

## RESEARCH ARTICLE

# Perceptions and pathways: Linking biodiversity to health and well-being in lower-income contexts

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## Abstract

1. The biodiversity loss and human health crises are deeply interconnected, but existing frameworks linking the two are largely derived from high-income contexts, limiting their applicability to much of the world. While these frameworks have been valuable, this gap is especially critical in rapidly urbanising low- and middle-income regions, where health inequalities and biodiversity loss converge.
2. To address this gap, we conducted research in Accra, Ghana, exploring how urban biodiversity influences health and well-being. Using photovoice, 36 participants documented their lived experiences of local biodiversity and their perceptions of its impact on their health and well-being. The resulting data were coded both using emergent and a priori codes based on existing conceptual frameworks.
3. We found that biodiversity interacts with multiple domains of health and well-being through four pathways ('reducing harm', 'building capacities', 'restoring capacities' and 'causing harm') that align with existing framings.
4. We also observed two additional pathways ('spirituality' and 'livelihood support'), both of which may have greater prominence in lower income contexts. Incorporating these pathways into our understanding of how biodiversity influences health and well-being contributes to a more inclusive framework that reflects the socio-economic and cultural diversity of rapidly urbanising regions in low- and middle-income regions.
5. We present an adapted framework that integrates these pathways, offering a context-sensitive model to guide future research. Such a framework is essential for informing policy and practice in a way that benefits a broader range of communities, and thus, potentially, better allows us to address health and biodiversity crises together.

## KEYWORDS

Africa, Ghana, greenspace, livelihoods, photovoice, spirituality

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## 1 | INTRODUCTION

Biodiversity and human health and well-being are widely regarded as 'inextricably linked' (Campbell et al., 2011, p.407), something first brought to wide attention when the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005) highlighted the interdependence between ecosystems and human well-being. Meanwhile, progress towards health-related Sustainable Development Goals (SDGs) remains off track, with fewer than one third expected to be achieved by 2030 (World Health Organisation, 2024). At the same time, biodiversity continues to decline globally (Díaz et al., 2019), emphasising the need to preserve environmental resources and understand how they influence health and well-being in more regions of the world.

Urbanisation is accelerating alongside these global biodiversity and health challenges, with nearly 70% of the world's population projected to live in cities by 2050 (United Nations Department of Economic and Social Affairs, 2018). For much of the global population, towns and cities are therefore the primary site of contact with nature, making urban contexts particularly important for understanding the links between biodiversity and human health and well-being (Cox et al., 2018; Guerry et al., 2021; Tuhkanen et al., 2022). Almost 90% of this urban growth is concentrated in Asia and Africa (Kundu et al., 2023; United Nations Department of Economic and Social Affairs, 2018). Africa, currently the fastest urbanising region, is experiencing expansion that often outpaces infrastructure and service provision, exacerbated by limited planning and governance capacity (Danquah et al., 2024; Dodman et al., 2022; United Nations Department of Economic and Social Affairs, 2018, 2022).

In lower income urban settings, interactions with nature often occur in informal greenspaces such as vacant lots, roadside verges, unmanaged plots or areas of unplanned urban agriculture (Amoah & Drechsel, 2024; Rupprecht & Byrne, 2014). These spaces typically operate outside formal regulation and can be multifunctional, supporting, among other things, subsistence farming, social interaction or cultural practices (Sadler et al., 2010; Stanford, 2025; Stanford et al., 2025). However, they may also present health risks linked to poor maintenance (Pedrosa et al., 2021), exposure to pollution and vulnerability to degradation (Nematinasab, 2017), particularly in tropical regions where climatic conditions support disease vectors, such as mosquitoes and rodents (Obame-Nkoghe et al., 2023). Though these features do not make informal greenspaces inherently low-income in character, such spaces are often more widespread and relied upon in lower income cities, where formal green infrastructure may be limited, underfunded or inaccessible (Sikorska et al., 2020). Yet, they are frequently overlooked in conceptual frameworks linking biodiversity with human health and well-being, which largely reflect high-income or formally planned contexts (Follmann et al., 2021; Huynh et al., 2022; Nawrath et al., 2021). Incorporating diverse knowledge and experiences can reveal new insights or alter the importance of existing knowledge (Intergovernmental Science-Policy Platform

on Biodiversity and Ecosystem Services (IPBES), 2019; Roué et al., 2017; Tengö et al., 2014), highlighting relational understandings of the environment, such as those embedded in many non-Western worldviews (Mazzocchi, 2020; Van Opstal & Hugé, 2013; Zidny et al., 2020). This is especially important when addressing complex social and environmental challenges, where technical expertise may overlook local contexts or cultural perspectives (Wilder et al., 2016).

Several theoretical frameworks conceptualise the connections, or pathways, between the natural environment and human health, focusing on nature (e.g. Bratman et al., 2019; Hartig et al., 2014), greenspace (e.g. Markevych et al., 2017) and biodiversity (e.g. Marselle et al., 2021). These frameworks typically describe pathways akin to 'reducing harm' (e.g. provision of food and medicine), 'restoring capacities' (e.g. reducing stress and restoring attention), 'building capacities' (e.g. facilitating physical activity) and 'causing harm' (e.g. exposure to allergens). Such interactions are likely influenced by socio-economic and cultural characteristics, and multiple pathways often operate simultaneously (Marselle et al., 2021). Marselle et al. (2021) further advance earlier frameworks by explicitly incorporating biodiversity and moving beyond a sole focus on psychological benefits to include dimensions such as social cohesion (similar to frameworks developed by Hartig et al. (2014) and Markevych et al. (2017)), while also recognising both positive and negative interactions, such as harmful wildlife interactions (Methorst et al., 2020), disease exposure (Wood et al., 2017) and allergens (Luschkova et al., 2022). Yet, these frameworks largely emerge from high-income contexts and are expert-driven (e.g. Bratman et al., 2019; Hartig et al., 2014; Markevych et al., 2017; Marselle et al., 2021), which risks overlooking how people perceive and experience biodiversity–health relationships in lower income, rapidly urbanising settings (Nawrath et al., 2021; Shuvo et al., 2020). Given the global burden of ill health, the rapid pace of urbanisation, and the multifaceted role of biodiversity, there is a need to refine and expand theoretical frameworks to better reflect diverse contexts, particularly in lower-middle-income countries (LMICs) (Markevych et al., 2017; Nawrath et al., 2021).

