African Journal of Housing and Sustainable Development (AJHSD)
Volume 4, Number 2
http://ujh.unilag.edu.ng/index.php/ajhsd
https://doi.org/10.52968/28467620

Office Sustainability Assessment for Endearing Resilience in an Academic Environment

Temilola Oluseyi[1], Aliu Soyingbe[2], Abdulganiyu Adelopo[3]*, Afolasade Nubi[3], Adetinuke Aina[3], and Aisha Abdulkareem[4]

[1] Analytical/Environmental Chemistry Research Group, Department of Chemistry, University of Lagos, Nigeria
[2] Department of Building, University of Lagos, Nigeria
[3] Works and Physical Planning Department, University of Lagos, Nigeria
[4] Department of Community Health, Lagos University Teaching Hospital

To cite this article: Oluseyi, T., Soyingbe, A., Adelopo, A., Nubi, A., Aina, A., & Abdulkareem A. (2023). Office Sustainability Assessment for Endearing Resilience in an Academic Environment. *African Journal of Housing and Sustainable Development, 4*(2), pp. 57-71

Abstract

Office conditions are crucial to assessing the sociocultural, economic, environmental and public health of the majority of the urban population. The office is a built environment that takes up the bulk of the time and energy of society's elite. As such, the quality of office spaces has a significant effect on the health, comfort, satisfaction and productivity of office workers. No doubt, inadequate indoor environmental quality will impede workers' productivity and well-being. Sustainability in the office addresses the interface through which resilience in both the biotic and abiotic components of the indoor working micro-environment can be measured and transformed for full productivity. In the light of this, this article evaluates the factors driving infrastructural, health and economic resilience in academic institutions.. The study reviews the literature on the theory of human behaviour, with a view to establishing the link between key concepts in infrastructural, health and economic resilience *and* office sustainability within an academic environment. It identifies office sustainability as a major determinant in the effective measurement and development of resilience in academic environments. It was observed that the dimensions of infrastructural, health and economic resilience are in-built features which academic institutions should adopt to achieve overall resilience in the academic environment. This assessment should bring about major social and economic benefits, given the quantum of time that members of the university staff spend in their offices.

Keywords: Academic institution; Indoor environment; Office sustainability index and resilience

1.0 Introduction

There are growing concerns about how the built environment contributes to the global goals of environmental sustainability and resilience. The built environment comprises buildings and living spaces that are created or modified by humans. Clearly, the infrastructural utilities

✉ aadelopo@unilag.edu.ng*

designed to serve built spaces relate in one way or another to the 17 Sustainable Development Goals (SDGs) (Larsen & Jensen, 2019). For example, SDG Goal 7 (affordable clean energy), SDG Goal 8 (decent work and economic growth), SDG Goal 9 (industry, innovation and infrastructure), SDG Goal 11 (sustainable cities and communities), SDG Goal 12 (responsible consumption and production) are significantly influenced by design and management practices within the built environment. Beyond the immediate social, economic, health and environmental benefits of infrastructures for the present generation, the needs of future generations must also be anticipated. Indeed, the nature, location and roles of the built environment (homes, buildings, offices, streets, sidewalks, open spaces, transportation options, etc.) are critical to determining their sustainability contributions (Bergefurt et al., 2022).

Office buildings are often specifically designed to consume higher quantities of energy compared to commercial and domestic buildings. (Xue et al*.,* 2016). Additional features such as daylighting, natural ventilation, natural view, open space and places of respite (Bergefurt et al*.,* 2022) help to boost worker health, well-being and productivity via optimisation of such elements. While there are at least eight established office building design and construction standards, the choice of office design for most organisations will depend on issues of cost and staff needs for optimum performance (Akadiri et al., 2012).

In academic institutions, various office designs are adopted to achieve teaching, research, technical and administrative objectives within built environment. For example, a medical laboratory office will differ in design from a mechanical engineering laboratory office, even when both office types are managed by technical officers. Academic institutions provide an opportunity to evaluate diverse office types – in terms of operations and performance output.

Tertiary institutions are pivotal to the drive towards sustainability (Leal et al*.,* 2018; Zuo et al., 2016), as active drivers of the SDG agenda through multi-disciplinarity. However, to achieve the required education and training on sustainability principles, higher institutions need to strategically incorporate sustainability into their curricula, modus operandi and organisational culture (Dedeurwaerdere, 2013). For a start, there should be assessments of the sustainability ratings of office buildings within the academic environment. This process should involve students as key actors in the broader environmental sustainability drive.

2.0 Literature Review

Not much multidisciplinary research has been undertaken on sustainable academic office structures in Nigerian academic institutions. Although a number of works on individual sustainability parameters such as indoor air quality and energy efficiency in higher institutions have appeared, most of them fail to focus on sustainability measurements. For example, Otolorin et al. (2018) reported a correlative relationship between total volatile organic compound content in academic offices at a university and staff productivity performances.

