Exploring a Methodological Framework for Understanding Adaptive Change in Cities

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Abstract

Resilience is about change and how systems respond to change. To understand resilience it is therefore important to understand how cities respond to change. Cities can be described as social ecological systems that react to change and perturbations through responses at various spatial and temporal scales. In the study of resilience of ecosystems, this is described through the concept of panarchy and the metaphor of the adaptive cycle. The adaptive cycle is used widely as a key metaphor to describe resilience. Central to this metaphor is the idea that systems undergo periodic cycles of change without fundamentally changing functional identity, remaining within a particular basin of attraction. However, internal or external pressures may also cause the system to tip into another basin of attraction or system state, with a different functional identity.

In ecosystems, these different states are well described and the characteristics indicating a change in identity are well defined. However, in the study of urban social ecological systems, this is still a mainly unexplored topic and the methodologies for identifying and mapping different urban system states and phases within the adaptive cycle, let alone the application of the adaptive cycle concept requires further investigation.

This purpose of this paper is to present a proposed a methodological framework for describing the movement of cities or neighbourhoods through the various phases of the adaptive cycle and possibly, different system states. This method is illustrated using the example of two neighbourhoods in South Africa and the changes they experienced over a period of approximately one hundred years.

Keywords: Resilience, **Panarchy, adaptive cycle, urban systems**.

1. Introduction

Cities, like ecosystems, are complex adaptive systems (Holland, 1996; Gunderson and Holling, 2002; Johnson, 2002; Taylor, 2005; Davoudi et al., 2012). As a great deal of work on resilience has been done on the study of ecosystems, and social-ecological systems

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(Davoudi et al., 2012) it would seem only appropriate that in our quest to understand urban resilience that we build on and apply the thinking and concepts that have already been developed within this field. However, unlike ecosystems, the processes and methodologies for describing urban systems and the way they change have not been fully explored. Such exploration is necessary as resilience in the urban environment may mean something different to resilience of an ecosystem. This paper aims to explore a possible methodological framework to map adaptive change, based on the concept of panarchy and the metaphor of the adaptive cycle. This framework was developed while reflecting on previous studies of two neighbourhoods in Tshwane that the authors have undertaken.

2. Background to key resilience concepts

2.1 Panarchy

Among the most notable of theories that describe resilience of social-ecological systems and explain how these systems naturally change and evolve is the concept of panarchy and the metaphor of the adaptive cycle introduced by Gunderson and Holling (2001). The concepts behind the panarchical view of social-ecological systems as described by Gunderson and Holling (2001) are:

1. Social-ecological systems should be treated as complex adaptive systems in which the various agents are constantly adapting to the changes within their environment. Due to the interactions by the various components the system may produce unpredictable behaviour.

2. A system can have more than one stable state instead of a single point of equilibrium. Change can still happen within each stable state; however a few, normally three to five, important variables and interactions remain the same. A system with more than one stable state can move quickly between states when a critical threshold or tipping point is reached. A prime example of this is the cycles of growth and recession that happen within an economy.

3. “Panarchy emphasizes the importance of relevant interactions across geographic and time scales” (Gunderson and Holling, 2002, p3). This highlights the importance of a system’s history as well as that a system interacts at higher and lower spatial scales, also referred to as nested systems. Systems at higher scales tend to move at a slower rate though the adaptive cycle than those at the lower scales. “In panarchies transformational change can be generated from below or from above. At the same time larger, slower levels can act to reinforce and sustain the panarchy” (Gunderson and Holling, 2002, p25).

The concept of panarchy still needs to be tested on urban systems. The Resilience Alliance 2010, p30) suggested that the city be seen as the focal scale, with neighbourhoods forming sub-systems, and one can add, within neighbourhoods the streets or buildings forming sub-systems of the neighbourhoods. This understanding comes from the practice of defining large ecosystems such as a watershed as focal scale. However, the complexity of the city

and the diversity in its smaller sub-systems suggest that for urban resilience it would be more practical to look at a smaller scale such as the neighbourhood or city district as focal scale.

