A CRITICAL EVALUATION OF THE SUSTAINABLE BUILDING ASSESSMENT TOOL (SBAT)

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ABSTRACT

Very rapid urban growth rates have meant that now 40 % of the Africa's population live in cities. A large proportion of this growth has been in informal settlements which accommodate over 60% of the urban population Sub Saharan African cities. Continued growth and climate change has meant that it is becoming increasingly important to address these informal settlements and develop improved housing. The Sustainable Building Assessment Tool (SBAT) for housing has been developed for this context. The tool has a focus on developing countries and provides a way of assessing sustainability performance. The paper reviews the SBAT to understand the theoretical basis for the approach. An application of the tool in a housing case study is also evaluated to determine the value of the tool as a means of measuring the sustainability performance of buildings. The review finds that the SBAT provides useful sustainability guidance for built environment projects is more responsive to developing country issues than conventional green building rating tools such as BREEAM and LEED. It also finds that it may possible to strengthen the tool and makes a number of recommendations in this respect.

Keywords: Sustainability Assessment, Housing, Africa, SBAT, Sustainable Building Assessment Tool

INTRODUCTION

In 1960 Africa was the least urbanised continent, with an urban population of less than 20% (United Nations Environment Programme, 1999). Urban growth rates of 4.87% led to rapid change and by 2010 over 40 % of the population lived in cities (United Nations Centre for Human Settlement, 2002). Much of this growth has been in the form of informal settlements and in 2012 the UN estimated that 62% of people living in Sub Saharan African cities were living in slums (UN-Habitat, 2014). There is an urgent need to address backlogs resulting from this growth by improving housing and developing more sustainable urban environments.

This context is addressed by the Sustainable Building Assessment Tool (SBAT) which has a focus on developing countries. The SBAT aims to measure sustainability performance and not just environmental impacts of buildings. It therefore includes social and economic sustainability indicators as well as environmental sustainability indicators. The tool has a markedly different approach to conventional green building tools and rating systems such as BREEAM and LEED (USGBC, 2013; Gibberd, 2003).

This paper includes a review of the theoretical underpinning of the SBAT to understand the rationale for the approach. In addition, the value of the tool is evaluated through a case study where the SBAT is applied. The review finds that the tool provides useful sustainability guidance for built environment projects. It, however, identifies a number of weaknesses and makes recommendations for further development of the tool. The paper is structured around the following research questions:

- How is sustainability interpreted in the Sustainable Building Assessment Tool (SBAT)?
- How is sustainability performance in the built environment measured in the SBAT?
- What findings are generated through the application of the SBAT?
- Are SBAT findings useful for assessing the sustainability performance of built environments and supporting improved performance?
- Are there shortcomings in the SBAT and its application? How can these be addressed?

The paper therefore is structured as follows. Firstly, a literature review is carried out to introduce sustainability and the theoretical basis of the Sustainable Building Assessment Tool (SBAT). This addresses the first and second research questions. Secondly, the application of the SBAT to case study is described. This addresses the third research question. Thirdly, a critical review of the SBAT, in terms of its objectives, theoretical basis, practical application and results, is carried out and the findings discussed. This addresses the fourth and fifth research questions. Finally, conclusions and recommendations from the study are drawn.

SUSTAINABILITY

Sustainability is contested issue and there are many different definitions (Ravetz, 2000). These are often vague and are difficult to translate into practical actions that can be implemented in built environments (Curwell & Cooper, 1998). In order to be applicable to built environments, definitions must capture the essential characteristics of human and environmental systems (Curwell & Cooper, 1998). Definitions must also understand, and reflect, the complexity of the ‘human system’ being evaluated by reflecting the performance of both the technical systems, such as an electrical system in a building, as well as behavioural aspects, such as the way occupants use the electrical system (Williams, 2007).

The complexity of the relationship between environmental and human systems is captured in a definition of sustainability developed by the World Wildlife Fund which relates human activity and technological systems to both quality of life and to environmental limitations (World Wildlife Fund, 2006). Sustainability is defined as the ability of human populations to achieve a Human Development Index (HDI) of 0.8 while simultaneously realising an ecological footprint (EF) of less than 1.8 global hectares (gha) per person (World Wildlife Fund, 2006). To understand this definition better, it is useful to review the Human Development Index and Ecological Footprints.

