Health & Wellbeing Framework

Six Principles for a Healthy, Sustainable Built Environment

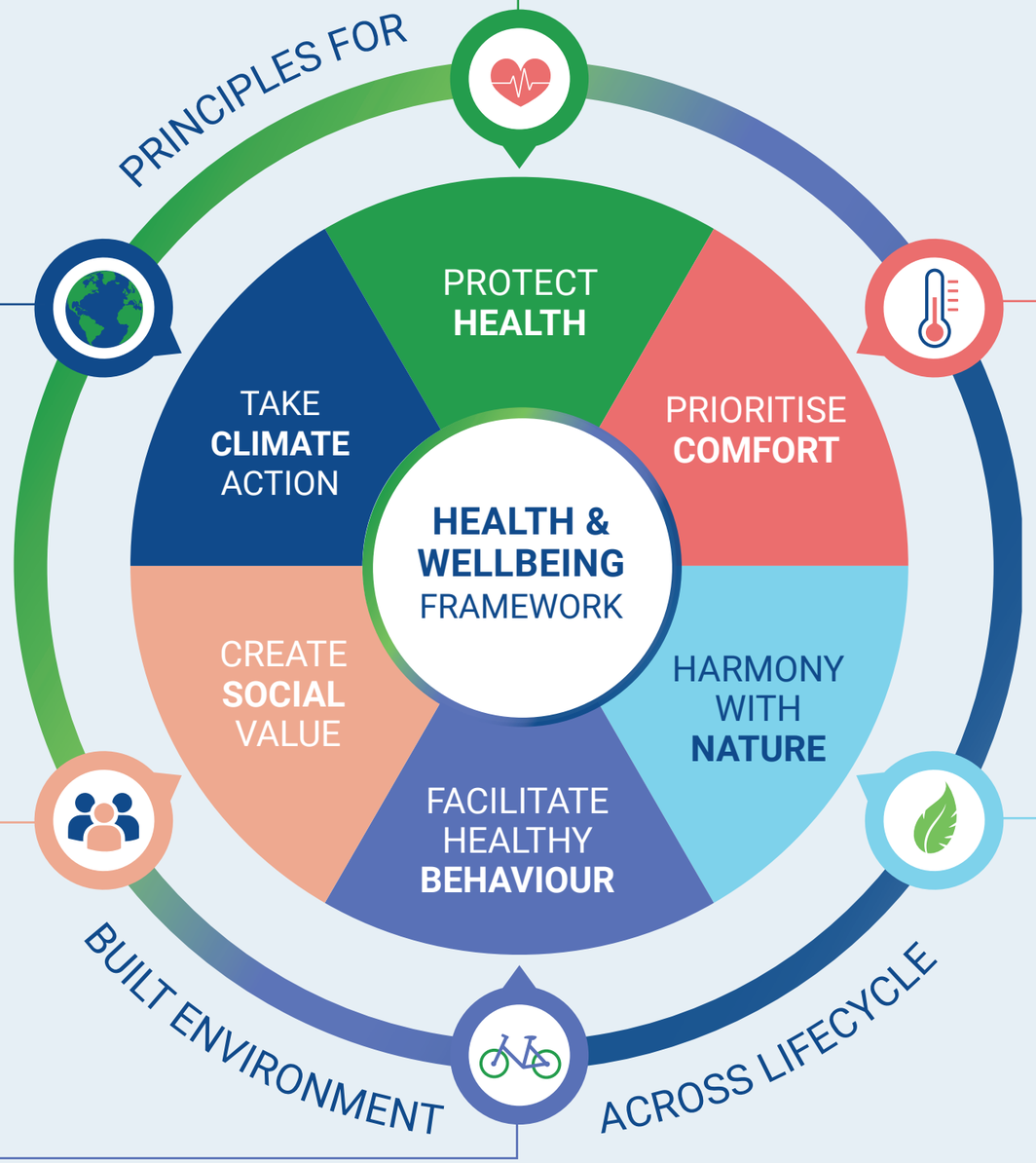
WORLD GREEN BUILDING COUNCIL

BETTER PLACES FOR PEOPLE

FULL REPORT
September 2021

The WorldGBC Health & Wellbeing Framework

Six Principles for a Healthy, Sustainable Built Environment



TAKE CLIMATE ACTION

Climate Change Mitigation

Adaptation and Resilience

Water Efficiency

Resource Efficiency

CREATE POSITIVE SOCIAL VALUE WITH BUILDINGS AND COMMUNITIES

Human Rights

Construction Worker Health

Community Health

Social Value

FACILITATE POSITIVE BEHAVIOUR AND HEALTH

Active Design

Nutrition

Hydration

Social Connectivity

PROTECT AND IMPROVE HEALTH

Air Quality

Water Quality

Mental Health

Infectious Disease

PRIORITISE COMFORT FOR BUILDING USERS

Thermal Comfort

Lighting

Acoustics

Visual

Ergonomic

Inclusive Design

DESIGN FOR HARMONY BETWEEN THE NATURAL AND BUILT ENVIRONMENTS

Biophilic Design

Access to Nature

Biodiversity

Nature-Based Solutions

Discover WorldGBC's Health & Wellbeing Framework online at
worldgbc.org/health-framework

About WorldGBC

The World Green Building Council (WorldGBC) catalyses the uptake of sustainable buildings for everyone, everywhere.

Transforming the building and construction sector across three strategic areas—climate action, health and wellbeing, and resources and circularity — we are an action network comprised of more than 70 Green Building Councils (GBCs) around the globe. As members of the UN Global Compact, we work with businesses, organisations and governments to drive the ambitions of the Paris Agreement and UN Global Goals for Sustainable Development. Through a systems change approach, our network is leading the industry towards a net zero carbon, healthy, equitable and resilient built environment.

The WorldGBC Health & Wellbeing Framework has been developed in partnership with the Better Places for People project Steering Committee and members of our network, building on the work in this area from our GBCs to date. The Framework serves to continue progressing this topic.