2.2 The Adaptive Cycle

The metaphor of the adaptive cycle is used to describe the movement of a system through four distinct phases typically followed by social-ecological systems. The various phases of the adaptive cycle are: Growth (r); Conservation (k); Release (Ω) and Reorganisation (α) and are described in further detail in Table 1 below.

Table 1: A summary of the characteristics of each phase of the Adaptive Cycle as described by (Gunderson and Holling, 2001, 2002; Folke, 2006; Davoudi et al., 2012)

Phase of Adaptive Cycle	Characteristic of each phase	Level of Resilience
r Growth	This phase occurs early in the cycle and is characterised by a period of rapid growth, and an accumulation of resources, as 'agents' (often innovators or entrepreneurs) seizes opportunities after a disturbance and make use of this time to exploit new niches. The system components are weakly interconnected with little or no internal regulations. There is an increasing degree of diversity; however the system is more vulnerable and far more easily influence by external variability. The agents (individuals) that function best in this phase are those that are best "adapted to dealing with the stress and opportunities of a variable environment – the risk takers, the pioneers, the opportunists"(Gunderson and Holling, 2001, p 43). These agents typically operate at a local scale and over short time periods.	High, but decreasing
k Conservation	The transition from the r phase to the k is a slow incremental process that happens as resources begin to accumulate (as the system moves closer to the k phase its growth rate slows). The connections between the different agents increase as the system moves towards a more regulated but stable state. The increase in stability comes at a cost as the system is only able to deal with a decreasing range of situations. The agents that reduce uncertainty are now favoured over those that functioned better in a variable environment. The shift from the k to the Ω (Release) phase can happen at any time as the system is now more vulnerable to shocks.	low
Ω Release	When a system transitions into this phase it is usually rather sudden and happens when a disturbance pushes the system past a particular point or threshold. The resources that were accumulated during the k phase are now released as the strict regulations and interconnectedness of the system is now broken. This continues until the disturbance has dissipated.	Low but increasing
α Reorganisation	The shift from Ω to α is characterised by the system having weak internal controls; the opportunity for innovation; high potential. However there is a large degree of uncertainty and a reorganisation of the system's structure. The system is also easily influenced by external factors which can lead to renewal or collapse of the system.	high
*An agent can be an individual, household, firm, organisation, government, etc.		

The concept of the adaptive cycle falls within the lager concept of panarchy whereby social-ecological systems form sets of nested adaptive cycles that operate at varied scales. The

larger scales tend to have slower cycle speeds while the lower, smaller scales, tend to have more rapid cycles through the adaptive cycle (Gunderson and Holling, 2001; Folke, 2006; Resilience Alliance, 2010). It is by examining how systems undergo these changes and their behaviour at the various phases that we may begin to better understand resilience in general and more specifically, urban resilience. It is also important to note that “transitions between the four phases of the adaptive cycle do not always follow the same sequential pattern” (Resilience Alliance, 2010) as described by the adaptive cycle. Some systems may skip a phase completely and move onto the next or even go back to the previous phase (Resilience Alliance, 2012).

2.3 What has been done before

The Resilience Alliance (2010) has developed a workbook for assessing the resilience of social-ecological systems that draws on insights derived from complex adaptive systems and concepts such as panarchy and the adaptive cycle. This workbook provides a process to assess the resilience of a particular function of a system or sub-system. It is based on the development of a conceptual model of the social-ecological systems being studied, with the intention of identifying critical thresholds between different system states. To develop the conceptual model the assessment process uses an issue based approach to a) focus the assessment; b) determine the boundaries of the focal scale, and c) identify critical stakeholders and elements. It further uses the tool of historical narrative to map the movement of the system through phases of the adaptive cycle, as well as identify disturbances, cross-scale (spatial and temporal) interactions, different possible system states and the variables that determine these states and which point to the thresholds between states. However, there are a number of uncertainties that are not yet resolved in a satisfactory manner, especially as concerns its use in urban systems. The primary focus of the assessment process is on ecosystems and the effects of human systems on the environment and vice versa, and therefore the examples that have been used are rooted in ecological science and or disaster risk reduction. There is very limited guidance on how to address the concerns of urban resilience, with the urban environment being evaluated as an integrated system. In particular, the workbook does not provide adequate guidance on how to identify the key elements, drivers and agents, especially within the urban system. As practitioners continue to engage with the assessment workbook, more of its shortcomings are exposed and gaps in understanding are bridged. Haider et al, (in Davoudi et al, 2012, p 317), suggest a number of ways to improve the usefulness of the workbook, one of them being a larger diversity of examples of how the resilience assessment has been used. This paper (and the studies on which it is based), attempts to contribute to the development of the assessment process by including the urban social-ecological system. What we are suggesting is not an assessment framework, but rather a process for understanding the adaptive change cycles that an urban area undergoes and the forces that shaped the study areas, so as to discover the key elements, drivers and agents within the urban system being studied. As such it is seen as another tool in the larger assessment framework proposed by the Resilience Alliance workbook.

