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Does the Built Environment Sustainability Tool (BEST) Address Resilience Sufficiently?

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Abstract

Climate change is already having significant impacts globally. These impacts are experienced most acutely in developing countries where infrastructure and population are often more vulnerable and resources and capacity for mitigation are limited. It is therefore particularly important to understand vulnerabilities to climate change in developing countries and address these in the most effective and efficient ways possible. The Built Environment Sustainability Tool (BEST) was created to guide the development of more sustainable neighbourhoods in developing countries. Through analysis of current climatic change projections for South Africa, key implications for neighbourhoods are ascertained. These are reviewed against criteria in the BEST to investigate whether the tool adequately addresses projected climate changes and promotes associated resilience measures. Findings from the study indicate that while the BEST provides a useful guide for addressing sustainability in neighbourhoods it could be enhanced by addressing resilience more comprehensively. Recommendations are therefore made for the further development of the BEST.

Keywords: *Sustainability, resilience, BEST, Built Environment Sustainability Tool.*

1. Introduction

Climate change is already having a significant impact globally (Pachauri and Meyer, 2014). As a result, there is a growing realisation that urban and built environment policies and guidance have to be updated to address climate change adaptation as well as mitigation (Hamin and Gurran, 2009; VijayaVenkataRaman *et al*., 2012; Hrabovszky-Horváth *et al*., 2013). Adapting to climate change, however, is still an emerging science and has not been addressed widely in built environment policies, strategies and guidance (Hamin and Gurran, 2009). Methodologies to support this are therefore urgently required.

This paper explores how methodologies in this area can be developed. It proposes, and tests, a climate resilience assessment framework that can be applied to assess built environment tools. The framework is applied to Built Environment Sustainability Tool (BEST) which has been developed in South Africa to assess the extent to which the tool addresses climate change adaptation and resilience (Gibberd, 2015). Findings are discussed and developed into recommendations which can be incorporated into an updated version of the BEST. The following research questions will therefore be addressed in the paper:

- What types of climate change impacts are projected for South Africa?

- Can these climate change projections provide the basis for a climate resilience assessment framework that can be used to evaluate the building design guidelines and tools?
- What are the findings of applying the climate resilience assessment framework to the BEST?
- Do findings from applying the framework provide useful guidance on how the BEST can be updated to address climate change adaptation more effectively?

The paper addresses these questions in the following way. Firstly, the paper reviews current climate change studies to understand climate change projections for South Africa and to develop a list of key impacts that will affect the built environment. Secondly, a literature review is undertaken to define resilience for built environments and the South African context. Thirdly, this review is used to propose a climate resilience assessment framework, which is presented in the study. Fourthly, the BEST is introduced. Fifth the climate resilience assessment framework is applied to evaluate the BEST. Sixth, the findings are reviewed and discussed in relation to the research questions and other neighbourhood sustainability tools. Seventhly, conclusions and recommendations are presented.

2. Climate Change

Climate change is one of the most significant issues facing mankind (Hamin and Gurran, 2009). Climate change science has advanced rapidly, enabling improved understanding of the existing impacts and the ability to project future situations with increasing accuracy. For the first time, climate change modelling has been carried out at a resolution of 8x8km in South Africa (Engelbrecht, 2017). This level of detail has provided in depth future climate change projections which show localised non uniform effects across the country. In this study, results from the low mitigation scenario (RCP 8.5) are reviewed for the period 2021 – 2050 relative to 1961-1990. This scenario indicates a number of broad trends for South Africa which outlined below.

Higher temperatures: Increases in temperature of 1 to 2.5°C in southern and 3°C in the northern areas of South Africa are predicted for the period 2021 to 2050, compared to temperatures over 1961 – 1990.

Very hot days: Very hot days (days above 35°C) are projected to increase significantly during the period 2021 – 2050, compared to 1961 – 1990.

Changes in rainfall: Annual rainfall increased are predicted in the interior and east of South Africa, while reductions in rainfall are expected in the western interior and the north eastern parts of South Africa over the period 2021-2050, relative to 1971 – 2000.