Human Development Index

The Human Development Index (HDI) of a population is is based on the following indicators:

- 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 measured by the GDP per capita in purchasing power parity (PPP) in terms of US dollars

Each of these indicators has minimum and maximum values (goalposts) as indicated below:

Dimensional indicator	Maximum value	Minimum value
Life expectancy at birth	85	25
Adult literacy rate (%)	100	0
Combined gross enrollment ratio (%)	100	0
GDP per capita (PPP US$)	40,000	100

The Human Development Index is the average of three-dimensional indexes, as captured in the equation below (United Nations Development Programme, 2007):

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

A Human Development Index of 0.8 has been defined as a target for human development. This is regarded as a minimum universal quality of life standard that must be achieved (World Wildlife Fund, 2006).

The implications for built environments of the HDI target are that built environments must have the characteristics, and be configured, to enable occupant populations to achieve this target. Another way of stating this would be to say that built environments must have the capability to enable occupant populations to achieve the HDI targets.

Ecological Footprint

An Ecological Footprint is compiled by calculating the biologically productive land and sea required to provide the resources a human population consumes and absorb the corresponding waste. The following consumption and wastes and emission production rates are used:

- Food, measured in type and amount of food consumed
- Shelter, measured in size, utilisation 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

The area of biologically productive land and sea required for consumption and waste patterns are calculated in global hectares (gha) (Wackernagel & Yount, 2000) This measure is then compared to the earth's carrying capacity which is estimated to be about 1.8 global hectares (gha) per person (World Wildlife Fund, 2006). This provides a sustainability target of 1.8gha per person.

The implications for built environments are that they must have characteristics, and be configured, to enable this to be achieved. Again, this can be described as a requirement for built environments to have the capability to enable occupants to follow living and working patterns that achieve the EF target.

The WWF sustainability definition has specific implications for strategies designed to achieve sustainability. For instance, developing countries may have an ecological footprint that is within target (under 1.8gha) while their Human Development Index is not, as it is below 0.8. In this case, sustainability strategies should focus on achieving the HDI target while maintaining EF performance. In the case of developed countries, countries may have an ecological footprint that is over the target (over 1.8gha), while they may have achieved the HDI targets (over 0.8). Their focus, therefore, should be on reducing their EF to achieve the target, while maintaining HDI performance. This confirms that priorities in developing and developed countries are dissimilar and that different strategies will be required (Holden and Linnerud, 2007). It also suggests that sustainability can be understood in terms of the capability of communities and their environments to improve local quality of life while remaining within environmental carrying capacities (Gibberd, 2015).

THE SUSTAINABLE BUILDING ASSESSMENT TOOL

Environmental, economic and social built environment objectives and criteria within the SBAT have been derived to support the achievement of the HDI and EF targets defined in the WWF sustainability definition. Criteria measure the extent to which characteristics and configurations required to achieve HDI and EF targets are in place in built environments. The extent to which these characteristics and configuration are in place is also referred to as built environment capability for sustainability.

Thus, for instance, space and equipment for recycling in built environments (capability for recycling) are required to enable and encourage occupant populations to recycle their waste and therefore ensure that the waste aspects of the ecological footprint are in line with the required target. The *recycling capability* is required in order to achieve the EF target. The structure and criteria of the SBAT can therefore be understood in terms of environmental, economic and social performance. Performance in each of these is captured in terms of a particular area, objective and sets of indicators. This relationship between sustainability areas, built environment objectives and indicators can be charted as a table and is shown in table 1.

