Connecting Biophilic Design to Neighbourhood Energy Use Optimisation in Rural Towns: The Case of Birchenough Bridge

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Abstract

The article is based on a study that examined the relationship between nature integration in residential neighbourhoods and the cooling energy requirements. This is against the background of rapid urbanisation accompanied by climate change, causing high temperatures and leading to thermal discomfort in buildings, among others. To ensure thermal comfort, building occupants resort to artificial methods of cooling, giving rise to energy consumption in cities amid challenges of energy supply. Whilst there is a significant amount of literature on the need to integrate nature into the design of cities, little has been done to examine the link between biophilic design and the energy requirements for cooling at neighbourhood level. The study adopted a qualitative approach to guide the collection of data. Document review was used to address the research objective. The findings revealed that the biophilic design reduces energy consumption for cooling by modifying the microclimate. There is little appreciation by authorities of the potential of biophilic urbanism in reducing temperatures of neighbourhoods. It is recommended that the planning and design standards for residential neighbourhoods be revised by including specific details as to how public open spaces should be distributed and treated.

Keywords: *energy, nature, design, planning, neighbourhood, biophilia*

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INTRODUCTION

The need to integrate nature into the design and planning of cities is receiving increasing attention owing to the desire to improve the quality of the built environment. Resultantly, there is multiple scholarly literature on enhancing the relationship between the natural and the built environment through green buildings, green infrastructure, green cities, biophilic design and urbanism, among other efforts (Kellert, 1993; Nayak and Prajapati, 2006; Beatley and Newman, 2013; Newman, 2014; Xue, Gou, Lau, Lau and Chung, 2019). The ideas contained in the afore-referenced studies are put under a common denominator of mitigating the degradation of urban ecological systems because of urban development and poor planning and design practices.

There is increased energy demand in residential areas, due to rapid urbanisation, poor design and planning practices amid climate change and energy provision challenges (Feibse, 2010; Makonese, 2018; Morrissey and Horne, 2011) raise questions on what can be done to reduce energy demand in residential places. However, possible solutions from a scholarly perspective emphasise on the integration of nature in urban design as a mechanism of improving the carbon sinking capacity and the aesthetics of cities and promoting environmental preservation and reducing energy consumption in buildings (Beatley and Newman, 2013; Nayak and Prajapati, 2006; Newman, 2014). Whilst these studies are important in informing practice, there is need to establish the link between nature integration in residential neighbourhood design to save energy. That is, how can biophilic design, which integrates nature in the built environment, be applied to reduce energy demand at neighbourhood scale? The study informing this article sought to answer the question by exploring the relationship between the biophilic design and energy demand reduction in a residential neighbourhood scale focusing on Birchenough Bridge Growth Point in Manicaland Province of Zimbabwe.

The context specific nature of climate change (Project and Division, 1992a), urbanisation and energy provision challenges require that a context specific conceptualisation of the biophilic concept as a measure of reducing residential energy demand be done. In this case, Birchenough Bridge, a fast-growing urban centre with an annual average temperature ranging between 22.5 and 25°C and even beyond in the hot season, was considered. Continued urbanisation in this area and similar places presents threats of heat islands that can lead to increased energy demand for cooling. It is, therefore, important that a conceptualisation of the potential of the biophilic concept in addressing thermal comfort issues without extra demand in energy requirements be done. Thus, this article provides a conceptualisation of this relationship with the aim of triggering scientific studies and review of planning and design guides for residential neighbourhood planning.

CONCEPTUAL FRAMEWORK

The study is anchored on the Biophilic Urbanism Concept which provides for close contact of people with nature by bringing it closer to the city environments. In return, awareness of caring for nature is fostered (Beatley and Newman, 2013).

Biophilic urbanism acknowledges that nature in cities goes beyond public parks to include trees on the streets, rooftops, courtyards and hydrological features. Some of the key components of biophilic urbanism include providing a park within 100 metres of all residents, an integrated ecological network and green urbanism from rooftop to the city region. Biophilic cities also encourage provision of strips of median grass and landscaping allowing residents to experience nature and establishment of community gardens and plots. Some of the qualities of Biophilic Cities are non-physical and infrastructural related, but also include recreational activities, attitudinal change and governance aspects. Biophilic urbanism has enhanced the adoption of a biodiversity action plan for a locality.

