produced energy affects a second critical driver, i.e., the % use of clean energy. This driver, on the one side affects the change in CO2 emissions in the territory (i.e. a third end-result); on the other side, it directly affects the territory attractiveness (i.e. a third performance driver). In fact, a higher % of clean energy produced in the territory will not only affect the environmental pollution levels, but also will directly generate less expensive available electric power available for the different players in the territory.

The previously mentioned performance driver named as "territorial attractiveness" is also affected by the stock of CO2 emissions in the urban area.

The ultimate effect (i.e. the outcome) of the described policies can be related to the effect of territory attractiveness – other things being equal – on community satisfaction (prosperity and wealth) and on the stock of population.

This set of outcome measure is likely to play a quite counter-intuitive behaviour in the urban area. In fact, on the one side a higher achieved community prosperity will sustain more investments to foster the described policy. This might also imply a stronger and wider level of participation by several decision makers from different public/private sector institutions. This would indicate a higher level of trust and cohesion in the territory. Therefore, such first effect of the policy would underlie a growth-oriented reinforcing loop.

However, on a longer time horizon, a higher community prosperity might attract more people to live or work into the city. A higher population – other things being equal – might increase the level of waste. This might counterbalance the positive effects generated by the reinforcing loop previously described. Therefore, an increase in population might generate a shift in loop dominance, i.e. from a reinforcing to a balancing loop, acting as a limit to growth.

Policy makers might decide to counteract this loop by exploring alternative scenarios and policies. For instance, they might increase the volume and quality of investments in recycling equipment, with a view to keep stable the % of recycled waste. They might also consider levying taxes on accumulated waste. This policy might discourage further increases in population. However, it might level off – or even reduce – the territorial attractiveness, and community prosperity.

The role of e-government policies and systems in the production of the results described above is not the least important. According to a 2007 Swedish Country Report to the International Council for Information Technology in Government Administration (Verva, 2007), the following three emerging e-government trends were reported from within Sweden:

- The traditional reliance on *independent individual agencies* is complemented with a reliance on *functional 'agency federations'*.
- The Swedish national agenda becomes more and more intertwined with the agenda as an *EU Member State*.
- The new (Autumn 2006) Government is signaling more *emphasis on joined-up issues* and an *extended eGov portfolio for Verva*, an Administration Development Expert Agency.

The Swedish public administration made an early start on computerizing its work systems and information. The Swedish administrative model (an early adopter of New Public Management), with its independently managed central-government agencies, is considered to have had a major bearing on the rapid development of digital applications and e-services within the public administration. Thanks to a parallel implementation of performance management and delegation of powers, it was possible to create a development-oriented public administration. The prioritized objectives were: 1) improvement of the agencies' information management, 2) increase in information security, and 3) automated IT support for case management and procurement. The Swedish government stressed early on that the public administration should not be locked into specific platforms and technological solutions with the use open standards as far as possible (Verva, 2008). According to Andersson et al (2008) and Lind et al. (2009) the historical reconstruction of Sweden's efforts in e-government point strongly towards the requirement for common standards in order to establish a fully integrated networked public administration. Such standardization has had a good resonance in relation to inter-organizational IT innovation, but crucially for the case study we present in this paper also for its simultaneous contribution to the support for the creation of the successful example of the Hammarby eco-cycle model.

As early as 2001, the Swedish government appointed a forum for ICT and the environment, under the then Minister for the Environment, with a mandate until December 2003. The idea of the forum was to create a natural platform for ICTs and ecologically sustainable development. Work was implemented in a working group consisting of representatives from industry, research, the Swedish Environmental Protection Agency (Swedish EPA), ministries and environmental organisations. One of the group's tasks was to study the potential of ICT use in the development of emerging infrastructures, products and services that are resource efficient and less environmentally harmful. The work continued in the form of the Government's Strategy Group on IT Policy under the then Minister for Industry. Members of the group and its secretariat staff were recruited from both the private and the public sector (Government Offices of Sweden, 2010).

Hence, while Hammarby's vision was being implemented by the municipal government of Stockholm all Swedish government agencies were preparing to move from an agency centric mode of information production and management to a service oriented architecture to offer their information vault capabilities 'as a service' This approach was adopted not only for any other Swedish government organisation (at the state, regional or municipal level), but also EU-wide to industry (EU PSI Directive) and public authorities (EU Services Directive) (European Commission, 2012).