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Introduction

There are few issues relating to human health, wellbeing and quality of life that are not impacted, directly or indirectly, by the attributes of our built environment.

The built environment has a major influence on our quality of life. It underpins our communities, as it includes all types of buildings and the urban infrastructure that supports our daily lives - our homes, schools, workplaces, hospitality - and forms the foundation that makes our cities great places. However, buildings can also be silent adversaries to our own health and wellbeing.

It is time to unlock the huge potential that the building and construction sector can have in improving human health and quality of life. The industry needs to address its responsibility regarding the quality of our indoor environment, our mental and physical health, and influence on our behaviour. These considerations must also embrace the people involved along all stages of the building lifecycle, from the health of construction workers to the environmental impacts of how we source materials, construct and operate our buildings.

Health and wellbeing is a fundamental human right for all people.

The principles that underpin this framework consider broad socio-economic and environmental determinants of health for all people connected to the lifecycle of buildings and infrastructure - not only users or occupiers. This represents a progressive stance for the WorldGBC network. We are proud to champion this ambitious transformation.

Cristina Gamboa
CEO, WorldGBC

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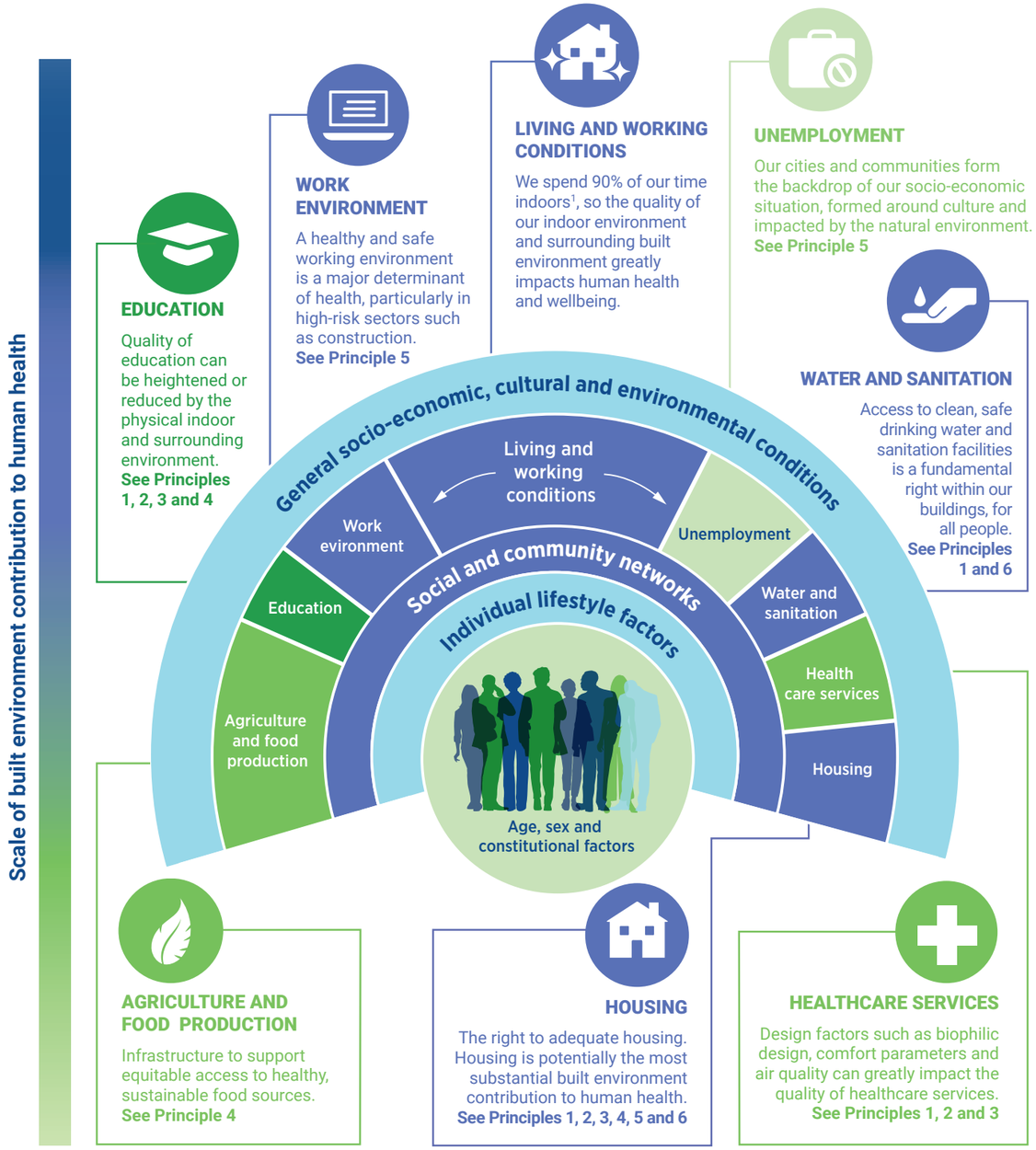
Mapping the determinants of health relating to the built environment

WorldGBC aims to catalyse change in industry ambition and transform the meaning of health and wellbeing for the sustainable building movement and wider sector. The WorldGBC Health & Wellbeing Framework equips the industry with the guidelines and tools to begin this fundamental transition.

The Framework is a high-level educational resource, structured across six core principles for health and wellbeing in the built environment. The principles are conceptual, allowing them to be universally applicable for an international audience and diverse range of stakeholders. It can be used by actors across the value chain, from designers to occupiers, construction firms to policymakers.

The goal of the initiative is to expand the scope and meaning of health and wellbeing for the industry and mobilise action-oriented solutions to the health and wellbeing challenges directly impacted by the building and construction sector. The full, digital version of the Framework is available at worldgbc.org/health-framework.

Determinants of health relating to the built environment



Based on Dahlgren-Whitehead 'Rainbow model', 1991.