The elements of biophilic urbanism are applied at various scales of the city including the plot level, building rooftops – green rooftops, rooftop gardens, at block scale – green courtyards and houses clustered around green areas. At street level, it includes green streets and sidewalk gardens. At the neighbourhood level, it includes urban forests, ecology and neighbourhood parks and community gardens used to bring nature to the neighbourhood. At the city-wide and regional scale urban ecological networks, community forests and orchards, the greening of utility corridors, transport corridors and regional green spaces are major elements to be considered.

Beatley (2011) acknowledges that biophilic urbanism links green cities and green urbanism arguments to human wellbeing but less with environmental conservation and energy use. However, the framework of design that is provided by the Biophilic Urbanism concept gives guidelines for the design of neighbourhoods, responsive to the physical wellbeing of the inhabitants – thermal comfort (Newman, 2014; Xue *et al.*, 2019), environmental concerns of residential neighbourhoods (Beatley, 2011; Beatley and Newman, 2013) and aesthetical aspects of residential places (Beatley, 2016).

The ideas embodied in the 'biophilic urbanism' concept provide a guiding framework for integrating nature into the city environments at various levels of planning and design. This study is concerned with the guiding framework for neighbourhood planning and design. However, the concept does not relate nature presence in cities to energy use, hence, the study conceptualises this relationship to establish the extent to which nature integration in neighbourhood planning and design can influence the energy demand for cooling in hot regions. Although studies have been conducted to establish the relationship between trees and energy-saving (Project and Division, 1992b; Series and Science, 2020), these have been at a building and plot scale and do not provide a guiding framework on how this can be done at neighbourhood level to reduce energy consumption in residential places.

LITERATURE REVIEW

This section presents the findings of literature review on the implementation of biophilic urbanism in various cities across the world to reduce energy consumption through the moderation of neighbourhood temperatures. The review focused on the purpose and benefits of biophilic urbanism relative to cooling energy requirements. The review also assessed constraints to the successful implementation of biophilic urbanism initiatives and the options for enhancing the impact of biophilic projects and programmes.

Biophilic urbanism is an approach for improving the outdoor life in cities by harmoniously blending the built environment and nature (Beatley and Newman, 2013; Newman, 2014). Biophilic urban planning is the designing of the cities with an aim of achieving objectives of biophilic urbanism (*ibid.*). Thus, biophilic urbanism consciously seeks to integrate elements of nature with the built environment in a manner that creates liveable outdoor conditions for people, which foster good health and wellbeing at minimal cost.

Previous research demonstrates that there are several socio-economic and environmental benefits of biophilic cities on a micro-scale. This is supported by a recent research that shows that there seems to be limited research on the benefits of biophilic cities on a city scale (Xue *et al.*, 2019), especially, outside America, Asia and Europe. Past studies indicate that biophilic initiatives, if implemented on a broader scale, can reduce energy consumption and dependency on fossil fuels which cause pollution and its attendant problems (Newman, 2014; Ryan *et al.*, 2014; Kellert and Calabrese, 2015; Xue *et al.*, 2019). Biophilic urbanism achieves this energy consumption reduction in buildings through insulation from tree foliage coverage (Beatley and Newman, 2013; Kellert and Calabrese, 2015). This tree canopy also creates micro-climatic conditions which reduce temperatures through shading and evapotranspiratiou (Beatley and Newman, 2013; Newman, 2014). For instauce, it is postulated that the cooling effects of vegetation, if well harnessed through greening ,can moderate the predicted rise in global temperatures, due to climate change (Beatley and Newman, 2013).

Further, the role of biophilic urbanism in moderating temperature is demonstrated by the ambient conditions in Singapore and the two German cities of Freiburg and Stuttgart (Beatley, 2011; Newman, 2014). These three cities have been addressing effects of urban heat islands through planning measures linked to the biophilic urbanism principles (*ibid.*). Additionally, estimates show that the installation of green rooftops reduces temperature by 0.5 to 2°C. Based on this evidence, it is assumed that larger tree canopies in cities can significantly moderate temperature in cities (Beatley, 2011). Thus, the air-conditioning effects of vegetation assist both in creating a good habitat for people and reducing energy demand for cooling in addition to other benefits.

