Measuring capability for sustainability: the Built Environment SustainabilityTool (BEST)

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Abstract

An alternative approach to conceptualising and measuring the built environment is developed which forms the basis of a new assessment tool. The role of buildings is reframed to consider what capabilities for sustainability a building can provide to the inhabitants and local community. This capability to support sustainability is defined as the ability to improve the local quality of life (Human Development Index) whilst remaining below the environmental carrying capacity (Environmental Footprint). This approach has clear implications about the role of buildings in enabling residents and users to achieve these targets and outcomes. This shifts the focus of net-positive development toward the configurations and characteristics of the built environment that are appropriate for a particular context. A Built Environment Sustainability Tool (BEST) is presented which defines and assesses these configurations and characteristics. Assessments can be conducted by measuring the extent to which required configurations and characteristics exist (i.e. 'the capability of the built environment to support sustainability'). BEST is compared with other green building rating tool approaches in order to critically review the methodology and evaluate this as a means of improving built environment sustainability performance.

Keywords: building assessment systems, built environment, neighbourhood, net-positive, sustainability, sustainable buildings, sustainability criteria, sustainability indicators

Introduction

Most of the existing green building assessments have a very limited approach to social and economic criteria that inform sustainability. Many green building tools have little or no direct linkage to the earth's ecological carrying capacity and instead focus on performance improvements about the baseline set by regulations and standards. Their relevance to large sections of the developing world is therefore extremely limited. In the context of net-positive, the discussion will need to shift to embrace a wider set of issues about sustaining life: the contribution that a building makes to the overall health and well-being of the community, to the local ecological system and to the remaining within the limits of wider ecological carrying capacity.

An alternative approach to conceptualising and measuring the built environment is developed and presented. This approach considers what the role of the built environment (in particular: buildings) plays in providing the *capabilities* to communities, rather than measuring (hypothecated) technical performance. This capability to support sustainability is defined as the ability to improve the local quality of life (Human Development Index) whilst remaining within the environmental carrying capacity (Environmental Footprint).

The Built Environment Sustainability Tool (BEST) was developed as a way of assessing the sustainability performance of built environments and identifying ways of improving this. Although the acronym, 'BEST', reflects the name of the tool, it also captures the intent of the tool in assisting in the identification of the *best* built environment solutions, or interventions, to support sustainability for a *given* context.

The process of developing the tool involved addressing the following questions:

- What is sustainability?

- What configuration and characteristics are required in built environments to support the achievement of sustainability?
- How can these built environment configurations and characteristics be assessed?
- Can the process of assessing the sustainability of built environments be used to diagnose areas of weaker, and stronger, performance?
- Can the process of diagnoses inform the development of interventions and options which address areas of weak performance?
- Can proposed interventions and options be tested and evaluated within the existing context to identify the best solutions and interventions for a particular context?
- Where resources are limited, is it possible to support the development of sustainability strategies and plans where interventions to support sustainability can be sequenced and implemented over time, in order to achieve full sustainability capability in a structured and efficient way?

The first part of the paper describes how these questions were addressed in order to develop the Built Environment Sustainability Tool. The second part of the paper discusses the BEST in relation to conventional green building rating approaches and the concept of net positive design.

Defining sustainability

A wide range of definitions exists for sustainability and sustainable development. One of the most widely used definitions refers to ensuring that needs of current populations are met without negatively affecting future populations:

"…development that meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations" (World Commission on the Environment and Development, 1987).

Translating this definition into action is difficult. 'Needs' and 'aspirations' are subjective and interpretations vary on what this means. Explicit reference is also not made to environmental limitations which determine whether current and future generations are able to meet their needs (Button, 2002).

A more recent definition of sustainability addresses these limitations by referring to specific quality of life targets and environmental limits that must be achieved. Sustainability, in this definition, is described as the simultaneous achievement of above 0.8 on the Human Development Index (HDI) and an Ecological Footprint (EF) of below 1.8 global hectares per person (World Wild Life Fund, 2006; Moran, Wackernagel, Kitzes, Goldfinger & Boutaud, 2008).

Human Development Index

The Human Development Index (HDI) is a quality of life measure developed by the United Nations. It is based on following health, knowledge and income aspects (United Nations Development Programme, 2007):

- 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.

The HDI is the average of three measures and is calculated in the following way:

HDI = 1/3 (life expectancy index) + 1/3 (education index) + 1/3 (GDP index)

The HDI is used as international measure of development and national figures are published annually by the United Nations. A HDI of 0.8 or above is recognised as evidence that minimum acceptable standards of quality of life have been achieved (Moran et al 2008).

Ecological Footprint

An Ecological Footprint (EF) is a measure of the amount of biologically productive land and sea required to provide the resources required by a human population and to absorb the corresponding waste. The types of resources required and waste generated by populations are classified in the following way:

- 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

The area of land and sea required for this consumption and pollution is calculated in global hectares (gha) and the sum of these areas provides the Ecological Footprint (Wackernagel & Yount, 2000). Given that the earth's surface is finite, a maximum equitable share can be determined. At current population numbers this is about 1.8 global hectares (gha) per person (Moran et al 2008).

