

# **Advancing climate-resilient and sustainable human settlements: Innovative building technologies in South Africa**

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## **Abstract**

This paper critically evaluates the innovative building technologies (IBTs) in low-cost government-assisted housing developments and their contribution towards climate-resilient sustainable human settlements in South Africa. The study applies the enabling approach to understand housing development and inform the application of IBTs in housing development. The enabling approach to housing asserts that if housing is treated as an activity rather than a manufactured and packaged product, the power of decision-making must necessarily remain in the hands of the end users. An integrative (critical review) approach is used for the review of literature, to assess, critique, and synthesize literature to enable the development of new perspectives. A qualitative approach is used through thematic analysis of local and international literature, existing policies, and reports. The findings of the study show that IBT interventions in housing provide eco-friendly building materials and methods. These mechanisms amount to less deforestation, less transportation of building material to reduce carbon emissions, less depletion of natural resources such as water and soil, less household use of energy in cold and hot weather conditions, and fewer defects in houses leading to instability that exposes houses to natural disasters such as floods and fire. The study concludes that the new methods and materials for low-cost housing delivery through IBTs will have a good impact on climate change reduction if they are carefully applied. The study recommends that the application of

these new building mechanisms must minimize the role of profit-driven corporate private institutions and allow a housing delivery method that is people-centred, and where primary consumers are the key actors in the entire building life cycle, in line with the policy framework.

**Keywords:** climate change, human settlements, innovative building technologies, sustainability, resilience

## **Introduction**

Innovative building technologies (IBTs), regarded as an alternative to traditional methods of building, provide manufacturing or production methods that are considered less polluting and more resource-efficient than the traditional methods. In addition, these technologies are considered as conserving or renewing natural resources and are environmentally friendly. They are alternatives to the much more costly conventional technologies with their negative effects on the natural environment (Wienecke 2010). The intervention and use of these systems have become indispensable, as cities continue to contribute increasingly to the generation of greenhouse gases that cause climate change (Seto, et al., 2014)

Cities around the world are estimated to be producing about 70% of carbon emissions, with transport and buildings being major contributors (Dasgupta et al. 2022). According to the World Economic Forum (2024), while buildings account for 39% of global energy-related carbon emissions, about 11% comes from materials and construction and 28% from their operations. The United Nations reported that the construction and operation of buildings constitute 36% of global energy use, and it was noted that since the life span of buildings can be centuries-long, building smarter is highly recommended (World Economic Forum 2024). In addition, the building industry has been considered a major contributor to environmental pollution, and a major consumer of raw materials, with three billion tons consumed annually or 40% of global use, and produces an enormous amount of waste, a combination of actions greatly contributing to global warming (United States Environmental Protection Agency 2019).

According to Akadiri et al. (2012), the entire building cycle consumes energy, with humans involved in all stages, from building material production to the construction phase, including the operation or use of a completed building which consumes energy for heating, lighting, power, and ventilation. Notwithstanding these contributions to environmental depletion,

housing remains the single largest component of the construction industry and is in high demand. Across the world the number of people without access to adequate, safe, and affordable housing was expected to grow to 1.6 billion by 2025, with an estimated 1 billion new homes needed by 2025, costing up to US \$11 trillion (Gillard et al. 2018). The South African Minister of Human Settlements reported to parliament that as of March 2023, more than 2.4 million households were registered and still awaiting assistance with housing provision (Parliamentary Monitoring Group 2023).

Responses to the abovementioned housing challenges have been a massive contributor to environmental depletion resulting in climate change, owing to building designs and technologies that are not environmentally sensitive. Climate change exposes human lives to various risks. Le Roux et al. (2017) projected that climate change will expose people and the built environment to hazards such as severe weather events, drought, water shortages, floods, sea-level rise, heatwaves, vector-borne diseases, coastal erosion, storm surges, cyclones, and sinkhole formation. In addition, these natural disasters are highly likely to cause injury and loss of human life, as well as severe damage to the built environment, and negatively impact service delivery and sustainable development, especially in the developing world. A recent climate change report by the University of Cape Town shows that “climate change doubled the likelihood of the intense rain that hit parts of South Africa in April 2022, which led to 400 people being killed and many thousands being forced to flee their homes. Women-led homes are more affected by these climate disasters” (Johnston et al. 2024, pp. 4, 13). The report further warns that there is a high likelihood of climate change impacts increasing drastically in South Africa; however, the extent will depend greatly on the level to which global emissions are reduced (Johnston et al. 2024).