Successful implementation of biophilic urbanism involves several actors. The actors include public institutions, responsible for planning policy-formulation and preparing greening plans for guiding the implementation of biophilic initiatives (Beatley, 2011; Newman, 2014; Xue *et al.*, 2019). They are also responsible for implementing the biophilic initiatives including monitoring and enforcement of standards (*ibid.*). Other important stakeholders are the built environment professionals who include landscape architects, architects of urban designs and planners who organise the use of space for greening (Beatley and Newman, 2013; Newman, 2014; Xue *et al.*, 2019).

Communities, the private sector, community-based organisations and educational institutions are other stakeholders in the implementation of biophilic activities (Beatley, 2011; Newman, 2014; Xue *et al.*, 2019). An analysis of research on actors in the greening of cities reveals that many communities, policy-makers and planners lack adequate knowledge about the role of biophilia in reducing energy consumption through the moderation of temperatures (*et al.,ibid.*). This problem points to the need for building capacity and promoting knowledge about biophilia-energy nexus among stakeholders. This analysis also showed that biophilic urbanism is a multi-dimensional phenomenon and it is important to adopt an inclusive approach in implementing it.

Existing literature shows that several cities worldwide are implementing biophilic urbanism. The biophilic initiatives are being implemented on property sites comprising housing where green rooftops, green gardens, woodlots and orchards are established in addition to the greening of streets and walkways (Stewart-Pollack, 2006; Blanc, 2008; Newman, 2014). Besides that, greening initiatives are occurring at neighbourhood levels through the establishment of ecological and recreational parks and greening of public open spaces and other grey areas (Beatley and Newman, 2013; Ryan *et al.*, 2014; Newman, 2014). In addition, other initiatives are being implemented on a city and regional scale, through the greening of highway corridors, river courses, schools, servitudes for utilities and establishment of community forests (Blanc, 2008; Beatley, 2011; Newman, 2014). To maximise impact in terms of energy-saving and thermal cooling, previous researches underline that biophilic initiatives must be implemented on all the scales (Beatley and Newman, 2013, Newman, 2014). For instance, Singapore has a comprehensive scheme of greening under its programme of building a 'City in the Garden'. In light of this observation, it is important to have a hierarchical system of environmental plans for guiding the implementation of greening initiatives in each city.

There are several strategies for greening cities with a view to moderate temperatures through biophilic urbanism. The greening of cities is implemented through the planting of trees in parks, street sides, premises along highways and river courses (Beatley, 2011; Newman, 2014; Kellert and Calabrese, 2015). For example, Singapore initiated a greening programme along its major roads in 2001, namely the Heritage Road and Heritage Tree Scheme 2001, in addition to its extensive network of green streets (Newman, 2014). Public schools have been targeted in greening activities since they have more space for establishing woodlots and orchards on their premises (Beatley, 2011; Newman, 2014). The Hougang Primary School in Singapore has embraced the biophilic initiatives and has established one of the famed green walls (Newman, 2014).

Another biophilic urbanism strategy is the conservation and protection of existing natural forests that is less expensive in comparison to establishing new forests and planting trees (Beatley and Newman, 2013; Newman, 2014; Ryan *et al*., 2014). This approach has resulted in the establishment of the famous Singapore Botanical Gardens with the aim of conserving indigenous vegetation (Newman, 2014). Besides that, literature review shows that the establishment of community gardens and promotion of urban agriculture, as in the cases of Chicago and Montreal, are some of the pathways for greening cities (Beatley, 2011; Beatley and Newman, 2013; Newman, 2014). The other strategies involve the establishment of vertical gardens (Blanc, 2008; Newman, 2014) through the installation of green walls of creepers that climb on brick and concrete walls and trees planted along property boundaries to provide shade (Stewart-Pollack, 2006; Beatley and Newman, 2013).

A study on the pathways to biophilic urbanism has noted that the adoption of strategies is determined by planning regulations, the nature of landscape and buildings, economic and technical considerations, project size and objectives and socio-cultural and ecological conditions (Kellert and Calabrese, 2015). It is emphasised that for better impact on energy consumption reduction and temperature regulation, biophilic strategies should be implemented in an integrated approach where various initiatives complement each other (Beatley and Newman, 2013; Newman, 2014). One way of achieving the holistic and coordinated implementation of biophilic urbanism is to develop city-wide greening plans and policies.