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Redefining health and wellbeing

Health and wellbeing in the sustainable building movement: the light bulb moment

Over the past decade, stakeholders from businesses to policymakers have started to recognise that the quality of our built environment, indoors and outdoors, impacts strongly how we feel, the way we behave, and even our susceptibility to health risks.

Building rating tools including, or focused on, health & wellbeing have catalysed this increase in global awareness. A focus on enhancing productivity in the workplace has been a core driver, with the private sector recognising a business case for a health-focused indoor environment that supports the wellbeing & capabilities of the human capital within. The impact of the COVID-19 pandemic has heightened this awareness of the impact of the built environment on people's mental & physical health.

Awareness of human health and wellbeing has had a transformative impact on the design and operation of buildings in the past decade. **However, health and wellbeing in the sustainable building sector has for too long focused primarily on the building occupant.**

This focus on productivity has left other areas of health and wellbeing underdeveloped. The financial co-benefits of a healthy built environment have created such a powerful driver for sustainable buildings that the focus of design interventions for health have inadvertently shifted into one sector of society (in many cases, the people who may not have been most in need of dedicated health interventions).

The WorldGBC network recognises that the industry is ready for change. Topics such as social equity and value, community resilience to the climate emergency and nature-based solutions are rising in the sustainability agenda. Global recognition of the UN's Sustainable Development Goals has led to the appreciation of a more holistic view of sustainability. Both public and private sectors are recognising a responsibility for all sectors to tackle the three pillars: the social, economic and the environmental elements of sustainability. The built environment must do the same.

Our methodology for change

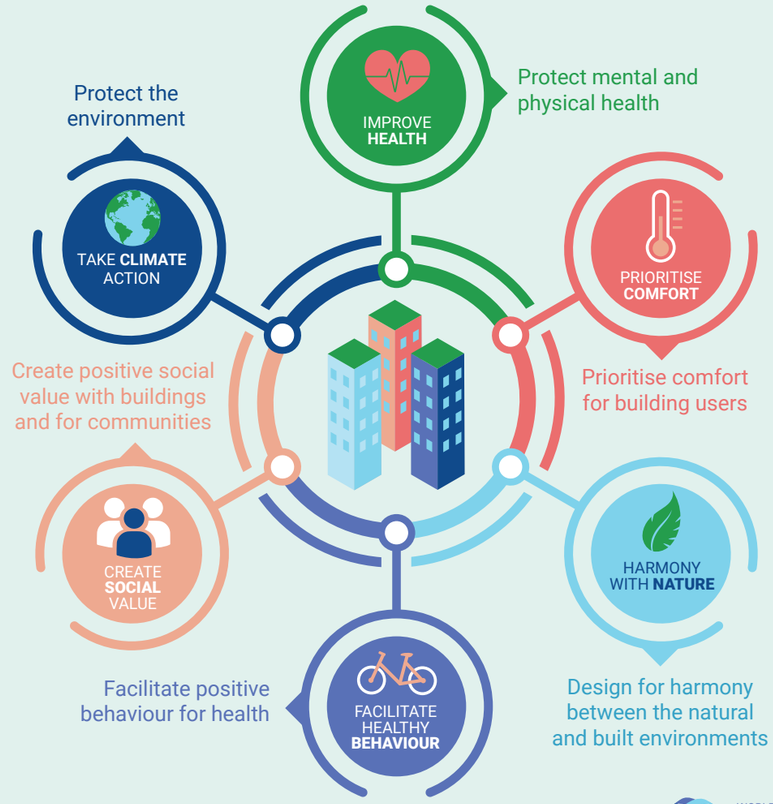
WorldGBC has led a two-year global consultation to redefine the scope of health and wellbeing in the built environment sector.

Our consultation has demonstrated that the built environment sector is ready to expand the focus of health and wellbeing into all sectors of society. A technical working group of Green Building Councils (GBCs) and industry partners was assembled to analyse determinants and drivers of health and wellbeing in the built environment and assemble key themes into a set of principles.

Our research involved focused engagement from GBCs, GBC members, public & private sector partners and policymakers from across the WorldGBC network. Through this extensive input, we believe our Framework offers a representative set of health & wellbeing principles for the sustainable built environment movement globally. We thank the dedicated members of the Health and Wellbeing Framework Taskforce, the full GBC Steering Committee, & the expert peer review panel for their support of this ambitious project.

WorldGBC Health & Wellbeing Framework

The Six Principles



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Key outcomes for the industry

WorldGBC is proud to announce ambitious new outcomes for the building and construction sector based on the principles of the Health & Wellbeing Framework. These include the inclusion of broader socio-economic & environmental determinants of health, & the drive for improving public and environmental health across the whole lifecycle of the building.

Human health, wellbeing and quality of life is impacted by social, economic and environmental factors, demonstrated through mapping against the UN Global Goals for Sustainable Development

- 1: No Poverty
- 2: Zero Hunger
- 3: Good Health and Wellbeing
- 4: Quality Education
- 5: Gender Equality
- 6: Clean Water and Sanitation
- 7: Affordable and Clean Energy
- 8: Decent Work and Economic Growth
- 9: Industry, Innovation and Infrastructure
- 10: Reduced Inequality
- 11: Sustainable Cities and Communities
- 12: Responsible Consumption and Production
- 13: Climate Action
- 14: Life Below Water
- 15: Life on Land
- 16: Peace, Justice and Strong Institutions
- 17: Partnerships

All people across the building lifecycle should have their health protected & enhanced

Our Framework principles call for the building and construction sector to take a whole lifecycle approach to human health and wellbeing, as people's quality of life is impacted at all stages.