For this study on office sustainability assessment, the general building sustainability evaluation reports are used as premises for the literature review. According to the World Business Council for Sustainable Development, buildings could be generating up to 42.4 billion tons of carbon globally by 2023 – an increase of 43% since 2007 (Khan et al., 2021). Therefore, buildings can play a critical role in the evaluation, monitoring and reduction of carbon emissions to control the adverse impact of global warming (Bulut et al., 2020; Zuhaib et al., 2017). Mannan and Al-Ghamdi (2021) reported that the indoor greenhouse gas generated in developing countries is more contaminated than outdoor air. Indoor activities such as smoking, use of domestic machinery and vehicular activities within the compound are also considered as possible sources. Greenhouse gas and other air quality elements (e.g., Total Volatile Organic Carbon [TVOC]), formaldehyde, Volatile Organic Compounds [VOCs], mould, benzene, particulates, radon) of buildings have been linked with health, well-being and the productivity ratings of occupants (Losacco & Perillo, 2018). At different times, the built environment contains both established and transient microorganisms in different spaces, with both being affected by practices such as cleaning and remediation. Akadiri et al. (2012) identified nature of materials, quantification and design for infrastructure longevity, as well as adaptive utility and futuristic innovative use, as core sustainability measures of resource conservativeness in buildings.

Prominent green building rating tools, such as Leadership in Energy and Environmental Design (LEED) (US) and Building Research Establishment Environmental Assessment Method BREEAM (UK), incorporate special tools for office building types. Similarly, the Green Building Council of Australia (GBCA) has released three rating tools for office buildings: Green Star – Office Design, Green Star – Office As Built, and Green Star – Office Interior (Zuo et al., 2016). In Africa, only South Africa has a national approved green building rating, known as Green Star SA; the country is also a full member of the World Green Building Council. Although Kenya, Ghana, Mauritius, Morocco, Namibia and Nigeria have each established National Green Building Councils, they continue to adopt South Africa's Green Star SA rating for buildings.

In this regard, the study reviews research on the nexus of infrastructural, health and economic resilience in academic institutions by assessing their systemic office sustainability monitoring and adaptation practices. The study will thus be able to determine the international assessment system that is most suitable for offices locally. Furthermore, the evaluation will provide baseline information for the assessment of different offices in academic institutions in order to bridge the gap of local content in the national green building assessment tool.

According to Park et al. (2017), building rating tools are systematic frameworks that enable the assessment of buildings with established criteria to measure and compare their compliance towards more sustainable forms of design, construction, operations, and dismantlement. Building rating tools are rigorous assessment methodologies involving diverse elements, i.e., environmental, economic, social, cultural, and value-based ones. Sustainable building certifications are often used as approved documented quantifications of the sustainability compliance of buildings that support integrated design and interdisciplinary collaborations. Although there are over 600 building rating tools globally, the most prominent are BREEAM-UK, LEED-USA, GBI-Malaysia, GREEN STAR-Australia, and GREEN GLOBES (Park et al., 2017). [Table 1 provides a summary of the indicators used by the prominent certification standards.]

Table 1: Summary of indicators used by the prominent certification standards

Building Tools	Sustainability Dimensions				
	Environment	Social	Economic	Culture	Governance
LEED	Location and transportation Sustainable sites, water efficiency Energy and atmosphere, material and resources, indoor environment quality	Location and transportation Material and resources Regional priority	Management		Integrative process
BREEAM	Health and wellbeing, energy Transport, water, material Waste, land use and ecology Pollution	Health and wellbeing Transport	Management		
GREENSTAR	Management, indoor environment quality, energy, transport, water Material, land use and ecology Emissions	Indoor environment quality, transport Material, emissions			Management
CASBEE	Indoor environment, energy Resources and material, off-site environment Quality of service	Quality of service On-site environment			Quality of service
DGNB (97)	Global and local environmental impacts Resource consumption and waste Quality of technical implementation Quality of construction, site quality	Health comfort and user-friendliness, functionality, aesthetic quality Quality of technical implementation Site quality	Life cycle costing Financial performance		
SEED (100)	Location and transportation Sustainable sites, water efficiency Energy and atmosphere, material and resources, indoor environment quality	Location and transportation Sustainable sites, indoor environment quality		Sustainable sites	
Athena	Embodied primary energy use, global warming potential, solid waste emissions, pollutants to air, pollutants to water, natural resource use.				
Envest 2	Resource consumption, environmental loading.	Indoor air quality	Whole life costs		

Source: (Khan et al., 2021)

Regarding office assessment for contractors and other stakeholders, this study adopts "a common EU framework of core sustainability indicators for office and residential buildings". The manual provides a guide to using any of the micro-objectives as they relate to specific sustainable indicators (Dodd et al., 2021); it also identifies definite indicators to be measured. [Table 2 specifies the detailed indicators measurable for each micro-objective.]

Table 2: Detailed EU framework of core sustainability indicators for office and residential buildings for each micro-objective