In light of these gaps, this study examines how residents in Accra, Ghana, perceive and experience local biodiversity and its links to human health and well-being. We refine and expand the framework presented by Marselle et al. (2021), enhancing its relevance across a wider diversity of contexts, including settings not typically classified as high-income. In doing so, we continue to build on a sequence of frameworks (e.g. Bratman et al., 2019; Hartig et al., 2014; Markevych et al., 2017) that have advanced how research, policy and practice conceptualise, understand and operationalise the links between nature, biodiversity and human health. Accra provides a valuable case, as one of Africa's fastest-growing cities (Ghana Statistical Services, 2021; World Bank, 2014), where formal greenspace provision is limited and everyday interactions with biodiversity often occur in informal, multifunctional environments.

## 2 | METHODOLOGY

### 2.1 | Study setting

Accra is the national capital of Ghana, a LMIC in West Africa, and one of the fastest-growing urban centres in the region (Ghana Statistical Service, 2021; World Bank, 2014). In 2021, approximately 5.46 million people lived in the Greater Accra Metropolitan Area, 91.7% of whom resided in urban areas (Ghana Statistical Service, 2021). Reflecting patterns exhibited in its capital, approximately 65% of the Ghanaian population will reside in urban areas by 2030 and 72.3% by 2050 (Amoah & Drechsel, 2024; Bonsu & Bonin, 2023; United Nations Human Settlements Programme (UN-Habitat, 2015).

Much of the predicted global urban expansion is expected to occur in biodiversity hotspots, that is, regions that once supported high levels of native biodiversity (Seto et al., 2012). Accra lies within the broader Guinean Forests of West Africa biodiversity hotspot and the Guinean forest-savanna mosaic ecological region (Critical Ecosystem Partnership Fund, 2015; Hackman et al., 2017), and while much of the surrounding landscape is highly modified, the city still supports pockets of biodiversity within informal greenspaces, vegetation and urban agriculture (Simkin et al., 2022). This makes Accra a valuable context for exploring how urban residents perceive and interact with biodiversity amid rapid environmental change.

The city's urbanisation has been accompanied by substantial economic transformation. Ghana has experienced sustained economic growth and infrastructural development since the 2000s, with Accra the primary hub for investment, services and industry (Ackah et al., 2016; Newman et al., 2016). Urban expansion has occurred unevenly, producing strong contrasts in socio-economic conditions across neighbourhoods, from high-income, planned areas to lower income informal settlements (National Development Planning Commission (NDPC), 2013; Danso-Wiredu, 2018).

Looking ahead, Accra can be seen as a pathfinder for other African cities, given its longstanding role as the primary destination for foreign direct investment in Ghana since the 1980s (Korah et al., 2019). Compared to many countries on the continent, Ghana has more effectively leveraged urbanisation to support economic growth, gaining early benefits from the process and demonstrating greater capacity to harness its potential (Owusu & Yankson, 2017; World Bank, 2014). This runs counter to the general trend in many sub-Saharan African countries, which appear to experience urbanisation without significant economic growth (Onjala & K'Akumu, 2016; Opal & Fay, 2000). Therefore, the city's 'rapid growth rate, economic reliance on globalisation [...] and underrepresentation in urban research make it a novel and significant study area' (Korah et al., 2019, p. 4).

### 2.2 | Participants and sample

Communities and living standards in Accra are diverse and range from affluent private residences to lower income informal settlements (National Development Planning Commission (NDPC), 2013;

Danso-Wiredu, 2018). To reflect this diversity, we purposively selected three neighbourhoods covering a socio-economic gradient within the city (Figure 1): East Legon (high-income), Abelenkpe (middle-income) and Nima (low-income). These categorisations were informed by Songsore et al. (2009), Cavanaugh et al. (2023) and Hogba and Yiran (2024).

These neighbourhoods were selected to maximise variation in socio-economic characteristics rather than to be statistically representative of the city. Neighbourhood-level population figures are not available from the Ghana Population and Housing Census (Ghana Statistical Service, 2021), and as such, we cannot provide precise population sizes of East Legon, Abelenkpe and Nima, though all are located within the Greater Accra Metropolitan Area (Ghana Statistical Service, 2021).

It is also important to recognise that the selected neighbourhoods are largely populated by long-standing generations of immigrants from various regions of Ghana and neighbouring countries such as Burkina Faso, Togo, Côte d'Ivoire and Nigeria (Anarfi et al., 2003; Essuman-Johnson, 2006; Schürmann et al., 2022; Turolla & Hoffmann, 2023). This ethnic and tribal diversity is reflected in the participant sociodemographic characteristics (see Table S1).

Our study population consisted of residents from the selected neighbourhoods. Interviews were conducted in English, the official language of Ghana, or Twi, the most widely spoken local language in the study area. This approach allowed us to focus on residents who were directly connected to the neighbourhoods, ensuring their insights were relevant to the context of the study.

The ethical principles of participatory research emphasise the importance of including participants whose voices are often ignored or excluded from academic inquiry (Sutton-Brown, 2014). To achieve this, we worked through gatekeepers (i.e. individuals or groups from whom permission is required to conduct research). The gatekeepers, including community group leaders and Accra Metropolitan Assembly (AMA) Members, played a crucial role in facilitating our access to a broad range of participants across age and gender. While gatekeepers can introduce selection bias by influencing who is invited to participate (Green & Thorogood, 2018), this approach was both appropriate and necessary in the context of this study, where researchers can be considered outsiders, and building trust and gaining entry often depend on the support of locally embedded actors (Kerstetter, 2012).

In total, 36 participants were recruited across the three neighbourhoods: East Legon ( $n = 14$ ), Abelenkpe ( $n = 10$ ) and Nima ( $n = 12$ ). Recruitment involved distributing information sheets, conducting brief presentations at community group meetings and advertising the project via AMA Members. We requested that gatekeepers advertise the research project to a range of participants, attempting to achieve a gender balance and capture variation in age. Snowball sampling was also used, whereby initial participants were asked to recommend others for inclusion, to reach participants not directly affiliated with gatekeepers' networks (Naderifar et al., 2017). Participant sociodemographic characteristics are detailed in Table S1.



**FIGURE 1** Map and satellite imagery of Accra, Ghana, showing three study neighbourhoods: East Legon (orange), Abelenkpe (green) and Nima (blue), purposively selected to cover socio-economic gradients. East Legon represents a high-income area, Abelenkpe a middle-income neighbourhood and Nima a lower-income, informally developed settlement. The central panel shows the neighbourhoods on a street map of Accra, and the right-hand panel provides corresponding satellite imagery, illustrating spatial differences in building density, land use and vegetation cover. Corresponding population estimates are not provided in the Ghana Population and Housing Census (Ghana Statistical Service, 2021).