Table 1: Sustainable Building Assessment Tool Areas, Objectives and Indicators

Category	Area	Objective	Indicator
Environmental	Energy	Built environment is energy efficient and uses renewable energy	EN1 Orientation, EN2 Building Depth, EN3 Roof Construction, EN4 Wall Construction, EN5 Floor Construction, EN6 Window to Wall Ratio, EN7 Ventilation openings, EN8 Daylight, EN9 Internal Lighting, EN10 External Lighting, EN11 Installed Equipment Power Density, EN12 Food Cooking, EN13 Water Heating, EN14 Renewable Energy Generation
	Water	Built environment minimises the consumption of mains potable water	WA1 Toilets, WA2 Wash Hand Basins, WA4 Showers, WA5 Hot Water, WA6 Landscape, WA7 Rainwater harvesting
	Waste	The building minimises emissions and waste directed to landfill.	WE1 Recycling Area, WE2 Recycling Collection, WE3 Organic Waste, WE4 Sewage, WE5 Construction Waste
	Materials	Construction impacts of building materials are minimised.	MA1 Building Reuse, MA2 Timber Doors and Windows, MA3 Timber Structure, MA4 Refrigerants, MA5 Volatile Organic Compounds, MA6 Formaldehyde, MA7 Locally Sourced Materials
	Biodiversity	Built environment supports biodiversity	BI1 Brownfield Site, B14 Municipal Boundary, BI3 Vegetation B14 Ecosystems
Economic	Transport	The building supports energy efficient	TR1 Pedestrian Routes, TR3 Cycling, TR3 Public Transport

		transportation.	
	Resources	The building makes efficient use of resources.	RE1 Site Density, RE2 Area per occupant RE3 Renewable Energy Generation, RE4 Food Production
	Management	The building is managed to support sustainability.	MN1 Manual, MN2 Energy Metering, MN3 Water Metering, MN4 Recording, MN5 Residents Association
	Local Economy	The building supports the local economy.	LE1 Locally Sourced Materials and Products, LE2 Small Enterprise, LE3 Construction Workers Support
	Services and Products	The building supports use sustainable products and services.	SP1 Fruit and Vegetables, SP2 Bakery Products, SP3 Beans and pulses, SP4 Milk and Eggs, SP5 Clothing, SP6 Furniture, SP7 Equipment Hire, SP8 Notice Board
Social	Access	The building supports access to facilities.	AC1 Internet Access, AC2 Banking, AC3 Groceries, AC4 Post Office, AC5 Creche, AC6 Primary Schools
	Health	Built environment supports a healthy and productive environment	HE1 Exercise, HE2 Health facility, HE3 Fruit and Vegetables, HE4 Bean and Pulses, HE5 Milk and Eggs, HE6 Water, HE7 External Views, HE8 Daylight, HE9 Openings, HE10 Roof Construction, HE11 Wall Construction, HE12 Volatile Organic Compounds, HE13 Formaldehyde, HE15 Construction Worker Health
	Education	The building supports education.	ED1 Primary Schools, ED2 Secondary Schools, ED3 Ongoing education, ED4 Internet, ED5 Noticeboards, ED6 Space for Learning, ED7 Building User Manual, ED8 Construction Worker Education

	Inclusion	The building is inclusive of diversity in the population.	IN1 Public Transport, IN2 Groceries, IN3 External Routes, IN4 Entrances and Exits, IN5 Lobby, IN6 Window, door and lighting controls, IN7 Doors, IN8 Bathroom, IN9 Kitchen, IN10 Inclusive Employment, IN11 Affordability
	Social Cohesion	The building supports social cohesion.	SC1 Occupants, SC2 Community space, SC3 External Facilities, SC4 Residents Association

Actual performance is measured by assessing existing or proposed housing using the indicators listed. Performance in terms of the indicators is calculated in the tool to provide a value from 0 to 5, with 5 indicating that all aspects are in place within housing for occupants to achieve HDI and EF targets and that therefore full performance has been achieved. The scales used in the SBAT rating are shown in table 2.

