

Developing a Biophilic Behavioural Change Design Framework - A Scoping Study

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Abstract

This study argues that as a key measure of success in biophilic design, biophilic behaviours, should be defined, understood, supported, and encouraged within the design process. The study reviewed social science and built environment literature to define and evaluate behaviours and behavioural determinants relevant to biophilic design. An outline methodology proposes the alignment of behaviour change techniques to biophilic design stages. This incorporates the conditions of behavioural opportunity, motivation, and capacity. We conclude by calling for multidisciplinary cooperation and the alignment of behavioural objectives across the built environment and social science fields.

Keywords: Biophilic Behaviour, Nature based solutions, urban built environment, Behaviour change techniques

1. Introduction

Whilst human technological and societal advancement has brought about an abundance of benefits, it has also resulted in a condition of human-nature disconnection, which is posited to be a contributing factor in current urban environmental, health and wellbeing crises (Adevi, Uvnäs-Moberg and Grahn 2018; Kim & Miller, 2019; Ives et al., 2018; Novotný et al., 2021; Pyle, 2003). The challenge to increase the human-nature connection (HNC) requires

profound changes in the way we build and manage cities, how we live and consume, and the value individuals and societies attribute to nature. This idea is reflected in biophilic design, which integrates natural elements into architectural and urban spaces (Wilson 1983, Kellert and Wilson 1993, Beatley 2011, Kellert and Calabrese 2015). The idea is also reflected in recent definitions of human-nature connection (HNC) comprising the broad concepts of material (Circular Economy), experiential, emotional, cognitive and philosophical connections between humans and the wider biosphere (Ives et al., 2018). Theorists have argued that nature-based solutions form a core component in the future prosperity of society and the environment (Xing et al. 2017, Xing et al, 2021), particularly as half the world's population currently reside in cities, with 68% predicted by 2050, representing approximately 2.5 billion more urban dwellers (UN, 2015; 2018). Biophilic design approaches elaborated by Kellert and Wilson (1993) seek to balance modern architecture and urban living with elements of the natural world, fostering a deeper, inherent connection with nature. Several authors have extensively contributed to the understanding and application of biophilic design principles (Kellert and Wilson 1993, Beatley 2011, Kellert and Calabrese 2015, Calabrese and Dommert 2018, Browning and Ryan 2020). The application of biophilic design is increasingly seen as essential in sustainable urban development, addressing both environmental concerns and human well-being. Although the well-being of the citizens is considered the primary design outcome, biophilic behaviours and human values of nature (Kellert, 1993; Ives et al., 2018) are key elements of biophilic design. Biophilic design is not just about incorporating natural elements into architecture but ensuring these elements work together to create a cohesive and interconnected ecological whole (Kellert and Calabrese 2015). However, biophilic behaviour is under-studied and often overlooked in design evaluations (Xing et al., 2017; Thomas & Xing, 2021).

Biophilic behaviour can be defined as an important outcome of biophilic design, comprising the sustained actions tied to local ecosystems and fostering a compassionate relationship between humans and nature (Wilson 1986, Kellert and Wilson 19, 3; Ives et al., 2018).

Forming the lived and enacted aspects of HNC, biophilic behaviours may include, for example, regular consumption, health and leisure actions such as cycling to work, consuming locally produced food or relaxation time in a local park. This paper posits that to shape a sustainable built environment that increases biophilic behaviours, it is necessary to understand and design interventions to influence both the physical, psychological and philosophical antecedents of biophilic behaviour.

The most commonly quoted definition of biophilia originates with Erich Fromm's conceptualisation of the term as 'the passionate love of life and of all that is alive' 1973, p.406. The concept of biophilia and the importance of nature play an important role in several of his works that critically explore the human condition in Western capitalist societies. Fromm's cross-disciplinary approach combines philosophy, sociology and psychotherapy to theorise the causes of mental ill-health and potential solutions. Contra Freud, Fromm emphasised the importance of society in shaping our personalities and mental well-being. For example, in *the Sane Society* (1955), he argues that capitalism has resulted in a sick society where, although our basic physiological needs may be met, our psychological needs remain unfulfilled due to various conditions. This results in a mental health crisis. For instance, he states, "man is torn away from the primary union with nature, which characterizes animal existence. Having at the same time reason and imagination, he is aware of his aloneness and separateness; of his powerlessness and ignorance; of the accidents of his birth and death" (Fromm 1955). The existential characteristic of the human condition generates a self-awareness that all is not right in the world, leading to feelings of anxiety, loneliness and alienation. Therefore, from a philosophical or psychoanalytical perspective, a moral imperative can be generated to promote behaviours that create environments that reconnect humans with other natural living things in pursuit of individual well-being and collective societal sanity.

Biophilic design incorporates nature, nature-like elements, and natural systems into the design of every element of the built environment (Beatley & Neman, 2013; Browning, & Ryan, 2020; Kellert & Calabrese, 2015; Richardson & Butler, 2022; Novosadová & van der Knapp., 2021). The related concepts of biophilic urbanism (Beatley 2011, Xue et al., 2019) and biophilic cities (Panlasigui et al., 2021) are considered part of biophilic design, emphasising how the operational and systemic factors associated with the design of cities, such as land use, infrastructure and civic engagement can be more closely connected with nature. Whilst biophilic design seeks to increase HNC, the approach is primarily concerned with physical components of the built environment, based on the premise that increased opportunity to connect with nature may lead to an increase in biophilic behaviours (for example, park availability leads to increased park visits). However, research suggests this may not always be the case. For example, psychological factors have been shown to influence the noticing of nature in one's surroundings (Chen et al., 2022), the perception of natural spaces to be safe, legible, and restorative (Cohen et al., 2016; Tang et al., 2015; Xu et al., 2023), engagement in environmental volunteering (Dresner et al., 2015) and the use of private gardens and parks (within 300 metres of home), above park availability (Lin et al., 2014).