The above facilitated the emergence of a viability loop for integration with EU wide e-government solutions allowing for the simultaneous consideration of the environment in budgets, excellent spatial planning, reporting and territorial policy monitoring. This led to the creation of Minister for Information Technology and Energy within the Ministry of Enterprise, Energy and Communication in 2011.

Figure 6 presents a dynamic performance management model of e-government policy in Sweden.

The following ministerial initiatives are also worth mentioning: the monitoring and direct management of energy consumption, the emphasis on services, such as e-commerce, teleworking and e-government.

These initiatives – while supporting dematerialisation – facilitated the emergence of ICT solutions also beyond e-government, which are themselves energy efficient, such as thin clients, grid computing and virtualisation technologies.

In this context, partnerships between sectors have been introduced also to accelerate the development and wide-scale roll-out of ICT-based solutions for monitoring, managing and measuring energy-use and carbon emissions in energy-using activities. Finally, smart meters were introduced to enable feedback to be given to the end-user and instructive online solutions that encourage energy efficiency, eco-visualisation and energy simulations, which can promote a more responsible behaviour in energy use and information transparency. The positive impacts on environmental sustainability should not underscore also a series of counter-intuitive developments, resulting from reinforcing virtuous viability loops beyond government initiatives in other parts of the economy and society. For example, a number of successful best practices have been noted emerging from the private sector (especially in knowledge based industries) and substantial increase in projects and initiatives also in traditional sectors like buildings, transport and logistics – overall increasing the attractiveness of the territory and creating new professional profiles, job opportunities and employment.

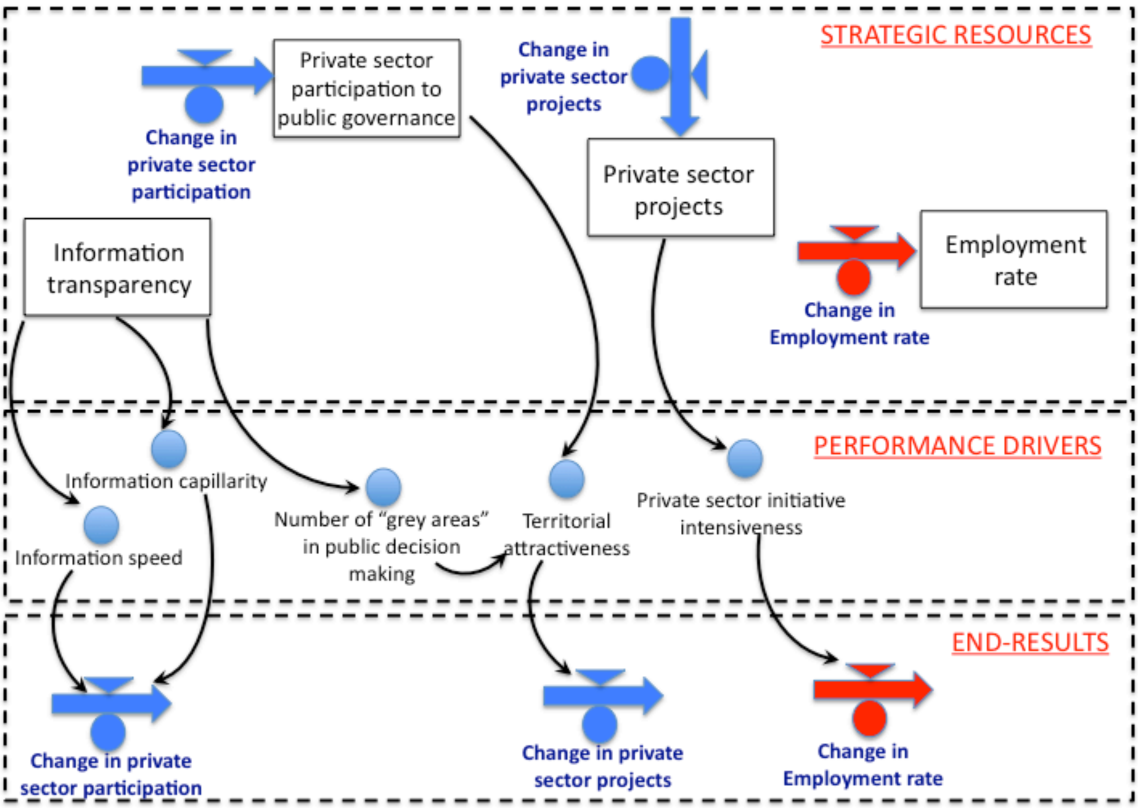

Figure 6: A dynamic performance management model of e-government policy in Sweden.