The sample size was intended to generate rich qualitative insights, consistent with best practice in photovoice research, rather than to achieve statistical representativeness (Catalani & Minkler, 2010; Ronzi et al., 2016). This study does not aim to generalise to the total neighbourhood populations, but to capture diverse experiences across the city's socio-economic gradient.

### 2.3 | Study design

Photovoice, 'a process by which people can identify, represent, and enhance their community through a specific photographic technique' (Wang et al., 2000, p. 82), was employed to explore perceptions of the links between urban biodiversity and human health and well-being. We utilised this bottom-up approach to empower participants to communicate their personal experiences (Catalani & Minkler, 2010).

Biodiversity and health are interpreted in different ways across contexts (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2019). To provide clarity, this study adopts well-established definitions for both concepts. *Biodiversity* is defined according to the Convention on Biological Diversity (CBD) as 'the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological

complexes of which they are part; this includes diversity within species, between species and of ecosystems' (United Nations, 1992, art.2). *Health* is defined by the World Health Organisation (WHO) as 'a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity' (World Health Organisation, 1948, p. 16). In this study, *well-being* encompasses five domains: physical, emotional, mental, social and spiritual (Irvine et al., 2023). Accordingly, we use the term 'health' to encompass both the WHO definition and these five dimensions of well-being.

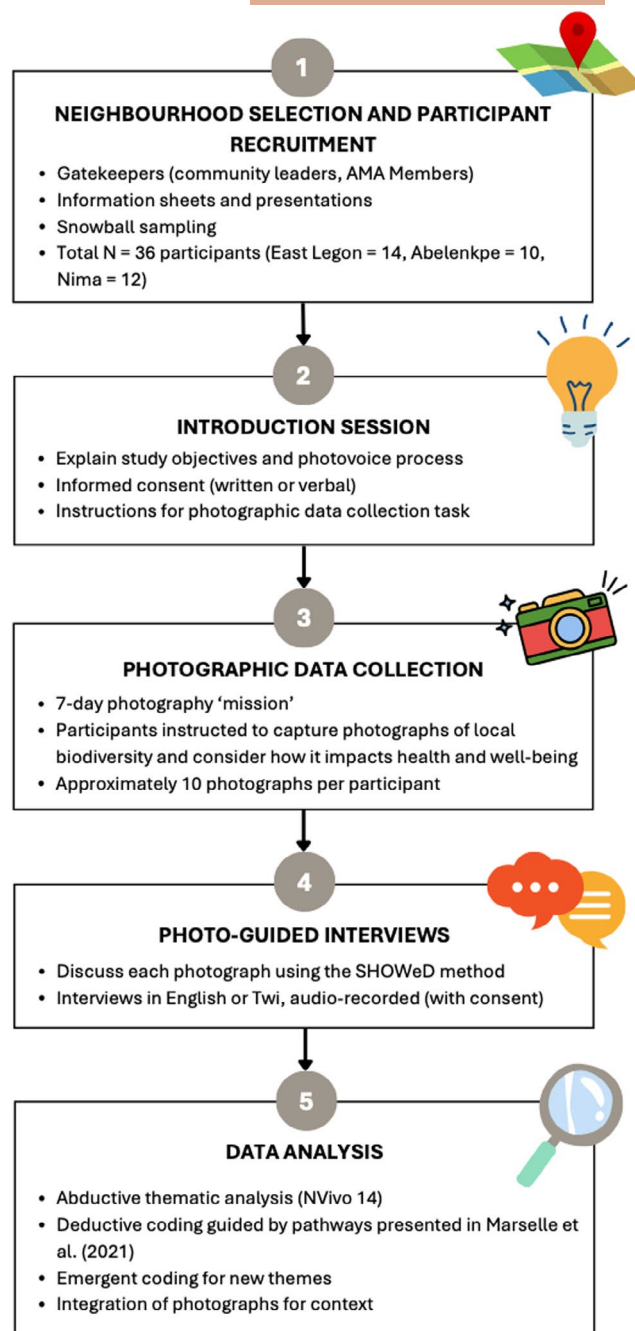
Given that photovoice reflects participants' perceptions rather than objective biodiversity measures, our study explicitly positioned it as a method for documenting how residents interpret and interact with biodiversity in their daily lives. Accordingly, the study identifies perceived associations between biodiversity and health and well-being, rather than causal relationships. Nykiforuk et al. (2011) note that photovoice is particularly useful when exploring the context of the neighbourhood, where residents may have different perceptions of biodiversity based on their sociocultural backgrounds. This contributed to our decision to select neighbourhoods as study areas, enabling us to reflect the diversity of residents' experiences in a city facing challenges like biodiversity loss and rapid urbanisation (Kwawuvi & Yangouliba, 2023).

Given our chosen methods, potential participants had to be willing to take photographs using a smartphone or digital camera.

However, to remove this potential barrier to taking part, participants could be accompanied by a friend or family member of their choice to take the photos if needed. We also supplied digital cameras to those who did not otherwise have access to a smartphone or camera. Finally, participants had to agree to attend an introduction session and an individual interview.

The photovoice process was informed by Wang and Burris (1994) and comprised the following steps (Figure 2):

1. Our approach to neighbourhood selection and participant recruitment is described above. We informed gatekeepers (e.g. community leaders and elected AMA Members) about the project and its aims (including accessing a broad range of participants across age and gender) through presentations and meetings. We also provided information sheets for the gatekeepers to disseminate to residents. Snowball sampling was used to reach participants who were not directly affiliated with these networks.
2. An introduction session was organised in each neighbourhood for potential participants, where we discussed the topic, schedule and methodology. Information sheets were provided to all participants, and informed consent was obtained before participation. Given that literacy levels are low in several communities in Accra, reading the information sheet and providing written consent may not have been feasible for some participants. In such cases, verbal informed consent was obtained to ensure that participation was both informed and voluntary. During the introduction session, participants were instructed to capture and submit photographs that did not include people, and therefore, photograph release forms were not made available (Wang & Redwood-Jones, 2001). Additionally, we confirmed that participants could take clear, focused photographs using their smartphones or the provided digital cameras.
3. Over 7 days, participants completed photographic data collection, also known as the photography 'mission' (Strack et al., 2004), by photographing images of the biodiversity they interacted with in their daily lives, which they considered may influence their health and well-being. While there was no strict minimum or maximum number of photographs required, participants were informed that the individual follow-up interviews would allow time to discuss a limited selection. To support this, participants were encouraged to submit approximately 10 photographs they believed to be most important. This approach aimed to allow participants to complete the photography 'mission' with flexibility, while avoiding excessive data that could overwhelm the interviews or hinder focused analysis. Limiting the number of images submitted also helped to ensure that discussions centred on the most meaningful content. This strategy aligns with existing photovoice studies, which typically instructed participants to take between 3 and 30 photographs (e.g. Novek et al., 2012; Ronzi et al., 2016).
4. Photographs were colour-printed by the research team and brought to the respective individual photo-guided interviews. All participants were provided with an information sheet during the introduction session and at the start of each interview. A consent