Nevertheless, potential negative attributes (e.g., biophobia ecosystem disservices) of the natural elements can also act as a barrier to fostering biophilic behaviour. Biophobia helps explain human responses to certain natural elements, such as snakes that may pose threats or discomfort to humans. Biophobia is discussed as an integral part of understanding human-nature relations (Ulrich 1993). In comparison to biophobia, biophilia represents a more complex concept for study and remains a less explored area of research, as noted by Ulrich in 1993. The “vicious cycle of biophobia” has recently been explored as a theme that encapsulates how excessive aversion towards nature might emerge and grow in society (Siga et al., 2023). A related concept, “Environmental Generational Amnesia (EGA)”, is elaborated by Kahn (2002) to highlight the phenomenon of a gradual shift in the baseline

perception of the environment across generations. Each new generation tends to accept the state of the environment they grow up in as normal, often unaware of past degradation. Kahn (2002) investigates the implications of shifting baseline perceptions for conservation, highlighting the challenge of younger generations not fully recognizing environmental degradation due to EGA. This underscores the necessity of incorporating generational shifts in environmental perception into conservation and education efforts (Kahn Jr, 2002). Ecosystem disservices (EDS) are also important to consider during biophilic design. Ecosystem disservices (EDS) include safety issues in dark parks or pollen causing health problems, decreased water quantity, plant-related diseases and infrastructure damage (Lyytimäki, et al. 2008, Wu, Li and Li 2021). Urban rewilding can increase wildlife populations in urban areas, which may lead to conflicts with human interests and safety. The interplay between ecosystem disservices and wildlife conflict underscores the need for biophilic design to carefully balance urban biodiversity with human well-being, as described in Beatley and Newman's research on sustainable and resilient cities (Beatley & Newman, 2013). Furthermore, socioeconomic status may influence the frequency of green space-based activities (Leslie et al., 2010), whilst, in older adults, social networks have been found to be a predictor of park use (Enssle & Kabisch, 2020). Overall, this research demonstrates that psychological and social factors may represent a significant precursor to biophilic behaviour above opportunities presented in the environment alone.

Research suggests that routine active engagement and interaction with nature, rather than passive exposure, is necessary to achieve increased psychological HNC, operationalised as an individual self-concept that includes nature (Giusti et al., 2017; Kurth et al., 2020; Lumber et al., 2017; Pérez-López et al., 2020; Richardson and McEwan, 2018). Importantly, as a relatively stable construct, the inclusion of nature in the self (Schultz, 2001) is associated with several positive health and wellbeing outcomes (Capaldi et al., 2014; 2015; Martin et al., 2020), pro-environmental behaviour and willingness to protect the environment (Mackay & Schmitt, 2019; Martin et al., 2020; Whitburn et al., 2019). This evidence is consistent with

recent evolutionary explanations of biophilia. Whilst the biophilia hypothesis is often conceptualised as an innate desire for humans to connect with nature, including flora and fauna plus the abiotic environment in which they thrive (Kellert & Wilson, 1993; Wilson, 1986), the concept is increasingly understood as a preserved human predisposition to incrementally learn from, and interact with, nature over time (Barbiero & Berto, 2021). As a product of both innate biological and environmental interactions, it is posited that an individual requires frequent contact and experience with nature in one's environment before biophilia is consolidated (Barbiero & Berto, 2021). This is particularly apparent in children, who typically demonstrate interest and affiliation with nature from early developmental stages (Kalvaitis et al., 2015), with early contact with nature shown to support cognitive development (Dadvand et al, 2015) and predict nature connectedness in adult life (Windhorst & Williams, 2015). Taken together, psychological HNC research and evolutionary theories of biophilia highlight that whilst preference for nature may be innate based on millions of years of evolutionary development, lived experiences of nature may consolidate biophilia over time through human behaviour and exposure.

This study aims to define a theoretical framework for biophilic behaviour change, conceptualising how integrated physical, social and psychological interventions may lead to increased connection with nature, human well-being, and environmental sustainability. Section 2 introduces the methods used to select relevant publications in addition to the analysis and synthesis of these resources. Section 3.1 aims to define biophilic behaviour as a core component of HNC, explaining the relationship to the psychological components of HNC. Section 3.2 explores the predeterminants of biophilic behaviour and behaviour change, comprising factors related to motivation, opportunity and capacity. Section 3.3 addresses implementation considerations necessary to incorporate behaviour change strategies into the biophilic design process. Finally, the article concludes with an evaluation of the study and considerations for future research.

2. Method

2.1. Identification of relevant publications

Electronic databases (PsycARTICLES, PsycINFO, Web of Science and Google Scholar) were searched for articles published up to July 2022, and reference lists of included studies were hand-searched for further relevant papers. Keywords 'biophilia', 'biophilic design', 'green space', 'nature connection', 'nature connectedness', 'behaviour change', 'intervention' and 'theories of behaviour' were searched. The eligibility criteria set to identify relevant publications were (1) defined behaviours related to HNC leading to well-being and pro-environmental outcomes through qualitative or experimental findings, (2) explained the individual variables and moderators contributing to HNC-related behaviours through experimental findings, (3) explained the social and environmental factors contributing to HNC related behaviours through qualitative or experimental findings, (4) explained behaviour change strategies, (5) written in English. As a supplementary search, the snowball method was used to identify publications from the earliest collected literature. Literature was identified from the sub-fields of the built environment and sustainability in addition to health, transport and environmental psychology.

2.2 Integrated analysis and synthesis framework

The study of obtained publications includes analysis and synthesis of the following three aspects, as shown in Fig. 1:

- *Identification of biophilic behaviours and measures.* Literature review of the definitions of behaviour, behavioural measurement techniques and definition of a proposed term - biophilic behaviours;
- *Evaluation of the psychological factors contributing to biophilic behaviour and behaviour change.* Evaluation based on the Capacity, Motivation, Opportunity and Behaviour Model (COM-B; Michie et al., 2011). *Evaluation of behaviour change and biophilic design implementation.* Evaluation based on the Behaviour Change Wheel (BCW; Michie et al., 2011);
- *Integration of operationalisation of psychological connection with nature from the psychological literature* (RIBA, 2020).