A number of factors affect the implementation of biophilic urban design and urbanism strategies. These challenges include social and cultural, environmental, governance and institutional challenges (Beatley, 2011; Beatley and Newman, 2013; Newman, 2014; Ryan *et al.*, 2014; Kellert and Calabrese, 2015; Xue *et al.*, 2019). The social and cultural challenges pertain to lack of knowledge on the role of green cities in reducing energy consumption through the cooling effects of shading and evapotranspiration (Beatley and Newman, 2013). For instance, a recent study on stakeholder perception on green cities, carried out in Singapore revealed that some communities have little understanding on biophilic urbanism aspects (Xue *et al.*, 2019). This lack of understanding partly causes wanton destruction of trees and forests in cities and apathy in communities towards the support of biophilic design and urbanism efforts in some cities.

The lack of sound legal instruments to guide the implementation and enforcement of green cities initiatives is also another challenge compromising the impact of biophilic design and urbanism in influencing energy consumption in cities. The existence of properly codified planning and design standards is necessary to support the sustained building of biophilic neighbourhoods and cities (American Planning Association, 2006; Beatley and Newman, 2013). Despite the importance of these instruments, previous studies indicate that most countries do not have appropriate legal codes and this is constraining the building of green cities(Beatley and Newman, 2013; Kellert and Calabrese, 2015).

The lack of appropriate standards, compounded by weak enforcement of regulations, is associated with slum developments in some countries, particularly in the Global South, which makes it difficult to implement green city initiatives (UN-HABITAT, 2010, 2016; Mycoo, 2017). In light of this impediment, it is important for municipalities to plan, design and develop guidelines that support biophilic urbanism and energy-saving models.

Additionally, there is also need to consider the enforcement of the new regulations and standards.

The impact of green city initiatives in influencing energy consumption reduction through cooling cities is enhanced by favourable environmental conditions in the form of ambient temperatures and good rainfall patterns (Ryan *et al.*, 2014; Newman, 2014). For example, Singapore has been successful in implementing biophilic initiatives, due to the tropical conditions in the city which support the growth of plants (Newman, 2014). However, unfavourable environmental conditions because of climate change, particularly droughts, are a threat to biophilic urbanism and the building of sustainable cities that minimise energy consumption through greening initiatives (Keivani, 2010; Yigitcanlar, Kamruzzaman and Teriman, 2015). In light of this challenge, it is necessary to carry out risk assessment for each neighbourhood with the aim of designing appropriate strategies for developing resilient cities that foster green city initiatives in the face of adverse ecological conditions.

An assessment of literature shows that there are potential solutions to the constraints that affect the greening of cities, among other issues, aimed regulating extreme temperatures in metropolitan environments. The success of the green cities' initiatives can be enhanced through dissemination of biophilic knowledge to communities as this has the effect of changing attitudes (Beatley, 2011; Newman, 2014). This approach should encompass educating the communities on all the benefits of supporting greening of cities besides the energy consumption reduction and cooling aspects. For instance, the city of Vitoria-Gasteiz in Spain initiated a programme to educate residents and school children about the importance of nature and this included establishment of an Ataria Nature Resource Centre, near Salburua wetlands (Beatley, 2011). In addition, the State of Florida in America, with the Backyard Wildlife Habitat Programme, administered by the Florida Wildlife Extension Service has also conducted a community educational project biophilic urbanism (*ibid.*). This shows that governments and local authorities promote the greening of cities through collaboration with community-based organisations.

The adoption of biophilic design and urbanism to reduce energy consumption in cities, among other issues, is also enhanced through influencing built environment professionals and policy-makers. Past studies suggest that these stakeholders can be influenced by imparting environmental education on biophilic cities through various means (Beatley, 2011; Beatley and Newman, 2013; Newman, 2014). Further, the incorporation of biophilic components in the curriculum of built environment degree programmes has been seen as important (*ibid.*). Besides that, literature review shows that the implementation biophilic pilot projects in Chicago has facilitated the buy-in of greening initiatives by urban managers and policy-makers in the city (Beatley, 2011). Thus, there is potential in using creative solutions to gain the much needed official and political commitment and support in the greening of cities.