Examples of interventions for health and wellbeing to consider at every stage of the lifecycle

1 DESIGN	2 PRODUCE	3 BUILD
All health and comfort parameters Active lifestyles Community design Net zero emissions resilience and circularity	Worker welfare Material emissions, non-toxicity and circularity	Worker welfare Community impacts Embodied carbon Access to nature

4 IN-USE	5 RE-USE	6 DECONSTRUCT
All health and comfort parameters Community engagement and social equity Net zero operational emissions Supporting healthy user behaviour	All health and comfort parameters Community engagement and social equity	Worker welfare Community impacts Embodied carbon Nature-based solutions Adaptation, resilience and circularity

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Using the Framework

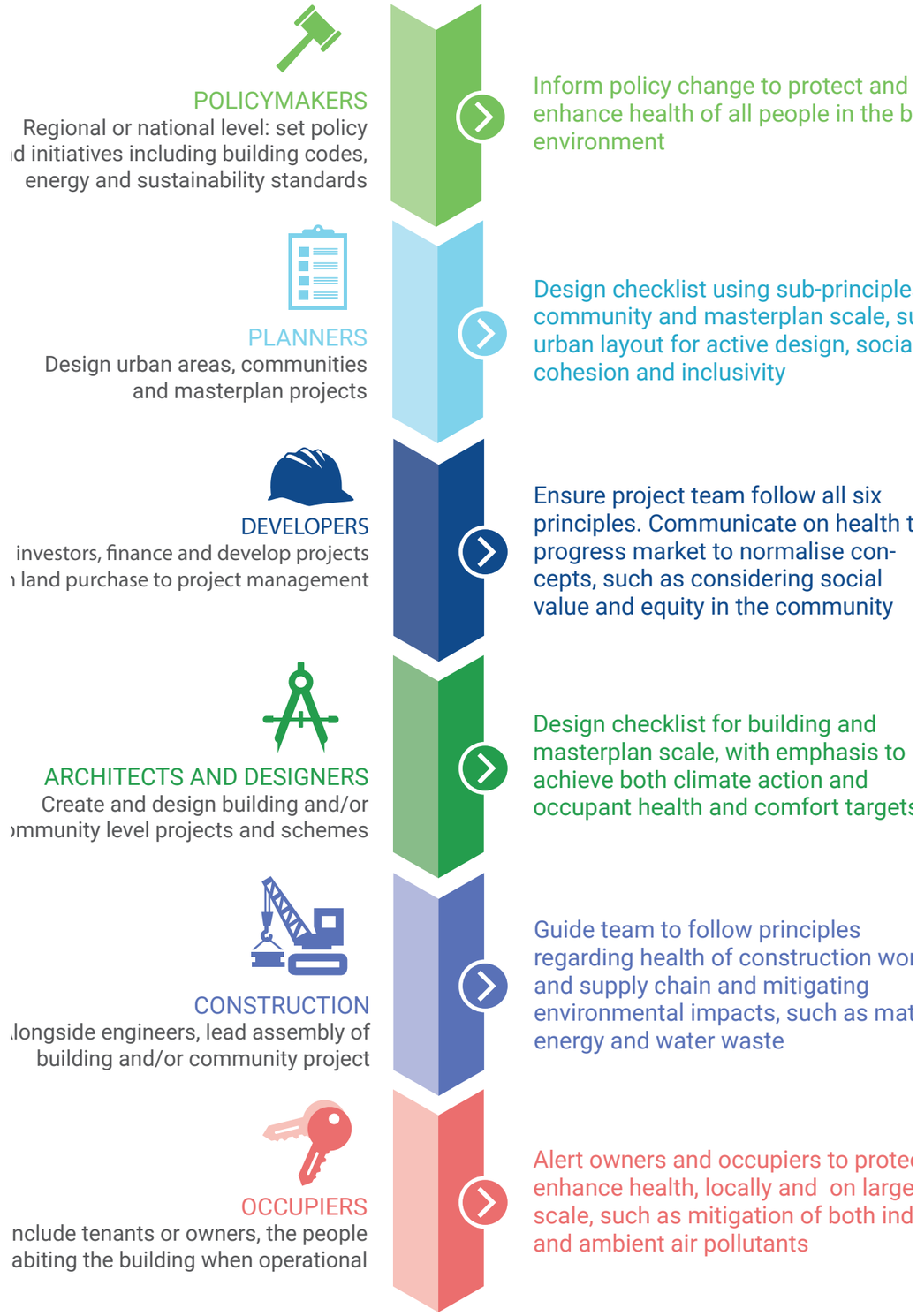
The Health & Wellbeing Framework can be used in a diverse range of ways, intended for use by all actors across the building and construction lifecycle.

An educational resource: The full version of the framework is available at (worldgbc.org/health-framework) . A live resource library has been created through consultation with the WorldGBC global network, including academic articles and building rating tools, and is regularly updated to ensure presentation of most relevant information.

A design stage checklist: The sub-principles of the Framework can be utilised as a checklist for design teams at early stages of project planning and throughout implementation to ensure that human health and wellbeing considerations are being addressed for building or community scale projects.

A stepping stone to certification: The Framework can act as a stepping stone to comprehensive national or international building certifications, which offer third-party validation of implementation of health and wellbeing strategies against standardised benchmarks. A global list of rating tools is available at: worldgbc.org/rating-tools.

An advocacy tool: Building and community level strategies can be analysed by city or regional scale policymakers to map alignment against building, construction and urban planning policies, design codes and standards, and highlight potential gaps in human health and welfare protection.