**FIGURE 2** Overview of the photovoice study methodology, illustrating neighbourhood selection and participant recruitment, introduction session, photographic data collection, individual photo-guided interviews informed by the 'SHOWeD' technique (Wang et al., 1998; Wang & Burris, 1994) and the data analysis process.

form was signed (if appropriate), or verbal consent was obtained before each interview commenced. A brief interview protocol, informed by the 'SHOWeD' technique (Wang et al., 1998; Wang & Burris, 1994) and repeated for every photograph, was used to guide interview discussions, as follows:

- a. What does the photograph show?
- b. Why did you take this picture?
- c. What is the unseen story behind the picture?

- d. How does this relate to your life?
  - e. How did it make you feel?
  - f. What does this photo tell us about life in your community?
  - g. What are the positive and/or negative impacts of this on your health and well-being?
5. Data analysis comprised abductive thematic analysis using NVivo 14 (Thompson, 2022) to examine the interview transcripts and the submitted photographs provided additional context (see Section 2.4).

Data were collected in August and September 2024. The introduction sessions and interviews were conducted in English or Twi, according to the wishes of the participants, with the intention that they felt comfortable and safe expressing their ideas. With participants' consent, interviews were audio-recorded. The audio recordings were translated into English and then transcribed.

Conducting research with translation may introduce potential bias in the process of perception and interpretation (Cook-Sather, 2013), presenting a challenge in accurately portraying participants' experiences and avoiding the filtering of their insights through the translators' words. To mitigate this, the translator had experience in the field of environmental science research and was embedded in the cultural context of Accra. This helped to strengthen the validity of the data, as misrepresentation due to linguistic or cultural differences can compromise the quality of translated material (Kapborg & Berterö, 2002; Temple et al., 2006). Additionally, the translator's familiarity with the dialect and cultural norms of participants enabled a more nuanced and context-sensitive interpretation of meaning, helping to contextualise participants' narratives and preserve the integrity of their accounts (Al-Amer et al., 2015).

Ethical approval was obtained from the ethics committee of the University of Leeds (ref. BESS+ FREC 1577).

## 2.4 | Data analysis

Data analysis comprised abductive thematic analysis using NVivo 14 (Thompson, 2022) to examine the interview transcripts and the submitted photographs provided additional context. This approach combined deductive and inductive elements. First, coding was guided by the existing theoretical framework by Marselle et al. (2021), with predetermined (a priori) codes and themes including the 'reducing harm', 'restoring capacities', 'building capacities' and 'causing harm' pathways. A corresponding codebook was developed, informed by the steps outlined by DeCuir-Gunby et al. (2011), and is available in Table S2. To avoid constraining the analysis to pre-established categories, as Creswell (2013) cautions, we also applied emergent coding techniques (Elliott, 2018). This allowed new themes to emerge directly from participants' narratives. The abductive strategy enabled us to identify themes that may not have been recognised in the current literature, while

also situating our findings within the theoretical framework we aimed to develop and build upon (Bingham, 2023).

## 2.5 | Positionality

The research team in this study is interdisciplinary, spanning social science, geography, biology and environmental science, situated in the United Kingdom and Ghana. We recognise that this shaped the design and interpretation of this study. Additionally, the team's varied lived experiences, including international and local perspectives, influenced how we engaged with participants and interpreted their insights. By acknowledging these positionalities, we aim to provide transparency and enable readers to critically assess how our standpoints shaped the research process and its interpretations.

## 3 | RESULTS

Below, we present results including direct quotations from the photovoice interviews. Each quotation is followed by an indicator denoting the participant's neighbourhood: H (high-income), M (middle-income) or L (low-income), along with the participant number. Sociodemographic information about the participants is available in Table S1.

### 3.1 | Deductive coding results (a priori themes)

#### 3.1.1 | Reducing harm: Physical health and exposure reduction

Participants identified several ways that biodiversity supported physical health, particularly through medicinal uses and reduced exposure to environmental stressors. Medicinal plants were widely relied on for treating common ailments, often positioned as equivalent to biomedical interventions: 'Coconut is equivalent to the drip doctors put on patients at the hospital' (H11). Other species were assigned other names to reflect their medicinal benefits; for example, 'This is "Far from the Hospital"—it was my mother that told me about it' (H09); and, "'Nkwadaa Nkwadaa Brodie" is used in curing many sicknesses [...] When a child's temperature rises, you bathe the child with it and their temperature will come back to normal' (L05).

Biodiversity also reduced participants' exposure to environmental stressors like heat and air pollution by providing shade ('trees provide shade from the scorching sun' (M03)), and improving air quality ('without trees, there is no fresh air' (L03)). These interactions simultaneously influenced mental and emotional well-being, as participants reported a reduction in stress levels relating to accessing medical care: 'It is good to have [medicinal plants] in your garden so that in case of an emergency you will rely on it' (L11).

### 3.1.2 | Restoring capacities: Stress reduction and mental clarity

Participants frequently reported that biodiversity facilitated the restoration of mental and emotional capacities by providing tranquil, restorative environments. Lakes and gardens were described as 'cool, quiet and serene' (H10) and relieved stress: 'Mentally, when I'm stressed, I go to the lake to calm myself down [...] You can have a sound mind whenever you see it' (Figure 3).

Beyond these restorative spaces, participants highlighted sensory qualities of biodiversity they believed portrayed beauty, such as shapes ('Leaves [...] because they have natural lines', M05), colours ('The way the dandelion is very, very green', L09) and breeze ('The garden also comes with a lot of breeze, so somehow the flow of the air [...] it helps with the well-being; keeps you calm', H09).

