

Consideration of ecosystem services in urban resilience in South African cities

Emmarie Otto¹; Chrisna du Plessis²

Abstract

In 2011 South Africa published the 3rd State of Cities Report (SoCR) for its nine largest municipalities. This report, titled: "Towards Resilient Cities, a Reflection on the first decade of a democratic and transformed local government, 2001 – 2011", sets out to view the various economic, environmental, social and governance issues of the cities from a resilience perspective. The purpose of this paper is to critically examine the use of resilience thinking as an analytical framework for State of Cities Reporting, by using the Resilience Assessment Framework (developed by the international Resilience Alliance for assessing resilience in social-ecological systems) as a measure against which to interrogate the 2011 State of Cities Report (SoCR). For reasons of economy, the focus was on how the SoCR considered resilience in terms of ecosystem services provided to cities, and specifically the ecosystem service of fresh water. The objective of this paper is to critically examine how the resilience of urban ecosystem services was considered in the South African SoCR. It was found that while the 2011 SoCR opened the door to using a resilience approach in discussing the sustainability of cities, it does not really allow the user to gain an understanding of the resilience of the ecosystem services in South Africa's main cities and the reporting methodologies needs to be adapted in future reports. The paper concludes with recommendations for future reports.

Keywords: Urban resilience, urban ecosystem services, State of Cities, South Africa

1. Introduction

According to the UN-HABITAT (2010) in 2009, Africa's total population for the first time exceeded one billion, of which 395 million (or almost 40 per cent) lived in urban areas. Africa should prepare for a total population increase of about 60 per cent between 2010 and 2050, with the urban population tripling to 1.23 billion during this period. "With a projected 61.7 per cent of its population living in urban areas, Southern Africa remains the most urbanised sub region on the continent" (UN-HABITAT, 2010, p14). Furthermore, 62% of South Africa's population currently live in urban areas, mostly concentrated in the large metropolitan areas of Cape Town, the Gauteng Urban Region and eThekweni (Population Reference Bureau,

¹ MSc candidate; Dept of Construction Economics, University of Pretoria, emmarieotto@mweb.co.za

² Associate Professor; DEpt. of Construction Economics, University of Pretoria, chrisna.duplessis@up.ac.za

2011). These statistics paint a picture of great challenges to a global social-ecological system which is already under huge strain.

The State of Cities Report (SoCR) is acknowledged as a global tool to understand these challenges at an urban level and monitor progress towards set development goals, informing policies which allows for improved and more innovative public management and governance (Cities Alliance 2013). Since 2001 several State of the World's Cities Reports have been published by UN HABITAT and most members of the global Cities Alliance have published regular country reports of their own. In 2011 South Africa published the 3rd State of Cities Report (SoCR) for its nine largest municipalities. This report, titled: "Towards Resilient Cities, a Reflection on the first decade of a democratic and transformed local government, 2001 – 2011", sets out to view the various economic, environmental, social and governance issues of the cities from a resilience perspective. This is the first time that resilience has been introduced as an analytical framework for State of Cities Reporting. Previous reports have used concepts of productivity, inclusivity, sustainability and governance as an analytical framework.

The purpose of this paper is to critically examine the use of resilience thinking as an analytical framework for State of Cities Reporting, by using the Resilience Assessment Framework developed by the international Resilience Alliance as a measure against which to interrogate the 2011 State of Cities Report (SoCR). For reasons of economy, we will focus on how the SoCR considered resilience in terms of ecosystem services provided to cities, and specifically the ecosystem service of fresh water.

The first half of the paper introduces the theoretical frameworks used to frame the study, namely resilience theory (especially in the context of social-ecological systems) and the Resilience Assessment Framework developed by the Resilience Alliance, as well as the notion of ecosystem services. In the second half of the paper the State of Cities Report and its approach to resilience and ecosystem services is introduced. The paper will then proceed with assessing how three steps of the Resilience Assessment Framework can be used to understand how the SoCR considered resilience in terms of ecosystems services, before concluding with recommendations for future reports.