3. A Proposed Methodological Framework for Understanding Adaptive Change within Cities

The methodological framework that is being proposed was developed through deliberation of the processes that the authors have developed while investigating urban systems and their resilience. Its theoretical base stems from the rationale that the urban environment is a complex adaptive system, and the concepts of panarchy and the adaptive cycle as a primary means to describe changes that systems undergo. Although the panarchical and adaptive cycle concepts have been developed for use for social-ecological systems (Gunderson and Holling, 2001), with the focus being on the ecological system, we believe that these concepts can be adequately translated to describe the urban system.

As discussed, cities are a particular subset of social-ecological systems and any method that seeks to assess or understand their resilience needs to look at the integrated urban system, considering the interactions between not only its ecological and socio-economic systems, but also its spatial and physical attributes and the requirements of community resilience. Furthermore, it should be able to deal with the diversity of its sub-systems and with the complexity and sheer amounts of data that is required. The complexity of the issues means that the rule of hand often cannot capture the critical dynamics at the scales where social and individual resilience come into play and where the tensions between remember (the slow-changing spatial and institutional structures) and revolt (critical self-organization at neighbourhood scale that combines to change or threaten the larger scale functions of the city, e.g. enclosed neighbourhoods or service delivery protests destroying infrastructure) creates the greatest dangers for tipping the system into another system state.

We are proposing that for urban resilience the appropriate focal scale should be at the level of neighbourhood or city district as the level that sits between the self-organising activities of individual agents (households, businesses) that ultimately shapes the structure and functions of the city, and the larger urban system that provides the slow changing variables. This brings in the multiple scale perspective that lies behind the idea of the panarchy. Furthermore, because a “city is a kind of pattern-amplifying machine: its neighbourhoods are a way of measuring and expressing the repeated behaviour of the larger collective… [as] those patterns are fed back to the community, small shifts in behaviour can quickly escalate into larger movements” (Johnson, 2002, p40). The neighbourhood forms a subsystem of the larger city system while the street and site level form subsystems of the neighbourhood system.

The case studies that we will use as examples are based on a study completed in 2011. This study explored spatial change and the drivers behind it within the context of a South African neighbourhood. We have reinterpreted and added to the data from the original study in order to begin to look as how neighbourhoods go through a cycle of adaptive change. Throughout the description of the proposed framework, reference will be made to previous studies in the form of examples as well as part of the reflective process of what has been done.

The two case studies used were of Lyttelton Manor (Lyttelton) and Irene, both in the former town of Centurion that now forms part of Tshwane (Tshwane is the municipal area that

includes Pretoria). These neighbourhoods are located in close proximity to each other but have developed very differently over the past one hundred years. The studies involved a historical overview of the development of the two neighbourhoods, and considered social, economic and institutional factors that played a role in shaping their spatial structure. The findings of the studies suggested that, in the case of these two neighbourhoods, the availability of water, the community attitude to development, location in relation to employment centres as well as to services and retail facilities that are in close proximity are amongst the principal forces that have shaped these neighbourhoods (Nel, 2011). The findings further indicated that no one specific factor can be attributed to having the largest effect of transforming these neighbourhoods spatially. It was rather a combination of different factors, and the interaction between them that occurred at different times and scales, throughout the history of the two neighbourhoods that influenced them. This confirms the idea that one needs to consider the urban environment holistically as a complex adaptive system. However, due to the nature of the studies no ecological data was included. Future studies should take this into consideration.