### 3.1.3 | Building capacities: Skills, knowledge and social cohesion

Biodiversity also contributed to building capacities by strengthening social cohesion, enhancing local knowledge and providing symbolic meaning, illustrating the ways that biodiversity supports well-being beyond individual health benefits. For example, trees and plants reportedly served as focal points for social interaction and collective practices, described as a 'sense of connecting people' (H02). More specifically, one participant described a Neem tree (*Azadirachta indica*) being used as a gathering place for church services, vaccinations and health outreach programmes:

Every Sunday, there are [church] services and people gather under the tree [...] On the first Tuesday of the month, clinic nurses come and sit under the tree, and you can go with your baby – I've done it with my son – and you can weigh them [...] And you can even get the shots under the tree, like all the vaccinations and



FIGURE 3 Photograph of a lake (submitted by H11).

everything. For me, that's Africa! You're sitting under a tree, and then there's the church, and it's an accommodation – that makes me happy, it's a community centre

(H01, Figure 4).

Caring for biodiversity was also linked to pride and personal agency, which could be interpreted to enhance emotional well-being, while facilitating intergenerational knowledge-sharing and expertise:

I am very proud that there is an Avocado tree in my area. If someone says they do not know what an Avocado tree looks like, I will direct them to this place and show them so they will know and also teach others

(L03, Figure 5).

For others, biodiversity evoked memories and life lessons, often associating particular species with personal histories ('When I started crawling as a child, it was this tree I held onto and began to walk', H07), or reflecting on cycles of growth and renewal ('The cycle of life [...] With every leaf that falls off, another grows', H02). Such reflections highlight how biodiversity serves as a resource for contemplation and meaning-making, encouraging self-reflection, which



FIGURE 4 Photograph of a Neem tree (*Azadirachta indica*) used for community events (submitted by H01).



**FIGURE 5** Photograph of an Avocado tree (*Persea americana*) (submitted by L03).

could be interpreted to improve participants' emotional and spiritual well-being.

### 3.1.4 | Causing harm: Negative interactions and perceived risks

Participants reported negative experiences and risks associated with biodiversity, highlighting potential harms to mental, physical, social and spiritual well-being. Certain species, such as amphibians, reptiles and insects, were feared: 'In our village, Thousand Legs [millipedes] crawl on the skin of children [...] I am afraid that it will get into your ears or your mouth when you sleep' (L12, [Figure 6](#)).

Physical hazards, including thorns 'that can pierce your skin' (H07) and property damage from roots were also described: 'The Neem tree's roots grow under your building, and it can collapse the building and cause rust on the roof' (M04). At times, negative perceptions resulted in participants attempting to remove or avoid species: 'When you have a Neem tree in your house, there are mostly snakes hiding in the leaves, so that is why some people cut down such trees' (M03).

Additionally, participants reportedly destroyed elements of biodiversity altogether, motivated by the nuisance caused by the constant maintenance required: 'The Orange tree brings a lot of rubbish when the leaves fall. You have to be sweeping all the time—that is why people cut the trees down' (M09). When it was not possible to



**FIGURE 6** Photograph of 'thousand legs' (*Telodeinopus aoutii*) (submitted by L12).

eradicate or destroy the species, participants deliberately avoided interactions with biodiversity altogether, such as 'sitting outside in the evening because of the mosquitoes' (H01), due to the fear of being harmed, bitten or infected.

At times, these negative feelings transformed into 'hatred' of certain elements of biodiversity, even when those dislikes are based on inaccurate perceptions and views. Such fears were seen to jeopardise both physical safety and emotional well-being:

I hate [wall geckos]! There are many bad things: they are able to enter rooms even where there are no entry points in the ceiling; I wonder how they are able to enter [...] They are harmful to human life because if one falls into food, about five people die. So, what will happen if two fall into your food? And why do they like the kitchen most? They are everywhere! [...] They are more dangerous than mosquitoes—we know malaria kills, but they kill faster!

(L01, [Figure 7](#)).

## 3.2 | Inductive coding results (emergent themes)

The inductive coding revealed themes that extend beyond existing frameworks. In particular, 'spirituality' and 'livelihood support'



**FIGURE 7** Photograph of a wall gecko (*Hemidactylus mabouia*) (submitted by L01).

emerged as central to participants' experiences, yet these dimensions are under-recognised in biodiversity–health frameworks.

### 3.2.1 | Spirituality: Symbolism, protection and dangers

Religious and spiritual beliefs appeared to play a significant role in the links between biodiversity and health for most participants. Biodiversity was valued as a space for spiritual practice: 'If you stand there and pray, God will answer your prayers' (L06), supporting spiritual well-being. Interactions with certain species were also believed to have spiritual consequences or protect from spiritual harm: 'You must put money under your bed before plucking a Miracle Leaf [...] It prevents bad or evil spirits from getting close to your home if you have it in your house' (H05) and, 'The cactus drives away evil spirits—if you have this plant in your house, nobody can steal from you' (H07).

Additionally, participants reflected on the symbolic references to the creation of biodiversity, with a spiritual focus: 'God is powerful – he can make anything with colours [...] When [people] walk past, they see the strength of the tree, and they will think about God's nature' (L06).

On the other hand, participants reported potential negative spiritual effects, reflecting culturally embedded perceptions of the capabilities of biodiversity to 'invite evil spirits' (L04), or 'used in a negative way to harm or attack the person spiritually' (H12). Biodiversity was also a main factor in 'blessings or curses' (M04), for example: 'Pawpaw is not good to plant at home because it invites evil spirits [...] Whenever we see one at home, we cut it down' (L04).



**FIGURE 8** Photograph of crops planted to provide livelihood (submitted by M01).

### 3.2.2 | Livelihood support: Income, nutrition and financial resilience

Participants' accounts illustrated that biodiversity functions as a livelihood resource by providing food, income and security. For example, participants cultivated crops such as pepper, kale and cocoa for sale and subsistence, linking biodiversity to household survival and reduced financial stress: 'I cultivate [pepper] about twice a year. It is what gives much of my income, so I love it! [...] When you engage in cultivating these crops, you always have a source of income' (M01, Figure 8).

Food crops also supported physical health ('Kale is very nutritious – it is high in iron and vitamins', H02) and created opportunities for education and advancement: 'Through this farming, my son has been able to graduate from school, and it's all thanks to this farming' (M01).