Table 2: Sustainable Building Assessment Tool Scales

SBAT Scale	**Sustainable Built environment performance**
5	Built environments provide **full** capability to enable occupants to achieve HDI and EF targets and live in a sustainable way.
4 - 5	Built environments provide **excellent** capability to enable occupants to achieve HDI and EF targets and live in a sustainable way.
3 - 4	Built environments provide **strong** capability to enable occupants to achieve HDI and EF targets and live in a sustainable way.
2 - 3	Built environments provide **partial** capability to enable occupants to achieve HDI and EF targets and live in a sustainable way.
1 - 2	Built environments provide **limited** capability to enable occupants to achieve HDI and EF targets and live in a sustainable way.
0	Built environments provide **no** capability to enable occupants to achieve HDI and EF targets and live in a sustainable way.

The SBAT consists of a manual which describes the tool, the criteria, and how to apply to the tool to develop ratings (the manual). It also consists of a locked preformatted Excel spreadsheet (the tool). The tool generates reports, graphs and a rating based on data entered into the tool. Training and the manual ensure that assessments are objective and standardised. The tool generates reports provide an overall picture of the performance of the building in the form a spider diagram shown in figure 1. A sustainability performance rating is also provided at the top of the report, under 'achieved'. Performance in the different areas (environmental, economic and social) is provided and can also be seen in figure 1. Performance against targets is also provided and indicated in terms of percentage of target achieved. Finally, details of the Assessor and an External Validator, who validates the Assessor's measurements is also provided.

SUSTAINABLE BUILDING ASSESSMENT TOOL RESIDENTIAL
1.04

	Achieved
SB SBAT REPORT	**2.5**

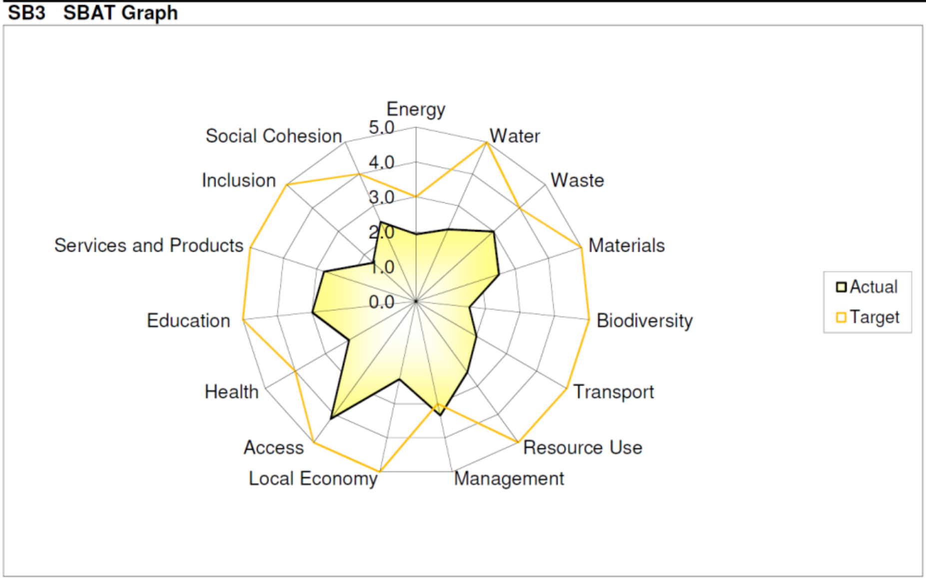
SB1 Project

0

SB2 Address

0

SB3 SBAT Graph



SB4 Environmental, Social and Economic Performance	Score
Environmental	2.2
Economic	2.9
Social	2.4
SBAT Rating	2.5

SB5 EF and HDI Factors	Score
EF Factor	2.3
HDI Factor	2.3

SB6 Targets	Percentage
Environmental	57
Economic	65
Social	57

SB7 Self Assessment: Information supplied and and confirmed by

Name	Date
Signature	

SB8 Validation: Documentation validated by

Name	Date
Signature	

SB9 Validation Report Version

IVR

Figure 1: SBAT report (generated by the SBAT)

The SBAT was conceptualized by Jeremy Gibberd and versions for a range of different building types have been developed and applied in different contexts (Gibberd, 2001; Gibberd 2003). The version described in this paper is the SBAT Residential 1.04 tool and has been specifically developed for housing and associated neighborhoods.