Micro-objective	**Indicator**	**Unit of Measurement**	**Summary Information**
1. Greenhouse gas and air pollutant emission along a building's life cycle	1.1 Use stage energy performance	Kilowatt hours per square metre per year ($KWh/m^2/yr$)	This indicator measures the primary energy demand of a building in the use stage. In a life cycle approach, this energy demand is also referred to as 'operational energy consumption'. It takes into accou nt the benefits of generating low carbon or renewable energy.
	1.2 Life cycle Global Warming Potential	Kg CO_2 equivalents per square metre per year (kg CO_2 eq./m^2/yr)	This indicator measures the greenhouse gas (GHG) emissions associated with the building at different stages in its life cycle. It therefore measures the building's contribution to emission that cause the cause the earth global 2warming or climate change. This is sometimes also referred to as 'carbon footprint assessment' or 'whole life carbon measurement'.
2. Resource efficient and circular material life cycles	2.1 Bill of quantities, materials and lifespans	Unit quantities, mass and years	This indicator measures the quantities and mass of construction products and materials necessary to complete part of the building. It also allows for the estimation of the lifespans of defined pats of the building.
	2.2 Construction and demolition waste and materials	Kg of waste and materials per m^2 total useful floor area	This indicator measures overall quantity of waste and materials generated by constructed, renovation and demolition activities. This is then used to calculate the diversion rate to reuse and recycling, in line with the waste hierarchy.
	2.3 Designs for adaptability and renovation	Adaptability score	This indicator assesses the extent to which the design of a building could facilitate future adaptation to changing occupier needs and property market conditions. It therefore provides a proxy for the capacity of a building to continue to fulfils its function and for the possibility to extend its useful service life into the future.
	2.4 Designs for deconstruction, reuse and recycling	Deconstruction Score	This indicator assesses the extents to which the building could facilitate the future recovery of materials for reuse of recycling. This include s assessment of the ease of disassembly of minimum scope of building parts and their associated sub -assemblies and materials.
3. Efficient use of water resources	3.1 Use of stage water consumption	m^3/yr of water per occupant	The indicator measures the total consumption of water for an average building occupant, with the options to split this value into potable and non -potable water that is supplied. it also supports the identification of water scare locations.
1-3 Full LCA	n/a	10 impact categories	Climate change; Ozone depletion; Eutrophication aquatic freshwater; photochemical ozone formation; depletion of abiotic resources- minerals and metals; Depletion of abiotic resources –fossil fuels; water use.
4. Healthy and comfortable spaces	4.1 Indoor air quality	Parameters for ventilation, CO_2 and humidity Targets list of pollutant: TVOC, LCI ratio, mould, benzene, particulates, radon	The indicator measures a combination of indoor air conditions and target air pollutants. Ǽ The design indoor air conditi on relates to the ventilation rate and how this is adjusted to keep CO_2 and humidity at healthy levels. Ǽ The target air pollutant can be controlled by selecting and reporting on low pollutant fit out materials, controlling the risk of mould growth and speci fying ventilation systems with adequate filters for polluted outside air.

	4.2 Time outside of thermal comfort range	% of the time out of range during the heating and cooling seasons	The indicator measures the proportion of time during the year when building occupiers are comfortable with indoors thermal conditions. It measures the ability of a building (with & without building services) to maintain pre-defined thermal comfort specs during hot & cold weather.
	4.3 Lightning and visual comfort	Level 1 checklist	The indicator measures the availability and quality of light, considered in items of a combination of installed electric lighting systems and penetration of natural light into a building.
	4.4 Acoustics and protection against noise	Level 1 checklist	This indicator measures the potential for disturbance from unwanted noise in the form of impact and airborne transmission of sound between residential dwellings and office specs, reverberation sound in office spacers and in both types of building e xternal sources of noise disturbance.
5. Adaptation and resilience to climate change	5.1 Protection of occupier health and thermal comfort	Projected % time out of range in the years 2030 and 2050 (see also indicator 4.2)	This indicator measures the potent ial for a deviation of the thermal comfort simulated using projected weather conditions in 2030 and 2050 from present conditions. The indicator relies on the same methodology as indicator 4.2.
	5.2 Increased risks of extreme weather events	Level 1 checklist (under development)	This indicator assess es the potential for extreme weather events in the future (e.g. , storms, rainfall, snowfall, and heatwave) and their impact on the service life of a building component or materials.
	5.3 Increased risk of flood event	Level 1 checklist (under development)	This indicator measures all building element costs incurred at each life cycle of a project for the reference study period and, if defined by the client, the intended service life.
6. Optimized life cycle cost and value	6.1 Life cycle costs	Euros per square metre per year (e/m^2 /yr)	The indicator measures all building element costs incurred at each life cycle stage of a project for the reference study period and, if defined by the client, the intended service life.
	6.2 Value creation and risk exposure	Level 1 checklist	This indicator assesses the potential for the building design to have a positive influence on property valuation and risk in the main areas: ÁReduced overheads (by minimizing operational costs). ÁIncreased revenues and more stable investments (by making properties more attractive). ÁReduced risk (by anticipating future exposure)

Source: Dodd et al. (2021)

In recent years, resilience has become a prominent topic in the planning and design industry. The OECD Indicators for Resilient Cities (Indicators for Resilient Cities, 2018) relate a structure's resilience to four key dimensions: Health and well-being – ensuring the health and well-being of everyone living and working in the entity; economy and society – the social and financial systems that enable users to live peacefully and act collectively; Infrastructure and environment – artificial and natural systems that provide critical services, protect and connect users; and leadership and strategy – the need for informed, inclusive, integrated and iterative decision-making in the facility (Storms et al., 2019). Structural resilience is associated with four dimensions and 12 goals that are considered as the bedrock of endearing resilience. [Figure 1 shows the interrelationship between the dimensions and the goals.]