Beyond direct benefits, biodiversity fostered a sense of pride, enhancing both financial stability and emotional well-being: '[Cocoa] creates tourism, it creates a mood of excitement. People are happy when they see it' (H11). Biodiversity also provided shelter for business establishments from extreme weather conditions, such as extreme heat, sun or wind: 'The family lives under the tree and their whole business is under the trees [...] They need their trees' (H10; Figure 9).



FIGURE 9 Photograph of a store and house situated under trees (submitted by H01).

## 4 | DISCUSSION

Our findings reaffirm that biodiversity, including but not limited to urban areas, is increasingly recognised as a crucial dimension of health and well-being (Romanelli et al., 2015). This broader framing highlights the relevance of biodiversity to health and well-being across diverse ecological and social contexts. As cities expand, understanding the everyday ways people interact with biodiversity becomes increasingly important (World Bank, 2021). While our findings support established pathways linking biodiversity to health—such as reducing exposure to environmental stressors, restoring and building capacities and acknowledging the potential for harm—they also bring attention to underrepresented themes: *spirituality* and *livelihood support*. These dimensions emerged as central to participants' lived experiences, yet remain marginal in dominant frameworks shaped in high-income countries. We therefore propose an adapted framework (Figure 10) that incorporates *spirituality* and *livelihood support* as distinct pathways, offering a more inclusive framework for understanding biodiversity–health relationships in LMIC settings.

### 4.1 | Established pathways in LMIC

Participant narratives aligned closely with widely recognised mechanisms through which biodiversity influences health and well-being.

For example, participants described relying on locally available species as primary health interventions—used in malaria treatment, spiritual healing rituals, and other practices—reflecting the 'reducing harm' pathway (Adji et al., 2022; Juliani et al., 2009; Nortey et al., 2023). While our study did not quantify treatment outcomes or recovery rates, these accounts are consistent with broader trends in Ghana and the West African region, where biodiversity–health interventions often substitute formal care (Ayeni et al., 2022; Towns & Van Andel, 2016).

Restorative experiences, such as stress relief and sensory enjoyment, are well documented in global nature–health research (Bratman et al., 2019; Hartig et al., 2014; Jennings et al., 2016; Markevych et al., 2017). Similarly, participants described biodiversity as enabling physical activity and social interaction, reflecting pathways akin to 'building capacities' and 'restoring capacities' (Sandifer et al., 2015). Perceived harms were also noted, ranging from plant-triggered allergies to fears of certain species, echoing broader debates around the varied role of biodiversity and its links to health (Luschkova et al., 2022; Methorst et al., 2020).

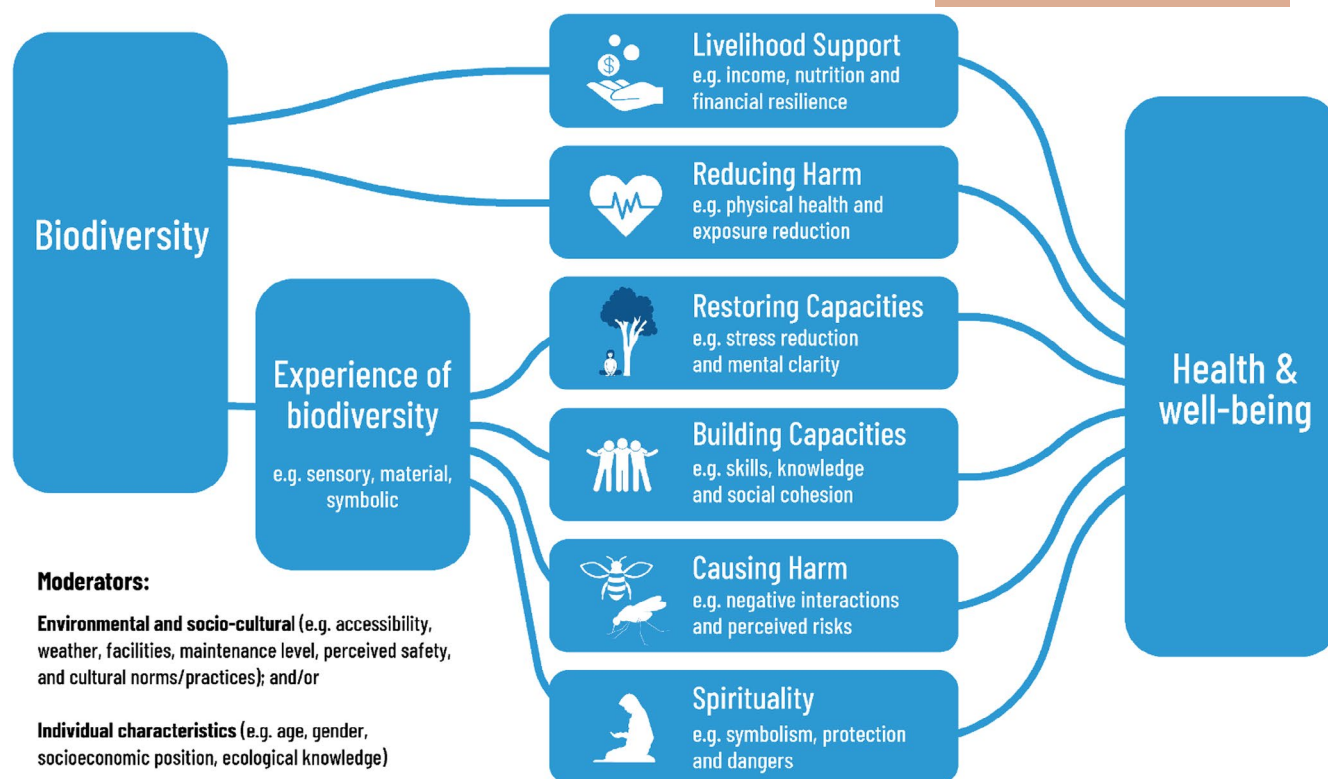
Importantly, our findings reaffirm that biodiversity–health interactions are shaped by intersecting socio-economic and cultural factors (Boyd et al., 2018; Dzhambov et al., 2018; Frumkin et al., 2017) and that multiple processes often occur simultaneously (Marselle et al., 2021). These results strengthen the applicability of established frameworks in LMICs while pointing to additional pathways that require greater recognition.