Implications for the built environment

The above definition of sustainability has direct implications for planning, design, construction and management of built environments. It implies that in order to achieve sustainability, built environments must *enable* and *encourage* their users, or occupant populations, achieve an HDI of over 0.8 and an EF of under 1.8 gha.

The criteria in the Built Environment Sustainability Tool have therefore been developed by analysing the elements that constitute the HDI and EF in order to identify the built environment configurations and characteristics required to achieve target performance. These configurations and characteristics are translated into BEST criteria and assessment scales developed (Gibberd, 2013a). The tool refers to these required configurations and characteristics as 'built environment sustainability capability'. Built environment sustainability capability requirements in relation to EF and HDI criteria are listed in Tables 1 and 2.

Table 1 Ecological Footprint criteria, corresponding built environment sustainability capability requirements and BEST criteria

Ecological Footprint criteria	Built environment sustainability capability requirements	Examples of BEST criteria
Food: measured in type and amount of food consumed	The built environment must ensure that user populations are able to access low ecological footprint food	Facilities where low ecological footprint affordable food is available
		Facilities that enable low ecological footprint food to be produced
Shelter: measured in size, utilization and energy consumption	The built environment must ensure that user populations have low ecological footprint working and living environments	Low ecological footprint affordable accommodation
		Spatially and energy efficient facilities
Mobility: measured in type of transport used and distances travelled	The built environment must ensure that user populations can access all key daily requirements using low ecological footprint mobility	Availability and quality of support for walking and non-motorized transport
		Availability and quality of public transport
Goods: measured in type and quantity consumed.	The built environment must ensure that user populations can access required low ecological footprint goods	Availability and quality of support for low ecological footprint goods
		Facilities that support shared and efficient use of goods
Services: measured in type and quantity consumed	The built environment must ensure that user populations can access required low ecological footprint services.	Availability and quality of support for low ecological footprint services
		Facilities that support shared and efficient use of services
Waste: measured in type and quantity produced	The built environment must ensure that user populations can avoid waste and access required recycling services	Availability and quality of support for waste avoidance
		Facilities that support recycling
Biocapacity: measured in type and quantity of provision	The built environment must include resilient and productive biocapacity	Availability and quality of support for biocapacity
		Facilities that support resilient and productive biocapacity

Table 2 Human Development Index criteria, corresponding built environment sustainability capability requirements and examples of BEST criteria

Human Development Index (HDI) criteria	Built environment sustainability capability requirements	Examples of BEST criteria
Health: a long healthy life, measured by life expectancy at birth	The built environment must ensure that user populations live and work in healthy environments and can access all facilities required for a long and health life	Health facilities: that enable healthy affordable food and water to be accessed
Knowledge: measured by adult literacy rate and combined primary, secondary and tertiary gross enrolment ratio	The built environment must ensure that user populations can access all facilities required for knowledge including primary, secondary, tertiary education and ongoing learning	Education facilities: that support ongoing learning and education
Standard of Living: a decent standard of living, as measured by gross domestic product (GDP) per capita in purchasing power parity (PPP) (US$)	The built environment must ensure that user populations can access opportunities required to earn sufficient income	Local businesses: that support employment and self-employment

Assessing capability for sustainability

Three key factors were considered in developing the methodology for assessing sustainability capability in built environments. The first is that sustainability performance of the built environment is a combination of (1) the *inherent configuration* *and characteristics of the built environments* and (2) *how built environments are used and managed*. Sustainability performance is governed by both of these factors and cannot be related to just one or the other. Built environments must therefore be planned, designed and managed to have the right inherent qualities. They must also enable and encourage occupant to use these qualities appropriately to achieve sustainability targets. The ‘enabling and encouraging’ aspect of the built environment is taken into account in the BEST methodology by integrating standards, capacity, physical access and affordability as considerations in assessments.

The second factor is that if the built environment is to support the achievement of HDI and EF targets, required configuration and characteristics must be part of everyday living and working environments of users. This means that these configurations and characteristics must be integrated effectively into these environments and be physically present in a way that influences user behaviour appropriately. This is taken into account in the BEST by requiring built environment configurations and characteristics to be either physically integrated into working or living built environments, or to be accessible locally. Local access is defined as being within the local neighbourhood or not over 2 km from the environment being assessed.

The third factor is that as specific EF and HDI targets have to be achieved for sustainability, it is important to ensure that all of required built environment configurations and characteristics are in place to allow this to happen. The tool therefore defines optimal arrangements for targets to be achieved and refers to this as ‘full capability’. Assessments then rate built environments from ‘no capability’, which score ‘0’, to ‘full capability’ which score ‘5’ in terms of the extent to which the required configuration or characteristics exist to support sustainability. Scoring scales for each BEST criteria are defined in a manual. 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

The tool assesses capability in these areas for existing built environments or for proposed built environment designs, within a neighbourhood context. The tackling of sustainable development is a complex undertaking, entailing a detailed understanding of local systems is needed before proposals are made (Van Pelt, 1993; Lowton, 1997; Meadows, 2008). Assessments of the existing situation and the identification of areas with weak or strong sustainability capability are used to provide a framework for developing and refining designs. The suitability these designs is then evaluated by measuring the extent to which built environment sustainability capability is improved. Therefore to achieve high performance, buildings or built environment interventions, must respond directly to the local situation and improve sustainability capability where this does not exist, or is weak.