3.1 Towards a Methodological Framework for studying adaptive urban change

This section outlines the methodological framework used. This framework builds on the Resilience Alliance assessment process (2010), but adapts it to suit the urban system. Examples will be given from the mentioned case studies to help the reader understand and to help support the concept.

Step 1: Select a focal area and set boundaries

To begin an assessment the study area must be selected and boundaries must be set (Resilience Alliance, 2010, p10). Boundaries are placed in order to maintain the focus on the focal area. The bounding of the focal area becomes increasingly important as systems are open to their environments and rarely have clear, well defined, boundaries (Meadows, 2008; Innes and Booher, 2010). The boundaries that are applied should be not only over space but time as well. They should take the form of soft/porous boundaries; which acknowledge that there are cross scale interactions and that systems cannot be cut off as they are open to outside influences. The boundary is placed as a means to keep the study practical. Setting boundaries is up to the discretion of the observer and may have to be adjusted to include or exclude some particular aspects as the assessment is carried out;. This is a very iterative process. For the case studies the existing boundaries of the two neighbourhoods were used, as they were already well defined (see Figure 1).

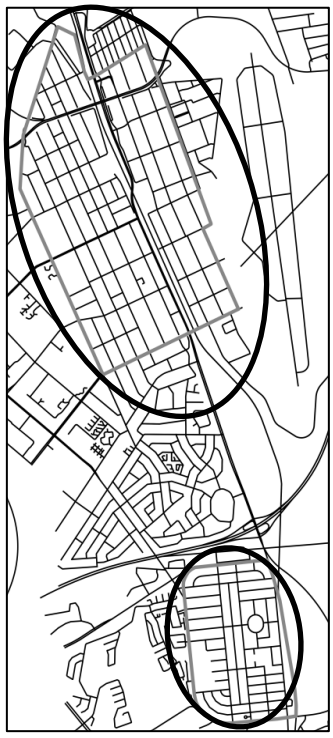

Figure 1: Lyttelton (top) & Irene (bottom).

Step 2: History of the focal area

Once the boundaries have been delineated for the study, the second phase of the framework is to compile a history or timeline of the focal system. A system's history matters, as its present and future behaviour are largely due to its past (Cilliers, 2000; Geyer and Rihani, 2010). As we will illustrate, the history of the system will begin to allude to the system's resilience. Developing such a timeline needs to consider various sources from the different physical, institutional and social systems at play. Throughout this process it is important to begin to identify spatial and temporal patterns that repeat themselves. The history of the focal system should be done as far back as possible, while remaining plausible and relevant to the study.

A one hundred year period was selected for the case studies as this was when the two neighbourhoods were established. There was also sufficient historical information available to allow for a study over this length of time.

Step 3: Identification of key events and changes

The next phase is to begin to look for 'frozen accidents'; events which have inadvertently set the system on a specific path or become an underlying part of that system which in turn shapes the system's current and future behaviour (Holland, 1996; Gunderson and Holling, 2001; Geyer and Rihani, 2010). Once a 'frozen accident' has been identified it is important to describe the circumstances that created it, as this will allow for a better understanding of the drivers of change. The changes and events, as well as their impacts, will begin to guide the study in identifying the relevant information needed to describe the events and subsequent changes that form part of the systems history. The relevant data that will be needed for the study will begin to 'emerge' from the systems history. To help with this it may be useful to look at the timeline through various 'lenses', i.e. social, economic, spatial, institutional, etc. The different lenses bring different types of changes and events into focus.