### 4.2 | Spirituality as a distinct pathway

Spirituality emerged as a central theme in our findings, shaping how participants experienced and interpreted interactions with biodiversity. In many cultures, spirituality is a key part of a person's identity. While some approaches frame it as being at one with a God, others emphasise meaning-making, coping with life or connecting oneself with something larger (Balboni et al., 2022; Chuengsatiansup, 2003; Cornah, 2006; Jones et al., 2019).

The concept of *ecospirituality*, which recognises the intrinsic value of all life and the interdependence between people and nature, provides a useful lens here, aligning with non-Western knowledge systems that emphasise relational ties to the land (Bellehumeur et al., 2022; Choné, 2017). Such perspectives have long informed environmental stewardship in communities outside of the West, where sacred groves, forests and ritual plants underpin both cultural continuity and biodiversity conservation (Djagoun et al., 2022; Nyamweru & Kimaru, 2008; Rath & Ormsby, 2025; Wassie et al., 2010). Though historically marginalised in academic discourse (Robinson et al., 2024), they remain central in many LMIC contexts where biodiversity is directly embedded in healing and well-being practices (Linhares et al., 2023).

Our findings contribute to ongoing debates about conceptualising human–nature relationships. The Nature's Contributions to People (NCP) framework (Díaz et al., 2018) has sought to



**FIGURE 10** Adapted framework illustrating the pathways through which biodiversity influences human health and well-being. This framework extends the model by Marselle et al. (2021), which identified four pathways (reducing harm, restoring capacities, building capacities and causing harm), by incorporating two additional pathways that emerged strongly from participant accounts in Accra: Spirituality and livelihood support. These dimensions reflect significant relationships with nature that are often overlooked in biodiversity–health research, particularly in high-income contexts. The framework also recognises the mediating role of biodiversity experiences (sensory, material and symbolic) and contextual moderators (e.g. accessibility, safety, cultural norms, age, gender, ecological knowledge). By integrating spirituality and livelihood support as distinct pathways, the framework offers a more inclusive lens for understanding biodiversity's role in health, particularly in rapidly urbanising LMICs.

move beyond the framings of ecosystem services (Braat & De Groot, 2012; Daily, 1997) by recognising the cultural, spiritual and relational values of nature (Cocks & Dold, 2006; Romanelli et al., 2015). Participants' accounts illustrate these non-material contributions, in which land, water, species and people are understood as interconnected and meaningful (Kimmerer, 2013; Whyte, 2020), and our findings extend this framing by showing that cultural and religious meanings were not only a backdrop to experience but actively shaped how participants found meaning, belonging and mental clarity. Building on NCP by making spirituality more explicit would therefore strengthen the applicability of biodiversity–health frameworks globally.

Existing frameworks often treat spirituality as a cultural 'moderator' rather than a distinct, separate pathway (Marselle et al., 2021). While such moderators are well documented in broader nature–health literature (e.g. Lindley et al., 2018; Triguero-Mas et al., 2017; White et al., 2017; Zijlema et al., 2017), Marselle et al. (2021) note that spirituality remains underexplored in biodiversity–health studies, which could be partly due to its 'complexity, fluidity and depth' (Bellehumeur et al., 2022, p. 3). However, our findings demonstrate that spirituality functioned as a primary mechanism of health and well-being. For example,

the Neem tree (*Azadirachta indica*) functioned simultaneously as a site of worship, healing and social gathering—demonstrating multifunctionality that combined pathways akin to 'reducing harm', 'restoring capacities' and 'spirituality' (Figure 4). Similar dynamics have been documented in India (Nagendra, 2016) and Nepal (Nawrath et al., 2022), where spiritually significant trees and sacred groves act as social anchors and support well-being (Gavin et al., 2015; Pretty et al., 2009).

Our results also revealed that participants perceived culturally or spiritually shaped beliefs as influencing their health experience, even when they diverge from scientific understanding. Participants' fears of wall geckos (*Hemidactylus mabouia*) (Figure 7), perceived as poisonous or unlucky, triggered emotional distress that was compared to malaria, a parasitic disease with 233 million recorded cases and 580,000 deaths in Africa in 2022 (World Health Organisation, 2022). Although the University of Michigan's *Animal Diversity Web* states that geckos are 'normally harmless' (Lennox, 2017, par. 23), this perception illustrates that cultural beliefs—whether based in myth, symbolism or past experiences—while not grounded in scientific or biological fact, can provoke strong emotional responses. This misinformation, when deeply embedded in cultural knowledge systems, may have unintended ecological and public health consequences,

as the fear-driven persecution of geckos, for example, could lead to a reduction and eradication of a species that preys on mosquitoes, thereby undermining a key form of biological control against malaria (Canyon & Hii, 1997; Meshaka, 2000). This illustrates how deeply held spiritual beliefs can affect both human and ecological health.

Some may argue that spirituality already fits within existing pathways such as 'building capacities', through mechanisms like transcendent experience (Ballew & Omoto, 2018; Capaldi et al., 2015). However, our evidence suggests that this framing is insufficient; spirituality not only supported other processes but also was often the primary mode through which people experienced and derived meaning from biodiversity. We therefore propose that spirituality should be repositioned as a distinct pathway in future frameworks (Figure 10).

Participants' perceptions of the links between biodiversity and health were deeply embedded in personal histories, cultural references and everyday encounters. These findings reflect research showing that people interpret environments through perceptual memories and deep-rooted cultural associations. For example, Austen et al. (2021) found that childhood memories shaped connections with woodlands, while Fish et al. (2024) argue that encounters with biodiversity are often 'rooted in a wider set of everyday references that people actively bring to bear on their encounters with biodiversity' (p. 337). Our findings also align with Nawrath et al. (2022), who emphasise that cultural ecosystem services are often the most meaningful pathway linking greenspaces to mental health in LMICs. Their research in Kathmandu, Nepal, showed that although provisioning and regulating services were important, participants most preferred cultural ecosystem services and perceived them as deeply embedded in their society.

In contexts like Accra, where greenspaces are often multifunctional and unevenly distributed (Akanbang et al., 2025; Amegah et al., 2023), recognising these spiritual, symbolic and relational roles of biodiversity is vital to capture how nature supports health and well-being (Lindley et al., 2018; Shackleton et al., 2015).

### 4.3 | Livelihood support

Our findings suggest that *livelihood support* represents an under-recognised pathway linking biodiversity and health. Participants described growing crops in informal urban plots to feed their families, generate income and access medicinal plants. Such practices are common in sub-Saharan Africa, where urban agriculture and herbal medicine supplement fragile food systems and overstretched healthcare (Marshall, 2011; Obosu-Mensah, 2002; Robineau, 2015; Swanepoel et al., 2021).