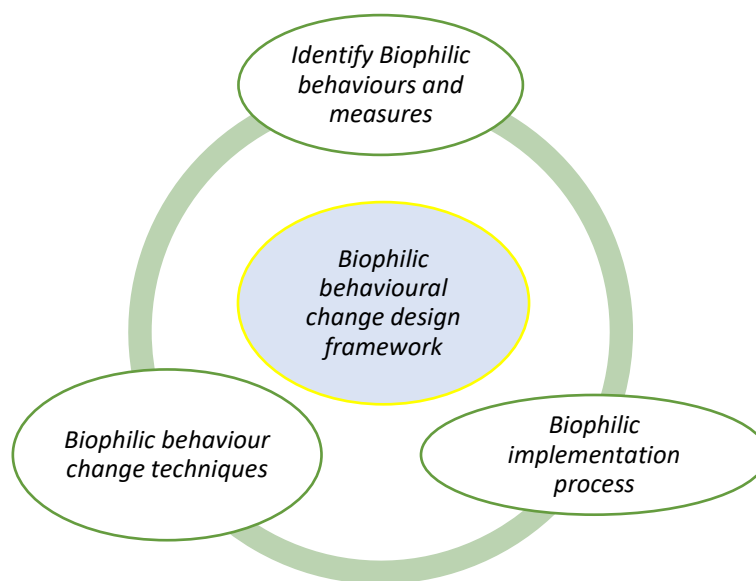


Figure 1: The scoping study method

3. Results and Discussion

3.1 Biophilia and Biophilic Behaviours

In general, behaviour is defined as the action or reaction of an individual or group within their environment (Bateson, & Martin., 2021). Behavioural structure relates to the appearance, physical form and temporal patterning of the behaviour, whereas the consequences of behaviour may relate to the environment or the individual (Bateson, & Martin., 2021). The behavioural tendencies that determine the human-nature connection may be conceptualised into five categories: materials, experiential, cognitive, emotional and philosophical aspects related to the nature connection (Ives et al., 2018). For example, the *behaviour* of tending to a vegetable garden is an observable temporally based action, whilst the consequences of the behaviour may be observed in the garden (e.g., plant yields), the environment in general (e.g., reduction of carbon due to reduced food miles), in the state of the individual (e.g., affect or emotional state) or in others also engaged in the activity (e.g., social influence and support) related categories. *Material* nature connection relates to behaviours that involve the consumption of goods, energy and resources that strengthen ties to local ecosystems (Ives et al., 2018), with these behaviours also defined as pro-environmental behaviour and/or sustainable behaviour in behavioural research (Linder et al., 2022; Martin et al., 2020). *Experiential* nature connection relates to behaviours that involve direct contact with nature, also referred to as pro-nature behaviours (Richardson et al., 2016), nature indicators (Lumber et al, 2017) or the use of nature for psychological restoration (Whitburn et al., 2019) in biophilia research. It may be possible for a behaviour to be conceptualised within one or both categories. For instance, cycling to work involves both a shift in *material* connection to nature (reduction in carbon emissions) and, subject to environmental opportunities and motivational factors, a shift in the *experiential* relationship with nature (use of nature for a sensory experience). Whilst material and experiential behavioural categories are frequently considered separately within the health, transport and environmental literature, addressing the categories together as 'biophilic behaviours' (Table 1) may serve as an advantage from a biophilic design perspective, as opportunities in the environment may realise multiple routes to nature connectedness within society.

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246 Whilst the focus of this paper is behavioural change aspects of nature connectedness,
247 psychological connection with nature remains an important predictor (Mackay & Schmitt,
248 2019; Martin et al.,2020; Whitburn et al., 2019) and outcome (Pérez-López et al., 2020;
249 Richardson & McEwan, 2018) of pro-environmental and biophilic behaviour, associated with
250 positive health and wellbeing outcomes (Capaldi et al., 2014; Martin et al.,2020; Richardson
251 & McEwan, 2018). Psychological connection with nature has been operationalised by
252 several constructs in the psychological literature, which may be categorised in terms of
253 emotional, cognitive and philosophical HNC (Ives et al.,2018). *Cognitive* HNC comprises
254 knowledge and awareness of environmental issues and attitudes towards both nature and
255 nature-related behaviours (Graham-Rowe et al., 2019; Ives et al.,2018). This may also
256 include perceptions of and preferences for different environments (Korpela, & Hartig, 1996;
257 Tang et al., 2015). *Emotional* HNC comprises feelings of attachment, empathy and care for
258 nature (Kals et al., 1999; Kurth et al., 2020; Perkins, 2010; Tam, 2013), as well as general
259 positive affect and mood states in biophilic environments (Gaekwad et al., 2022).
260 *Philosophical* HNC comprises the perspective and world view of what nature is, why it
261 matters and may be operationalised through measurement of identity and self-concept (for
262 example, Martin & Czellar, 2016; Schultz, 2001), as well as personal environmental values,
263 defined as trans-situational life goals which are relatively stable over time (Bouman et al,
264 2018; Steg et al., 2014). A biophilic behaviour onion was developed to model different levels
265 of natural connection from philosophies and ethics to Behavioural Outcomes (see Fig. 2).
266 The biophilic behaviour onion provides a conceptualisation framework of possible levels for
267 empirical investigation.
268
269 Researchers recognised the difficulties in determining which aspect of HNC is being
270 analysed at any one time (Ives et al., 2018). In this paper, the measurement of these
271 different HNC aspects is explored. A set of examples of measurement instruments is created

to assess biophilic behaviours in each of the five categories (Figure 2), as summarised and presented in Table 1. For example, Biophilic behaviour may be measured in terms of frequency (number of occurrences), duration (length of time) or intensity (measured at a local rate, such as steps per day; Bateson & Martin., 2021). In the behavioural sciences, digital technologies are increasingly employed to measure behavioural change based on rate, frequency, and duration on a within-person basis, using methods such as app-based diaries (Kwasnicka et al., 2018; Wallén et al., 2021). Nevertheless, typically in the study of behaviour, surveys, interviews, and questionnaires may represent a less time-consuming and effective subjective measure compared to performing observations of actual objective behaviour. However, self-reported measures rely on the memories of the behaviour, which may be at risk of bias or inaccurate recall (Bateson & Martin., 2021). In response to this, a number of biophysiological measurements, e.g., eye tracking or EEG methods were developed as summarised in table 1.