Extreme rainfall events: Extreme rainfall events are predicted to increase in frequency in the interior and east of the country over 2021-2050, compared to 1961 – 2000. In Lesotho and areas of Kwa-Zulu Natal Midlands reductions in these events are projected over the same period.

Increased wind speeds: Wind speeds are projected to increase in the northern interior regions of South Africa and decrease in other regions over 2021-2050, relative to 1961 – 2000 (Engelbrecht, 2017).

Further detail is available on maps which chart impacts across South Africa for different provinces, RCP scenarios and timeframes. This level of detail enables implications of climate change for buildings to be analyzed and understood. Understanding implications and how they can be addressed can be described as resilience, which is addressed next.

3. Resilience

Resilience can be understood as 'the persistence of relationships within a system and the ability of this system to absorb changes, and still persist' (Holling, 1973). While the concept of resilience can be illustrated fairly simply in examples from ecology, this becomes much more complex in large entities such as urban environments and cities which consist of both natural and artificial systems (Holling, 1973; World Health Organisation, 2009; Piketh *et al.,* 2014). To avoid making the framework and assessment process overly complex, resilience in the proposed assessment framework for this study, defines and assesses resilience in relation to built environments in three ways.

Firstly, resilience in built environments can be enhanced by incorporating measures that respond directly to projected climate changes. These measures respond to projected changes, such as extreme rainfall events, by strengthing aspects of building fabric such as the roof structure to adapt to future events (Gibberd, 2018). In the resilience assessment framework these measures are referred to as 'Direct building adaptations'.

Secondly, built environments can enhance the resilience of local natural systems. Natural systems play a valuable role in helping environments adapt to climate change impacts. For instance, local wetlands can reduce the extent of flooding and mitigate the impacts of this when it does occur by providing a 'buffer' where runoff can be stored and released in managed way (Woods-Ballard *et al*., 2007; Gibberd, 2017). By protecting and fostering these systems, local 'natural systems resilience' is enhanced which contributes to the resilience of built environments. In the resilience assessment framework these measures are referred to as 'Enhancing natural systems resilience' (Gibberd, 2018).

Thirdly, built environments can support local social and economic resilience. It is argued that humans are not passive receipts of climate change impacts but can develop mechanisms to resist and cope with these impacts (Jones and Boer, 2003; Pelling, 2003; Smith, 2001; Blaikie, Cannon, Davis, and Wisner, 1994). For instance, local organizational structures and co-produced policies and strategies can be used to reduce and adapt to climate change impacts (Pahl-Wostl, 2007; Pelling, *et al.,* 2008; Lemos and Morehouse, 2005). Access to resources are also important addressing climate change impacts (Vincent, 2004). Therefore a strong diversified local economy provides a valuable 'safety buffer' which enables valuable resources to be drawn on for both anticipatory strategies as well as for coping with post-shock events (Vincent, 2004). In the resilience assessment framework these measures are referred to as 'Enhancing artificial systems resilience' (Gibberd, 2018).

The Resilience Assessment Framework is shown in table 1. This shows the three built environment resilience areas under **Area**. To the right of this is **Objectives,** where resilience objectives are defined. To the right of this are **Questions**, which are applied to assess the extent to which built environment tools and guidance address resilience.

Table 1: Resilience Assessment Framework (Gibberd, 2018)