Step 4: Multiple scales:

A panarchical view requires that, significant events and changes that have happened at a higher and lower spatial scales, i.e. city, street, national or international scales, be added to the focal scale timeline. This is important because lower and higher scales within the panarchy will have an effect on the focal system (Gunderson and Holling, 2002; Resilience Alliance, 2010). From the case studies, an example can be given where the combination of economic recession in the 1980s, due to sanctions posed on South Africa, as well as an aging white population, had a large effect on Lyttelton leading to a large number of subdivisions within the neighbourhood (Nel, 2011)

Step 5: Distinction between changes

Within this step the identification of the various characteristics that have changed, and when these changes have happened, will be needed. This should be done by firstly distinguishing the changes and events according to the magnitude of the effect that they had on the system. These groupings can be defined as small, medium and large events/changes (this should be done in terms of what the long term effects of that event/changes were on the

system or, for more recent events, what the perceived long term effect will be). Secondly, these events/changes are differentiated into categories or types of change, i.e. social, economic, spatial, and institutional. Some events may fit into more than one of these categories, which may also fit into different levels of magnitude, i.e. the decision of the community of Lyttelton to decide against having small blocks with internal roads during an urban renewal process was a 'small' social event, however it had a significant 'large' long term effect on the physical and spatial nature of the neighbourhood.

From the differentiations between magnitude of change and type of change a new series of timelines can be created, were the history of the area has been divided into various separate components. These timelines also represent specific change within the system. This part of the process is to ensure an understanding of the events and changes, and how these may affect more than one category, i.e. spatial and ecological, and possibly various scales of impact. Figure 2 illustrates an example of how this can be represented using the two neighbourhoods changes as an example.

Lyttelton	Large	P	E	P										P	I	E	S	S		E	P	S	I	E	P		P	I	E	S	P	I							
	Medium									P	I	S	P	S	I			I		E	P	S	P	I	E	S	P	I	E	S	I	S	E		P	I	E		
	Small			P	I					I	S							S	I	S	I		P	S	I		I	S	E		P	I	E	S					
		P-1900		1900			1910		1920		1930			1940				1950		1960			1970				1980				1990				2000				
Irene	Small			P	S	I	P			I	S		I							S	I	P	I	P			S	I	P										
	Medium							P	S	I	P	I	S	P	I			P	S	S	I	P	S	I	P		S												
	Large	P	E	P	S						P	S		S				P	E	I	S		P	I	E	S					P	S	E		S	E	I		

Key
P – Physical E – Economic I – Institutional S - Social

Figure 2: How the various characteristics and magnitudes of change where separated in the cases of Lyttelton and Irene

Step 6: Combine timelines

In order to understand the system wide changes that have occurred, as opposed to the specific changes, the various timelines are now reconstituted into a new 'combined' timeline