The implementation of green cities initiatives can be promoted by adopting proper planning, design and building standards. Evidence from literature shows that several American cities have introduced planning and building codes that mandate the installation of green features and promote biophilic designs and urbanism (Beatley, 2011; Kellert and Calabrese, 2015). Further, the planning standards of Chicago, Baltimore and Montreal encourage the greening of all street sides and public open spaces (Beatley, 2011). In relation to this, other cities across the globe like Dublin (Ireland), Hannover, Vitoria-Gasteiz, Boulder (Colorado), Singapore and Cape Town, have also prepared city-wide diversity greening plans to complement the planning and building design standards in guiding the greening of cities (Beatley, 2011; Newman, 2014). Singapore is also an exemplar of how sound planning, good regulations and strategies are pre-conditions for successful biophilic urbanism (Newman, 2014). Previous research also shows that incentives and subsidies are necessary for promoting the greening of cities as this has worked for Chicago and Portland (Beatley, 2011). This shows that the success of biophilic initiatives is dependent on a combination of sound urban planning and design accompanied by incentives and subsidies.

Literature also suggests measures for addressing the resource constraints that affect the greening of cities with the aim of tackling high temperatures and other issues (Burukhina, Tsarkova and Maltceva, 2020). For instance, municipalities are recommended to commit five % of their budgets to cover biophilic related activities (Beatley, 2011; Beatley and Newman, 2013; Newman, 2014). Besides that, local authorities are encouraged to collaborate with existing organisations involved in biophilic conservation activities. Past studies indicate that US cities and Singapore collaborate with several organisations that provide them with invaluable complementary support in their greening programmes (Beatley, 2011; Beatley and Newman, 2013; Newman, 2014). In 2012, Brisbane in Australia managed to plant two million trees with the support of partners who have interest in biophilic initiatives (Beatley and Newman, 2013).

In addition, some cities have developed their resource mobilisation capacity for greening programmes. This is the case with Dublin, Ireland; Boulder, Colorado; Singapore and Cape Town that have developed metropolitan diversity plans being used to harness resources for implementing greening projects from partners (Beatley, 2011; Beatley and Newman, 2013; Newman, 2014; Ryan *et al.*, 2014). These efforts have given credence to the old saying that, 'resources follow plans'. Generally, there are limited resources to support municipal activities, including biophilic programmes, but with judicious planning, more resources can be unlocked from partners.

Past studies show that ecological challenges to biophilic activities, particularly the shortage of water, due to droughts, can be counteracted through the use of drought resistant plants (Beatley, 2011). Other municipalities have invested in collaborative research into sustainable urban metabolism by assessing ways of relying on internally generated resources including recycling various types of wastes (Stewart-Pollack, 2006; Beatley and Newman, 2013; Newman, 2014). These efforts have led to the use of both urban solid waste and grey water to support greenspace initiatives in the face of dwindling water resources (*ibid.*). Literature emphasises that proper utilisation of water needs to be accompanied by innovation in the water supply infrastructure (Zimunya and Sango, forthcoming; Newman, 2014). This shows that the implementation of biophilic activities can be improved through adaptive practices backed by collaborative research with various institutions.

METHODOLOGY

The study adopted an exploratory approach, making use of desktop review and key informant interviews with purposefully selected persons in relevant central government departments and local authorities. The collection of data was premised on the relationship between nature integration in residential neighbourhoods and heating and cooling energy requirements. Desktop review, based on the analysis of existing literature and the analysis of relevant documents through which the design of residential neighbourhoods is informed and guided. Interviews with key informants played a complementary role in the data collection process to ensure that the data from desk review and document review is reliable and valid. Thus, interviews were conducted with provincial offices of planning, the Ministry of Environment and the Ministry of Energy. While the review may not be exhaustive, it provides adequate information to provide insights and lessons the relationship between biophilia and heating and cooling demands.

RESULTS

This section is presented under three main themes. The first theme presents findings regarding the shortfalls of the residential design and legal frameworks in providing for adequate distribution of open spaces and tree plantings. The second theme focuses on the implementation of biophilic urbanism – the actors, institutional arrangements and challenges and opportunities. The third theme presents findings and discussions on the extent to which biophilic urbanism can lead to reduction in heating and cooling energy demands.