2. The Resilience Assessment Framework

2.1 What is resilience?

There are a number of definitions and interpretations of resilience (Holling and Gunderson, 2002; Walker and Salt, 2006; Pendall et al. 2010). The Resilience Alliance (2010, p5) describes the resilience of social-ecological systems as: "Resilience is fundamentally a system property. It refers to the magnitude of change or disturbance that a system can experience without shifting into an alternate state that has different structural and functional properties and supplies different bundles of the ecosystem services that benefit people". However, it should be noted that the definition of resilience in an urban context is still under contestation, with the definition by the Resilience Alliance (see above) being criticised as

equilibrant and not suitable for cities which are characterised by constant evolutionary change and multiple desirable states (Simmie and Martin, 2010).

The city can be described as a special category of social-ecological system, reflecting an ecosystem which consists of a community of plants and animals and the physical environment of that community (Rowe, 1961). In the city the physical environment would include the built environment and the community of animals would include humans and the individual and collective normative and functional institutions they contribute (Du Plessis 2012). The resilience of a social-ecological system is determined by the presence of certain values and characteristics within both the tangible and intangible components of the city. These include adaptive capacity, (determined by factors such as diversity, modularity, degree of connectedness and tightness of feedback loops); the potential available in the system, whether social capital or system reserves and variability in critical ecosystems services; and an acknowledgement of slow variables (Holling and Gunderson 2002; Walker and Salt 2006, pp145-148).

2.2 The Resilience Alliance Framework for assessment

The Resilience Alliance (2010) proposes an iterative and reflexive process for assessing resilience in social-ecological systems that follows five main stages (described in Figure 1).

The first step is to develop a description of the system including the key components of the system and, in order to focus and direct the assessment, the main issues (or disturbances) that should be considered. (Resilience Alliance 2010, p13) These are identified by asking resilience of what to what, and by investigating the dynamics in the system. This requires that the history of the system be considered to identify changes across multiple scales of time and space and the social and ecological dimensions that interact with the focal system. (Resilience Alliance, 2010, p18). This is followed by **step two** where the Resilience Alliance (2010) further proposes that different thresholds and system states can be identified that create a panarchy of adaptive change cycles that leads to the **third step**. In this step, the interaction between the different systems are assessed through investigating the influence of and the interaction between the larger-scale systems in which the social-ecological systems are entrenched as well as with the smaller scale systems which it consists of (Resilience Alliance 2010, p29). By identifying the present phases of the connected systems, potential vulnerabilities and opportunities in the focal system is revealed (Resilience Alliance 2010, p29). This step therefore assesses how the system variables might be expected to interact. This is valuable information and important for management decisions (Resilience Alliance 2010, p32) This

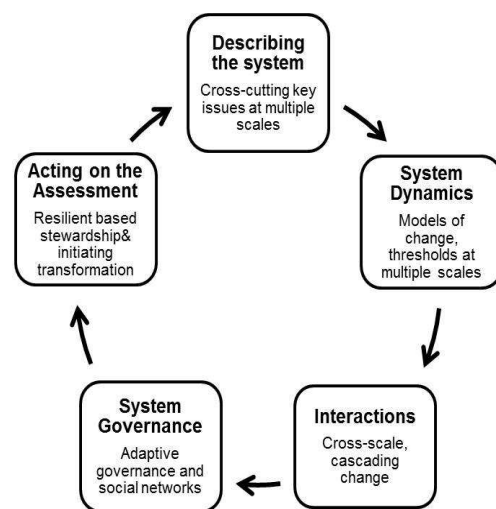


Figure 1: Framework for Assessment (Resilience Alliance, 2010, p5)

leads to the **fourth step**, which deals with evaluation of the governance in terms of its adaptive governance capacity and the strength of the social networks that exists (Resilience Alliance 2010, p41); and then the final step, **step five**, in the Resilience Assessment Framework, is to evaluate how to best act on the assessment through synthesising the assessment findings, identifying the thresholds interactions, the development of stewardship strategies, timing the transformation and finally implementing the resilience assessment. (Resilience Alliance 2010, pp43-50)