Occurrences mentioned above inform a two-way relationship between human settlements development and climate change, with one affecting the other, and with human activities such as building construction and operation at the centre. While the development of human settlements through construction processes contributes largely to the depletion of the natural environment and climate change, the consequences of global warming lead to the destruction of physical infrastructure such as homes, roads, schools, clinics, electricity stations, and so on when natural disasters occur. Hui (2007) asserted that there is an urgent need to promote and enhance sustainable practices in the built environment, especially for developing countries with fast economic growth and building developments. The South African Department of Human Settlements noted that global risks such as climate change, environmental degradation, and

depletion of resources require new ways of managing resources, using science, technology, and innovation to respond to these risks (*The Mercury* 2019). The STI 4 SHS Road Map (Science, Technology, and Innovation for Sustainable Human Settlements Forum 2019) asserted that “transition to an environmentally, and socio-economically sustainable future is dependent on the successful adoption of appropriate technological innovation, and that technology and innovation can potentially pave the way to achieve the progressive realisation of the constitutional right to access to adequate housing and the pursuit of improved quality of household life.”

This paper examines the significance of innovative building technologies (IBTs) for low-cost government-assisted housing developments and their contribution towards climate-resilient sustainable human settlements in South Africa. It explores how sustainable building and design strategies and their application to human settlements development respond to the fundamental challenges imposed by conditions of climate change, and those imposed on the natural environment in South Africa by construction. The study concludes that the new methods and materials for low-cost housing delivery through IBTs will have a good impact on climate change reduction if well contextualized in low-income communities.

## **Materials and methods**

The study applied a critical review of existing information sourced from desktop research to examine the IBTs for building and design in creating sustainable human settlements that respond to climate change. It highlights some of the practices that have been introduced and applied in South Africa for the implementation of innovative building systems. The international case studies of climate-responsive housing implementation mechanisms that consider community involvement are explored, to set the scene for a South African housing delivery model. The study makes reflections on the South African policy framework that relates to sustainable human settlements development and mitigation of climate change. The policy framework involves the Breaking New Ground Housing Policy, National Development Plan, Integrated Urban Development Framework, Climate Change White Paper, and the Housing Act. These reflections are made to assess if the IBTs would fit into the existing policy framework in South Africa.

## Results

### *Innovative building technologies*

Innovative building technologies (IBTs) is a generic term used to describe the use of alternative building systems, products, and materials, preferably made in a factory, either in part or wholly, and assembled on-site (Van Wyk 2013). IBTs can be classified according to mass (heavy, light), onsite or offsite, and type (light steel frame, heavy panels, hybrids). They reduce the time and cost of construction and enhance health and safety and environmental performance (Van Wyk 2013). Other attributes of IBTs are that they use less energy and water for the production of building materials and heating of the house and reduce greenhouse gas emissions.

With the varying purposes that they stand to achieve, alternative building technologies are perceived to be an alternative to environmentally destructive building practices, being environmentally friendly, affordable, and offering people greater control over production processes (Sanya 2010). According to the Market Intelligence Report, the stipulation to use IBTs to construct 60% of new social infrastructure projects by 2017 was adopted by the Cabinet in 2013 and was executed through the construction of 12 schools in the Eastern Cape in 2012 as part of a development agency (Independent Development Trust) pilot project (Didiza 2014). IBTs are expected to generate a lot of benefits. They can produce enhanced habitats while also increasing other opportunities for the local poor communities, such as decent jobs and income, as well as bringing other socio-economic and environmental benefits (Sanya, 2010). According to the CSIR (2013), the use of IBTs is predicted to reduce construction time by up to 35% and construction costs by up to 41%, thus improving the quality of construction, performance, and sustainability of construction products.

In 2020 South Africa had about 41 active IBT manufacturers certified by Agreement South Africa; 36 were based in the Western Cape and 4 in other provinces. Among these manufacturers, is AV Light Steel, specializing in lightweight steel roof trusses, floor joints, frame structures, and associated alternative, innovative, and energy-efficient building products. The Fortis Building System used by this manufacturer for heavy-weight concrete walls and roof trusses is considered to provide multiple benefits for consumers and the natural environment (Zulu 2019). These include: (i) structural performance for resistance against structural cracks and survival of hurricanes, tornadoes, earthquakes, and harsh climatic conditions; (ii) fire behaviour classified as type FR non-combustible, rating up to 60 minutes' resistance; (iii) thermal performance and energy efficiency, with the installation of insulated

polycool ceiling boards and perlite application on external walls tested to yield good thermal performance for the house, resulting in non-use of electric heaters and air conditioners; (iv) light steel roof trusses are a replacement for timber and a solution to deforestation; and (v) lightweight materials and walls erected in factory cater for convenience in transportation and less carbon emissions are produced. AV Light Steel IBT manufacturer also supplies the EcoSan waterless toilet system, which is believed to provide a safe, non-polluting, and cost-effective solution to sanitation challenges. While this is a health benefit to consumers, it means less pressure for water and sewer infrastructural needs, especially in rural areas (Zulu 2019).