Figure 1: The interrelationship between the dimensions and goals of resilience ("Indicators for Resilient Cities," 2018)

The resilience dimensions are closely linked with the sustainability criteria under health and well-being, economy and society, leadership and strategy, infrastructure and ecosystems (see Figure 2). It could be inferred that the critical features of resilience are a measure of sustainability stability, flexibility, and changing features.

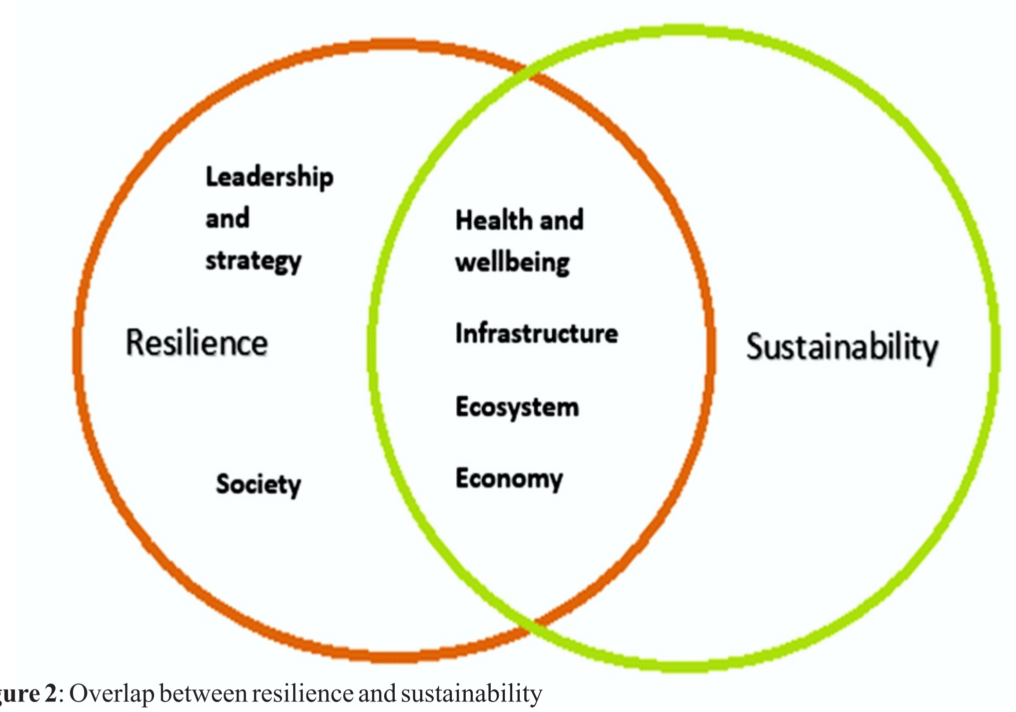

Figure 2: Overlap between resilience and sustainability

Source: Authors (2022)

This provides a nexus that could be explored for evaluation and determination of stability, flexibility and adaptability of sustainability of structures to withstand resilience demands.

Over the years, universities have played leading roles in proffering solutions to issues of resilience and sustainability in society (Storms et al*.,* 2019). Now they need to provide similar leadership in addressing resilience on campuses. In the literature there is little evidence of studies on university campus resilience, probably because most university and college campuses remain more focused on sustainability and less involved with the notion of resilience. It is therefore not surprising that there are few examples of resilient campus planning and operational implementation in tertiary institutions. Although some institutions have faculties and centres studying resilience within the framework of urban and regional planning, policy and governance stability and disaster management, there is an urgent need to link theory with practice via empirical studies showing the nexus of structural sustainability and resilience.

3.0 Methodology of Assessment

The researchers undertook a desktop review of the literature on office sustainability parameters and the theoretical framework for their measurement. The search focused on identification and broad grouping of parameters and development of measurement via the theoretical framework.

3.1 Identification and Broad Grouping of Parameters

The Science Direct web page was searched for information on review journals focusing on office sustainability objectives and indicators in the field of environmental science and engineering between 2012 and 2022. The search was in three phases to enhance the identification of stakeholders' participation and the identification of experts' assessment areas. The groupings are as follows:

(i) office infrastructural and economic sustainability assessment
(ii) office environmental sustainability assessment
(iii) office health and social sustainability assessment.

3.1.1 Development of Measurement via the Theoretical Framework

In order to investigate the theoretical link between behavioural concepts and sustainable office productivity, the researchers selected and reviewed 15 articles on human behavioural theories and sustainability measurements**.** The theories present systematic ways of evaluating human behaviour, events and/or situations (Kwon & Ahn, 2019), with a set of interrelated definitions, concepts and propositions that predict or explain events or situations by specifying relationships among variables (Abusafieh & Razem, 2017). For each bit of evaluation, human behaviour is key to achieving the desired sustainability. Three human behavioural theories that align with each broad grouping were evaluated: Environmentally Responsible Behaviour (ERB), Health Belief Theory, and the SBToolPT model. An inference analysis was used to establish parameters such as aggregation, Sustainable Office Score (SOS) and the resilience integration overview.

3.1.2 Results and Discussions

Table 3 provides details on sustainability objectives, expert of interest, indicators and the related human behaviour theory and journal source.