Area	**Objectives**	**Questions**
Direct building adaptations	Built environments are resilient to projected higher temperatures	Does the tool or guideline include built environment measures that address very hot days? Measures could include measures indicated for Higher Temperatures (above) as well as specific measures such as well as support for personal adaptation measures. These measures enable people to adapt their behavior to cope with increased temperature, by for instance, drinking more water and being less active during the hottest periods of the day.
	Built environments are resilient to projected increases in very hot days (days above 35°C)	Does the tool or guideline include built environment measures that address increased or reduced rainfall? Measures for increased rainfall could be improved waterproofing, drainage provision and flood prevention. Measures for decreased rainfall include more efficient water fittings, the adoption of rainwater harvesting and greywater systems, the avoidance of water-based sanitation and xeriscape landscaping strategies.
	Built environments are resilient to projected increases and decreases in rainfall	Does the tool or guideline include built environment measures that address extreme rainfall events? Measures for extreme rainfall events include strengthened roof and building structure, enhancing the capacity of rainwater goods, improved onsite drainage systems.
	Built environments are resilient to projected extreme rainfall events	Does the tool or guideline include built environment measures that address extreme rainfall events? Measures for flooding avoidance measures such as avoiding flood zones, building on stilts and increased floor levels.
Enhancing natural systems resilience	Built environments enhance the resilience of local natural systems	Does the tool or guideline include built environment measures that enhance the resilience of natural systems? Measures to enhance resilience of natural systems include retaining and enhancing existing natural systems and environments and creating and supporting new ones, through for instance the creation of indigenous ecosystems and landscaping, roof gardens and biological waste water treatment plans.

Enhancing artificial systems resilience	Built environments enhance the resilience of local artificial systems	Does the tool or guideline include built environment measures that enhance the resilience of artificial systems? Measures to enhance resilience of artificial systems include support for social cohesion, the local economy, economic diversity, communication and education.

4. The Built Environment Sustainability Tool

The Built Environment Sustainability Tool (BEST) aims to enhance the sustainability of neighborhoods. It provides a methodology that can be used to assess the sustainability of neighborhoods and enables options to improve sustainability performance to be evaluated. The tool provides a holistic assessment of the sustainability of neighborhoods and is based on definition of sustainability developed by the World Wildlife Fund (2006). This defines sustainability as the ability of human populations to achieve minimum universal quality of life standards without exceeding the earth's carrying capacity. Quality of life in the definition is based on the Human Development Index (HDI), developed by the United Nations. This defines quality of life in terms of:

A long healthy life, measured by life expectancy at birth

Knowledge, measured by the adult literacy rate and combined primary, secondary, and tertiary gross enrolment ratio

A decent standard of living, as measure by the GDP per capital in purchasing power parity (PPP) in terms of US dollars (United Nations Development Programme 2007).

For sustainability to be achieved, populations must achieve at least 0.8 on this index. Currently many developing countries in Africa, Asia and South America are below this, while developed European, Asian and North American countries, exceed this level.

This quality of life however must be achieved within the carrying of the earth. In order to quantify this as a clear target, the earth's carrying capacity is measured in terms of global hectares (gha) and divided by the global population to delineate an equitable share. This is defined as being 1.8gha per person (Wackernagel and Yount, 2000). In order to ascertain whether individuals are achieving this target it is necessary to calculate their ecological footprint. The ecological footprint (EF) measures the amount of land and sea required to provide resources for a human population and is based consumption of resources and the production of waste in the following areas:

Food, measured in type and amount of food consumed

Shelter, measured in size, utilization and energy consumption

Mobility, measured in type of transport used and distances travelled

Goods, measured in type and quantity consumed

Services, measured in type and quantity consumed

Waste, measured in type and quantity produced (Wackernagel and Yount, 2000).

The WWF definition of sustainability is useful because it provides quantified targets and a clear indication of the key issues that need to be focused on. The Built Environment Sustainability Tool therefore closely follow the theoretical basis of this definition by focusing on built environment characteristics related to the HDI and EF. The BEST therefore aims to define, and measure, the capacity of the built environment to support the achievement of Human Development Index and Ecological Footprint targets (Gibberd, 2014).

BEST criteria areas are derived directly from the sub criteria of the Human Development Index and Ecological Footprint and are listed below:

Shelter

Food

Mobility

Goods

Waste

Biocapacity

Products

Services

Education

Health

Employment

Within each of these areas the tool defines sets of built environment characteristics that are required for occupants to achieve HDI and EF targets. For instance, in order to achieve an overall ecological footprint of 1.8gha requires individuals to ensure that respective EFs for Shelter, Food, and Mobility etc do not exceed specified limits. Avoiding exceeding these limits requires that local built environments have specific characteristics, for instance, in order to have a Food EF within required limits, low ecological footprint food such as locally grown affordable fresh vegetables and fruit must be available within walking distance.