Birchenough Bridge is among the fast-growing growth points in the country, attracting people from surrounding rural places with different backgrounds. The establishment of Birchenough Bridge was in line with the government's thrust of the growth point policy, which sought to provide services closer to rural areas as a way of combating rural-urban migration and encouraging the growth of rural places. The growth points were to graduate into towns as is the case of Gutu among others. Like any other urban centre, Birchenough Bridge Growth Point falls under the guide of the national energy policy of prioritising the generation and use of renewable energy and efficiently using the energy. Water supply is the responsibility of the Zimbabwe National Water Authority (ZINWA) and respective local planning authorities. The local authorities provide reticulation pipelines to individual stands.

The Layout Design Manual and Circular 70 of 2004 guide the design of residential layout plans in the study area. Both the design manual and the circular were prepared by the Ministry of Local Government and Public Works to provide a guiding framework to good practice for designing neighbourhoods, liveable and environmentally friendly. Concerning the provision of open spaces, the layout design manual provides for public parks and "open spaces". The manual specifies that 1.2 hectares of land should be left vacant per every 1,000 people and that consideration for public parks placement should be guided by the difficulties for development by the site and being accessible to service vehicles.

Two issues come out of this specification. First, most layouts are designed without information of the household size. This means that the decision is on the size of land to allocate for public parks to meet the standard of 1.2 hectare per 1,000 people. Secondly, the criteria for the selection of space for public parks is based on economic rationality of reserving cheap land to develop against that land for other purposes, other than public parks. The manual also recommends that 5% of the total planning area should be devoted to open spaces. An analysis of this guide to public park provision indicates that designers can make use of peripheral spaces as public parks and open spaces. Whilst this provision shows an acknowledgment of the importance of public parks as recreational and green spaces in neighbourhoods, the emphasis on the economic rationale in allocating space for public parks and the less precise method of determining the size, makes this provision inadequate to meet the requirements for biophilic urbanism and the expected microclimatic modifications.

The study area has some planned and unplanned developments. The study focused on the planned areas since they provide opportunities for biophilic urbanism implementation and enforcement of the various principles of the concept. Figure 1 is a layout diagram for the study area, that shows the proposed developments at neighbourhood level. The distribution of open spaces – as indicated on the layout plan – inclined to the peripheral areas of the layout.

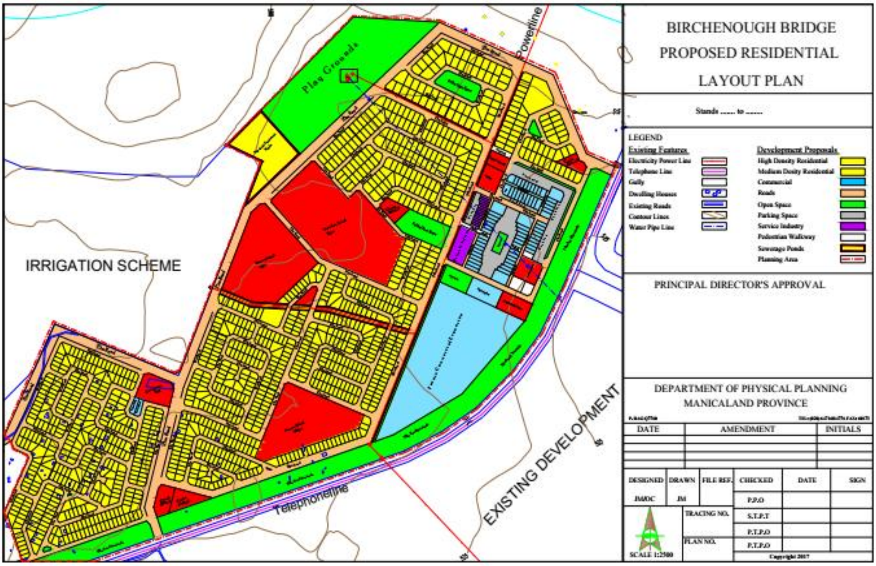

Figure 1: Layout plan for one of the residential places at Birchenough Bridge

According to the design manual, spaces should be reserved for a primary school and pre-schools in every neighbourhood of 500 to 700 residential stands. The manual also gives an outline of the road hierarchy in the design of residential neighbourhoods. Circular 70 of 2004 also sets the minimum standards for roads, minimum stand sizes and minimum building lines in residential areas. Circular 70 of 2004 also provides restrictions of the buffer requirements for major rivers and streams, among others. In line with the provisions of biophilic design, schools provide suitable spaces for tree planting and other forms of soft landscaping. The minimum road sizes prescribed by the circular for high-density development is 10 to 12 metres. Usually, the road servitude carries utilities, such as water, electricity, gas and storm water drains. If the biophilic urbanism concept, which calls for tree and grass plantings along streets, is to be adopted, the 10-metre road width is not suitable. It will not have adequate space to accommodate the carriageway, storm water drains, especially, in the study areas where flash floods are common, utilities, pedestrian walkways and tree and grass plantings. However, the building lines provide allowances for tree plantings on the plot, enhancing the possibility of applying the biophilic cities concept.