According to the Resilience Alliance (2010), the resilience of the urban system is compromised when it's supporting ecosystems services are threatened and degraded as a result of ineffective and inflexible institutions, loss of biodiversity, pollution and a focus on production and increased efficiencies, which in turn leads to a loss of functional and response diversity and redundancy. Ecosystem services are more often than not recognised only after they have been lost. Planning for resilience would include ecosystem services in development strategies and proposals in contrast to purely market driven economies where ecosystem services are ignored. (Walker and Salt, 2006; Resilience Alliance, 2002)

Ecosystem services can be summarised into four groups, as described in UNEP's Millennium Ecosystem Assessment (MEA 2005, p7):

- Provisioning of services: food, water, timber, and fiber, natural medicines, pharmaceuticals, genetic resources and biochemicals;
- Regulating services: climate regulation, air quality regulation, water regulation, erosion regulation, water purification and waste treatment, disease regulation and pest regulation, pollination, natural hazard regulation;
- Cultural services: spiritual and religious values, aesthetic values, ecotourism and recreation; and
- Supporting services: soil formation, photosynthesis, and nutrient cycling.

3. Resilience and ecosystem services in the SoCR

3.1 Resilience as defined in the South African SOCR

Opposed to the approach to urban resilience which implies "...coping with or ameliorating the effects of the problem and restoring the position that existed beforehand. (SACN 2011, p12), the SoCR supports an approach to resilience which implies "transforming local conditions for the better, based on experimentation, creativity and innovation, therefore using a more dynamic approach of resilience" (SACN 2011, p12). The SoCR defines the concept of resilience as, "the capacity of a place to anticipate, respond and adapt successfully to challenging conditions, such as global recession, environmental threats or pressures of population growth." (ibid). The resilience theme in the SoCR recognises that "change is necessary to avoid being locked into inefficient urban structures, outmoded environmental technologies, obsolete industries, conflicting social patterns and inflexible institutions" (SACN 2011, p12). The SoCR also establishes the link with ecosystems in the context of

resilience and describes the cities' dependence on healthy supporting ecosystems to cope with global crisis such as food crises and riots and natural disasters (SACN 2011, p88). The SoCR also emphasises that the current patterns in which cities conduct their business, have the potential to destroy the very ecosystems on which cities' livelihood depend, unless significant change are made in the way settlements are managed.(SACN 2011, p88). In considering resilience the SoCR looked at four aspects of the city: the economy and the financial state of the city, city governance, social resilience as supported by the built environment, and cities as life supporting systems (including ecosystem services). The SoCR discusses a number of critical concerns which can be considered as press disturbances on the city system. These include economic transformation, social division, natural resource depletion and climate change, and the spatial and institutional structures of South African cities.

3.2 What ecosystem services were included in the SoCR?

The SoCR deals with the natural resources in the city under the topic: 'Cities as Life Supporting Systems'. This is done in three sections, the first deals with 'Improving Resource Productivity' which include issues of water, electricity and transport fuel, although the latter two is not regarded as ecosystem services as such. The second section addresses "Enhancing Local Capacity", which deals with the issues of food supply, sustainable energy and ecosystem goods and services. The ecosystem goods and services covers the valuing of ecosystem services in general, it also refers to biodiversity initiatives in the city, conservation and wetland rehabilitation and forestation. The third and final section, describes 'Closing the Waste Loops" and include issues on solid waste recycling, waste to energy and water re-use, these are not addressing ecosystem services as such, but rather how city infrastructure is replacing regulating ecosystem services such as water purification and waste management.