The Selcrete innovative panel system is produced by another South African-accredited IBT manufacturer using mostly a combination of cement, polystyrene, and additives. This is a technique said to be proven in Scandinavia and northern Europe which provides homes with a lower risk of fire, three to four times better insulation than traditional bricks during winter and summer, and is considered as environmentally friendly. The Selcrete blocks and panels are lightweight, can be produced on-site, and are quick to assemble (Sparks 2018). A demo house built in Ekurhuleni took approximately 3 weeks, comprising the demolition of an existing shack, the construction of a bathroom, and the balance of a new home (Sparks 2018).

According to the 2017 Global Status Report, improving technology performance is a key component of the transition to sustainable buildings. The report has also listed South Africa among the 87 countries, both developed and developing, that have committed to the implementation of interventions for sustainable design and building that will ensure energy efficiency, reduction of carbon emissions, and reduced impact on the natural environment (UN Environment and International Energy Agency 2017). Other countries mentioned as having made this commitment include the United States, France, China, Australia, Brazil, India, and Nigeria, to highlight key developed and developing nations.

### ***Climate change***

The worldwide phenomenon of climate change has been experienced in various ways, but the definition of the concept remains universal. Climate change is understood as a long-term shift in the average weather conditions of a region, such as its typical temperature, rainfall, and windiness (Government of Canada 2018). These shifts and changes are caused by extra heat in the climate system due to the addition of greenhouse gases to the atmosphere, primarily due to human activities such as burning fossil fuels (coal, oil, and natural gas), agriculture, physical

developments, land clearing or deforestation (Austrialian Government, 2019). The kind of climate change currently experienced worldwide is being caused primarily by these human factors (Government of Canada 2018).

Impacts of climate change vary from region to region, many posing risks to human and natural systems, and the physical infrastructure, in the form of more frequent and severe heat waves, coastal inundation due to sea level rise, disruptions to rainfall patterns, and other effects (Australian Government 2019). According to the Academy of Science of South Africa (2015), climate change poses a significant threat to South Africa's water resources, food security, health, infrastructure, ecosystem services, and biodiversity. Furthermore, in a country like South Africa where many people are poor and levels of inequality are very high, these effects of climate change are critical development challenges and thus require urgent interventions.

### ***The enabling approach and community participation in housing development***

Given housing development, the enabling approach regards housing as an activity and a process rather than a commodity, in that housing is a sphere of action in which everyone plays a role. The approach holds the idea that housing is not a simple commodity, but a complex process of many people and organizations doing many things to get many kinds of real or expected results (Turner 1980). Therefore, any programme of housing delivery will be too complex for any large organization to decide on unilaterally. In addition to this view, the government must support what people and their local organizations do, instead of attempting to substitute corporate for local action, treating housing as a commodity to be supplied (Turner 1972). This is an idea that is supposed to inform guidelines for the development of human settlements according to the building life cycle and aligns with the principles of the National Housing Act. Turner asserted that unless housing is locally controlled and becomes an activity rather than a centrally administered commodity, resources will continue to be wasted. In addition, if housing is treated as a verbal entity, as a means to human ends, as an activity rather than as a manufactured and packaged product, decision-making power must, as a matter of necessity, remain in the hands of the consumers (Turner 1972).

The assertion in the enabling approach is that the actual housing need should neither be assumed nor distorted. The provision of housing shall respond to the actual needs, which can be the better way through which impacts on the natural environment could be minimized. If the needs assessment is not carefully conducted before provision, the housing provision would

lead to unnecessary expenditure and result in more environmental depletion. In another view, Turner reflected on housing by the masses versus mass housing. South African housing delivery has always followed the mass provision of houses, focusing on meeting quantity targets. This has left many defects in low-cost houses where the quality of structures is compromised, exposing them to risks of natural disasters caused by climate change, such as floods and heavy winds.