Birchenough Bridge is one of the growth points in Zimbabwe whose economic base is agriculture. The agricultural activities are dependent on irrigation from water extracted from the Save River. It is located along the national highway that connects major cities in Zimbabwe, Harare, Mutare, Masvingo, Chipinge, Chiredzi and Checheche (another growth point) and South Africa and Mozambique. A combination of the agricultural activities and the strategic location along the major highways makes Birchenough Bridge attractive to other economic activities, particularly trade of agricultural products and clothing. With an increased rate of rural-urban migration, Birchenough Bridge Growth Point has seen a rise in population and subsequently a demand for residential space. This makes the growth point an important development in Zimbabwe as it contributes to the growth of the country economically and socially through the expansion of services. Whilst the growth of Birchenough Bridge has positive effects to Birchenough and the surrounding communities, the combined effect of the climatic conditions and the microclimatic conditions created by the emerging urban environment, increases the energy demands, for heating and cooling.

Birchenough Bridge is characterised by low rainfall patterns and high annual average temperatures (22.5°C) which makes the area generally very hot during the greater part of the year. The combination of low rainfall and high temperatures makes it difficult for trees to grow and survive. As such, the vegetation cover is sparse. The combined effect of sparse vegetation and built up area increases the reflective capacity of the areas and the surfaces to absorb and retain heat. This makes the area hot, making habitation in and outside the buildings uncomfortable. To improve thermal comfort, people use artificial cooling systems, such as air-conditioners and fans. This makes energy demand for cooling in the area higher than in other urban places whose climatic conditions are not as hot as Birchenough Bridge.

Morphologically, the built-up area is generally low-density development according to the layout plans. The stand sizes in the area are generally medium and low densities (300 square metres and above) with one storey buildings. The building designs are not unique to reflect the climatic conditions; they resemble designs in any other town or city in the country in terms of materials used for construction, window types and sizes and roof types and materials, that is flat, parapet, heaped and/or gable with either corrugated iron sheets, asbestos or clay tiles. The painting is not also reflective of the climatic conditions as there is no dominance of light colours, but a mixture with dark colours whose heat absorption capacity is high. The low-density nature of the existing developments makes the cooling needs difficult to meet and the building types, materials and roof types and materials leave artificial heating mechanisms as the only options to improve thermal comfort in the study area.

Table 1: Characterising the Study Area (Research, 2020)

Item/Issue	Current State	Comment
Housing Needs	• Demand for accommodation (rented and owned) is high. • High uptake of planned stands and growth of unplanned housing developments within and near the Growth Point.	The high demand in accommodation results in shared accommodation by different households. This increases the demand for energy consumption per house. Some unplanned housing developments are connected to electricity and compete for energy with the planned developments. This increase demand for energy in the Growth Point.
Infrastructure	• Electricity connection in some parts of the growth point (residential) • Water reticulated on some stands within the Growth Point. • Gravel access roads to all planned stands – no surfaced roads except the national road that passes through the Growth Point. • Bridges – Birchenough Bridge and Maunganidze. • Telecommunication boosters.	Infrastructure plays a key role in the use of energy. Reticulated water requires energy to pump to the min water works. The telecommunications boosters also require electricity. These requirements for electricity add the demand for energy in the Growth Point.
Economic Activities	• Trade (agricultural products, clothing, spare parts, fast food, wholesaling and retailing) • Agriculture – horticulture • Tourism (bridge) • Accommodation (guest houses) • Light industrial (sewing, welding, repairs, carpentry etc.)	Economic activities in the centre require energy for various enhancements. These include powering devices, such as tills, POS machines, refrigerators, cold rooms, among others. Lighting, heating and cooling are some of the energy requirements for economic activities in the area and powering machinery used in the light industry.