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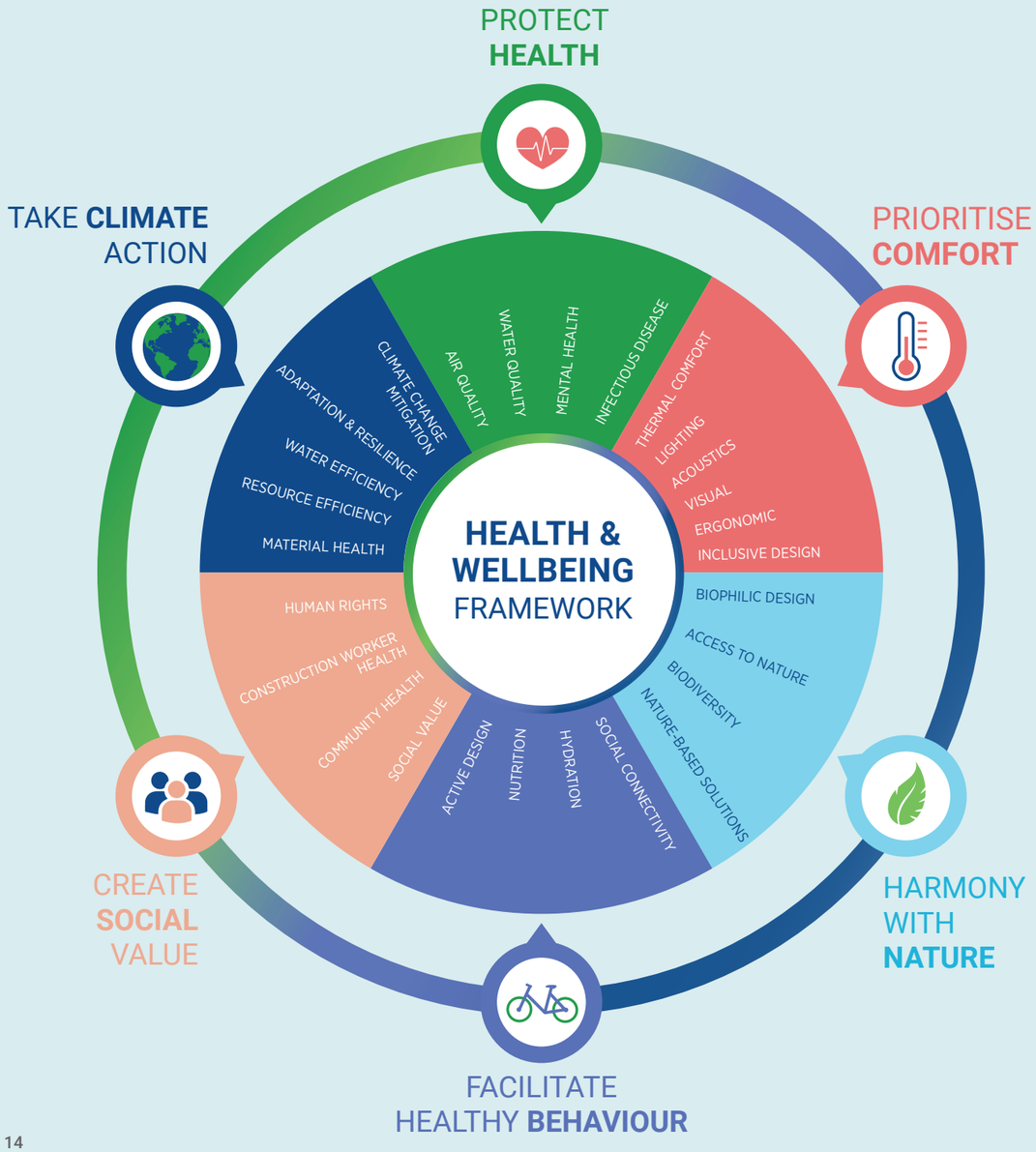
The WorldGBC Health & Wellbeing Framework

Six Principles for a Healthy, Sustainable Built Environment



1 PROTECT AND IMPROVE HEALTH

1.1 Protect people from air pollution by maintaining healthy indoor air quality, and improve air quality at building, community, and wider scale

State of health

'9 out of 10 people worldwide breathe polluted air' (World Health Organization[1])

Air pollution is considered today as the greatest environmental threat to human health, causing approximately seven million deaths each year[2]. Exposure to polluted air increases mortality risk to people from stroke, heart disease, pulmonary disease, lung cancer and respiratory infections[3]. Our buildings and cities across the world both expose people to indoor air pollution and contribute to the ambient (outdoor) pollution crisis. Both pollution sources have distinct causes across the building lifecycle and must be tackled accordingly to protect human health and wellbeing.

Indoor air quality

Studies suggest people spend 90% of their time indoors[4]. Therefore, exposure to pollutants within the home and other indoor environments can be highly damaging to human health, and worsened in sealed or contained indoor environments with reduced air flow. The primary causes of indoor air pollution that pose risk to human health are as follows:

- Household air pollution from solid fuel combustion: 3.8 million premature deaths are attributed to household air pollution annually[5], primarily due to the use of solid fuels and kerosene which creates toxic particulate matter through combustion. Primarily an issue in developing nations, where alternative sources of fuel can be scarce, the World Health Organization estimates that around 3 billion people worldwide lack access to clean or modern energy services for cooking[6]. Exposure to particulate matter can cause cardiovascular and respiratory disease and strokes[7].

- Household air pollution from gas appliances: gas stoves are used worldwide for heating and cooking, and often considered the 'clean and safe' upgrade from solid fuel combustion. However, research shows that pollutants released from gas appliances can lead to heightened nitrogen dioxide levels, which can worsen respiratory conditions such as asthma[8]. Gas is a fossil fuel; combustion of which releases greenhouse gas emissions, worsening climate change.

- Release of harmful gases and chemicals from materials: pollutants released within the indoor environment include volatile organic compounds (VOCs) from building or fit-out materials including paints and varnishes, adhesives and furnishings, and household items such as electronics and cleaning materials. Exposure to these pollutants can be concentrated in an indoor environment, and consequently trigger health issues such as nausea, headaches, respiratory irritation, and allergies[9]. Organically derived gases, such as radon, can also generate a form of indoor pollution that presents major health risks. Exposure to hazardous chemicals within buildings is further detailed in Principle 6.4 below.

- Biological contaminants: often linked to building quality, infiltration of air through cracks in the building façade (exterior) can cause damp, leading to mould and fungi growth within walls, releasing airborne microbial pollution within indoor air[10]. This occurs in both hot, humid climates and cold, temperate climates. Research has shown that asthma risk increases by up to 40% when occupants live in homes with mould[11].

- Infiltration from outdoors has also been identified as a significant health risk for people within buildings, with studies showing that 65% of our exposure to outdoor air pollution occurs indoors[12].