What fundamentally features the enabling approach is end-user participation as the most effective method for the development of human settlements. Out of the nine objectives of environmental impact assessment participation, developed by Glucker et al. (2013), three of them are most relevant for the development of climate-resilient human settlements. These include social learning to enable deliberation among participants, a process from which local people will be educated about climate change and the management and maintenance of their housing stock. Secondly, empowering and emancipating marginalized individuals and groups, to alter the distribution of power within society. Thirdly, harnessing local information and knowledge to enhance the quality of decision output by providing decision-makers with environmentally and/or socially relevant information and knowledge (Glucker et al. 2013).

A study conducted in three regions in India, Kochi, Trivandrum, and Kerala, for consumer participation in housing delivery, found that by placing participation at the centre of the housing delivery processes these cities have achieved 100% occupancy rates at a lower cost, while also cutting carbon emissions and providing economic benefits (Gillard et al. 2018). India's construction sector used to contribute about 22% of greenhouse gases, while the country faced an expected deficit of 110 million low-income housing units by 2022, at an estimated cost of US \$2 trillion (The World Bank Group, 2018). This housing need therefore indicates the potential pressure placed on the natural environment, impacting negatively on climatic performance. What has been witnessed in these towns was a strong civic sector as a primary driver of development. Kudumbashree is a community-based organization established in 1997, with a membership of 4.3 million women, supported by 941 community-level societies. This organization focuses on the implementation of various central and state government policies, including low-cost housing. It is structured in a hierarchy of three levels, from the neighbourhood, ward, and municipal scale, to provide formal links between low-income groups and decision-makers at various levels (Gillard et al. 2018).

Turner (1978) then began to raise significant matters to ponder concerning housing design and the development of human settlements in favour of participation in the housing delivery process. In a sequence of questions, he asked:

... are we, as architects, planners, and specialists of all kinds, working to increase corporate power over people or people's powers over their own lives; are we telling people what they want, and making money out of supplying their consequently distorted needs; or are we working with people so that they can satisfy themselves in their ways; are we concerned just to consult with people or, more practically, with their representatives, to improve the details of what we design for them?

To mitigate the impacts of housing development on climate change, and the impact of climate change on balanced sustainable human settlements, the model of housing delivery must address these questions first before implementation. This would provide proper guidelines for the development of climate-responsive human settlements.

### ***Human settlements development and climate change***

South Africa's Breaking New Ground housing policy defines sustainable human settlements as "well-managed entities in which economic growth and social development are in balance with the carrying capacity of the natural systems on which they depend for their existence and result in sustainable development, wealth creation, poverty alleviation, and equity" (Department of Housing 2004, p. 6). Fulfilment of the desire to deliver sustainable human settlements in South Africa has been delayed by, amongst other significant reasons, the shortage of affordable and more environmentally friendly building methods, that can find common ground with all stakeholders involved in the provision of low-cost housing. The development of human settlements continues to have a significant impact on climate change.

With the trend of growing urbanization in African countries, South Africa, in particular, has been among other significant factors contributing greatly to global warming and consequently climate change. According to the Integrated Urban Development Framework (IUDF), by the year 2050 Africa's urban population is expected to double from approximately 1.23 billion (in 2015) to 2.5 billion people, or 60% of the total population, rising from approximately 40% in 2009 (Republic of South Africa 2016). In South Africa, it is estimated that the urban population living in urban areas will rise to 71.3% by 2030 and reach nearly 80% by 2050. This urban

population growth continues to put pressure on the performance of the natural environment and gives an indication that more damage will be caused if measures of mitigation are not immediately put into action (United Nations 2015). As a result of high concentrations of people, buildings, and physical infrastructure, the urban settlements have high exposure to hazards such as floods, earthquakes, fires, infectious diseases, industrial accidents, and so forth (Republic of South Africa 2016).

The UN's Department of Economic and Social Affairs warned that as the world continues to urbanise, sustainable development largely depends on the successful management of urban growth, especially in low-income and lower-middle-income countries, where the pace of urbanisation is projected to be the fastest (UN 2018). In addition, some of the challenges that will be faced by these countries in meeting the needs of their growing urban populations include housing, transportation, energy systems, and other infrastructure, as well as employment and basic services such as education and health. These are all factors incorporated in the development of sustainable human settlements, and without any innovative measures to implement them, urban settlements will suffer more climate change defaults.