Energy Types	• Renewable – electricity, solar power on some buildings, LP gas • Non-renewable – firewood, paraffin, coal.	The types on energy vary from one household to another. Electricity is the major source for all stands, connected to electricity whilst solar either complement or is the main source of energy for lighting and entertainment in some houses. Firewood is also a major source of energy in the area.
Energy Needs	• Cooking • Lighting • Heating and cooling (air-conditioner, fan, refrigeration, heater) • Industrial	People cook; need light and cooling for improved thermal comfort in the study area. These energy needs can be met through the different types of energy. Thus, some use solar energy for lighting and entertainment and then use firewood and/or gas for cooking.

As argued before, the requirement for 5% open space can be met but distributed in a manner that does not allow the implementation of biophilic urbanism. The road width (minimum of 12 metres), however, allows for tree plantings, bringing vegetation closer to houses to enable tree canopies to provide shade to the buildings. The layout also reserves spaces for schools. These present opportunities for the densification of trees, increasing the opportunities for integrating nature into the neighbourhood.

DISCUSSION

Findings reveal that the implementation of the biophilic urbanism concept requires a multi-disciplinary approach. These can share responsibilities in terms of regulation, landscaping (tree and grass planting) and management or caring for nature (Burukhina, Tsarkova and Maltceva, 2020). According to the research, the local authority can enforce the preservation of existing trees and planting of new trees and grass within the neighbourhood. The neighbourhood inhabitants can also play a role in planting grass and trees within the plot and immediate surroundings. However, a guide is required to ensure conformity to the requirements for development in the neighbourhood. Birchenough Bridge being a hot area, frequent watering of trees and grass is required, hence, ZINWA, that is the water supply authority for the area, is a key stakeholder in in the biodiversity plan to ensure that there is enough water to irrigate the trees and grass. Thus, from the findings, landscaping, through the guide of a landscape or biodiversity plan, is a requirement for successful implementation of the biophilic urbanism concept. Actors in water provision are an important inclusion in the implementation of the biophilic urbanism concept.

Planting trees in the study area influences the microclimatic conditions. As indicated earlier, the sparse vegetation coverage has an effect on the amount of solar radiation that reaches the ground surface, effectively raising the temperatures. Biophilic urbanism is anchored on, among other practices, the planting of trees and grass along streets and on plots, among other places in the neighbourhood. The tree leaves provide shade, which reduce the amount of solar radiation that reaches the ground as some will be absorbed by the leaves during photosynthesis and some reflected into the atmosphere. This in turn reduces the heat transmitted into the buildings by 11 to 25°C (U.S. Environmental Protection Agency, 2008).

The dry conditions of Birchenough Bridge contribute to the high temperatures. Bringing trees closer to houses, the microclimatic conditions can modify temperatures. The trees and vegetation absorb water through the roots and emit it through the leaves (transpiration). Using heat from the air, trees cool the air through evapotranspiration. Studies show that suburban areas with mature trees are 2 to 3°C cooler than suburban areas. In a similar research, shading the building reduce the air-conditioning demand. Thus, Biophilic Urbanism, through greening the neighbourhood, can reduce the energy needed to cool buildings.

CONCLUSION

The study concludes that the link between biophilic urbanism and energy demand in residential places is not well understood. This is deduced from the observation that there is no provision for landscaping or greening of neighbourhoods in the design and legal frameworks guiding the design and development of residential areas. The implementation of biophilic urbanism is a multi-sector activity, that requires multiple actors at all scales ranging from the neighbourhood to the plot and, those who provide water and water infrastructure. As such, biophilic urbanism goes beyond layout designing to include, but not limited to, landscaping or biodiversity planning. This will create conditions for the modification of the neighbourhood microclimate. However, biophilic urbanism modifies the microclimate of a neighbourhood if the principles of the concept are followed. This improves the thermal comfort of residential neighbourhoods and within the buildings therein. Recommendations made in this article are that:

- The manual and circular that guides the design of residential layout plans should be reviewed if biophilic urbanism is to be adopted as a measure of reducing the energy demand, improving the aesthetics and protecting the environment in residential places.
- The manual and circular should clearly specify how the open spaces for greening should be distributed and treated to make sure that networks of green spaces are well distributed within the neighbourhood.
- Awareness should be made on the roles of the various stakeholders in greening cities and for the stakeholders to know the importance of nature in residential neighbourhoods.

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