Table 3: Assessment grouping and building sustainability objectives

Assessment grouping	**Objectives**	**Faculty of expert required**	**Indicators**	**Theory**
1. Building infrastructural and building economics	Resource efficiency and circular material life cycles	Engineering/ Environment science/ Quantity surveyors/ Architectural / Economist	Bill of quantities, materials and lifespans Construction and demolition waste and materials Design for adaptability and renovation Design for deconstruction, reuse and recycling	SBToolPTeH model (Mateus & Bragança, 2011)
	Efficient use of water resources		Use stage water consumption	
	Optimised life cycle cost and value		Life cycle costs Value creation and risk exposure	
Assessment group	Objectives from the EU	Faculty of expert required	Indicators	Theory
2. Building environmental	Greenhouse gas and air pollutant emissions along a building's life cycle	Environmental chemist, environmental science,	Life cycle Global Warming Potential Use stage energy performance	Environmentally Responsible Behavior (ERB) (Abusafieh & Razem, 2017)
	indoor air quality		Target list of pollutants: TVOC, formaldehyde, CMR VOC, LCI ratio, benzene, particulates, radon	
	Waste management		Office waste management index	
Assessment grouping	Objectives from the EU	Faculty of expert required	Indicators	Theory
3. Building health and social	Healthy and comfortable spaces	Public Health, Microbiologist, Sociologist	Time outside of thermal comfort range Lighting and visual comfort Acoustics and protection against noise	Health Belief Theory (Abusafieh & Razem, 2017)

Based on the sustainable assessment office data in Table 3, the builders, quantity surveyors and architect are crucial to office infrastructural design and economic evaluation. They are able to assess the structural and economic implications of academic offices using life cycle assessment. They will provide resource demand and utility analysis, building adaptability and land-use assessment. With the indicators measurement, researchers can measure the overall potential quantity of waste and materials that will be generated by construction, renovation and demolition activities, as well as the estimated diversion rate to reuse and recycling, in line with the waste hierarchy.

3.1.4 Environmental Sustainability Assessment in Offices

The design of the office indoor air condition will affect the targeted air pollutants, which can be selectively measured and reported, thus avoiding the impact of polluted outside air. Determining the role of the ventilation system, as well as how this is adjusted to keep CO_2 and humidity at healthy levels, will also be essential. An environmental chemist is best qualified to measure air quality parameters such as levels of carbon footprint, greenhouse gas emission and pollutant emission in academic offices and buildings.

3.1.5 Health and Social Sustainability Assessment in Offices

The office occupier's thermal comfort with indoor conditions during seasonal variations is evaluated based on microbial load and temperature functionality. The effects of office wall colour and illumination on mental and eye comfort are also evaluated. Experts in public health, sociology and microbiology will focus on the parameters of buildings that affect health and comfort. No doubt, office space quality has something to do with productivity and challenges, social integration and inclusion, as well as privacy and performance. The relevant faculties might consider supplying staff and students for the evaluation, as a way to ensure project ownership and sustainable knowledge transfer.

3.1.6 Environmentally Responsible Behaviour (ERB)

Proponents of the theory of Environmentally Responsible Behaviour (ERB) argue that having the intention to act is a major factor influencing ERB. The ERB model suggests that a person's adaptation of environmentally positive behaviour will depend on the following variables: intention to act, locus of control, attitudes, sense of personal responsibility, and knowledge. Figure 3 presents a complex of interactions likely to emerge as ERB. According to proponents of the theory, the control centre directly affects an individual's attitudes, leading to an improved intention in acting and improving behaviour. Thus, the theory concentrates more on existing interactions among parameters that influence a person's behaviour than on the singular impact of a single variable.

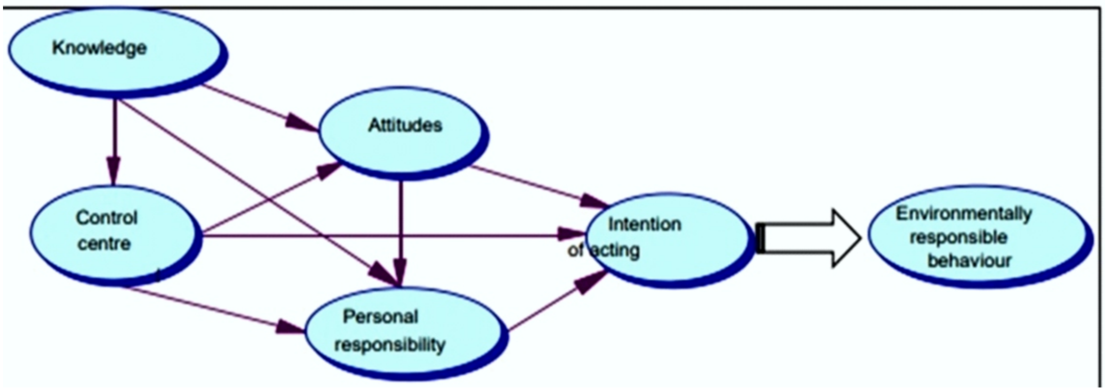

Figure 3: Interaction parameters in development of ERB

Source: Abusafieh & Razem (2017)

The theory helps to establish an evaluation scheme that rates users' knowledge of office indoor air pollutants (KP), value of indoor air quality (IAQ), greenhouse gas source (Gs), office green gas generation value (Ogg), waste generation index (WGI) and willingness of office users to transit to sustainable behaviour in greenhouse gas and air pollutant generation (Tg). The rating focuses on office sustainability based on users' knowledge, contributions and transition potential. This can be expressed as follows:

$$OEA = \frac{OAP+IAQ+Gs+Ogg+OWGI}{Ot} \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