The development of human settlements mainly features the construction of buildings for residential and social services, which takes place within the building life cycle, consisting of multiple stages which involve design, raw material extraction, manufacturing, construction, operation and maintenance, demolition and disposal, reuse or recycling (Ngwepe and Aigbavboa 2015). As highlighted earlier in the introduction, the contribution of cities to global climate change involves high levels of energy consumption and greenhouse gas emissions, with cities producing 70% of carbon emissions and buildings being the largest contributor. It is also projected that cities in low-lying coastal areas are exposed to risks associated with sea level rise, such as storm surges, flooding, wetland displacement, and altered tidal range, which may cause harm to human life and the infrastructure. In South Africa, such cities include eThekweni, Cape Town, and Nelson Mandela Bay, with a population of above one million (Ngwepe and Aigbavboa 2015).

Many other domestic activities have also contributed to problems affecting human life, due to buildings and designs that are not environmentally efficient. According to the UN Environment and International Energy Agency (2017), above four million deaths annually are attributable to illness from household air pollution, including cooking with solid fuels such as wood, animal dung, and crop waste, and burning gas in inefficient systems that result in higher risks of

nitrogen oxide and carbon monoxide emissions. The report added that technology choice is also an opportunity to improve clean energy access and local air quality, both of which are a key challenge for many developing countries.

Many problems related to human settlements and climate change in South Africa have been contributed to by the government's model of housing delivery. Immediately after 1994 the government, through the Housing White Paper, was obsessed with meeting the quantity targets for mass housing development. The initial target envisaged was the provision of one million houses in ten years, which resulted in a compromised quality of houses delivered in the first phase of the housing policy (Department of Housing 1994). The General Household Survey released in 2009 revealed that 16.1% of beneficiaries of government low-cost houses felt that the walls of their houses were weak, while 14.9% felt their roofs were weak (Statistics South Africa 2008). Reasons for the defects included houses built on unsuitable land, poor workmanship, and corruption of contractors who did not meet the stipulated building standards. As a result, the then Minister of Housing announced R1.3 billion (10% of the national department's budget) for demolition and rectification of badly constructed houses, with about 40,000 houses due to be rebuilt (Tissington 2011). This has therefore meant the vulnerability of human lives to natural disasters as caused by global warming, due to houses that are unstable and non-resilient.

The introduction of Breaking New Ground (BNG) in 2004 brought with it an obsession with another quantity target: the eradication of informal settlements by 2014 (Department of Housing 2004). While none of the quantity targets set in the housing policy framework has been met, the housing challenges have kept on increasing. This therefore requires urgent solutions that take into consideration sustainable human settlements and climate change. The BNG Housing Policy has been presented as a demand-driven and people-centred approach, shifting away from quantity towards quality, placing priority on size, workmanship, settlement design, and alternative technology (Tissington 2011). This has indicated a need for innovations in housing delivery but has not considered a people-driven approach in the application of these alternative technologies.

According to Ngwepe and Aigbavboa (2015) energy is largely consumed during the following stages of building: extracting raw materials; processing and manufacturing the raw materials; fitting the produced components of construction materials together; ensuring usage of the building, such as cooking and lights, among others; to demolish the building and the use of

equipment; and lastly, to dispose of the rubble from site, and recycling. For each of these stages in the building life cycle, an impact is caused on the natural environment and consequently changes in climatic performance. These require interventions and efforts for more sustainable solutions to minimise negative impacts on the natural environment and human life. For Hui (2007) sustainable design involves considering the whole life of buildings, taking environmental quality, functional quality, and future values into account, and requires the joint efforts of building designers, contractors, and end-users.

The basic, most effective means through which human settlement developments can be responsive to climate change is when the sustainable design of buildings and building services systems carefully considers local climatic conditions and characteristics (Hui and Tsang 2005). According to Hui (2007), without enough information and understanding of the local climate, it is not possible to ensure optimal building design and efficient building services operation. The climatic projections have indicated that due to unprecedented changes in climatic performance in the period between 2011 to 2040, dense rural settlements and smaller towns are expected to experience the highest risk of extreme rainfall events, which may cause harm to human life and damage to infrastructure (Le Roux et al. 2017).

The UN Environment and International Energy Agency (2017) advised that during the implementation of low-cost housing access to affordable, lower-carbon public transport systems, incorporation of thermal efficiency into designs, and use of climate-resilient technologies must be ensured. Bunn (2003) pointed out that sustainable building services in developing countries must find best-fit technologies. He argues that energy-efficient solutions will not perform as intended unless they are appropriate for the climate, is well detailed, installed, and commissioned, and are of a level of complexity that can be understood by building managers and users.