Assessments are performed by evaluating buildings and the neighbourhood against the sub criteria listed in the tool. These are shown as ‘BEST criteria’ in Figure 1. Scoring of these criteria is on a 6-point scale that ranges from ‘0’ (no capability) to ‘5’ (full capability). A score of ‘5’ indicates that all built environment characteristics and configuration are in place to support the achievement of HDI and EF targets. A score of ‘0’ indicates that none of this in place. Scores for existing neighbourhoods and buildings and designs are assessed in the ‘Existing’ column shown in Figure 1.

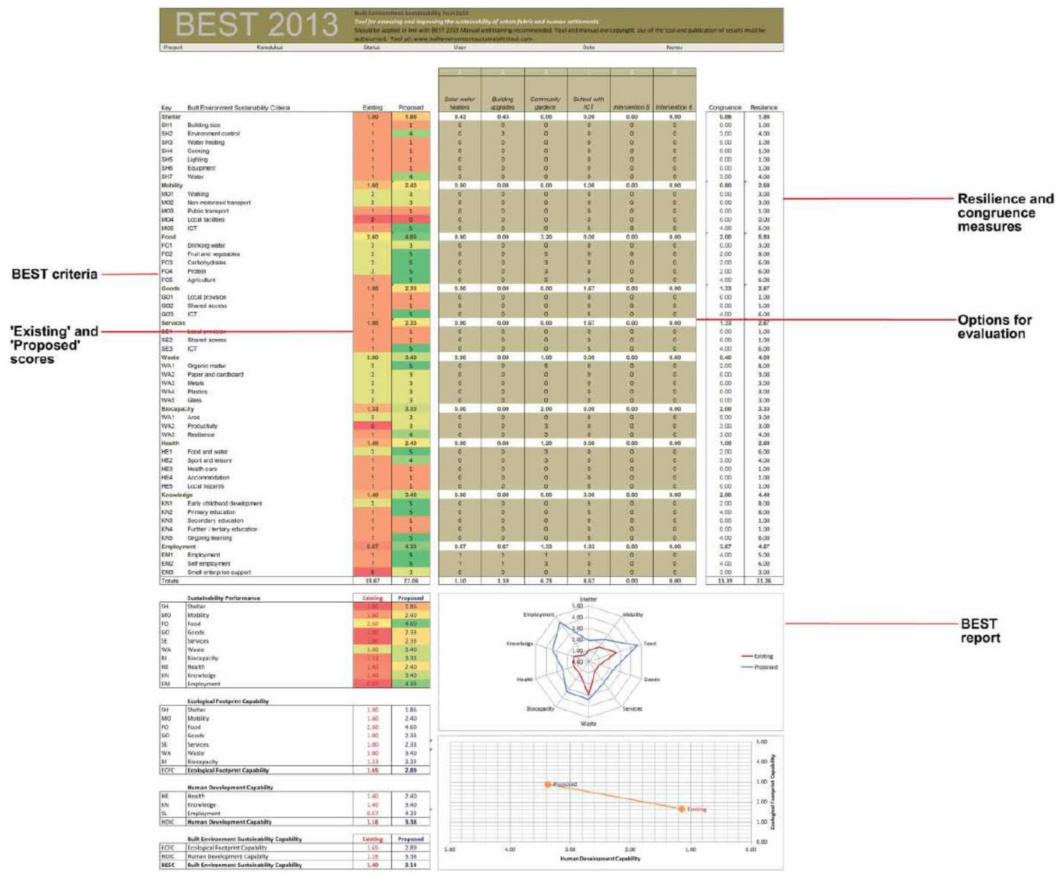

Figure 1 Built Environment Sustainability Tool (BEST)

On completion of an ‘Existing’ assessment, performance can be understood by reviewing the BEST report at the bottom of the tool, as shown in Figure 1. This is also shown in Figure 3. This report can be used to diagnose the areas of good and poor performance. The report can be used to identify and develop options for improvement that are based on the diagnosed areas of poor performance. Once identified, options for improvement can be evaluated by inserting as many as 6 different options in the columns to the right of the tool, as indicated in Figure 1. These options are scored in their columns in relation to the BEST criteria in the tool in accordance with the scales defined in the manual. On completion of the scoring, the impact of the option can be evaluated by reviewing the ‘Proposed’ scores relative to ‘Existing’ scores, as shown in Figure 1. The differences between these scores provide an indication of the nature and extent of the impact of the option. Thus, the extent to which the score increases in the ‘Proposed’ environment relative to the ‘Existing’ indicates the level of improved sustainability capability. The tool also includes indicators labelled ‘Resilience’ and ‘Congruence’ as shown in Figure 1. The ‘Resilience’ measure provides an indication of improved resilience resulting from additional systems or capacity resulting from implementing the option(s). For example, the addition of a rainwater harvesting system, which provides an additional supply of water to a municipal supply, would be reflected as improved resilience within the tool. ‘Congruence’ measures the fit between proposed options and gap in capability performance. Therefore options that effectively improved capability in areas of poor performance would be reflect higher values compared to options that were less successful at addressing these gaps. Different options can be switched ‘on and off’ in the tool in order to ascertain individual and combined impact. The BEST report includes spider diagrams, development trajectory chart points and tables to enable the impact of the option(s) to be readily understood as is shown Figure 3. This can be used to ensure proposed options are responsive to the existing situation and are tested, evaluated and refined before being selected.