APPLICATION OF THE SBAT

The SBAT was applied to evaluate a low-cost pilot housing near Lusaka, Zambia. Housing has been designed by a developer to investigate options before replicating this within a large-scale project. The developer wished to ensure that housing was as sustainable as possible within tight financial constraints. Ideally, the SBAT would have been used to set sustainability targets and inform design and specification decisions during the initial phases of the project. However, in this case, the SBAT was only used to evaluate the house once it had been completed (but not occupied).

SBAT methodology

The housing assessment was carried out using the SBAT Residential tool. Assessments were carried out in January to February 2016 through an analysis of construction drawings, interviews with the Architect, Quantity Surveyor and Developer and a visit to the building and the surrounding area. Data from these sources were used to complete the SBAT and generate SBAT reports and scores. Assessments followed guidance and protocols for the SBAT ensure that the processes were standardised and as objective as possible.

SBAT assessment

Findings using the SBAT indicate that the house has a sustainability capability of 2.1. This means the house provides partial capability for sustainability. The assessment can be summarised in terms of the three performances areas: environmental, economic and social sustainability.

Environmental performance

The house performed poorly in terms of environmental criteria. While the basic building form and envelope openings met energy criteria, other aspects such as building envelope colour, thermal conductivity and energy consuming equipment such as electrical cookers and water heating equipment performed poorly and there was no use of renewable energy systems.

It also performed poorly in terms of water and fittings were inefficient and the building had no capability to recycle water, such as a grey-water system, or to capture this on site, such as rainwater harvesting systems. Capability for reducing waste and supporting recycling also did not exist and no provision was made for recycling within the house or within the local area.

Performance in terms of materials used in the house was mixed. A locally-made interlocking concrete block was used for the walls. This reduced embodied energy and increased local content. Other materials however generally consisted of imported prefabricated materials and components, some of which contained hazardous materials such as formaldehyde. The building does not support biodiversity as it is located outside an urban area and in a green field site. It, however, benefits from the inclusion of food gardens that surround the house.

Economic performance

An assessment of the location and routes to the house indicates those while that while many facilities such as schools and shops are close by, access to these is difficult and require walking or cycling along busy roads and uneven, narrow paths. Similarly, public transport is available but is in the form of infrequent buses which stop at road location over 800m from the house.

Both the area per occupant of the house and the density of the development within which it is situated do not meet the SBAT criteria. However, some of the space on the site is put to productive use in the form of food gardens. Capability to manage the building and area to support sustainability is low. There are no meters in the building or guidance, such as manuals, on the building's systems. There is, however, a Residents' Association and the electricity system has a prepaid meter, which provides some control over consumption.

Other than the building envelope materials, local content of materials and equipment is low and products have generally been imported from China or South Africa. This means that construction of the building provide limited opportunities for local businesses and do not create many jobs within the country. Few measures to support local enterprises and employment have been included in the development however informal capability has been generated by occupants who operate vegetable gardens as well as small poultry, hair dressing and retail enterprises with the area.

Housing is located near a market which provides a wide range of locally produced food, furniture and other products. Many of the products available, such as locally grown fruit and vegetables, pulses, milk, bread and eggs, support low ecological footprint diets and therefore meet SBAT criteria in this area.