The development of sustainable human settlements is in line with the UN's Sustainable Development Goals (SDGs). Goal 11 mandates all member states to *make cities and human settlements inclusive, safe, resilient, and sustainable*. Relative to this, in the context of this paper is goal 13, entailing taking *urgent action to combat climate change and its impacts* (UN, 2015:14). These two goals clearly define the mandate for collective responsibility to all entities participating in the development of human settlements, such as the government, manufacturers/suppliers, contractors, financial institutions, and the consumers. It is these goals that should

inform the regulation of the building and design strategies and methods. The important targets aligned with these goals include the following (UN 2015, pp. 21-23):

- (i) By 2030, ensure access for all to adequate, safe, and affordable housing and basic services and upgrade slums;
- (ii) by 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, and resilience to disasters;
- (iii) strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries; and
- (iv) integrate climate change measures into national policies, strategies, and planning.

Various strategies have been explored as a way of honouring the mandate of the SDGs in various developing and developed international communities. Olotuah (2015) refers to *sustainable architecture*, which describes environmentally conscious design techniques, seeking to minimise the negative environmental impact of buildings, through enhancing efficiency and moderation in the use of building materials, energy, and development of space. Hasegawa (2003) refers to *sustainable buildings*, defined as buildings with minimum adverse impacts on the built and natural environment, in terms of the buildings themselves, their immediate surroundings, and the broader regional and global setting. Other concepts used for sustainable design include *green architecture*, *climate-responsive architecture*, and *high-performance architecture*, and they all have a common key objective: to apply sustainable principles through the entire life cycle of a building, from planning to disposal (Olotuah 2015).

According to Zymeri (2019), the design of green or [ecological architecture](#) is to implement human actions and decisions in daily life in a way that the lives of the next generations are not endangered. She added that sustainable buildings and houses present a new form of sustainable architecture that keeps the environment in mind when designed and built, aiming to be in harmony with nature and the surrounding landscape. Hasegawa (2003) outlined five objectives of sustainable buildings: resource efficiency; energy efficiency; pollution prevention; harmonisation with the environment; and integrated and systemic approaches. In meeting these objectives, the building process must consider sustainable sites, energy efficiency and renewable energy, water conservation, materials and waste management, and indoor environmental quality (Hasegawa 2003).

Part of the practices for sustainable architecture and building already incorporated in the innovative building systems include biodegradable materials; solar power for heating, ventilation, and air-conditioning; green insulation and lighting; smart appliances, cool roofs; sustainable resource sourcing; low-energy house and zero-energy building design; and water efficiency technologies (Solar Impulse Foundation 2019). In the view of Zymeri (2019), buildings have great potential to reduce emissions towards sustainable development of society. For this, she argued that good green designs fully assisted with energy and ecological techniques exist nowadays, so why not use them?

The development of sustainable climate-responsive human settlements should be considered and guided by a multidimensional concept of sustainability. Sustainability encompasses components such as economic sustainability, environmental sustainability, and social sustainability (UN 2015). Among the authors who have proposed principles for sustainable building is Halliday (2008), whose proposals are along the lines of the components of sustainability for consideration in design, construction, and other activities associated with the management of buildings, and include the following:

- (i) *Economy* – good project management is a vital overarching aspect in delivering sustainable projects, both in the short and long term;
- (ii) *Using resources effectively* – buildings should not use a disproportionate amount of resources, including money, energy, water, materials, and land during construction, use, or disposal;
- (iii) *Supporting communities* – projects should identify and seek to meet the real needs, requirements, and aspirations of communities and stakeholders while involving them in key decisions;
- (iv) *Creating healthy environments* – projects should enhance living, leisure, and work environments and not endanger the health of the builders, users, or others, through exposure to pollutants or other toxic materials; and
- (v) *Minimising pollution* – projects should create minimum dependence on polluting materials, treatments, fuels, management practices, energy, and transport.

According to Akadiri et al. (2012), adherence to the sustainable building approach would ensure that the building industry moves towards achieving sustainable development, considering environmental, social, and economic issues, as a way of taking responsibility for

protecting the environment. The important highlights of the building principles proposed above are resource- and energy-efficient methods, less depletion of the raw material and nature, protection of people's health, and involvement of the people in the decision-making process. It is an approach that seeks to favour the natural environment, the people, physical infrastructure, and financial resources, thus making a good deal between the current and future generations.