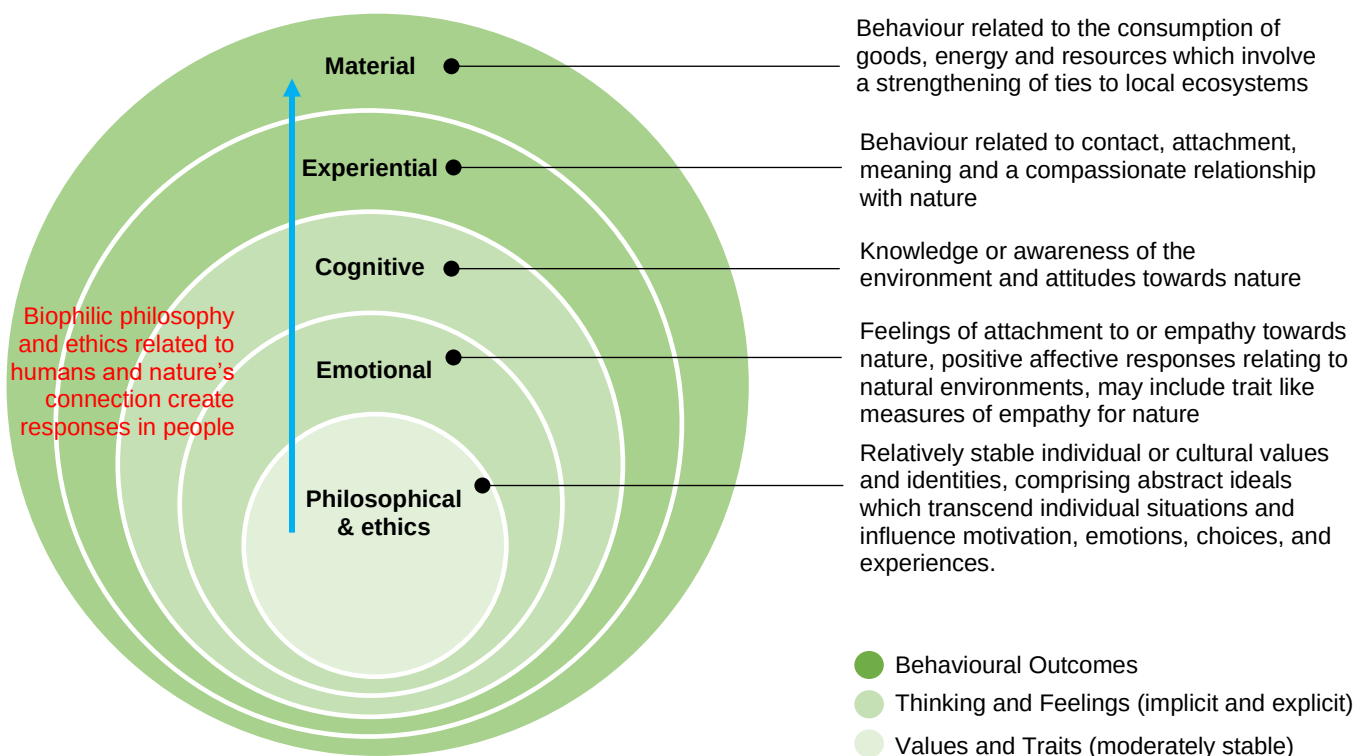


Figure 2: Biophilic Behaviour Onion. Note. Based on and developed from the proposed categories in Ives et al., (2017)

300 **Table 1: Summary of Biophilic Behaviour and HNC Constructs and Measures**

HNC Category (adopted from Ives et al 2018)	Examples of Measurement Instruments
Material	<i>General Ecological Behaviour Measure</i> (Frick et al., 2004; Kaiser, 1998) Self-reported 50 ecological behaviours across six domains: energy conservation, mobility and transportation, waste avoidance, consumerism, recycling, and vicarious social behaviours toward conservation.
Behaviour related to the consumption of goods, energy and resources which involve a strengthening of ties to local ecosystems	<i>Pro-environmental Behaviour Measure</i> (Whitmarsh & O'Neill, 2010) Self-reported 24 behaviours related to Defra's 'headline behaviours', including both one-off and regular behaviours in four domains, including domestic energy and water use, waste behaviour, transport and eco-friendly shopping. <i>Daily and Six-Month Green Action Index</i> (Kurth et al., 2020). Self-reported 36 frequent daily and 15 infrequent seasonal 'green actions'. <i>Energy Saving Behaviour</i> (Single domain measure example; Sharpe et al., 2021) Self-reported 9 behaviours to save energy at home over the past week. <i>Food Waste Behaviour</i> (Single domain measure example; Graham-Rowe et al., 2019) Self-reported 7 fruit and vegetable waste behaviours over the past week. <i>Behavioural observation</i> (for example, Linder et al., 2021).
Experiential	<i>Pro-nature Conservation Behaviour Scale</i> (Barbett et al., 2020) Self-reported 18-item long-form and 8-item short-form conservation behaviours comprising individual engagement, social engagement, planting, and wildlife.
Behaviour related to contact, emotional attachment, meaning and a compassionate relationship with nature	<i>Nature Indicators</i> (Lumber et al., 2017) Self-reported 27 nature-based actions categorised under nine biophilic values (Kellert & Wilson, 1993). <i>Use of Nature for Psychological Restoration Scale</i> (Whitburn et al., 2019) Self-reported 10-item measure of use of nature for psychological restoration, such as 'finding time in nature to unwind after a busy day'.

	<i>Behavioural observation</i>. For example, <i>Competencies and Practices for Cultivating Connectedness with Nature</i> (Zylstra et al., 2014). Indicators at an individual and collective level. <i>Behavioural observation</i>. <i>Children's Behaviour in Nature Situations</i> (Giusti et al., 2017). <i>Self-reported visitation frequency</i> (e.g., park use; Roberts et al., 2018).
Cognitive	<i>New Ecological Paradigm</i> (NEP; Dunlap et al., 2000) Self-reported 15-item scale measuring cognitive understanding of environmental issues. <i>Climate Change Concerns</i> (CCC; Pérez-López et al., 2020) Self-reported 3-item scale measuring beliefs and concerns relating to climate change. <i>Perceived Restorativeness</i> (Korpela, & Hartig, 1996) Self-reported perceived restorative qualities in the environment comprising being away, fascination, coherence, and compatibility. <i>Landscape Preference</i> (Tang et al., 2015) Self-reported preference for landscape types. <i>Self-reported Measures relating to attitudes, perceived norms, and perceived behavioural control related to pro-environmental behaviours</i> (Graham-Rowe et al., 2019). <i>Ecological Mindfulness</i> (Kurth et al., 2020). Self-reported attitudes and awareness towards living things include several behavioural items. <i>Implicit Associations Test</i> (IAT modified; Schultz 2004). Implicit associations test with words relating to built, nature and identity to measure nature implicit nature connectedness. <i>Habit and cue identification</i> (see, Linder et al., 2021). For example, <i>Self-Report Behavioural Automaticity Index</i> (SRBAI; Gardner et al., 2012). <i>Eye tracking</i> (Chen et al., 2022).
Emotional	<u>General affect</u>