Ambient air pollution

Ambient, or outdoor, air pollution is caused by a range of factors, including transport, agriculture, and waste. The contribution of the built environment across the building and construction lifecycle is substantial and must be mitigated to protect human and environmental health. Causes of ambient air pollution related to the built environment include:

- **Manufacturing of building materials:** notably the use of highly polluting brick kilns, which contribute to up to 20% of global black carbon emissions, alongside steel and iron production[13]. 90% of global brick production is concentrated in central Asia, causing direct localised health impacts to local people. Emissions from production are further increased by transportation to global markets[11].

- **Building construction:** 11% of global energy-related carbon emissions are attributed to emissions embodied in the construction process, which further impacts human health through dust creation[14]. The release of toxic dusts from construction sites (such as silica or hardwood, which are recognised as having carcinogenic properties) creates localised extreme health hazards to construction workers and people living nearby[15].

- **Operational buildings:**
  - 28% of global energy-related carbon emissions are attributed to operational buildings, predominantly from energy used for heating, cooling and lighting[12]. The release of carbon emissions is a core contributor to climate change, explained as a health risk in Principle 6.1.
  - Fine particles (PM2.5) are emitted from the combustion of fuels to power our buildings, and for heating or cooking within, as well as from transport emissions[16].
  - The use of traditional cookstoves, open fires or kerosene lamps for heating, cooking, and lighting within homes in the developing world is responsible for up to 58% of black carbon emissions worldwide[17].

Outcome:
Building provides only clean air through the mitigation of air quality risks and incorporation of health-based strategies, whilst maintaining energy efficiency. Air quality should be enhanced at all stages of lifecycle, including construction workers, and protecting health of people within and outside, considering both building occupants and neighbouring people.

Strategies across the lifecycle

Tackling ambient air pollution:

Design:
- Support the switch to more efficient building material production, particularly around traditional brick firing

- Energy efficient building design (and renovation) to improve the quality of building envelope and consequential energy load for heating and cooling
- Passive design strategies, including energy efficient building fabric, vegetation, and ventilation, can reduce heating or cooling requirement within buildings and maintain comfortable living conditions (see Principle 2.1 for more detail)
- Sustainable urban planning also has a role in the reduction of air pollution, through mitigation of emissions from transport through a low or zero carbon infrastructure network

Construction:
- Dust production should be appropriately managed with national and organisational regulation, best practice and policy adherence on site, and other dust-reduction strategies. Off-site, modular construction practices can be preferable due to lower volume and more controlled dust production
- Suport the switch to more efficient building material production, particularly around traditional brick firing

Operation:
- Reduce operational and embodied carbon emissions (see Principle 6.1 for more information)
- Commit to monitoring indoor and outdoor air quality in real-time, to increase awareness and promote data-driven action to mitigate pollution sources and improve public health. Air quality monitoring can be undertaken as part of World Green Building Council's Plant a Sensor campaign.

Improving indoor air quality:

Design:
- Lessen exposure to hazardous chemicals in the indoor environment through conscious product selection and the use of low emission materials, such as low volatile organic compounds (VOCs) emission paints, sealants, adhesives, fixtures, fit-outs, and flooring as well as low- formaldehyde products
- Energy efficient building design and/or renovation to reduce risk of damp or mould build up
- Minimisation of potentially harmful chemicals in building materials (see Principle 6.4 for information)
- Proper filtration of air for forced air systems, particularly in locations susceptible to poor air quality, such as areas susceptible to wildfires

Construction:
- Removal of harmful materials from existing buildings
- Installing porous materials after 'wet products' (adhesives/sealants and paints/coatings) have been given a chance to off-gas, when possible

Operation:
- Use appropriate ventilation to remove indoor air and toxins to exchange with fresh and clean air into buildings, including designs that maximise cross-flow ventilation. Ventilation can be mechanical, mixed-mode or natural, with energy efficient solutions prioritised.

- Minimise the use of traditional cookstoves through access to clean fuels and technology within buildings, prioritising electric alternatives rather than gas-based
- Phase out fossil fuels, including gas, as an energy source worldwide, prioritising residential
- buildings
- Ensure localised extraction around gas appliances when used
- Inspect installation, maintenance, and cleaning of filtration and ventilation systems to ensure cleanliness, filter functionality and reduce the potential for mould and bacteria growth
- Commit to monitoring indoor and outdoor air quality in real-time, to increase awareness and promote data-driven action to mitigate pollution sources and improve public health. Air quality monitoring can be undertaken as part of the WorldGBC Plant a Sensor campaign

Benchmarks:
The World Health Organization (WHO) provides guidance on outdoor air quality, including information of particulate and gaseous pollutants. These outdoor values are also relevant for indoor environments due to close infiltration of pollutants between outdoors and indoors (research suggests an average of 65% of our exposure to outdoor pollution happens indoors[4]). The WHO Air Quality Guidelines (AQGs) for 24-hour mean concentration limits are[18]:
- PM2.5 less than 10 µg/m³
- PM10 less than 20 µg/m³

These figures are published as 'the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to long-term exposure to PM2.5'[19]. Interim targets, which reduce mortality risk to a lesser extent than the AQGs, are also available within the WHO Air Quality Guidelines.

There is no simple measure for indoor air quality due to the broad spectrum of parameters that are influenced by external and adjoining environments as well the activities and construction of the internal space. Common factors that contribute to the assessment of indoor air quality are volatile organic chemicals (VOCs) such as formaldehyde, and other gases including carbon dioxide and carbonmonoxide, ozone, nitrogen dioxide water vapour and radon; particulate matter; and biological components including bacteria, fungi (such as mould) and pollen; and 'odours'. Benchmarks for air quality and ventilation are embedded within country specific standards.