3.1.7 Health Belief Theory

The Health Belief Model (HBM) evaluates positive human behaviour based on health and behaviour. According to the model, whenever there is increased potential in an individual's assessed level of risk, there is an increased possibility that the individual will adhere to preventive behaviour. HBM has been well applied to evaluate environmentally-friendly behaviour and healthy consumption behaviour in the built environment. The HBM contains four factors for predicting health-related behaviour: perceived benefits, threats, barriers, and susceptibility. Three factors (perceived benefits, threats, and barriers) were used in developing the research framework. Perceived susceptibility was not considered in the current concept owing to difficulties associated with linking disease source to individuals based on only office activities. Perceived benefits describe the positive outcomes that a person receives from healthy behaviour. Perceived threats include potential negative consequences as a result of not adopting the healthy behaviour. Perceived barriers are factors such as time, effort and structure, which prevent one from performing the healthy behaviour. Figure 4 provides a summary of the proposed concept, which is similar to the method proposed by Kwon and Ahn (2019).

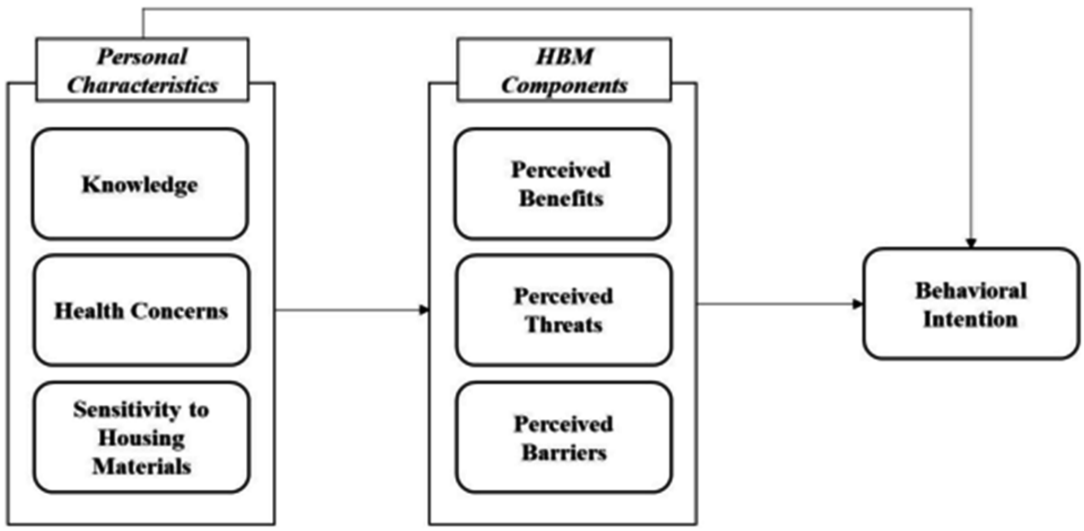

Figure 4: Parameters for Health Belief Theory (Kwon & Ahn, 2019)

Office health and social assessment has measurable parameters for Office Health Prevalent issue (OHP), Office Perceived Threat (OPT) and Office Health Barriers (OHB). OHP issue is evaluated based on Office Microbial Burden (MB), Illumination Factor (IF), Temperature Comfort (TC), and Noise Level (NL) in the respective offices. This is expressed as follows:

$$OHP = MB + IF + TC + NL \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

The World Health Organization standards and the local regulation standards for each of the measurements is used as a reference rating for conformity. OPT is rated based on values from office health prevalence measurement against identified potential disease. OPT ranged from Low, Moderate, High to Severe based on health issue prevalence rating and health severity evaluation.

The OHBs evaluate the structural, economic, cultural and operational factors that might prevent a positive transition to the reduction of the healthy condition. Hence, Office Health and Social Assessment (OHA) can be expressed thus:

$$OHA = \frac{OHPXOPT}{OHB} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

3.18 SBToolPT Model

The SBToolPT model is a global indicator that summarises building performance at the level of a key-sustainability aspect. The SBToolPT model is an innovative approach for developing building sustainability assessment and rating, evolving from the generic methodology while increasing the understanding of the different dimensions of sustainability through its accounting style. The SBToolPT has nine sustainability categories: Climate change and outdoor air quality; Land use and biodiversity; Energy Efficiency; Materials and waste management; Water efficiency; Occupant's health and comfort; Accessibilities; Education and awareness of sustainability; and Life cycle costs.

The SBToolPT model is deployed for infrastructural and economic assessment, given the indicators and parameters that align with the model. It allows for a combination of material and economic evaluation for the office infrastructure. In the quantification of material lifespan and construction and demolition waste from a completed building, a Life Cycle Assessment (LCA) is recommended using databases with the LCA data for the most commonly used building materials and components. For areas without well-developed building LCA, local compensation figures are provided within six categories of environmental impact on building lifespan. [Table 4 presents the unit of measurement for these factors.]