Feelings of attachment to or empathy towards nature, positive affective responses relating to natural environments.	<i>Positive and Negative Affect Schedule</i> (PANAS; Watson et al., 1988) Self-reported 20-item measure of positive and negative affect. <i>Zuckerman Inventory of Personal Reactions</i> (ZIPRS; Zuckerman, 1977) Self-reported 12-item scale measuring positive affect, sadness, attentiveness, fear arousal and anger aggression. <i>Profile of Mood States</i> (POMS; McNair et al., 1971) Self-reported 65-item measure of short-term mood states which are understood to be transient and frequently fluctuating. <i>Subjective Vitality Scale</i> (SVS; Ryan & Frederick, 1997) Self-reported 16 item scale measuring feelings of aliveness and energy. <u>Empathy and care for nature</u> <i>Ecological Empathy</i> (Kurth et al., 2020). Self-reported empathy for humans and more than humans comprising earth as a whole. <i>Dispositional Empathy with Nature Scale</i> (DENS; Tam, 2013) Self-reported 10 items measuring empathy towards nature as a stable trait. <i>Love and Care for Nature Scale</i> (LNC; Perkins, 2010) Self-reported 15-item scale measuring love and deep caring for nature. <i>Emotional Affinity to Nature Scale</i> (Kals et al., 1999) Self-reported 4-item scale measuring love of nature, feelings of freedom, feelings of safety, and feelings of oneness with nature. <u>EEG or other biomarkers e.g., oxytocin's</u> (Koivisto et al., 2022)
Philosophical Perspective or world view on what nature is, why it matters, and how humans ought to interact with it, comprising relatively stable traits of self-concept, identity, values and ideals.	<u>Identity and Self-concept</u> <i>Inclusion of Nature in the Self</i> (INS; Schultz, 2001) is a Single-item instrument designed to measure the degree to which an individual includes nature as part of their identity. <i>Extended Inclusion of Nature in Self Scale</i> (EINS; Martin & Czellar, 2016) is a 4-item instrument designed to measure the degree to which an individual includes nature as part of their identity. <i>Connectedness to Nature Scale</i> (CNS; Mayer & Franz, 2004). 14-item instrument measures the stated level of affective relatedness and

kinship with nature, comprising a sense of belonging and a perceived representation of the self in relation to nature.

Connectivity with Nature Scale (CwNS; Dutcher et al. 2007). The self-reported 5-item scale measures a sense of oneness and inclusion of nature in the self.

Environmental Self-Identity (van der Werff et al., 2014) Self-reported 3-item instrument measures the extent to which people see themselves as an environmentally friendly person.

Pro-environmental Self-Identity (Whitmarsh and O'Neil, 2010). A self-reported 4-item measure of the extent to which people see themselves as an environmentally friendly person living an environmentally friendly lifestyle.

Values

Environmental Portrait Value Questionnaire (E-PVQ; Bouman et al., 2018) Self-reported 17-item scale measuring personal biospheric, altruistic, hedonistic and egoistic values.

Environmental Schwartz Value Survey (E-SVS; Steg et al., 2014). Self-reported 16-item scale measuring personal biospheric, altruistic, hedonistic and egoistic values.

Holistic Measures

Measures of multiple nature connection categories

Environmental Identity Scale (EIS; Clayton, 2003). A self-reported 24-item instrument measures feelings, beliefs, attitudes, behaviours, values and life history relating to the natural environment.

Nature Relatedness Scale (Nisbet et al., 2009) is a self-reported 21-item measure comprising affective, cognitive, and behavioural items relating to the connection with nature.

Connection to Nature Index (CNI; Cheng & Monroe 2012). Self-reported 17-item scale measuring nature-based past behaviours, empathy, identity and perception of personal responsibility towards nature in children.

Disposition to Connect with Nature (DCN; Brügger et al. 2011). The self-reported 40-item scale measuring attitudes towards nature and previous nature-related behaviours and feelings.

3.2 Biophilic Behaviour Change Techniques

Understanding the predeterminants of biophilic behaviour and behaviour change techniques is necessary to increase biophilic behaviour. Behavioural change techniques (BCTs) are defined as observable, replicable, and irreducible component(s) of an intervention designed to alter or redirect causal processes that regulate behaviour (Michie et al., 2013). In other words, they represent an active ingredient which can be replicated in research and implemented in practical applications. The behaviour system proposed by Michie and colleagues (2011) is a widely utilised framework in applied settings such as health (Public Health England, 2020), comprising the essential conditions for behaviour change: Capability, Opportunity, and Motivation (COM-B). The COM-B framework posits that capability, opportunity and motivation interact to generate behaviour and that, in turn, behaviour may influence each of the conditions (Michie et al., 2011). The following sections seek to apply and evaluate the COM-B framework to biophilic behaviour change, drawing from empirical research in applied psychology, sustainability, and the built environment.

3.2.1 Capability

Capability is defined as the individual psychological and physical capacity to engage in a behaviour, such as the necessary knowledge or physical skills. Capability may also pertain to the thought processes involved in behaviour, such as perception and reasoning (Michie et al., 2011). Research suggests individual *perception of capability* is a contributing factor in behaviour intentions and behaviour change, which is assessed as a psychological variable through surveys or focus groups (Ajzen, 2020). For example, perceived behavioural control relates to the perceived presence of factors that can facilitate or impede the performance of

a behaviour. Control factors may include skills and abilities, financial means, time, other resources, and the cooperation of other people (Ajzen, 1991; 2020). A related factor is self-efficacy, defined as the belief in one's ability to perform specific behaviours formed through self-perception information (Bandura, 1977). Perceptions of control and ability may relate to the performance of a wide range of biophilic behaviours. Perceived behavioural control has also been found to be a strong predictor of pro-environmental behaviours, such as reducing carbon emissions, energy and water use (Gkargkavouzi et al., 2019) and conservation behaviours, such as protecting pollinators (Knapp et al., 2021).

Perceived behavioural control may differ from *actual* behavioural control, relating to the actual internal (skills, knowledge etc.) and external factors that influence behaviour performance (Ajzen, 2020) and may relate to demographics and individual differences. For example, in a study investigating gender differences in place perception and physical activity, environmental factors were not found to be a significant predictor of physical activity for men, however accessibility and amenities within walking distance were associated with moderate physical activity in women, moderated by perceived behavioural control (McCormack et al., 2009). This research suggests that perceptions of the environment and perceptions of one's ability to perform a behaviour within the environment may vary between individuals and influence behaviour over and above the actual characteristics of the environment.