Between 2001 and 2009 TeliaSonera, a telecommunication company, has increased the number of telemeetings per employee by 157 percent, improved its energy efficiency by 59 percent and used only green electricity since 2007. In October 2010 a total of 10,000 new homes and 30,000 new workplaces were planned in a pilot area in the City of Stockholm, which is known as Norra Djurgårdsstaden, one of Europe's most extensive urban development areas. The Swedish Energy Agency, in partnership with VINNOVA, approved financial support for developing a concept for development and field installation of new technology providing both general and specific knowledge about the optimisation, control, maintenance and regulation of future smart-grids. Finally, the City of Stockholm in cooperation with IBM have put in permanent operation since 2007 the Stockholm congestion charging system, which covers a 24-square kilometre area of the inner city and is one of the largest system of its kind in Europe.

Last, but certainly not least in response to the European Commission recommendation C2009 (7604)[1] ('Member States should encourage the use of energy simulation and modelling in the education and training of professionals in critical sectors, in particular: (a) architects, builders and installers; (b) energy auditors; (c) logistics and the transport of goods or persons; (d) public services, planning and policy functions'), the Swedish government promoted increased knowledge about energy issues in the construction and property sector in a wider sense. A cooperation project was implemented between the government, public authorities and the construction industry involving training programmes aimed at, among others, business operators in the construction industry. One of the focus areas of the training is energy issues in connection with new constructions. Although the trainings have taken place only until 2010 the Swedish Energy Agency and the National Board of Housing, Building and Planning, have set up an information and advice online portal providing information and advice on energy-efficient homes and business premises (Government Offices of Sweden, 2010).

Towards an Agenda for the Evaluation of Urban Performance and Sustainable Development

Four main developmental threads can be identified where a systems dynamics approach can contribute to the enhancement of territorial performance management and sustainable development in urban areas linking e-government, economic development and urban

[1] The recommendation of the European Commission is available from:
http://ec.europa.eu/information_society/activities/sustainable_growth/docs/recommendation_d_vista.pdf

governance, i.e.: a) the understanding of the underlying causal relationships affecting performance in an inter-institutional context, b) how information flows, modalities and procedures between the different public and private entities involved can lead to sustainable outcomes in urban contexts, c) the impact on coordination, territorial management and policy making across organisational boundaries concerning the interactions between stakeholders from the public and private sectors, and d) the role of prompt and selective feedback loop perception to manage dynamic environmental interdependencies in complex urban processes.

Therefore, to evaluate the outcomes of sustainable urban development policies, a public decision maker, e.g. a regional planner, needs to move the focus of analysis from an institutional to an inter-institutional perspective (Bianchi, 2010). The relevant system's boundaries for such analysis are much broader than those that can be associated to an institutional perspective. In fact, other public and private institutions are involved in such system.

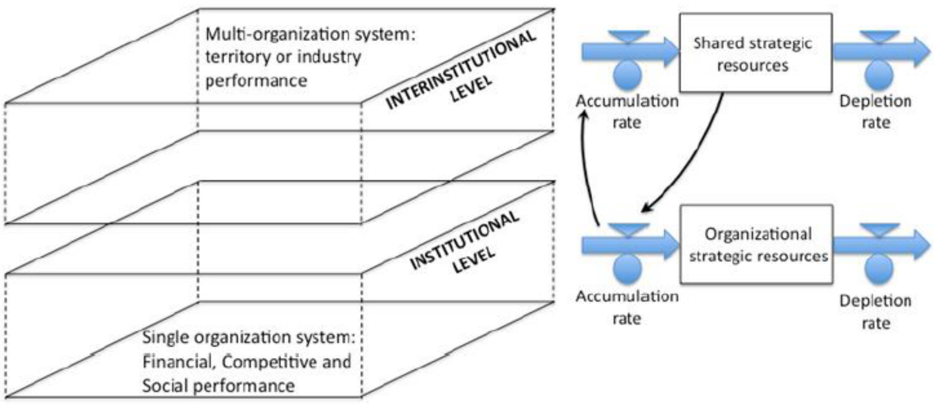

Figure 7: The institutional and inter-institutional levels for analysing sustainable urban development.