Table 4: The unit of measurement for the factors use in Life Cycle Analysis

Environmental impact categories	Unit/declared unit	LCA methods
Depletion of abiotic resources	[kg Sb equiv.]	CML 2 baseline 2000
Global warming potential (GWP)	[Kg CO_2 equiv.]	IPCC 2001 GWP 100a
Destruction of atmospheric ozone (ODP)	[Kg CFC-11 equiv.]	CML 2 baseline 2000
Acidification potential (AP)	[Kg SO_2 equiv.]	CML 2 baseline 2000
Eutrophication potential (NP)	[Kg PO_4 equiv.]	CML 2 baseline 2000
Photochemical ozone creation (POCP)	[Kg C_2H_4 equiv.]	CML 2 baseline 2000
Non-renewable primary energy	[MJ equiv.]	Cumulative Energy Demand
Renewable primary energy	[MJ equiv.]	Cumulative Energy Demand

Source: Mateus & Bragança (2011)

The Construction and Material Recycled Potential is rated for each parameter and converted into grades (see Table 5). The lower the value, the less sustainable the observation for the parameter, with the least scale being E (less sustainable/below the conventional practice) and the highest A+ (more sustainable/above the best practice).

Table 5: The construction and material recycled potential rating

Grade	Values
A+	$\overline{P_i} > 1.00$
A (Best practice)	$0.70 < \overline{P_i} \leq 1.00$
B	$0.40 < \overline{P_i} \leq 0.70$
C	$0.10 < \overline{P_i} \leq 0.40$
D (Conventional practice)	$0.00 < \overline{P_i} \leq 0.10$
E	$\overline{P_i} \leq 0.00$

Source: Mateus & Bragança (2011)

Economic performance is based on the market value of the materials and on their operational costs (costs relating to water and energy consumption). Value per square meter is provided based on the building or area size currently in use. For share facilities, the average person's utility is computed per office or area in use.

Utility value. Ec = material estimate x cost per unit + operational cost
Hence, office infrastructural and economic assessment (OIE) can be expressed as follows:

OIE = Ma + Ec .... (4)

3.1.9 Aggregation of Parameters

Each office assessment will be an aggregate for each of the objectives highlighted above; that is, the summation of Office Health Assessment (OHA), Office Infrastructural and Economic Assessment (OIEA), and Office Environment Assessment (OEA). In the summation, data normalisation is adopted to ensure values are not over- or underrated. A confident error curve is generated using predicted values from standard organisation such as LEED and BREAM as benchmarks for offices having similar features.

3.1.10 Sustainable Office Score (SOS)

The SOS of the office is based on the three broad categorisations of office health and social assessment (OHSA), office infrastructural and economic assessment (OIEA), and office environment assessment (OEA). The SOS will be determined from two dimensions of performance score and weighted score. The performance score is the value rating achieved by each office for OHA, OIEA and OEA respectively. The weighted score is the rating of the importance of each assessment unit to productivity and survival with the office. The global assessment weights of the environment, society and economy dimensions is in the order of 40%, 30% and 30% respectively. In the assessment, the highest value of 40% is attached to importance of issues of human survival within the assessed location, which is similar to the factors considered under OHA in this assessment. As such, the weighted scores of 40%, 30% and 30% are for OHSA, OEA and OIEA respectively.

4.0 Conclusion

Based on a review of literature, this paper has focused on parameters for evaluating the sustainability assessment of academic offices. It has presented an assessment method that incorporates an occupier's behavioural influence and their willingness to transit to sustainable action. Academic institutions are considered to be at the heart of knowledge discovery and demonstration globally, acting as a mini-laboratory for the larger society. Issues of sustainability and resilience have been keenly discussed across disciplines in academic institutions, although there has been limited application of their prescriptions in tertiary institutions in developing countries. While some institutions have made efforts to include sustainability in key sections of their operations, most have not considered campus resilience as a subject of strategic interest. This situation subsists despite resilience thinking being intended to bridge the conceptual divide between the natural and social sciences, as well as to connect knowledge of ecosystems with societal actions in the bid to meet the SDGs.

The paper discussed linkages and overlaps that make it possible to drive resilience through stable, flexible and adaptable sustainable strategies. The four goals of resilience (health and wellbeing, infrastructure, ecosystem and economy) align with the three major objectives driving sustainability (building infrastructural, and economics, building environment and building health and socials). Factors of office design and occupant behaviour were considered as pivotal to sustainable and resilience evaluations. The fact that employees represent the highest cost centre in office operation compels organisations to pay more attention to office design and operational conditions. Healthy office design strategies with economic values correlate with the higher productivity and sustainability needed to boost human and material resilience over time.

The office sustainable objectives and indicators were grouped into three assessment units to enhance stakeholder participation and identification of experts' focus areas during the assessment of academic offices. These were Office infrastructural and economic sustainability assessment (OIEA), Office health and social assessment (OHSA), Office environment assessment (OEA). For each of the evaluation concepts, three human behavioural theories that align with each broad grouping were evaluated. The theory of Environmentally Responsible Behaviour (ERB), Health Belief Theory and the Sustainable BToolPT model were respectively adopted in the calculation. Findings from this study may be applied in academic contexts to determine the sample number required to account for least-error factors. It is also necessary to account for the uncertainty associated with change in office occupant as well as for the institutionally allowed changes within offices.