It can therefore be concluded that the ecosystem services addressed in the SoCR, include food and freshwater as *provisioning services* for the city; forestation(climate/air quality regulation) and wetlands(water regulation/purification) under *regulating services*; and biodiversity as part of *supporting services*. To discover how resilience was approached in the way the SoCR's considered ecosystem services, this paper will focus on the ecosystem service provided by freshwater.

3.3 What characteristics of resilience did the SoCR consider?

Although the SoCR did not explicitly address the characteristics of resilience, in the discussion on ecosystem services the following characteristics of resilient systems were revealed. Diversity was addressed in terms of biodiversity. Social capital, modularity and tightness of feedback were briefly revealed in illustrating biodiversity initiatives in communities. Emerging policies in support of urban food production initiatives entering the system hints at openness. System reserves were discussed in terms of the expected shortage of freshwater reserves by 2025; ecosystem services were discussed but not ecological variability; and innovation was indirectly addressed as a solution to extend the

freshwater resources by reclaiming waste water through a waste water recycling facility to provide water for industrial use, therefore saving potable water supply

4. Using the Resilience Assessment Framework to describe the State of Cities from an ecosystem services perspective

Although the SoCR aims to use a resilience lens to engage with the state of cities it did not explicitly include a framework for resilience assessment. In this section the process suggested in the Resilience Alliance Workbook (2010) is used to test the usefulness of the current SoCR in assessing resilience with the intention to develop suggestions for how this aspect of the report can be improved. This will be done in three steps, firstly by looking if a focal system/s was identified, followed by considering if system dynamics was considered and thirdly assessing if, and how the cross scale interactions were taken into account.

4.1 STEP 1: Describing the focal system - setting soft boundaries

As suggested by the Resilience Alliance (2010), the first step includes the setting of the system boundaries and defining the focal system. This is done by identifying the main issues; determining the key components of the systems (and asking resilience of what?); identifying the key disturbances, disruptions and uncertainties in the systems (and asking resilient to what?); and lastly, understanding the multiple space and time scale of the system.

There are two issues which emerged in terms of freshwater in the SoCR. They are the adequate supply of freshwater and the quality of freshwater. Based on the SACN (2011, p91), South Africa is a semi-arid country with a shortage of water supply for beneficial water and sanitation services. "Few cities are currently self-sufficient in terms of their water supply..."(SACN 2011, p91), with a projection that by 2025 the supply of water in 58% of South Africa's water management areas will be outweighed by demand (SACN 2011, p92). The SoCR also briefly highlighted issues on water quality, as the quality of ecosystems and water bodies are affected by the polluted water coming from ineffective waste water treatment works and acid mine drainage. The following drivers of the focal system in terms of fresh water were identified: badly maintained water supply systems and unsustainable consumer consumption patterns and ineffective functioning of water purification plants.

Resilience assessment requires also that a time frame of relevance to the issues be determined. Although the SoCR speaks of the progress of the last 10 years, the data generally only covers a five year historical period, while future projections of fresh water availability is limited to 13 years.

The SoCR did not explicitly highlight what aspects of this ecosystem service the city needs to be resilient. However, these aspects can be inferred as healthy freshwater systems (ecological components) and supply of clean freshwater systems (social components). These two interdependent systems (the natural freshwater systems and the technical infrastructure to supply and purify water) can be seen as focal systems of the SoCR.

The following disturbances affecting freshwater supply could be identified from the SoCR: unpredictable weather patterns (droughts and floods), unsustainable per person water consumption, wastage of water due to poorly maintained water supply systems and the uncertainty of city level data on resource stocks and flows which cities require in order to be accountable for their resource.