Figure 7 shows the institutional and inter-institutional levels for analysing sustainable urban development. Framing sustainability under an *interinstitutional* level is a traditional viewpoint when the outcomes of public policies are assessed. In such a context, a public institution often takes a coordinating role in a system characterized by multiple actors, (i.e.

public and private institutions) as it was the case of the early forum for ICT and the environment under the then Swedish Minister for the Environment. Particularly if we aim to evaluate policy outcomes in such context, the inter-institutional system's performance would not result from a mere sum of the performance levels produced by each single institution. It would be, rather, the effect of the net of relationships and synergies between the different institutions linked each other and the corresponding outcomes (see figures 4, 5 and 6).

Shared strategic resources at the inter-institutional level of analysis can be modelled as stocks of available tangible or intangible resources for organisations at the institutional level of analysis in a given time. Their dynamics depend on the value of corresponding in-and-outflows over time. Such flows are modelled as 'valves' on which decision makers can act through their policies, to influence the dynamics of each strategic asset, and therefore – through them – organizational performance at both the institutional and inter-institutional level.

Managing strategic resources to affect performance is a dynamic and complex task. In fact, intangible resources, e.g., community prosperity, trust, knowledge, and image, are difficult to identify and measure. Hence what role can system dynamics modelling play in enhancing processes of sustainable urban development? Gudmundsson (2009) at the Seminar on Transport Knowledge and Planning Practice, 14–16 October 2009, in Amsterdam, suggested that models can play different roles within the planning process: (1) Models as eye-opener: e.g. models can be used to place new environmental issues like global warming on the political agenda. (2) Models as arguments in dissent: e.g. a model might be used to challenge opposing assessments by way of counter-expertise and/or visualization of alternatives. (3) Models as vehicles in creating consensus: e.g. models might be used to help to create a consensus view of a problem among different stakeholders. (4) Models for management: e.g. models are utilized to assist stakeholders in concrete policy decisions (Pfaffenbichler, 2011). Here we find that SD models present all of the above characteristics.

Figure 8 illustrates the building blocks of territorial performance, sustainable urban development and the role of e-government policies and systems. The end-results of the exemplary case study presented in this paper can provide an endogenous source in the urban territory to the accumulation and depletion processes affecting strategic resources for sustainable development. These can be outlined in terms of climate change preparedness, liveability and citizens' satisfaction. In fact, they can be modelled as *in* or *out*-flows, which change over a given time span the corresponding stocks of strategic resources and as a result of actions implemented by public decision makers, possibly with the active participation of private sector institutions.

For instance, municipal projects for sustainable urban development may change private sector participation in such projects (strategic resources) as well as the overall employment rate (end result). A responsible behaviour in energy use (an end-result) and the use of available and emerging technologies in the public sector and surrounding region (a strategic resource) may lead to the reduction of CO2 emissions (end-result) and can in turn influence performance drivers such as energy use. There are also interdependencies between different strategic resources, urban infrastructure and the resulting spatial planning and environmental quality of an urban area: energy produced, water used and waste produced and recycled may affect not only the reduction in waste and water pollution, but also air quality. Furthermore, both presence and functioning of e-government policies and systems can in turn affect changes in energy use and production and support overall progress towards sustainable development both in terms of processes as well as outcomes.