References

Abusafieh, S., & Razem, M. (2017). Human Behavior and Environmental Sustainability: promoting a pro-environmental behavior by harnessing the social, psychological and physical influences of the built environment. *E3S Web of Conferences*, *23*, 02003. https://doi.org/10.1051/e3sconf/20172302003.

Akadiri, P. O., Chinyio, E. A., & Olomolaiye, P. O. (2012). Design of A Sustainable Building: A Conceptual Framework for Implementing Sustainability in the Building Sector. *Buildings*, *2*(2), 126–152. https://doi.org/10.3390/buildings2020126.

Bergefurt, L., Weijs-Perrée, M., Appel-Meulenbroek, R., & Arentze, T. (2022). The physical office workplace as a resource for mental health – A systematic scoping review. *Building and Environment*, *207*, 108505. https://doi.org/10.1016/j.buildenv.2021.108505.

Bulut, M., Wilkinson, S., Khan, A., Jin, X. H., & Lee, C. L. (2020). Perceived benefits of retrofitted residential secondary glazing: an exploratory Australian study. *International Journal of Building Pathology and Adaptation*, *39*(5), 720–733. https://doi.org/10.1108/ijbpa-09-2020-0083.

Dedeurwaerdere, T. (2013). Transdisciplinary Sustainability Science at Higher Education Institutions: Science Policy Tools for Incremental Institutional Change. *Sustainability*, *5*(9), 3783–3801. https://doi.org/10.3390/su5093783.

Dodd N., Donatello S. & Cordella M., (2021). Level(s) – A common EU framework of core sustainability indicators for office and residential buildings, User manual 2: Setting up a project to use the Level(s) common framework (Publication version 1.1).

Indicators for Resilient Cities. (2018). *OECD Regional Development Working Papers*. https://doi.org/10.1787/6f1f6065-en.

Khan, M. A., Wang, C. C., & Lee, C. L. (2021). A Framework for Developing Green Building Rating Tools Based on Pakistan's Local Context. *Buildings*, *11*(5), 202. https://doi.org/10.3390/buildings11050202.

Kwon, H. J., & Ahn, M. (2019). Boomers' Intention to Choose Healthy Housing Materials: An Application of the Health Belief Model. *Sustainability*, *11*(18), 4869. https://doi.org/10.3390/su11184869.

Larsen, N. B., & Jensen, L. B. (2019). Current work on social sustainability in the built environment. *IOP Conference Series: Earth and Environmental Science*, *225*, 012063. https://doi.org/10.1088/1755-1315/225/1/012063.

Leal Filho, W., Pallant, E., Enete, A., Richter, B., & Brandli, L. L. (2018). Planning and implementing sustainability in higher education institutions: an overview of the difficulties and potentials. *International Journal of Sustainable Development & World Ecology*, *25*(8), 713–721. https://doi.org/10.1080/13504509.2018.1461707.

Losacco, C., & Perillo, A. (2018). Particulate matter air pollution and respiratory impact on humans and animals. *Environmental Science and Pollution Research*, *25*(34), 33901–33910. https://doi.org/10.1007/s11356-018-3344-9.

Mannan, M., & Al-Ghamdi, S. G. (2021). Indoor Air Quality in Buildings: A Comprehensive Review on the Factors Influencing Air Pollution in Residential and Commercial Structure. *International Journal of Environmental Research and Public Health*, *18*(6), 3276. https://doi.org/10.3390/ijerph18063276.

Mateus, R., & Bragança, L. (2011). Sustainability assessment and rating of buildings: Developing the methodology SBToolPT–H. *Building and Environment*, *46*(10), 1962–1971. https://doi.org/10.1016/j.buildenv.2011.04.023.

Otolorin, J. A., Odunlami O. A., Fakinle, B. S., Alagbe, A. A., Adeniran *et al*. (2018). Indoor Air Quality Level of Total Volatile Organic Compounds (Tvocs) in a University Offices, International Journal of Civil Engineering and Technology, 9(11), 2872–2882.

Park, J., Yoon, J., & Kim, K. H. (2017). Critical Review of the Material Criteria of Building Sustainability Assessment Tools. *Sustainability*, *9*(2), 186. https://doi.org/10.3390/su9020186.

Storms, K., Simundza, D., Morgan, E., & Miller, S. (2019). Developing a resilience tool for higher education institutions: a must-have in campus master planning. *Journal of Green Building*, *14*(1), 187–198. https://doi.org/10.3992/1943-4618.14.1.187.

Xue, F., Gou, Z., & Lau, S. (2016). Human factors in green office building design: The impact of workplace green features on health perceptions in high-rise high-density Asian cities. *Sustainability*, *8*(11), 1095. https://doi.org/10.3390/su8111095.

Zuhaib, S., Manton, R., Hajdukiewicz, M., Keane, M. M., & Goggins, J. (2017). Attitudes and approaches of Irish retrofit industry professionals towards achieving nearly zero-energy buildings. *International Journal of Building Pathology and Adaptation*, *35*(1), 16–40. https://doi.org/10.1108/ijbpa-07-2016-0015.

Zuo, J., Xia, B., Chen, Q., Pullen, S., & Skitmore, M. (2016). Green building rating for office buildings – lessons learned. *Journal of Green Building*, *11*(2), 131–146. https://doi.org/10.3992/jgb.11.2.131.1.