In the tool, required characteristics to achieve EF and HDI targets are also referred to as built environment capability and are measured in a scale from 0 (no capability) to 5 (full capability). An annotated illustration of the tool is provide in figure 1.

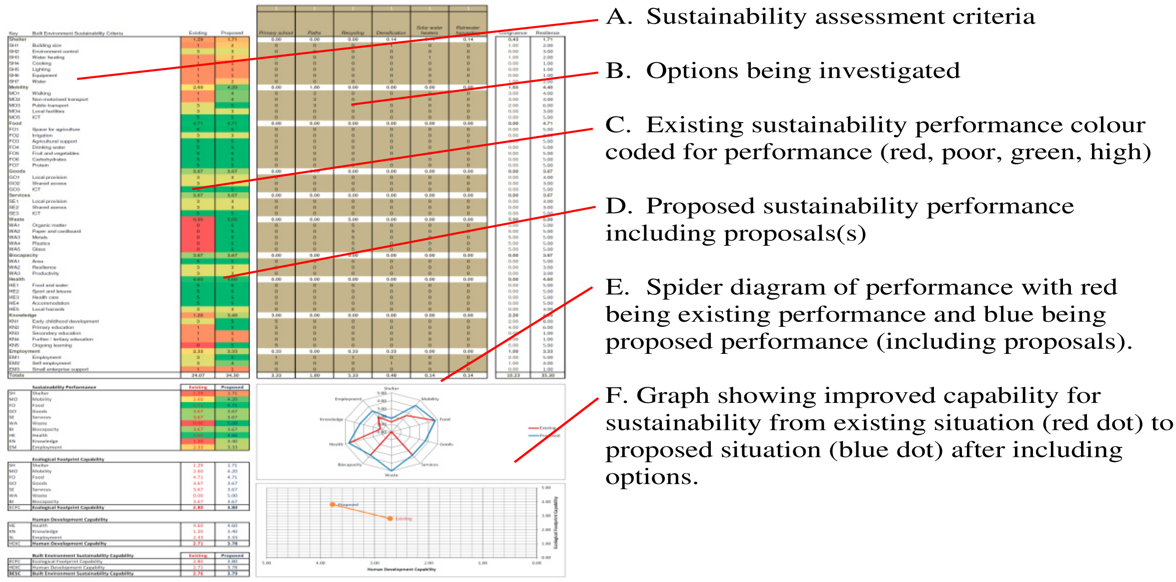

Figure 10: Built Environment Sustainability Tool (Gibberd, 2015)

5. Findings

The resilience assessment framework outlined below is based on a review of climate change projections, natural and artificial systems resilience. The framework aims to provide a useful way of assessing whether design tools and guidelines such as the BEST addresses climate change directly, through measures that address projected change, or indirectly through enhancing the resilience of natural and artificial systems.

5.1 Direct building adaptations

A review of the BEST criteria indicate that there some direct building adaptations are included. Under 'Shelter', the criteria for Environmental Control, indicates that full capability (score 5) requires that "Internal conditions are comfortable throughout the year or rely on renewable energy only for heating and cooling for comfort" (Gibberd, 2015). If this stringent criteria is achieved under current conditions it would ensure that built environments were adapted to some extent for higher temperatures and very hot days. It should however be noted that under projected conditions, the building would probably would not retain full capability as conditions become more extreme and additional measures may be required to retain this level of performance.

Under 'Shelter', the criteria for water indicates that for full capability (score 5) "All water used sourced from onsite / local rainwater harvesting" (Gibberd, 2015). Achieving this currently would enable the building to achieve a strong level of resilience to future projected conditions. However, under future conditions, this level of capability is unlikely to be maintained and additional measures would be required to retain this level of performance.