Using BEST: Atteridgeville example

The application of the BEST can be illustrated through a case study. The area selected is an informal settlement on the outskirts of Atteridgeville in Pretoria, South Africa (latitude -25.7733, longitude 28.0713). Hereafter, it is simply referred to as the 'Atteridgeville example'.

The area assessed is a neighbourhood indicated in the Figure 2 below. The area is characterised by informal self-built housing arranged in a loose grid. Services are limited and there are no schools or clinics within the neighbourhood. Housing does not have electrical, water or sewage connections. Small shops and stalls sell a limited selection of food and basic groceries. There is no established and scheduled public transport. Private vehicles are available to transport people and goods, but costs are relatively high.

The first step in a BEST assessment is the identification of the building or building type that will be assessed. For instance, this may be of a residential dwelling. The second step is demarcation of the neighbourhood. Accessibility is indicated through marking concentric rings indicating the distance from the building. Facilities within a maximum of 2 km are deemed to be accessible. Figure 2 indicates 1km diameter rings emanating from the building. The final demarcation of the neighbourhood is then derived using these maximum accessibility distances and geographical features such as walls and rivers that may influence access and movement.

Figure 2 Case study area

The third step is the assessment of sustainability capability of the built environment and neighbourhood within which it is located. This is either conducted through a physical survey (if an existing building and neighbourhood) or through a desk-based analysis of design documentation such as plans and specifications (if it is a design proposal). These steps have been followed for Atteridgeville; an informal dwelling and neighbourhood were selected and assessed. The initial assessment provides 'Existing' capability scores. These scores are captured in tables and graphs as indicated in the BEST report in Figure 3.

	Sustainability Performance	Existing	Proposed
SH	Shelter	1.00	1.86
MO	Mobility	1.60	2.40
FO	Food	2.60	4.60
GO	Goods	1.00	2.33
SE	Services	1.00	2.33
WA	Waste	3.00	3.40
BI	Biocapacity	1.33	3.33
HE	Health	1.40	2.40
KN	Knowledge	1.40	3.40
EM	Employment	0.67	4.33

	Ecological Footprint Capability		
SH	Shelter	1.00	1.86
MO	Mobility	1.60	2.40
FO	Food	2.60	4.60
GO	Goods	1.00	2.33
SE	Services	1.00	2.33
WA	Waste	3.00	3.40
BI	Biocapacity	1.33	3.33
ECFC	**Ecological Footprint Capability**	**1.65**	**2.89**

	Human Development Capability		
HE	Health	1.40	2.40
KN	Knowledge	1.40	3.40
SL	Employment	0.67	4.33
HDIC	**Human Development Capabilty**	**1.16**	**3.38**

	Built Environment Sustainability Capability	Existing	Proposed
ECFC	Ecological Footprint Capability	1.65	2.89
HDIC	Human Development Capabilty	1.16	3.38
BESC	**Built Environment Sustainability Capability**	**1.40**	**3.14**

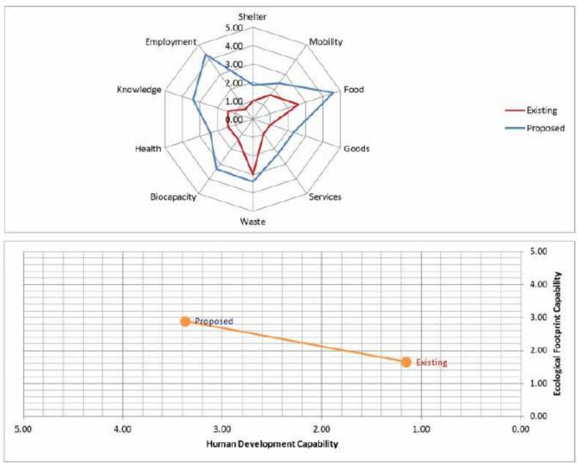

Figure 3 BESTreport

An analysis of the ‘Existing’ spider graph in the BEST report in Figure 3 reveals that the informal dwelling and neighbourhood has weak capability in the areas of ‘Employment’, ‘Shelter’, ‘Goods’, ‘Services’, ‘Biocapacity’, ‘Health’ and ‘Knowledge’ and that slightly stronger capability exists the areas of ‘Waste’ and ‘Food’.