### ***Housing policy framework***

The new housing policy direction unpacked in the BNG Housing Policy of 2004 required a new plan to redirect and enhance existing housing policy mechanisms to move towards more responsive and effective housing delivery (Department of Housing 2004). The redirection of the housing policy came after a review process that noted challenges in the then-existing housing policy, the Housing White Paper, such as poor-quality housing products and settlements, lack of community participation, slowdown in housing delivery, and growing housing backlog (Tissington 2011). The new human settlements plan reinforced the vision of the Department of Housing to promote the achievement of a non-racial, integrated society through the development of sustainable human settlements and quality housing. This vision was envisaged to be attained through utilising housing as an instrument for the development of sustainable human settlements, in support of spatial restructuring (Department of Housing 2004).

The fundamental housing legislative framework for the enforcement of the policy regulations supports the sustainable means of housing development which is people-centred and driven. According to the National Housing Act, all three spheres of government must: (i) consult meaningfully with individuals and communities affected by housing development; (ii) ensure that housing development is economically, fiscally, socially, and financially affordable and sustainable; (iii) encourage and support individuals and communities, including, but not limited to, co-operatives, associations and other bodies which are community-based, in their efforts to fulfil their own housing needs by assisting them in accessing land, services and technical assistance in a way that leads to the transfer of skills, and empowerment of the community; and (iv) take due cognizance of the impact of housing development on the environment (Republic of South Africa 1997). The current housing policy offers the Enhanced People's Housing Process (EPHP) as one of the key programmes for housing provision (Department of Housing, 2004). This programme requires that beneficiaries actively participate in decision-making over

the entire housing process. The aim is to empower housing consumers, create partnerships, and foster more stable communities (Tissington 2011).

The South African national policy vision of 2030, through the National Development Plan (NDP), has noted a need for further transformation in human settlement development. It has vowed that building and development of sustainable human settlements requires more than the traditional system of bricks and mortar, and that the process cannot be accomplished as a top-down process but must be the outcome of engagement through the participation of communities affected by the housing needs. (Republic of South Africa, 2012b). According to the 2012 Climate Change White Paper, South Africa needs a robust and highly functional climate change science and technology platform (Republic of South Africa, 2012a). In addition to replacing the traditional system of bricks and mortar, this would enable the development and implementation of appropriate actions to minimise the negative impacts of climate change on the economy and the people of South Africa.

In noting that the development of human settlements is largely associated with climate change, the NDP further mandated the government and non-government actors to promote awareness of sustainability issues within communities and disseminate context-sensitive information about the causes and effects of climate change. This may consider the existing government initiatives such as consumer education for public housing beneficiaries. An indication for the attainment of this vision would be that by 2030, a perspective on changing settlement patterns must consider the distribution of zero threats to natural resources, and the spatial implications of the emergence of green technologies and green economies as envisaged by the NDP. (Republic of South Africa, 2012a).

From the housing policy review in 2002, there was a desire to move towards a more local government-centred approach, away from a private developer-driven approach, since it was believed that this would address problems associated with the withdrawal of private developers from low-income housing due to tightening environmental regulations (Tissington 2011; Charlton and Kihato 2006). Later the NDP diagnosed that the system of state-provided housing has benefitted many poor households but may have undermined the incentive for people to upgrade their housing circumstances and may have increased dependency on the state for the supply of private goods. This is the effect resulting from the exclusion of the end users from the housing delivery process, which creates less responsibility and deprives them of a learning process on the management of their housing stock. After noting a number of these challenges,

the policy suggests the need for a national discussion on the future funding of housing in South Africa, specifically the respective roles of the state, the private sector, and individual households in providing housing and creating integrated and sustainable human settlements. Most fundamentally, the development of sustainable human settlements must ensure spatial resilience, where vulnerability to environmental degradation, resource scarcity, and climatic shocks must be reduced at all costs. (Republic of South Africa, 2012b).

The centrality of the matter of beneficiary participation is further emphasized by the Climate Change White Paper, which promotes that the implementation of low-cost housing must ensure access to affordable, lower-carbon public transport systems, incorporate thermal efficiency into designs, and use climate-resilient technologies. (Republic of South Africa, 2012a) The IUDF has proposed the development of the White Paper on Human Settlements that should provide an opportunity to progress to a model that regards human settlements as more than just housing, offering various housing choices and appropriate technology options (Republic of South Africa 2016). The climate change White Paper further suggested collaboration with social networks such as community organisations, non-governmental organisations, women and farmers' organisations, and the Adaptation Network to help raise awareness to transfer technology, and build capacity (Republic of South Africa, 2012a).