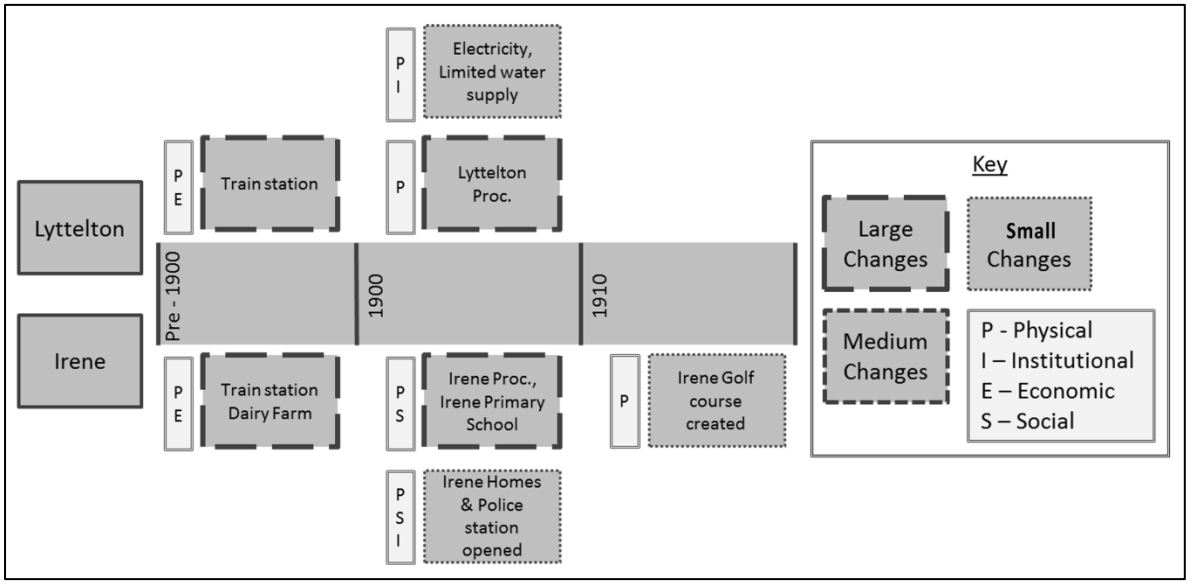

Figure 3: A breakdown of the events, characteristics and magnitude of changes for Lyttelton and Irene. Adapted from Landman and Nel, 2012, p5

that explores the events from different perspectives. During this process, as in the cases of Lyttelton and Irene, key events that had major effects on the system begin to become apparent. These key events point to tipping points or frozen accidents that have profoundly impacted the course of the systems history and the nature of its behaviour.

Figure 3 shows an example of how the original timeline can be recombined with the 'new' timeline; the example only shows a short period of the two neighbourhood's timelines. The key events have been separated into their different characteristics and magnitudes of change that were determined previously. The value of this part of the process is that it helps to show that over the course of a system's history various events from the past have a long term effect on the system and that during some periods there may be many different events and in other times there may be only a single small event. This new timeline will also be vital in determining the weight of each event/change has in the overall movement of the system though the adaptive cycle.