In widely cited frameworks (e.g. Marselle et al., 2021), livelihood-related elements tend to be embedded within broader sociocultural or contextual moderators (such as socio-economic status or cultural practices) rather than treated as a distinct pathway. Yet our findings highlight livelihoods as central mechanisms linking biodiversity to security, dignity and well-being. Beyond subsistence, biodiversity

supported participants' incomes through nature-based tourism (e.g. cocoa [*Theobroma cacao*]), echoing wider evidence that ecotourism stimulates local economies (Gidebo, 2023; Nepal et al., 2022), reportedly generating 40% more full-time employment than agriculture (United Nations Environment Programme (UNEP), 2019).

The *livelihood support* pathway, therefore, reflects that biodiversity provides tangible resources (e.g. food, medicines, income) and the psychological reassurance of having biodiversity as a buffer against uncertainty. This pathway overlaps with, but is not fully captured by, existing pathways such as 'reducing harm' and 'building capacities', and aligns with definitions of livelihoods as the capabilities, assets and activities that enable them to meet their basic needs while maintaining dignity and preserving knowledge for future generations (Chambers & Conway, 1992; United Nations Millennium Project, 2005).

We therefore propose *livelihood support* as a distinct pathway that can operate independently of direct contact with nature. In our adapted framework (Figure 10), this pathway does not necessarily pass through the 'experience of biodiversity' node, reflecting how perceptions of biodiversity can influence health and well-being indirectly. This addition is particularly relevant in under-resourced urban contexts, where rapid urbanisation continues to reshape lives and landscapes (Serdeczny et al., 2017). Without this addition, biodiversity-health frameworks risk overlooking a crucial mechanism by which perceptions of biodiversity contribute to human health.

The ethnic and tribal diversity in Accra's urban communities, shaped by long-standing migration from other parts of Ghana and international migration from neighbouring countries, has important implications for perceptions of spirituality and livelihoods (Anarfi et al., 2003; Essuman-Johnson, 2006; Schürmann et al., 2022; Turolla & Hoffmann, 2023). While the explicit role of Indigenous knowledge did not emerge as a central theme in the interviews, the participants shared cultural beliefs, many of which have been passed through generations, that were clearly influential in shaping their understanding of the relationship between spirituality, livelihoods and biodiversity (Kelbessa, 2022; Manyam & Japheth, 2022; Nur, 2025). For example, African Traditional Religion is deeply interconnected with the natural world, shaping beliefs, practices and environmental stewardship (Alifa, 2023). This aligns with the broader, well-established link between spirituality, livelihood support and biodiversity in Indigenous societies (Berkes, 2017; Gadgil et al., 2022). Amidst ongoing urbanisation in Accra, these knowledge systems continue to inform residents' environmental perceptions and practices, highlighting the importance of integrating such knowledge into considerations of biodiversity-health relationships.

### 4.4 | Adapted framework

We present an adapted framework (Figure 10) that extends existing approaches linking biodiversity to human health by explicitly incorporating two pathways that emerged strongly from our findings: *spirituality* and *livelihood support*. These dimensions, while

often overlooked or embedded as contextual modifiers in existing frameworks (particularly those developed in high-income settings), were central to how participants in low-income settings understood their relationships with biodiversity. By integrating these pathways alongside established ones, the revised framework provides a more inclusive and contextually relevant tool for understanding and leveraging biodiversity's role in urban health, particularly in LMICs. This approach also strengthens the framework's usability for informing biodiversity and health policy in rapidly urbanising environments.

## 5 | CONCLUSION

This study makes three key contributions to understanding the pathways linking biodiversity and health in rapidly urbanising, lower income contexts. First, it reaffirms the relevance of existing biodiversity–health pathways such as ‘reducing harm’, ‘restoring capacities’, ‘building capacities’ and ‘causing harm’ within an LMIC setting. Second, it introduces two additional pathways (‘spirituality’ and ‘livelihood support’) that were central to participants' experiences but remain underrepresented in dominant conceptual frameworks. Third, it presents an empirically grounded adaptation of an existing framework that better reflects participant perspectives of how biodiversity contributes to health and well-being in urban life in LMICs.

Our proposed adapted framework aims to present a more inclusive understanding of pathways linking biodiversity and health in a rapidly urbanising lower income context. This is especially urgent amid converging global crises such as biodiversity loss, rapid urbanisation and widening health disparities, which require integrated responses. Crucially, the inclusion of spirituality and livelihood support as distinct pathways opens new directions for biodiversity–health research and highlights overlooked avenues for policy and practice. Urban planning, conservation and public health strategies must recognise and incorporate the diverse ways that people relate to nature, not just as an ecological resource but as a source of meaning, resilience and survival.

Photovoice, as used in this study, offered a powerful means of capturing how participants visually interpret and relate to the links between biodiversity and health in urban environments. While photographs represent direct encounters with biodiversity, they also elicited rich narratives, memories and meanings (Cleland & MacLeod, 2021; Fawns, 2023). At the same time, we acknowledge that biodiversity provides services, both seen and unseen, that extend beyond what can be visually captured (Bentley et al., 2023; Bratman et al., 2024; Ratcliffe, 2021). Photovoice is therefore one method among many for exploring biodiversity–health relationships. Future participatory research could incorporate other sensory approaches, such as audio recordings, filmmaking or walking (e.g. Borish et al., 2021; Bruce, 2025; Lauwers et al., 2021), to cover more aspects of the multisensory experiences of biodiversity.

Future research should test the applicability of this expanded framework across different geographic, cultural and demographic

contexts. By doing so, and centring local voices and lived experiences, we can build more responsive frameworks and policies to address the complex, interconnected challenges of our time.

## AUTHOR CONTRIBUTIONS

Amelia Browne, Jennifer Hodbod, Steve Sait and Martin Dallimer conceived the ideas and designed the methodology. Gerald A.B. Yiran assisted with participant recruitment. Amelia Browne collected and analysed the data and led the writing of the manuscript. All authors contributed critically to the drafts and approved the final version for publication.

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## CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## DATA AVAILABILITY STATEMENT

This research uses qualitative data from interviews with participants. Due to participant anonymity and the conditions of our research ethics approvals, we cannot share the data.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

**Table S1.** Participant sociodemographic characteristics.

**Table S2.** Codebook with predetermined (a priori) codes.

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