The SoCR has not addressed any historical disturbances or their effects on the focal systems. Except for the demand of freshwater, which poses a potential future uncertainty in terms of the shortage of water supply, there is also no interpretation of the current disturbances presenting a concern. Neither ““pulse” disturbances that occur as singular events”, or ““press” disturbances that occur continually” and over a longer period of time, were considered in the discussions of the two focal systems. (Resilience Alliance 2010, p16) The SoCR does list management strategies relating to minimising the effect of disturbances of freshwater. These include Water Conservation and Demand Side Management (WC/WDM) strategies and projects to ensure improved water resource management. The SoCR also suggests of the improvement of government resource management through innovative strategies that encourage more efficient use of resources and minimise waste and input cost (SACN 2011, p91). A further uncertainty highlighted is the undervaluing or in cases ignoring the economic value of the benefits and potential contributions to disaster mitigation and management provided by features of the freshwater ecosystem such as wetlands (SACN, 2011, p107).

As suggested by the concept of the panarchy, the focal system is part of a hierarchy of nested systems that function at multiple space and time scales (Resilience Alliance 2010, p18). Although some issues originating in larger or smaller scale systems that pressurise the focal systems can be identified in the SoCR, there has been no attempt to structure these in a more comprehensive understanding of the interactions between these two focal systems or their larger or smaller scale manifestations as these relate to the city. Neither of these focal systems was considered against a historical timeline that included social and ecological dimensions of these systems at larger and smaller scales.

4.2 STEP 2: System dynamics

As suggested in the Resilience Alliance Workbook (2010), the next step is to investigate the dynamics in the system. This requires that the history of the system be considered to identify changes across multiple scales of time and space and the social and ecological dimensions that interact with the focal system. From this, different thresholds and system states can be identified that create a panarchy of adaptive change cycles that leads to the third step.

Although this is not highlighted by the SoCR, it can be assumed that the freshwater system in the SoCR can be described as moving from a rapid growth phase into a conservation phase. The SoCR did not explicitly draw on the context of the adaptive cycle or identified the phases of the adaptive cycle through which the system has moved over time. As there was no historical timeline done in the SoCR, it is difficult to infer the key variables that would allow the tracking of changes over the history of the system. Locating the key variables over

time can provide knowledge regarding the timing and nature of the changes in the system (Resilience Alliance, 2010, p24). The SoCR did not describe its ecosystem services in terms of the alternate states or historical state(s) of the systems, as seen in the phases of the adaptive cycle. It furthermore did not describe the transition phases between alternate states of the system and the key variables that determine a transition between alternate states (Resilience Alliance, 2010, p24). Except for the freshwater system where a future prediction of a clear tipping point and transition is predicted by 2025, the SoCR did not identify any possible thresholds or tipping points.

4.3 STEP 3: Cross scale interactions

As suggested by the Resilience Alliance (2010, p29), the third and final step addressed in this paper will assess the cross scale interaction found in the panarchy of the system, as well as the interacting thresholds and cascading of change. This will lead to a discussion of the general and specific resilience of the system.

The SoCR does not address the desirable and undesirable influences from larger-scale systems or describe any system vulnerabilities at the focal scale identified by considering cross-scale interactions. It also did not “characterize the balance (or tradeoffs) between flexibility and efficiency in the focal system”, as suggested by the Resilience Alliance (2010, p31). The SoCR also did not list “the main thresholds associated with key slow variables”, nor did it indicate any effects arising through the interactions which includes factors that influence the crossing of one threshold to another either by increasing or decreasing the effect (Resilience Alliance, 2010, p34).

The Resilience Alliance (2010, p35) considers the elements of general resilience to include diversity, openness, tightness of feedback, system reserves and modularity. When these concepts are applied to the discussion of the freshwater ecosystem services by the SoCR it can be seen that the following elements of general resilience were considered in the SoCR in terms of fresh water supply and quality. The element of system reserves was highlighted in terms of the freshwater supply, which is depreciating as demand grows. The element of diversity was also indirectly addressed in discussing the expansion of the city’s water resources through reclaiming waste water, which requires innovation and openness in the system.

5. Findings

The SoCR supported a transformative resilience approach. This places emphasis on change and renewal, and considers the building of adaptive capacity and potential in the system, enabling the system to adapt to the challenging conditions of global pressures, environmental threats and the dynamics of population growth, which cities need to deal with (SACN 2011, p12).