The BEST ‘Existing’ report provides an explicit basis for developing actions to improve sustainability capability. For instance, it may be decided that addressing areas of weak capability may the priority and therefore options that addressed this directly should be targeted. Alternatively, as illustrated in the example below, it may be decided that the options resulting in the highest overall improvement in capability should be prioritised and therefore that options that achieved this should be targeted.

In the Atteridgeville example, options investigated include solar water heater installations (Option A), building envelope upgrades (Option B), the establishment of community food gardens (Option C), the development of a local school with out-of-hours community access to computer and learning facilities (Option D) and undertaking all of these interventions together (Option F).

Testing these options against ‘Existing’ performance within the tool reveals that the community food gardens (capability improvement of 0.70) and the school with shared access to ICT (capability improvement of 0.80) have a greater overall impact (improvement in capability) than the solar water heater installation (capability improvement of 0.14) and building envelope upgrades (capability improvement of 0.25), as shown in Table 3 below.

Table 3 Built environment sustainability capability scores of different options using BEST

	Option A Solar water heater installation	Option B Building envelope upgrade	Option C Community food gardens	Option D School with shared access to ICT	Option F All interventions
Existing capability					
EF capability	1.65	1.65	1.65	1.65	1.65
HDI capability	1.16	1.16	1.16	1.16	1.16
Overall capability	1.40	1.40	1.40	1.40	1.40
Proposed capability					
EF capability	1.71	1.71	2.28	2.14	2.89
HDI capability	1.38	1.60	1.93	2.27	3.38
Overall capability	1.54	1.65	2.10	2.20	3.14
Difference					
Capability improvement	0.14	0.25	0.70	0.80	1.74

The higher impact (more substantial increases in sustainability capability of the built environment) of options C and D suggest that these options should be prioritised and implemented first. Option F indicates the cumulative impact of undertaking all of the interventions. This results in substantial improvements in capability, with overall capability improving from 1.40 to 3.14, as shown in column F in Table 3. The spider graph in Figure 3 also shows that Option F results in improvements in all areas (compare the blue line with the red line).

An analysis of the BEST report in Figure 3 provides an insight into the next set of options that may be used to address of areas of weak capability in the 'Proposed' situation (the blue line) and suggests that this should address low performance in the areas of 'Shelter', Mobility', 'Goods', 'Services' and 'Health'. Options that may be explored to address this include renewable energy sources, improved pedestrian routes linked to public transport, a local market for goods and services and facilities that support health. In this way assessments of the existing situation, combined with a process of testing and implementing proposed interventions, can be used to improve the sustainability capability of an area over time in a structured way.

BEST applications

BEST may be applied in a range of ways to support built environment improvements in sustainability. These applications are described below.

- **Architectural and urban design evaluation:** BEST can be used to evaluate architectural and urban design proposals by assessing these in terms of HDI and EF capability. The process of assessing proposals can be used to ascertain the highest performing proposals. Through an iterative process, it may also be possible to improve design proposals. This can lead to the development of integrated design and management solutions which improve local sustainability capability improvements in an efficient manner. An example of this is the Neighbourhood Facilities for Sustainability concept (Gibberd, 2013b).
- **Community involvement:** A BEST assessment of a neighbourhood by a community can be used to ascertain local sustainability capability performance and support the development of sustainability plans in order to address gaps and areas of weaknesses. Through this process, it is possible to develop local plans which integrate and coordinate local initiatives in a structured way. The broad, positive focus of the BEST, which aims to improve local quality of life and reduce environmental impact, can be used to involve diverse stakeholders and build consensus.
- **Municipal urban planning processes:** Municipal urban planning processes such as the development of Integrated Development Plans (IDPs) and Spatial Development Frameworks (SDFs) aim to support local sustainable development. However these plans may not be based on sustainability assessments and therefore may not respond to local priorities. The BEST can be included in IDP and SDF processes in order to ensure that these responded directly to gaps in

local sustainability capability. This process would help ensure that local government planning processes responded to area-specific issues and supported sustainable development (Cohen, 2006; Gibberd, 2013c; Theaker & Cole, 2001).

Discussion

The approach in the BEST tool is significantly different from green building rating tool approaches and it is therefore worth comparing and contrasting the two approaches. ‘Green building rating approaches’ in this paper refers to processes used for building environmental assessments and ratings using tools such as Leadership in Energy and Environmental Design (LEED). ‘BEST approaches’ refers to processes used with the Built Environment Sustainability Tool.

Assessment focus

The way society defines and measures progress is key factor in advancing sustainability (Dahl, 2012; Hall, 2012; Meadows, 1998; Pintér, Hardi, Martinuzzi, Hjorth & Bagheri, 2006). Pintér et al (2012, p. 22) argue that assessments of sustainable development progress must consider:

- “the underlying social, economic and environmental system as a whole and the interactions among its components, including issues related to governance
- dynamics and interactions between current trends and drivers of change
- risks, uncertainties, and activities that can have an impact across boundaries
- implications for decision making, including trade-offs and synergies.”

Improvements in sustainability performance therefore requires planning based on a detailed understanding of existing systems and appropriate progress indicators (Ness, Urbel Piirsalu, Anderberg, Olsson, 2007; Singh, Murty, Gupta, Dikshit, 2012).