Step 7: Adaptive change though a systems history

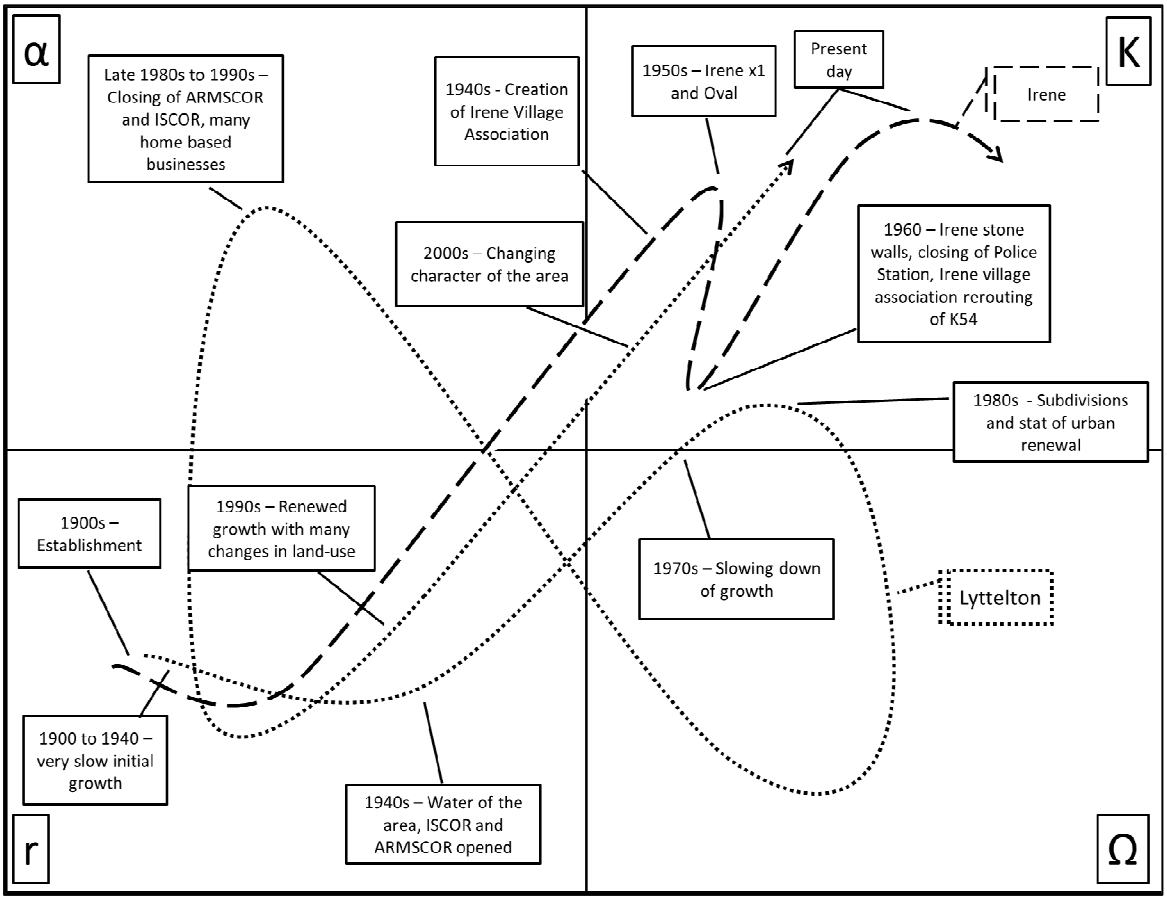

Figure 4: A representation of changes and movement of Lyttelton and Irene through the adaptive cycle with key events and changes being indicated as well as when they occurred. Adapted from Landman and Nel (2012, p9)

The adaptive cycle is now brought back in to focus as the means to describe change, as well as the characteristics of that change in terms of the systems resilience. Reconsidering Table 1 and looking at the characteristics of each phase of the adaptive cycle, one can now compare them to the system's general timeline of change; using the systems history to identify and 'match' the various stages of the adaptive cycle. By using the identified differentiation between the magnitudes of the long term effects, its gives guidance to which events have more weight and provide a greater pull or push factor in moving the system though any particular phase of the adaptive cycle.

Table 2 shows the simplified movement of Lyttelton and Irene though the adaptive cycle where Figure 4 shows a stylised version of the movement of the two neighbourhoods through the adaptive cycle, with the key events that have moved or halted progress the system through the adaptive cycle indicated for each of the neighbourhoods.

The value that Figure 4 adds is that allows us to visualise the movement of the system through the adaptive cycle, which in turn, begins to help to understand how some key events can greatly affect the system's movement though the adaptive cycle as well as the long term behaviour of the system. Understanding how systems adapt to changes may help us to better understand and manage change in the future.

Table 2: The development of Irene and Lyttelton in terms of the adaptive cycle

Phase	**Irene**	**Lyttelton**
Growth – r	1900s – 1960	1900s - 1940s
Conservation – K	1960s – Present	In the late 1970s
Release - Ω	Not happened yet	1980s
Reorganisation - α	Not happened yet	Late 1980s - 1990s
Growth – r	Not happened yet	1990s
Conservation – K	Not happened yet	2000s

4. Conclusion

In searching for a method to describe resilience and how complex adaptive systems go through a process of adaptive change, we have considered the Resilience Alliance's existing and well used approach contained in the 'Assessing Resilience in Social-Ecological Systems: Workbook for Practitioners'. We found the concept of panarchy and the metaphor of the adaptive cycle useful tools to describe changes within the urban environment.

However, the methodologies available are not yet adequate to describe the urban system and all its complexities as an integrated social-ecological system. The Resilience Alliance's workbook is also not clear enough as to how to identify the key elements, drivers and agents, especially within the urban system. To bridge this gap we have developed a methodological framework for identifying key drivers, events and agents and how these push or pull the urban system being studied through the phases of the adaptive cycle. We have proposed that the appropriate focal scale would be the neighbourhood and that by

comparing the changes in adjacent neighbourhoods, it will also be possible to identify the elements, drivers and agents at higher system levels. This method still needs to be tested further on different scales as it may not be appropriate for different scales other than on the neighbourhood level.

Throughout the study there were many challenges. One of the biggest being the challenge of translating the language and concepts of panarchy and adaptive cycle, and the associated terminology, that comes from the field of ecology, into the concepts and language used within the built environment. This is not just a matter of applying terminology to a different type of ecological system (the social-ecological system) or a translation of language. For resilience thinking to become a truly useful concept for the planning and management of urban systems, what is required is a translation of concepts.

Acknowledgements

We would like to thank the National Research Foundation who supported the production of this essay through NRF Grant no 78649.

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