Skills and knowledge are other relevant factors in biophilic behaviour. Social theorists have argued there has been a collective 'forgetting' in society related to the understanding of nature and our relationship to it, including knowledge of how to grow food (Pyle, 2003; Stoltz & Schaffer, 2018), and traditional knowledge related to the identification and use of non-cultivated plants through foraging (Turner et al., 2011). Several studies have reported the effects of interventions to increase environmental and nature-based knowledge and skills, such as in young children (Sellmann & Bogner, 2013), adolescents (Truong et al., 2016),

clinical health settings (Clatworthy, et al., 2013) and community gardening (Gray et al., 2022). Whilst these studies focus on wellbeing outcomes, it may be posited that enhanced skills and knowledge may increase self-efficacy and perceived behavioural control, leading to subsequent intentions related to biophilic behaviour. A study by Kahn and Hasbach (2013) emphasizes the importance of deepening children's interaction with nature to counteract EGA. This involves providing 'big nature' experiences, even in urban settings, to broaden children's understanding and perception of the natural world (Kahn & Hasbach, 2013). Furthermore, physical health-related factors such as functional ability, energy expenditure, and injury, in addition to accessibility, are a consideration in an individual capacity and have been reported in studies involving older adults (Nicklett et al., 2016).

3.2.2 Opportunity

Opportunity is defined as the environmental factors that lie outside the individual that make the behaviour possible or prompt it (Michie et al., 2011). Opportunity is subdivided into physical opportunities afforded by the environment and social, such as social and cultural practices or norms (Michie et al., 2011).

Affordance theory is a common approach in spatial design that posits opportunity for action is determined by affordances, defined as situation-dependent perceivable and utilisable possibilities in the environment for certain behaviours or experiences (Gibson 1979; Stoltz & Schaffer, 2018). In accordance with the theory, object classification is based on functional attributes rather than physical attributes. For example, in affordances for children's nature play, trees may be classified according to affordance for climbing rather than plant taxonomy (Zamani & Moore, 2013). Object classifications may be linked to behaviour classifications through the observation of behaviour in context (Giusti et al., 2014). Whilst affordance classification provides a useful way to identify potential environmental opportunities for

action, affordances in the environment can only invite behaviour if the agent (the individual whose behaviour is being considered) perceives the object as an opportunity. This relates to the above idea of individual capacity to the skills and knowledge necessary to perform a behaviour (Withagen et al., 2012) (See Section 3.2.1). For instance, if one has limited lived experience or knowledge of climbing trees, this may not be a behaviour performed with a high frequency or level of self-confidence. Furthermore, as affordance theory is examined through qualitative observations and classifications of behaviour types (Giusti et al., 2014), this area of research does not extend to the interrogation of observed behavioural change in real terms using the determination of causality through experimental procedures.

Another concept relevant to opportunity is choice architecture (also termed choice editing), the manner in which choices are framed and presented (Johnson et al., 2012). Whilst in familiar environments, frequent behaviours may be guided by past behaviour and habit (Wood & Rünger, 2016), in novel contexts, ease and convenience related to a spatial layout may have a strong effect on behaviour (Linder et al., 2021). This is particularly relevant in contexts where motivation to act in line with personal health or environmental goals may not be salient or where such goals conflict with other more pressing goals (Lindenberg & Steg, 2007). For instance, the goal to rinse out and pack a reusable cup may conflict with the immediate goal to leave the house on time to travel to work. This concept is illustrated in a study of recycling behaviour where, within a novel context, spatial positioning of bins explained more than half the variance in recycling behaviour (Linder et al., 2021). In a condition where the recycling bin was placed near the general waste bin away, participants recycled regardless of their intentions to act pro-environmentally (Linder et al., 2021). The researchers suggested that the conflicting goal of wanting to leave the experiment as fast as possible may have been prioritised by the participants. Choice editing methods have been applied in a range of domains, including diet, energy, waste, water and recycling, with a high probability of benefit (Nisa et al., 2020). Interventions include relative expansions of sustainable meal choices (Garnett et al., 2019) and default green energy, low/

zero carbon tariffs (Liebe et al., 2021). Choice architecture relates to the concept of social practice theory, which highlights the idea that the arrangement of material and social structures influences human behaviour (Kurz et al., 2015; Shove & Walker, 2010).

3.2.3 Motivation

Motivation is defined as the brain processes that energise and direct behaviour, such as goals and decision-making, emotional responding and habitual processes. It may be divided into reflective processes involving evaluations, plans, and automatic processes involving emotions and impulses that arise from associative learning (for example, based on cues in the environment) and innate dispositions (Michie et al., 2011). Therefore, increased opportunity (for example, proximity to a green space) may relate to increased noticing of wildlife during a park walk, growing of vegetables in a community allotment or encouraging wildlife into a private garden. Nevertheless, the performance of these behaviours may relate to past performance history, habitual tendencies, feelings and beliefs about the outcome of the behaviour or what the behaviour communicates to others about who one is.

Automatic processes such as habit has been found to be a stronger predictor of frequently enacted behaviours than conscious decision-making (Wood & Rünger, 2016). Defined as memory-based propensities to respond automatically to context-based cues, habits are acquired by repetition of context-specific behaviours in stable contexts and are posited to have evolved to conserve the limited capacity of human working memory for deliberate goal pursuit (Wood & Rünger, 2016). For example, if one enjoys visiting a local garden at lunchtime, this may, over time, become a healthy habitual pattern of behaviour without needing to decide where to go on each occasion. Nevertheless, existing habits relating to contextual cues associated with modern urban lifestyles may represent a potential barrier to the development of new nature-based habits. For example, the habit has been shown to be a strong predictor of basic tapping and scrolling on a smartphone (Hsiao et al. 2016).

Therefore, behaviour change strategies in the domain of habit relate to both the discontinuation of existing unwanted habits and the establishment of new habits (Marien et al., 2018; Verplanken & Whitmarsh 2018).

Two dominant approaches exist in supporting individuals to develop healthy and sustainable habits. Firstly, moments of change, such as a change of job or moving house, represent new circumstances where existing habits are unfeasible, new action contexts are available, and in the forming of new habits, individuals may be driven more by behavioural intentions and new information (Wood & R  nger, 2016). For example, in a study involving an informational campaign aimed at new university students, compared to non-movers, students who relocated to a new residential location with good transport connections increased sustainable transport use and reduced car use, with the informational campaign increasing public transport use only in the relocation group (Ralph & Brown, 2019). It may be posited, therefore, that in a situation where existing travel habits were discontinued, individuals may have been more open to receiving new information relating to travel options. Secondly, cognitive interventions, such as implementation intentions, mental contrasting, self-monitoring, and future thinking, have been shown to promote new habit formation whereby an individual becomes aware of the environmental cues associated with their existing behaviour, an increase in the saliency of future outcomes, alongside the steps associated with reaching a new goal (Baumeister & Heatherton, 1996; Nielsen et al., 2021). Whilst cognitive interventions are not commonly applied in the domain of nature-based behaviour change, large-scale studies have incorporated digitally-based approaches to encourage daily connection with nature (Richardson et al., 2016). Overall, in the development of any behaviour change strategy, it is necessary to consider whether there is an established routine associated with existing behaviour.