### **Discussion of research findings**

It appears as an emphasis in this paper that challenges of climate change are persistent and maximising over time around the world, mainly affecting the developing world, including South Africa, as urbanisation places more housing demand. There is a direct link between climate change challenges and responses to the needs of the housing sector, such as meeting the housing backlog, accelerating the pace of delivery, and ensuring housing quality. There is an evident two-way relationship between human settlements and the climate, in that one has an impact on the other if the delivery process is not sustainably managed. The development of human settlements in all stages, as explained through the building life cycle, contributes negatively to the balance and performance of the natural environment. This is worsening changes in the natural environment which involves global warming and consequently risks to human life and the built environment (Ngwepe and Aigbavboa 2015).

Certification of IBT building systems in South Africa qualifies them as fit to address the impacts of climate change, directly affecting the natural environment, human lives, and

physical infrastructure. The benefits of these systems include less greenhouse gas emissions, energy efficiency, use of less raw material (water, trees, sand, etc.), resistance to fire, improved quality, good thermal performance of houses, reduced time of construction, reduced costs of construction and so forth (Didiza 2014; CSIR 2013; Zulu 2019). A combination of all these benefits is the successful development and maintenance of sustainable human settlements where there is harmony between the people, the natural environment, and the physical infrastructure. However, the responsiveness of these systems to climate change depends largely on how they are applied throughout the building life cycle.

Local and international literature and the policy framework have advocated for the active participation of the primary users in addressing their housing needs as the best solution in solving housing and climate-related challenges. Objectives of participation in the environmental impact assessment developed by Glucker et al. (2013), social learning, empowering and emancipating marginalised individuals and groups, and harnessing local information and knowledge, indicated benefits to be achieved where community participation is taken into consideration. A case study of three cities in India proved these objectives to be achievable where there was participation in housing delivery, placing community participation at the centre of the housing delivery processes. The three cities achieved 100% occupancy rates at a lower cost, while also cutting carbon emissions and providing economic benefits (Gillard et al. 2018). The building life cycle clearly explains the relationship between the end users and the building process, also supported by the neoliberal explanation that views housing as a process and activity rather than a commodity. Thus, these dictate that public participation cannot be excluded from the development of sustainable human settlements that are responsive to the causes and outcomes of climate change.

The South African policy framework for the natural and the built environment has consensus in advocating for principles that support more environmentally friendly solutions, such as sustainable building methods, where community participation is at the centre of a sustainable human settlement development process. The framework considered in this paper is constituted by the BNG Housing Policy, NDP, Climate Change White Paper, IUDF, and the Housing Act. However, the housing policy character of a demand-driven approach does not give priority to people being at the centre of the development of sustainable human settlements. This might be risky, as it might retain the former challenges experienced with housing delivery since it has already prioritised a second failed target of eradication of informal settlements by 2014, as stated in the BNG. Unless the government pushes for the application of innovative building

systems through the people's housing process (EHP), where beneficiaries are at the centre of the building process of their own houses, the housing delivery process would move in the correct direction. The challenge with a demand-driven approach is that it aims for mass production of housing while maximising the role of the private sector, such as contractors, manufacturers, financial institutions, etc., in the provision of houses. It is an approach that will continue to put further pressure on the natural environment. The private institutions' primary objectives are normally focused on maximising profit over user comfort and satisfaction.

Mass production of houses will lead to more land degradation and depletion of the natural environment. However, a model that will put the end-users at the centre will ensure that beneficiary satisfaction and comfort are a priority in the provision of houses over profit production. When people are involved in the process, as suggested in the literature, that will provide opportunities for education on the maintenance and management of human settlements, and while a sense of responsibility is developed, as per the participation objectives unpacked by Glucker et al. (2013), this is unlike a model where the state and the private sector play a leading role, creating a sense of dependency. The enabling approach has suggested a model where the government must support what local people and organisations do, instead of attempting to substitute corporate for local action, treating housing as a commodity (Turner 1980).

## **Conclusions**

With growing pressure on the performance of the natural environment, such as climate, alongside the growing need for shelter due to trends of urbanisation, the world is in serious need of more innovative methods for building and design. The most effective method in addressing housing-related challenges, including climate change, is putting the people at the centre of the housing delivery process, and no innovation can be responsive if this approach is neglected. If this is done for the sake of the environment and comfort for people, the role of the end users must be at the centre, supported by the state and the private sector. The government must investigate the actual housing need, and not assume it on behalf of the people, and empower the local people to take the initiative in meeting their own housing needs, including management and maintenance using methods that respond to climate change, such as innovative building systems. If we consider public participation in the development of climate-resilient human settlements, then there is no uniform method of application of IBTs.

Implementation must be done according to local conditions, as advised through local knowledge and information. This could be the best solution, where IBTs can respond to climate change in the development of human settlements.

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