Green building rating tool criteria focus on environmental issues and therefore only provide a partial measure of sustainability performance (Cole, 2005; Cooper, 1999; Liu et al, 2010; Zuo & Zhao 2014). Some aspects of occupant health such as indoor air quality, views and lighting are included in green building rating tools. However, other social and economic aspects such as food, education and employment, cited as key requirements for sustainable development by the World Commission on Environment and Development (WCED), are not included (World Commission on Environment and Development, 1987; Zuo & Zhao, 2014).

City-scale approaches, such as the Cities for Climate Protection (CCP) initiative, similarly include a focus on environmental issues related to energy, housing, commercial buildings, transport, waste and water. However, while this approach does not include aspects such as health, education and food, it envisages and values beneficial social and economic impacts related to environmental actions, such as increased employment (International Council for Environmental Initiatives 2009).

London's Quality of Life Reports, a city sustainability indicator system, adopt a broader approach and give equal prominence to social, environmental and economic criteria. These include indicators for income equality, business survival, employment, life expectancy, childcare and Ecological Footprints. The chosen indicators aim to measure the key factors required for establishing a sustainable city and enhancing the quality of life within it (London Sustainable Development Commission 2012).

The approach taken in BEST has some similarities with London's Quality of Life Report. It aims to measure the performance of key built environment factors required for sustainability, namely the capability for achieving HDI and EF targets. Built environment capability is determined by assessing criteria relating to the achievement of HDI and EF targets and includes education, health, mobility and food. BEST criteria therefore cover economic, social and economic aspects and include sustainability requirements referred to by the WCED.

In developing countries, and in developed countries experiencing prolonged economic downturns, social and economic issues such as poor health, education levels and unemployment are a major concern (Zuo & Zhao, 2014). The size of populations experiencing these issues and living in underserviced urban areas is substantial (Cooper, 1999). For instance in Africa, an estimated 72% of the urban population live in slums, in Asia this is 43%, and Latin America this is 32% (United Nations Human Settlements Programme, 2003; United Nations Human Settlements Programme, 2004). In these contexts, the inclusion of social and economic aspects in assessments makes sense, as it enables these issues to be addressed simultaneously with environment aspects (Singh et al, 2012). By including, and assessing, a broader range of social, economic and environmental aspects, the BEST approach favours more integrated and multi-impact solutions.

As shown in the Atteridgeville example, the wider remit of BEST also enables unconventional solutions (e.g. shared access schools and food gardens) to be considered and assessed. In this particular context, these solutions prove to be particularly effective and efficient at improving local sustainability capability as multiple impacts are achieved which improve both HDI and EF performance. For example, food gardens reduce EF by providing locally grown fresh vegetables and fruit. HDI performance is simultaneously enhaned by improving local standards of living through the additional income generated from selling produce and improving health through better nutrition.

Responsiveness and prioritisation

Green building tool ratings rely on the accumulation of sufficient points in order to be eligible for a rating (Cole, 2005). While these tools may make the achievement of a number of criteria such as those related to carbon emissions and biodiversity, mandatory, little guidance is offered on on which performance aspects should be prioritised. This may lead to the inclusion of attributes and technologies that are cheap or easy to implement Such a strategy fails to incorporate aspects that may be more applicable but are more expensive or difficult to implement, or do not generate green points (Cole, 2005; Lee, 2012; Liu, Li, Yao, 2010).

Some regional differences, such as local climate, are taken into account in green building rating approaches. However, other significant variations are not acknowledged (Zuo & Zhao 2014). For instance, local differences in water, energy, renewable energy, sewage service availability and reliability, and access to education and health facilities are not captured or reflected in their assessments. Such an approach therefore may not particularly promote solutions that are highly responsive to local situations. When generic framework is applied that uses a points-based scoring system, it may result in opportunities to address local problems and utilise local resources being lost. This can be illustrated through an example.

An urban area (such as Atteridgeville) has no mains water, sewage or power and limited social infrastructure. A large new building being developed for this area could chose to respond to this situation by working with local infrastructure to improve access to renewable energy, water and social infrastructure for the *area as a whole*. Alternatively, it could choose to ignore the local situation and focus internally to maximise energy, water and sewage performance of the *building itself*. A green building rating system would rate these buildings similarly or may even assign a higher rating to the second internally-focussed building. Thus, the very substantial value of the first approach for *wider-scale sustainability* would not be recognised or valued.

In the example provided above, the first building that responded to the local situation would be scored significantly higher using the BEST than the second internally-focussed building. The value of the wider impact, is therefore assessed and valued. The BEST approach includes the extent to which the built environment contributes to improving HDI and EF capability within the area as a whole.

Where resources and timeframes are limited, a framework that informs the prioritisation of measures to support sustainability is valuable. This can be used to ensure that buildings and interventions identify and address weaknesses in local sustainability performance as a priority. A framework for the overall sustainability performance of an area can be enhanced over time.