Social performance

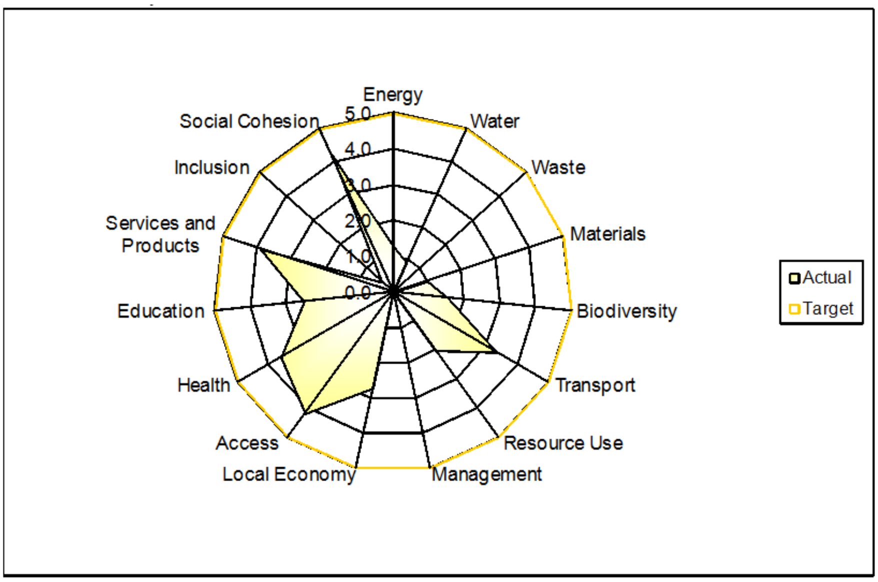
While routes (see Economic Performance) such as roads and paths are of poor quality, the house is well located in terms of access to facilities used on an everyday basis, such as schools, sports grounds, food retail, banking, post office and clinics. Local capability to support health also exists in the form of easy access to fresh healthy affordable food, clean water, clinics and exercise opportunities. The building form and envelope also provide for views, good daylight and ventilation.

Local capability to support education is available in the form of both a primary and a secondary school which are within walking distance (less than 2km) of the house. There is, however, no support for adult or post-school education. Internet access, while available, is expensive. The spatial layout of the house includes provision for studying and homework to be easily carried out.

The building performs poorly in terms of inclusion. It is not located near inclusive public transport and can only be accessed along narrow uneven paths. There are steps into the building and the layout of rooms results in restricted circulation space. Built-in furniture and fittings are difficult to use. Capital and operational costs of the house are also relatively high compared to average incomes making the houses unaffordable for most of the population. No provision has been made to provide more affordable accommodation within the housing area.

There is strong capability for social cohesion with the development. Community halls and sports fields are available a no cost for community activities. A residents' association exists and are involved in managing the area and initiating local events and activities.

This narrative description of the performance is underpinned by a detailed quantitative analysis using the tool which is used to generate the SBAT report, shown in figure 2. This shows that capability was lowest within the environmental area and was better in the economic and social areas.



SB4 Environmental, Social and Economic Performance	Score
Environmental	0.9
Economic	2.4
Social	2.9
SBAT Rating	2.1

Figure 2: SBAT report on housing performance (generated by the tool)

DISCUSSION

The description of the SBAT and the application of the tool and findings from its use provide a useful basis to evaluate and discuss the tool. This focusses initially on the design of the tool and then moves to its applicability and value as a means of supporting sustainability in the built environment in developing countries.

Theoretical basis

The link HDI and EF sustainability goals and the SBAT appear to be effective and have provided a useful means of defining the purpose and scope of the tool. In comparison, it is sometimes difficult to ascertain the basis used for the inclusion of criteria in other tools (Oswald and McNeil, 2010; Lützkendorf and Lorenz, 2006). LEED Residential, for instance, includes criteria related to Integrative Process, Location and Transport, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation and Regional Priority (USGBC, 2013). The justification for the inclusion of these criteria is not provided but appears to be implicitly aimed at reducing environmental impacts and improving internal conditions.

Criteria

Criteria and findings generated by the SBAT appear suitable to a developing country context and address many issues that relate to everyday local living and working patterns, such as food, schools, clinics, public transport and transport (Gibberd, 2001). In this respect, the tool appears to reflect, and respond to, developing country contexts better than green building rating tools such as LEED (Gibberd, 2003; Gibberd, 2015). LEED Residential criteria, for instance, include 'HVAC startup', 'air filtration', 'space heating and cooling' and 'garage pollution protection' which would not be relevant to most housing in developing countries. It also appears that an assumption in the tools such as LEED is that access to education and health facilities, availability of affordable local healthy food and local employment opportunities, required for sustainability are in place, are in place and therefore do not need to be measured. This is not the case many developing countries where these issues must be addressed in new developments (Ugwu and Haupt, 2007; Zuo & Zhao, 2014).