The BEST does not address flooding or increased rainfall. It also does not address extreme rainfall events. Under 'Biocapacity', the tool does make reference to natural systems which could support adaptation to extreme rainfall events, but this measure would not be considered a 'direct building adaptation' but rather a measure to 'enhance natural system resilience', so will be covered under this heading.

5.2 Enhancing natural systems resilience

The 'Biocapacity' set of criteria in the BEST provides strong support for natural systems resilience. Achieving full capability (score 5) in this area requires that natural environments cover over 30% of the site's environment, and consist of highly productive linked ecosystems with a diverse range of species (Gibberd, 2015). Other criteria that enhance natural systems resilience include criteria for recycling organic waste on site, through composting or other means (Waste) and support for local agriculture (Food). These criteria are strongly supportive of local natural systems resilience.

5.3 Enhancing artificial systems resilience

Enhancing artificial systems resilience refers to measures within the built environment that enhance local social and economic resilience. A number of criteria within the BEST align with these objectives. Measures to encourage walking (Mobility) enhance social resilience by increasing social interaction and fostering relationships between occupants (Gibberd, 2015). Similarly, a criteria for local facilities such as schools, retail, and recreation within walking distance (also under Mobility) would enhance social interaction as occupants would be more likely to build local relationships. The 'Local Facilities' criteria also enhances economic resilience as the local economy, local employment and a diversity in local incomes is supported.

The 'Goods' and 'Services' criteria of the BEST also have a number of criteria that enhance artificial system resilience. The 'Local' criteria for both of these enhances economic resilience as procurement of local goods and services are promoted, supporting a diversified local economy (Gibberd, 2015). This criteria also enhances social resilience as relationships between people are supported. The 'Shared Use' criteria within the BEST requires shared-use-facilities such as libraries, equipment hire/libraries and carpools to be in place (Gibberd, 2015). Shared-use-facilities within the local area can support economic resilience as the cost of starting and running a business is reduced supporting increased diversity of local small businesses and a wider range of employment opportunities. Social interaction at the shared-use-facilities can also enhance social resilience by encourage local relationships and social interaction. Finally, the criteria for 'ICT' could enhance local economic and social resilience by ensuring there is local low cost high speed access to internet and computing facilities. Lower costs and improved access to information can enhance economic resilience by reducing overhead costs and improving the competitiveness through increased access to economic opportunities and partners. Access to ICT may also enhance local social resilience by supporting relationships, for instance, through social media, as well as by providing improved access to information about local events, services and products, that could lead to local relationships.

The 'Health' and 'Education' criteria in the BEST may also enhance artificial systems resilience by placing an emphasis on local facilities that enhance education and awareness as well as health and wellbeing. Education facilities, such as crèches, primary and secondary schools, libraries, and ongoing learning centers within walking distance are likely to enhance social interaction and relationships between children, between parents and between adults enhancing their education (Gibberd, 2015). This will also enhance economic resilience as the these type of local education facilities can be more responsive to local business needs, enhancing the competitively of local businesses. Local education facilities also increases diversity in local employment and incomes enhancing local economic resilience.

Health and wellbeing facilities, such as local sports and recreation facilities, clinics, healthy food retail promote local social interaction and relationships, enhancing social resilience. These facilities also represent increased economic diversity and opportunity enhancing economic resilience. Within 'Health' there are also 'Hazards' criteria which requires the neighborhood to address, and avoid, any hazards that may affect health or wellbeing (Gibberd, 2015). Thus, measures in the neighborhood would have to ensure that hazards, such as crime and car accidents as well as natural disasters, such as flooding, would have to be avoided. This criteria directly enhances social and economic resilience. Reducing fear, for instance, of crime, within the neighborhood could increase walking and social interaction enhancing social resilience. Avoiding the costs of impacts, such as crime and natural disasters, could also reduce the overheads of businesses, who would not need to invest in measures to combat crime and disasters such as flooding, enhancing economic resilience.