The value of this approach can be illustrated through the previous Atteridgeville example. An analysis of the case study area using the BEST revealed the urgent need to improve local provision in areas such as education, health, employment, mobility in order for overall sustainability of the area to be improved. The explicit inclusion of an analysis stage early in the process makes it likely that new buildings and interventions proposed for the area will address local issues and improve sustainability performance of the area as a whole (Ding, 2005).

The requirement to respond to the local context also magnifies the potential role of buildings and built environments as means of stimulating change and creating wider-scale beneficial impacts. For instance, a BEST assessment may indicate poor education capability in an existing neighbourhood (Existing). A new building in the neighbourhood could help address this by including education facilities that can be accessed by occupants of the neighbourhood. If implemented, use of this capability will lead to improved education and HDI levels. In this way, the BEST approach encourages the development of new buildings and built environment interventions which respond to local situations.

However the tool could also be used to exacerbate sustainability differences between neighbourhoods. This would occur where private developers used BEST to identify high performing neighbourhoods and chose to develop within these rather than in poorly performing neighbourhoods, accentuating sustainability capability differences. This could be countered through incentives, planning regulations and targeted government programmes.

Internal and external impact

As previously mentioned, the green building rating approaches focus on building-specific assessments and optimising internal performance. Their focus is on the environmental aspects of the *building* i.e. minimising the negative environmental impacts whilst creating the internal conditions for comfort and productivity. However, they do not focus on the sustainability requirements of the *area or neighbourhood*. This focus may limit the potential role that building can have in creating beneficial external impacts (Cole, 2005).

Buildings and construction processes can create a wide range of beneficial external impacts. A construction process with intensive labour can create increased local employment (Gibberd, 2008). Procuring local products and materials can be used to support the development of the local economy and small businesses (Gibberd, 2008). Similarly, design features and management can ensure that amenities provided in a building or on a site (e.g. gardens, sports facilities, banking, crèches and learning facilities) are made available for public use. In poorly serviced areas, this type of provision and access can provide substantial local benefit for local communities who may not be able to access these amenities or would have to travel long distances for this (Gibberd, 2008).

This concept can extended through designed synergies in which built environment characteristics are deliberately included in buildings to support small businesses and local employment. Examples include the provision of small units within larger buildings which can be used by retail, catering, design and reprographic businesses to provide services to the larger main occupant organisation, as well as to the local neighbourhood. This creates both improved 'internal' impacts such as services and products which can be accessed more efficiently and improved 'external' impacts such as increased local access to services and products and small business support (Gibberd, 2007).

These positive, external impacts, if included in buildings, are recognised and captured by BEST. However, BEST provides very limited assessment capacity for the 'internal' performance of building and a much lower level of detail compared to green building tools. In particular, the type of criteria and granularity of the scales used to measure criteria in the BEST is very coarse relative to some of the methodologies used in green building tools.

The limited timeframes and resources available to mitigate and adapt to climate change and achieve improvements in education, employment and health mean it is becoming increasingly important to pursue integrated, multiple impact solutions. Buildings and built environments, it could be argued, must maximise their potential to make a positive impact *wherever* they can. Accordingly, assessment frameworks should be careful not to restrict these impacts by only measuring a limited set of internally-focussed environment outcomes (Cooper, 1999).

Innovative solutions

Addressing climate change effectively will not be achieved without challenging current design norms and the scale of change required mean that radically different solutions are now needed (Cole, Robinson, Brown, O'Shea, 2008; Cooper, 1999). Tools that aim to address climate change should therefore encourage and recognise innovative high performance solutions.

Performance in green building rating tools is measured in terms of highly structured specific and prescribed criteria. Standardised detailed measurement protocols are provided which must be complied with in order to demonstrate compliance required for points. The detailed requirements of green building rating submissions mean that extensive preparation work in the form of reports, calculations and modelling is required (Cole, 2005). While this level of structure and detail is useful for ratings and comparisons, it may also discourage innovation (Cole, 2005).

Conventional solutions in green building rating systems are supported through 'tried and tested' documentation that design teams have developed through previous rating submissions or in the form of templates supplied by rating agencies. Unconventional solutions do not have this type of support and need to be 'proven' to the rating agency through documentation which may include supporting statements from third party experts.

Novel and non-standard solutions that do not readily match the existing parameters in rating tools require additional effort from the design team. This additional work is needed to convince the green building rating assessors of the validity of the proposed approach. Design teams under pressure to complete design and rating submission documentation understandably may choose to avoid innovations that are 'untested' or those entailing substantial additional effort to document and achieve approval by the rating agency.

Although the BEST approach does not lend itself to detailed ratings of performance, it has a number of characteristics that may encourage greater experimentation and innovation. The simplicity of the criteria and assessment process mean that options can be evaluated quickly. This encourages users to identify a range of options to evaluate rather than limiting this to one or two. The tool also has a facility to input as many as 6 different options. These options can be switched ‘off and on’ in the tool to assess the impacts of these jointly or separately. This deliberately encourages comparisons, and the critical evaluation of options, as illustrated in in Table 3.