The discussion of the freshwater system does not reveal sufficient information to obtain a view on the resilience and the actual vulnerability of the current system. This is due to the

fact that it fails to acknowledge the slow variables associated with critical thresholds. The SoCR does not reveal a historical profile of the focal systems (freshwater systems in this case), depicting what were the “driving forces that contributed to or triggered major change” (Resilience Alliance, 2010, p21). By extracting the information of the various driving forces through time and understanding the patterns of past disturbances which shaped the current system, this knowledge increases the capacity of managing these effects better in the future, therefore increasing the resilience of the system (Resilience Alliance, 2010, p18).

Fresh water systems also need to be considered in a wider context to include their interdependence with the other systems to which they are connected. The issue of freshwater stretches far beyond the supply of water to the city, it also needs to be considered as part of a bigger ecosystem which spans regional, national and even international boundaries. As Folke et al suggest (2002, p10) “freshwater is required to sustain the capacity of, for example, forests, wetlands, agricultural land, and savannahs to uphold the flow of ecosystem goods and services to humans.” Future reports need to recognise that the resilience of the ecosystem service provided by freshwater cannot just be determined by considering the quantity of water. It is also necessary to acknowledge the human related challenges such as industrial pollution, untreated effluent, use of fertilisers, unmanaged water-thirsty alien vegetation and development in floodplains, which decreases the functioning of the freshwater systems and increases its vulnerability.

It would be valuable for future reports to include a more detailed investigation into the resilience aspects of a system, to pinpoint the real problems which could then be addressed to enhance resilience. Future reports should:

1. Clearly identify focal systems and the focal scale that serves as point of departure. This will allow the construction of a panarchy model for each focal system that will illustrate the systemic interactions between higher/larger scales of the system (e.g. national or regional water systems), the focal scale of the system (e.g. a watershed) and the lower/smaller scales of the system (e.g. wetlands) that are usually the subject of illustrative case studies.
2. Develop a systems perspective that can improve understanding regarding the interactions between different systems and the changes/disturbances that result from these interactions (e.g. the industrial system and its resultant demands for freshwater and pollution of water sources). To do this it is necessary to identify the key variables that describe the system, the potential thresholds in these variables that separate one system regime/ state from another and the pressures on these variables as a result of disturbances introduced by other systems.
3. Describe the changes in the focal systems along timeframes that can adequately capture change at larger system scales. This will necessitate the development of historical timelines that span at least 50 to 100 years in the case of ecosystem services.

4. Use the above information to establish the adaptive cycle phases exhibited by the focal system and its current position in this cycle. By monitoring this in successive State of City Reports, city managers will be able to identify possible threats and opportunities in the system that are opened up by the specific phase of the adaptive cycle the system is experiencing.
5. Gather and organise data on changes in the system that will allow the identification of attributes of resilience such as diversity, adaptive capacity and connectedness, exhibited by the system being studied.

6. Conclusions

The objective of this paper was to critically examine the use of resilience thinking as an analytical framework for State of Cities Reporting, as expressed in the 2011 South African State of Cities Report, with specific reference to the resilience of urban ecosystem services. This was done using a comparison with the Assessment Framework suggested in the Resilience Alliance Assessment Workbook. It was found that the resilience of ecosystem services was not adequately addressed in the SoCR. This can be remedied in future reports by incorporating wider and more integrated historical information of the various systems and the changes in the systems over time, including information on the drivers of those changes. There is also no discussion around critical aspects of resilience such as cross-scale interactions, thresholds and methods for monitoring these thresholds. Future reports could address fewer ecosystem services but those that are addressed should be assessed in more detail to determine their adaptive capacity and to reveal the thresholds of change, in order to enable the management of these systems. Overall, while the 2011 SoCR opened the door to using a resilience approach in discussing the sustainability of cities, it does not really allow the user to gain an understanding of the resilience of the ecosystem services in South Africa's main cities.

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