Nevertheless, complex multi-step behaviours, for example, infrequent volunteering at a local community garden, is likely to involve both automatic and conscious processes such as intentions (Mullan & Novoradovskaya, 2018). Several socio-cognitive models provide explanations for environmental or nature-based behaviour intentions, including the theory of planned behaviour (Ajzen, 1991) and the value-belief-norm theory (Stern et al., 1999). Evaluations of behaviour form a central component of these theories. Evaluations about whether the behaviour has more costs than benefits (financial, time, effort or functionality) or whether there will be anticipated positive feelings contribute towards the formation of individual attitudes. Evaluations of biophilic behaviour may also be influenced by feelings towards environmental factors, such as place attachment (Anton & Lawrence, 2016). Finally, evaluations may be influenced by individual values, defined as relatively stable traits representing desirable goals that transcend situations and serve as guiding principles in people's lives (Stern et al., 1999). For instance, biophilic values may drive behaviour relating to nature and the environment, whereas hedonistic values indicate that an individual evaluates the costs and benefits of potential behaviour to the self when making decisions and value self-enhancements (Steg, 2016). Further behaviour considerations include whether others also perform the behaviour or would approve or whether the action may communicate a status goal or signal an aspect of who an individual is, such as self-identity. These aspects represent the contribution of personal and social norms (Vesely & Klöckner, 2018). As such, behavioural change interventions may highlight the costs and benefits of behaviour to the individual tailored to their individual value system or self-identity and provide feedback on performance. Social influence may involve feedback based on the efforts of a group, information about descriptive norms or seeing others enact a recommended behaviour enhancement (Steg, 2016).

From the discussion above, it can be seen that biophilic behaviour change techniques are varied and multiple faceted. There is a need for more holistic approaches (Xing, et al., 2018, Xing, et al., 2013). Based on the COM-B framework (Michie et al., 2011), theoretical

determinants of biophilic behaviours are identified as shown in Figure 3. Behavioural motivation factors include but are not limited to the emotional, cognitive, and philosophical nature of connection constructs and measures outlined in Table 1. Biophilic behaviours include but are not limited to the material and experiential nature connection constructs and measures outlined in Table 1. Opportunity and capacity include but are not limited to the constructs and measures.

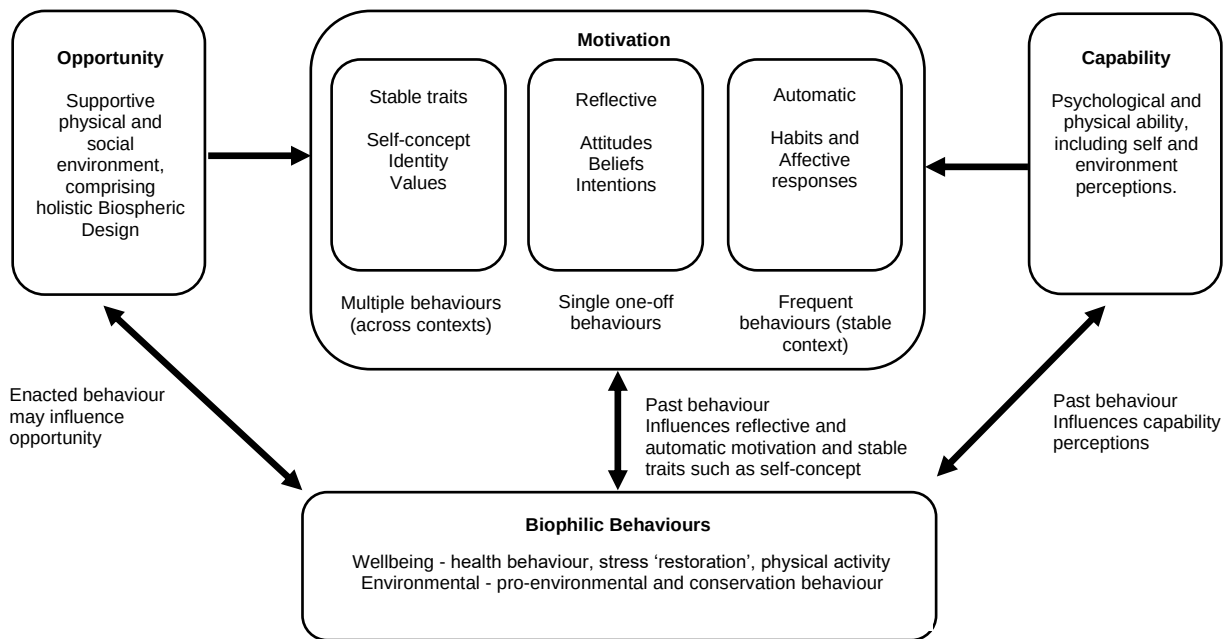


Figure 3: Theoretical Determinants of Biophilic Behaviours (adapted from Michie et al., 2011)

3.3 Incorporating Behaviour Change Strategies into the Biophilic Design Process

Theorists from both the built environment and the social sciences have highlighted that increasing human nature connection is an active process, including human behaviour and cognition as well as social and physical structures, associated with fundamental shifts in urban lifestyles to achieve health, wellbeing, and sustainability outcomes (Ives et al., 2018; Richardson & Butler; 2022). Such an approach stretches far beyond conceptualisations of biophilia and biophilic design as passive exposure to nature and aesthetic enhancements

(Richardson & Butler, 2022). This paper argues that it is necessary to understand biophilic behaviour and behaviour change through theoretical understanding, including the antecedents of behaviour and the causal determinants of change (Davis et al., 2015). This involves establishing reliable and valid measures of actual biophilic behaviour, biophilic design categories and typologies, and associated psychological constructs in order to conduct hypothesis testing and establish causality. Current approaches in biophilic design draw on empirical evidence related to the health and well-being outcomes of nature experiences (Browning & Ryan, 2020). This approach highlights the outcome of the behaviour and not the predeterminants of biophilic behaviour. A common approach in biophilic design is the qualitative categorisation of affordances, which relate to the potential behaviours within an environment. Whilst affordances may be designed in an inclusive and accessible way, such approaches do not consider personal motivations and capabilities to act, which represent influential factors in behavioural outcomes.