Stakeholders and users

Sustainability indicator systems were initially developed for use at a national level and aim to influence the development of policy by governments. However, Dahl (2012) makes a strong argument that the national-level approach is insufficient and that sustainability indicators are needed at local government, community and individual level. Dahl suggests that sustainable development indicator systems for individuals, families and villages should be developed that are sufficiently sensitive to provide positive feedback for even relatively minor efforts, in order to encourage further actions (Dahl, 2012). Green building rating tools acknowledge the role of individuals through the inclusion of criteria that recognise the importance of localised environmental control and the provision of building user guides. Although building owners or developers are advised to draw on independent professional advisers, green building approaches do not specifically advocate the involvement of building users in the design and development processes (Zuo & Zhao 2014).

The technical nature of green building assessment and documentation also limit the involvement of building users and non-technical participants in determining and developing building design and management solutions. It can be argued that the involvement of built environment users will become more important as the unpredictable and locally differentiated impacts of climate change occur. The development of responsive local solutions and improvisation rely on local knowledge, capabilities and participation (Cole et al, 2008).

Increasing an understanding of built environments and related systems within local communities and users would allow local communities to adapt and use these environments appropriately to cope with change. For example, increasing the awareness of climate change impacts (e.g. flooding) within a community would enable them to develop and use mechanisms such as early warning systems and flood defences or relocate away from areas of risk to reduce negative consequences.

Involving building users and local communities enhances capability in another way. An improved understanding of existing local sustainability performance can be used to identify areas of weaknesses and potential solutions. This process can be formalised in a 'sustainability brief' which can be used as an input to design processes. This enables users and the local community to be involved from the beginning of the project and influence this (Pintér et al, 2012). As users and the local community will have to live with the results of the development, it is likely this influence will be positive. Solutions exhibiting both positive 'internal' and 'external' (neighbourhood-wide) impacts will be identified and supported (Stiglitz, 2009).

An advantage of involving users and the community in sustainability assessments early in the process is that it enables a detailed understanding of local issues and potential solutions to be developed before professional design processes start. This ensures that ‘more informed’ stakeholders contribute direction and feedback to built environment professionals. ‘More informed’ stakeholders are likely to be more articulate and more assertive in ensuring that buildings are responsive to local conditions and user requirements (Pintér et al, 2012). This could help structure and inform public participation processes and reduce the potential for popular sentiment (i.e. without technical knowledge) to influence decisions inappropriately.

Conclusions and recommendations

A new approach to thinking about the sustainability of the built environment is its capability to support the achievement of HDI and EF targets by occupant populations. The combination of human development and ecological carrying capacity is vital to defining and measuring this capability. As this capability can be accessed in a building or within easy walking distance of this, assessments entail buildings *within their neighbourhoods* and *combined performance*. This means that buildings located in neighbourhoods with poor capability have to work much harder to compensate for this in order for high performance to be achieved.

BEST offers a facility to evaluate options that can be considered for improving the sustainability capability of building – neighbourhood combinations. This encourages a responsive approach in which solutions are developed and evaluated in order to improve or ‘make better’ the combined capability of the building and neighbourhood.

BEST provides an alternative to other green building rating tool approaches. Those approaches have a strong focus on the performance of the building itself and a reduction in negative environmental impacts (doing less harm).

The BEST approach contributes to the debate on net-positive design and the role of buildings in relation to sustainability. Net-positive design describes the ability of a building to make a positive contribution to its context. Although net-positive can be framed terms of water or energy (i.e. supplying an excess amount of water or energy to other neighbouring buildings), the BEST approach extends this to include net-positive social and economic impacts. This widened scope considers the capabilities that a building can offer to its neighbourhood. As well as catering for its occupants, a building can provide benefits to the surrounding community. This concept begins to capture the sustainability capability role of built environments and the potential of buildings to make wider and more substantial contributions to achieving sustainability than is currently envisaged in green building rating tool approaches.

BEST can be used in a variety of ways to understand and improve sustainability capability of built environments. The tool can be used to assess design proposals in conjunction with their sites in order to establish a measure of local sustainability capability. By enabling responsive design approaches, the tool supports solutions that not only achieve good 'internal' performance but also accomplish beneficial 'external impacts'. This is valuable in developing countries where resources and buildings have to be used efficiently to achieve a wide range of beneficial impacts.

The tool can also be used by communities to understand the sustainability capability of their neighbourhoods and identify areas of weak performance. This can form the basis of structured sustainability plans which coordinate resources to improve local conditions in an efficient way over time. Local municipalities can use the tool to measure and compare the sustainability capability of neighbourhoods in order to prioritise interventions and develop responsive solutions. By undertaking assessments with local communities, municipalities can support shared and structured development decision making which pool capacity and resources to improve sustainability capability efficiently.

Although the tool is innovative and shows potential as a means of measuring and improving sustainability capability of the built environment, it could be improved in a number of ways. Further research is needed on the relationship between built environment characteristics / configuration and local Ecological Footprint / Human Development Index performance. This should be reflected in the tool as more refined criteria and also provide for a more detailed assessment scales.

The tool can be improved through wide scale adoption in developed and developing countries, as well as within varied urban and rural contexts. Feedback from the tool's application will be vital for its further development.

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