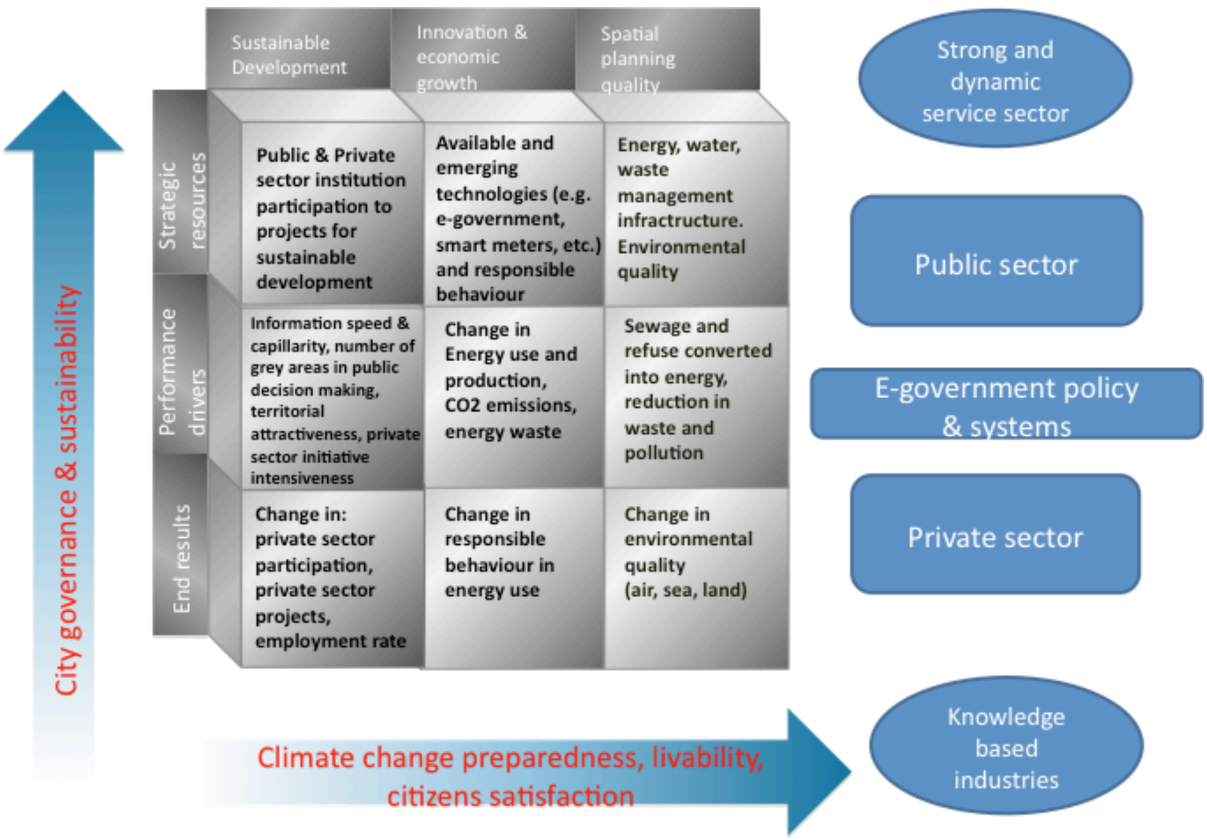

Figure 8: Building blocks of territorial performance, sustainable urban development and the role of e-government policies and systems.

A dynamic performance management perspective would stress that city governance and sustainability can improve if the rate at which end-results change the endowment of corresponding strategic resources is balanced. This implies that metropolitan management could be able to increase the mix of strategic resources and this increase is not obtained by reducing the endowment of the wider strategic resources in the territory including climate change preparedness, urban liability and citizens' satisfaction.

As shown in the case study, the combination of monitoring data with other urban data sets provided the base for the design of a dynamic performance management system on the theme of climate change and sustainable development supported by e-government policies and systems. If analyzed and designed from the perspective and demands of policy makers and with the adoption of a SD approach, e-government policies and systems can provide tailor-made information and maps which can directly be used in support of an integrated climate change policy, city governance and sustainable territorial development.

Conclusions

The literature reviewed, the exemplary case study and the discussion show that a SD approach can be used to identify strategic resources, performance drivers and end-results and to create a dynamic performance management model of key urban environmental processes with the greatest impact on the improvement of the urban sustainability and development. The case study of Hammarby provides evidence of the building blocks of territorial performance, sustainable urban development and the capacity of an integrated e-government policy and for the simultaneous consideration of the environment in budgets, excellent spatial planning, reporting and SD based territorial policy development and monitoring. Most interestingly, a scenario analysis using a preliminary dynamic performance management system highlights a number of counter-intuitive elements in the capacity to transform waste into environmentally sustainable electricity, the increase in job opportunities and of the employment rate and the conversion of a former city brownfield in Stockholm into one of the world's most successful eco-villages.

In conclusion, we can confirm all of the hypotheses presented in the introduction are true and remark that preliminary SD models can be used to highlight new ways enabling sustainable development in urban areas. The case study also suggests that SD can provide policy makers with an overview of the strategic resources, performance drivers and end results needed to support improvements in the environmental quality of urban areas and for future investigations on the roles of public and private institutions in the development and implementation of climate change policies. We also find that a SD approach can be used to present and analyse the interaction of various territorial governance policies established around a holistic programme for the improvement of environmental and social sustainability, to develop a dynamic performance management system for the evaluation of a territory's sustainable development policies. Finally, applying SD modelling in an inter-institutional context for the integration of sustainability issues in performance management and for the evaluation of sustainable development in urban areas may provide policy makers with new ideas to enable sustainable urban development and foster a common shared view among policy and decision makers allowing the networking of stakeholders at different levels (i.e. city, region and national) for the promotion of welfare and development and the extendibility of these networks to interact in collaborations on a global scale.

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