Therefore, this paper proposes a framework for incorporating evidence-based behavioural change into the biophilic design process, integrating the behaviour change wheel methodology (Michie et al., 2011; Public Health England, 2020) and architectural design pathway aligns to RIBA Plan of Work (RIBA, 2020) as illustrated in Table 2. The outline methodology proposes the identification of target biophilic behaviours to change aligned to the strategic definition and brief of the design project and the relevant well-being and sustainability goals of the individual project or organisation. During preparation of the design brief, initial community engagement represents an opportunity to gather baseline information relating to current behaviours, habit indicators and psychological factors such as nature connectedness and conduct behaviour mapping (Michie et al., 2011), related to the existing situation. Final behaviour selection is aligned to the conceptual design and relates to the high-level review of the general arrangement comprising physical elements in relation to the type of behaviour targeted. During the spatial and technical design, the development of behavioural change techniques is established, related to whether the intervention will target

increased opportunity, motivation, or capability of the behaviour. For example, in the case of enhancements to an existing community garden, *capability* and *motivation* may be a primary target over increased *opportunity*. By following this framework (Table 2), during design scheme implementation and handover, behaviour change strategies may be implemented, which may commence prior to handover if the behaviour change relates to community embeddedness in the design process, involvement in planting implementation and volunteering. Finally, during use (stage 7 in Table 2), monitoring of baseline psychological and behavioural variables will be measured at timely intervals to establish the qualifiable effect of the intervention.

Table 2

Biophilic Behaviour Change and Physical Design Project Pathway Integration

Design Pathway (and project stage) (RIBA 2020)	Engagement Pathway	Behavioural Pathway
0 - Strategic Definition	Community briefing	<u>Project goals and target group or population</u> Identify international, national, local or organisational level wellbeing and sustainability goals. Establish target group or population for behavioural change. Identify behavioural indicators, key actors and relationships Identify focus behaviour(s) as project key performance indicators (KPI's).
1 - Preparation and briefing	Community briefing and baseline questionnaires (timepoint 1)	<u>Baseline measurements</u> Measure target community baseline behaviours, and psychological constructs aligned to the project

		strategic definition and goals which may include one or more of the following. - Existing material and experiential biophilic behaviours, - Habits and context cue indicators, - Psychological measures of cognitive, emotional and philosophical nature connection, - Measures of individual behavioural capacity, - Measures of behavioural opportunity.
2 - Concept design	Community co-design	<u>Select intervention types</u> Integrate behavioural opportunity (for example, contextual cues) within concept design where applicable. Undertake behavioural change diagnostics comprising behavioural opportunities, capacities and motivation requirements to identify and select intervention types. Intervention type assessment.
3 – Spatial coordination	Community co-design	<u>Develop intervention types</u> Develop behavioural change interventions comprising behavioural opportunities, capacities and motivation. Coordinate spatial and behavioural interventions with spatial design team, client, community and stakeholder groups, site management and operators to develop behavioural change interventions. Intervention type assessment.
4 - Technical design	Community engagement in	<u>Develop implementation strategy</u> Constructing interventions may include. Clubs, societies

	behavioural change strategy development.	Digital – apps etc
5 - Construction	Community engagement in project physical implementation where appropriate.	<u>Initiate behavioural change interventions</u>
6 - Handover	Community engagement in behavioural change strategy implementation.	<u>Initiate behavioural change interventions</u>
7 - Use	Community briefing and questionnaires (timepoint 2)	<u>Monitor baseline indicators</u> Timepoint 2 measures of baseline indicators where applicable

4. Conclusion

The paper presents a novel approach to biophilic design, focusing on its potential to drive positive biophilic behaviour. This scoping study reviews literature from social sciences, psychology, and the built environment, examining the interplay between biophilic behaviours and design processes. This article presented a behavioural change framework for biophilic design that recognises the importance of human behaviour in establishing the human-nature connection and hereafter behaviour change as a key indicator of the success of biophilic design. While much research in biophilic design focuses on the well-being of citizens, the role of biophilic design in promoting positive environmental behaviour is understudied or often overlooked. The framework responds to calls for a greater human connection with nature across material and experiential domains and seeks to quantify behaviour change in an empirical manner to provide support to the biophilic design process.

578

579 The biophilic behavioural change framework developed in this scoping study includes the
580 identification of biophilic behaviours, indicators of psychological nature connection, and the
581 factors contributing to behaviour change based on the COM-B model. The COM-B model of
582 behaviour change suggests that to engage in a behaviour (B), a person needs to have the
583 capability (C), opportunity (O) and motivation (M) to perform that behaviour, so any
584 behaviour change will require modifying at least one of those components. This framework
585 addresses how these factors interact to generate biophilic behaviour and how behaviour, in
586 turn, influences each of these conditions. The paper also explores various aspects, like the
587 role of habit and motivational factors in shaping biophilic behaviour. Finally, an outline
588 methodology was proposed to incorporate behaviour change techniques into the biophilic
589 design process, aligning with the RIBA Plan of Work. It emphasizes the need for
590 comprehensive community engagement, behavioural mapping, and intervention
591 development tailored to specific behaviours and contexts, calling for multidisciplinary
592 cooperation and the alignment of objectives across the built environment and social science
593 fields. By highlighting the importance of behaviour change, the framework seeks to define an
594 approach for biophilic behaviour change for application in both empirical and applied
595 settings.

596

597 This paper proposes a unique strategy for urban planners, architects, and landscape
598 designers to employ environmental behaviour-focused Key Performance Indicators (KPIs) as
599 a measure of biophilic design effectiveness, a crucial aspect of sustainable biophilic design.
600 However, a potential limitation is the study's reliance on existing literature, which may not
601 fully encompass the diverse range of biophilic behaviours and their determinants in various
602 urban contexts. The theoretical framework presented in this paper, focusing on biophilic
603 design, would greatly benefit from more empirical research to validate and refine its
604 methodologies. This is particularly relevant in diverse urban settings, where factors like
605 biophobia, ecosystem disservices, and human-wildlife conflict and coexistence play a

significant role. Future research is essential to examine these contextual elements in biophilic design, ensuring the framework's applicability and effectiveness in various urban environments. It will contribute to a more nuanced understanding of how biophilic design can positively influence urban spaces. Moreover, close interdisciplinary collaboration is essential to discover effective methods to integrate behaviour change KPIs into the biophilic design framework. In this paper, we propose a biophilic behavioural change design framework that serves as both an integrative structure and a generative foundation for future empirical research. Such advancements are vital for improving biophilic design's impact on creating sustainable urban environments and to better understand the interplay between human behaviour and natural elements in the contexts of rapid urbanisation worldwide.

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