Scales

A review of the SBAT indicates that, within sets of criteria (such as Water), individual criteria are weighted differently, reflecting their relative importance. This, however, changes when, at the next scale up, scores for sets of criteria are not weighted but standardised to reflect a value from 0 to 5. This makes it easy to generate graphs and enables the relative strengths and weaknesses of a building to be readily identified. However, this aspect of the tool masks the differing levels of impact that different areas may have. For instance, energy may have a much more significant impact on an Ecological Footprint relative to Waste. In this respect, the differential weighting of categories of criteria, found in tools such as LEED may provide a more accurate reflection of performance (USGBC, 2013).

However, there are also counter arguments. Expressing performance very clearly in a spider diagram enables all project stakeholders to develop a holistic picture of the performance of the project. This enables stakeholder to 'balance' competing demands and identify and prioritise aspects that they consider important **(**Gasparatos, 2010**;** Ugwu and Haupt, 2007; Sharifi and Murayama, 2015; Ravetz, 2000).

Findings and recommendations from applying the tool

Findings from applying the tool are useful because clear guidance on how performance can be improved is provided. For instance, the environmental performance of the building could be improved by including more energy efficient equipment, a renewable energy system, more water-efficient fittings, a grey water and rainwater harvesting system and recycling provision. In future, care should be taken to specify nonhazardous, high local content building materials and components in new housing (Wallbaum et al., 2012).

Economic performance of housing could be enhanced through design changes. This could include a greater emphasis on designing improved cycle and pedestrian routes as well as links to public transport. In addition, site layouts and housing designs should increase development densities, productive use of space and the range of enterprises supported by the development. The inclusion of metering and sub-metering systems for services accompanied by support for improved building management capacity could also be used to enhance the efficient operation of systems.

Social performance of housing could be improved through a redesign of the housing which ensures that this was accessible to people with disabilities. In addition, sustainability and inclusion could be supported by ensuring that affordable housing is included in the development (Mulliner et al, 2013).

The findings and recommendations generated by the assessment are practical and readily implementable. An interesting aspect of the approach is the inclusion in the assessment surrounding area and not a sole focus on the building. This larger scope is useful because it also places an emphasis on improving the overall sustainability performance of the area, which in turn improves the sustainability performance of housing. For instance, making provision for greater productive use of spaces and creating small enterprises not only reduces environmental impacts as transport requirements are reduced as services and products (such as groceries) become available within walking distance of housing, it also supports social and economic sustainability of housing by creating addition employment opportunities and increases the diversity of incomes (Mulliner et al, 2013).

Value articulating institutions

Sustainability assessment tools can be described as 'value articulating institutions'. The tool and criteria indicate the values that must be subscribed to and the assessor, through their reports and recommendations, enforce these values **(**Gasparatos, 2010**).** A review of the SBAT indicates that there is there is an attempt to provide an objective basis for the selection and development of criteria and to link this to global sustainability targets (Gibberd, 2003). The target setting facility in the tool is also an attempt to ensure building users and stakeholders are involved in the setting of targets and that this is not left at the sole discretion of an assessor or design team (Gibberd, 2003; Pinter et al., 2012). In this way, the tool attempts to ensure that the values reflected in the tool relate to global sustainability targets while providing an way that stakeholders can be involved through defining which issues to should be addressed as a priority (Tanguay et al, 2009; Sharifi and Murayama, 2015).

CONCLUSION

A review of the SBAT indicates that it provides a robust way of measuring sustainability performance of built environments in developing countries. Assessment criteria appear to achieve strong relevance to the achievement of wider global sustainability targets while being appropriate to developing country contexts. Findings and associated recommendations generated through application of the tool also provided useful insight into how sustainability performance can be improved in practical and effective ways.

However, while graphical reports generated by the tool are useful for identifying sustainability strengths and weaknesses in the building they do not differentiate between performance in relation to global sustainability targets and local priorities. This aspect of the tool could therefore be investigated further. One way of addressing this would be to develop a weighting system linked to global sustainability targets and local priorities to generate ‘global’ and ‘local’ performance, in addition to the standard SBAT rating.

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