6. Discussion

The Built Environment Sustainability Tool is one of a range of tools that addresses neighborhoods. Others include BREEAM Communities, LEED-NC and Cascadia, as shown in table 2. The BEST takes a significantly different approach to these tools. Firstly, BEST by being linked to the WWF definition of sustainability, and HDI and EF targets, has a clear framework by which criteria are defined and targets set. This framework requires the BEST to ensure built environments 'provide the capability to enable occupants to achieve HDI and EF targets, defined in the WWF definition of sustainability'. Other tools appear to have less defined theoretical frameworks governing their development and the processes by which criteria, and their weighting, may be subjective and arbitrary (Sharifi and Murayama, 2013).

Other neighborhood tools generally have been developed in developed country contexts, for developed country neighborhoods. This leads to assumptions, that social infrastructure, such as local schools and clinics are in place. It may also include wide range of other assumptions such as; pavements and road crossings are in good condition and safe to use, there is a safe clean source of water, healthy affordable food is readily available, access to ICT facilities, such as the internet, is cheap and readily available, there are very low levels of crime, there are no environmental hazards, such as flooding and pollution, local employment opportunities are readily available and households have resources to pay for local schools and healthcare. In neighborhoods in developing countries, for instance, in informal settlements, many of these assumptions are incorrect. By avoiding these assumptions, the BEST recognizes the current state of neighborhoods, wherever this may be, and provides a way of improving this. This makes the tool much more applicable and useful for developing country contexts (Sharifi and Murayama, 2015).

Table 2: Neighborhood sustainability assessment tools (adapted from Sharifi and Murayama, 2013)

Neighbourhood Sustainability Assessment Tools	Country
LEED-ND	US
ECC	US
BREEAM Communities	UK
CASBEE-UD	Japan
Qatar Sustainability Assessment System (QSAS) Neighborhoods	Qatar
Green Star Communities	Australia
Green Mark for Districts	Singapore
Green Neighborhood Index (GNI)	Malaysia
Neighborhood Sustainability Framework	NZ
HQE2R	EU
Ecocity	EU
SCR	Australia
EcoDistricts Performance and Assessment Toolkit	US
Sustainable Project Appraisal Routine (SPeAR)	UK
Cascadia Scorecard	US

It is interesting to note that the BEST does not incorporate the direct building adaptations and it appears that this is an area that could be addressed in an update of the tool. In particular, neighborhood level measures of improving physical resilience, such as Sustainable Urban Drainage (SUDS) systems, could be integrated into the tool (Woods-Ballard, *et al.*, 2007).

The tool however, appears to be very successful at addressing 'Enhancing Natural Systems Resilience' and 'Artificial Systems Resilience' as a result of the numerous criteria related to achieving low ecological footprints and minimum Human Development Index performance. The emphasis of 'local' in the tool seem to be a particularly valuable mechanism for this. An emphasis on local bio capacity and agriculture directly support natural systems resilience. Similarly, the focus on provision of a diverse range of facilities within walking facility directly enhances social and economic resilience (Tight *et al.,* 2011).

Conclusions and Recommendations

The onset of climate change has confirmed that built environments and urban areas are inadequately prepared. Existing built environments have not been designed for projected climate change and design guidance and tools have not been updated to ensure that this is addressed in new built environments. This urgently needs to change. The study demonstrates how a simple assessment framework can support a process of addressing resilience and adaptation to climate change in built environments. Application of the framework to the Built Environment Sustainability Tool (BEST) indicates that it does not adequately promote direct building adaptations for climate change. However, it also demonstrates that tool includes criteria which directly enhance natural and artificial systems resilience. It is recommended that future updates of the tool include support for direct building adaptations for climate change and refine existing criteria that enhance local natural and artificial systems resilience. This will ensure the BEST responds to changing environment continue to support the pivotal role of neighborhoods and the facilities housed within them can play in supporting sustainability performance (Williams, 2007).

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