Examples of specific benchmarks or limit values used in international rating tools[20,21,22] are as follows:

- Carbon dioxide (CO_2): 800ppm
- Carbon monoxide (CO): 9ppm
- Formaldehyde (CH_2O): 27 ppb
- TVOC: 500 µg/m³
- Radon (Rn): 0.148 Bq/L [4 pCi/L]

An additional consideration for indoor air quality is humidity, which can heighten susceptibility to microbial airborne pollutants from damp or mould within a building. The American Society of Heating Refrigerating and Air-conditioning Engineers (ASHRAE) sets benchmarks for acceptable ventilation rates to control this risk. See also World Health Organization 'Guidelines for Indoor Air Quality: Dampness and Mould';

- ASHRAE Standard 62.1-2016 recommends that relative humidity in occupied spaces be controlled to less than 65% to reduce the likelihood of conditions that can lead to microbial growth
- Humidity levels significantly below 30% are considered less optimum for the respiratory system[23]. If the relative humidity is below 30%, the air is too dry

this can cause irritation of the mucous membranes of the nose and throat, and breathing difficulties in at-risk individuals (e.g., people with asthma). Dry air is also harmful to people with skin or eye conditions[24] .

In certain locations, filtration of air is required in addition to ventilation to ensure adequate air quality. MERV ratings of 11 or higher (or HEPA filters) provide air cleaning for pollutants that enter buildings or are recirculated in buildings. Residential homes can be designed to accommodate HEPA filtration.

1.2 Preserve water quality to minimise health risks

State of health

Access to clean and safe drinking water and sanitation facilities is a fundamental right within our buildings, for all people worldwide. Within this sub-principle we identify the specific health risks relating to water quality through the lens of built environment – water quality and sanitation and infrastructure.

Sanitation:
One-third of the world's population, 2.4 billion people, do not have access to adequate sanitation; 40% of the world does not have access to basic handwashing facilities[25]. Lack of access to poor sanitation is a leading risk factor for infectious diseases, including cholera, diarrhoea, dysentery, hepatitis A, typhoid, and polio. It ranks as a very important risk factor for death globally, with approximately 5% of deaths in low-income countries resulting from unsafe sanitation[26.] According to the Global Burden of Disease study, 775,000 people died prematurely in 2017 as a result of poor sanitation[27].

Water quality:
Health risks may arise from consumption of water contaminated with infectious agents, toxic chemicals, and radiological hazards. Improving access to safe drinking-water can result in tangible improvements to health[28]. Contaminated water can transmit diseases such diarrhoea, cholera, dysentery, typhoid, and polio as well as cause the ingestion of toxic materials, causing conditions such as lead poisoning[29]. Contaminated drinking water is estimated to cause 485 000 diarrhoeal deaths each year[30]. Micro plastics have emerged as an additional source of contamination[31].

The role of a sustainable built environment must be to enhance the quality of our infrastructure, serving occupants and surrounding community with clean, safe, accessible water. An important element to address is the disparity between developed and developing countries regarding buildings regulations and codes related to water quality. However, research studies in developed nations highlight that health risks persist worldwide: in 2015, at least 18 million Americans were served by water systems with lead violations[32].

Outcome:
All buildings should provide occupants with adequate, safe, and sustainable access to clean water and sanitation, whilst maintaining efficient use of water and striving for circularity on-site.

Strategies across the lifecycle

Regulatory:
- Implementation of universal health-based targets for water quality: locally developed standards and regulations, preventative risk management across the water supply chain (catchment to consumer) including filtration, with independent testing for microbiological and chemical compliance.

Operation:
- Test for toxins and contaminants, and roll-out of water treatment plans within the water distribution system. Smart water distribution systems can provide notification of testing results from the treatment plant within the distribution network to inform buildings of their risk management options
- Legionella management plan, controlling risk of legionella bacteria commonly found in water (mitigate risk of bacteria multiplication, particularly in temperature range of 20-45°C with available nutrients)
- Ensure regular, thorough cleaning takes place in communal areas like a shared kitchen and toilet facilities

Benchmarks:
The continuous delivery of safe water requires effective management and operation throughout the water-supply chain, from catchments to consumer taps and points of use. The WHO Guidelines for Drinking-Water Quality indicate that this is most effectively achieved through the Framework for safe drinking-water, which encompasses the following elements[33]:

- Establishing health-based targets as benchmarks for defining safety of drinking water
- Assuring safety by systematically assessing and managing risks
- Establishing a system of independent surveillance to verify the meeting of health-based targets

1.3 Support and enhance mental and social health through building and community design

State of health

Good mental health is related to mental and psychological wellbeing[34]. The global burden of mental health illnesses is significant. In 2010, mental illnesses and substance use disorders accounted for 183.9 million disability-adjusted life years (DALYs)[35] worldwide. It is estimated that the life expectancy among those with mental illness is over 10 years shorter compared to those without mental illnesses[36]. Considered building design can reduce stress, improve mental health, and positively impact comfort, well-being, and happiness, through the adoption of strategies such as biophilic design.

Outcome:
The built environment is designed and operated to enhance occupant & neighbouring community mental health & wellbeing. Ensure design strategies are accessible & inclusive to support social health for people of all levels of physical, cognitive & mental ability.

Strategies across the lifecycle

Design:
- Designing buildings to reduce occupants' stress, using strategies such as: incorporating biophilic design, aesthetically pleasing interiors, acoustic comfort, access to external views and integrated design, including the creation of break out and shared communal spaces

- Community and neighbourhood design to improve mental and social health, including access to nature, active space for exercise and design to facilitate social connection
- Design for social justice to reduce systemic stresses on under-represented communities, including racial justice and the suggested concept of direct mental and physical health impacts, which can be tied to under-lying conditions[37] (see Principle 5)

Regulatory:
- National services and programs access at a regional or national level, such as depression and mental health, suicide prevention, domestic violence and nutrition services
- Regional and national policies that advocate for increased availability and accessibility to housing, alongside tenure security, working towards increased general affordability of housing

Operation:
- Use post occupancy evaluation surveys to collect self-reported measures for occupant health and comfort
- Establish a feedback collection system for current occupants to share on the ongoing impact their built environment has on their mental and social health, such as via suggestion boxes

Benchmarks:
The World Health Organization has developed an Assessment Instrument for Mental Health Systems (WHO-AIMS) which is used for collecting information on the mental health system of a country or region, with the goal of collecting this information to improve and monitor mental health systems. The indicators include the presence of a mental health policy or plan as well as mental health expenditure. There is limited research available on benchmarks for building design for benefitting mental health. Incorporating bespoke strategies for specific projects, as well as awareness of other elements of the built environment that can impact an individual's mental and psychological wellbeing, is recommended.

1.4 Reduce infectious disease transmission within the built environment

State of health

In the 18-month period from 2019-2020 within which this Framework was developed and under consultation the COVID-19 pandemic changed the face of the planet, the atmospheric balance of pollutants and most substantially, human lifestyle, beyond any comparable alternative in peacetime history. As of October 2020, over one million have died from the coronavirus COVID-19 outbreak worldwide[38].
Research has suggested the primary route of transmission of COVID-19 is directly from person to person, which is applicable to many other infectious diseases. However, viruses also settle on surfaces, which can become heavily contaminated quickly, and virus survival on surface time remains uncertain. Guidance suggests that the COVID-19 virus can survive on inanimate objects and can remain viable for up to five days at temperatures of 22-25°C and relative humidity of 40-50% (which is typical of air-conditioned indoor environments)[39]. Estimates range from a number of hours to days, depending on the material and conditions[40]. Therefore, regularly cleaning surfaces, appliances and working locations and thorough handwashing are important[41].

survive on inanimate objects and can remain viable for up to five days at temperatures of 22-25°C and relative humidity of 40-50% (which is typical of air-conditioned indoor environments)[39]. Estimates range from a number of hours to days, depending on the material and conditions[40]. Therefore, regularly cleaning surfaces, appliances and working locations and thorough handwashing are important[41].

Ventilation and filtration strategies can also play a role in reducing disease transmission. Increasing the amount of air flowing in from outside and the rate of air exchange can dilute virus particles indoors, however, high air flow could also stir up settled particles and put them back in the air[42]. Research has also demonstrated the importance of lessening exposure to air pollution, particularly around particulate matter (PM). The Harvard School of Public Health have identified that a small increase in long-term exposure to PM2.5 leads to a substantial increase in the COVID-19 death rate, approximately 8% higher[43].

Outcome:
The indoor & outdoor built environment actively mitigates risk of infectious disease transmission, including both strategic design measures & implementation of building policies to enhance health, whilst maintaining energy efficiency.

Strategies across the lifecycle

Design:
- Use of technology to minimise physical contact within the building, such as sensor type activation for lifts, fixtures, and security control

Operation:
- Pandemic planning, (including planning for the reopening of buildings)
- Employ operational concepts to reduce/counter infectious disease transmission (including regular checks of the HVAC system and filters, replacing as indicated or needed)
- Clean/disinfect areas such as high touch surfaces sanitising, handwashing, social distancing provision
- Control of microbial count and bacteria (e.g. use of UV lamps, testing of surfaces)
- Maintain and clean pipes/faucets to prevent legionella in buildings that have been unoccupied as a consequence of the COVID-19 pandemic
- Monitor and implement health guidance from national government and other authorities
- Consider and mitigate wider sources of internal disease transmission, including fungal spores and pest control

Benchmarks:
Benchmarks around infectious disease mitigation measures related to the general built environment design and operation, particularly around COVID-19, do not exist at time of writing. We therefore share some useful guidance documents that offer tools for the built environment sector:
- The American Institute of Architects (AIA). 2020. 'Re-occupancy Assessment tool': http://content.aia.org/sites/default/files/2020-06/STN20_%20344901_ReOcc...
- ArcSkoru. 2020. 'Arc Re-entry': https://arcskoru.com/sites/default/files/Arc%20Guide%20to%20Re-Entry.pdf
- Guide to Pandemic Planning: http://bomacanada.ca/wp-content/uploads/2020/01/BOMA-Guide-to-Pandemics-...
- Centers for Disease Control and Prevention (CDC). 'Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation': https://www.cdc.gov/coronavirus/2019-ncov/php/building-water-system.html

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2

PRIORITISE COMFORT FOR BUILDING USERS

2.1 Ensure consistent thermal comfort with awareness of varying occupant needs, to enhance wellbeing

State of health

Thermal comfort is a primary indicator of human wellbeing, and the built environment's provision of shelter is a fundamental element of its very purpose. Design at both community and building level can substantially impact both the feasibility and energy requirements for achieving thermal comfort in a building.

Building design and operation relating to thermal comfort are influenced by a broad spectrum of environmental and socio-economic factors, which can both protect and heighten risks to the health of the occupant. Furthermore, population susceptibility to climate change is increasing, heightening exposure to both dangerous heat and cold temperature events across the world. Globally, extreme temperature events are observed to be increasing in their frequency, duration, and magnitude and this trend is predicted to continue[1].

Between 2000 and 2016, the number of people exposed to heat waves increased by around 125 million; in 2015 alone, 175 million additional people were exposed to heat waves compared to average years[2]. Such heat wave exposure causes heat illness (dehydration, heat cramps, heat stroke), and accelerated death from respiratory disease, cardiovascular disease and other chronic diseases. Additionally, continual exposure to cold temperatures (particularly in the home) increases the risks of cardiovascular, respiratory and rheumatoid diseases and may also negatively impact mental health. Cold homes are a significant contributor to the level of excess winter deaths in temperate climates[3].

Outside weather extremes, thermal comfort can affect people's mood, performance and productivity, with research showing a correlation between perceived comfort and productivity[4]. This is particularly true of overheating – however, creating the necessity for mechanical cooling interventions can lead to an increase in carbon emissions from energy expenditure. Humidity control also affects comfort and the spread of disease, which should be studied from a local climatic perspective to strike a balance of health and comfort.

Refrigerant management is a linked key issue, as cooling technologies utilised for thermal comfort and healthcare purposes across the world are emitting large quantities of HFC, a potent greenhouse gas and climate change forcer[5] (see Principle 6.1 for more information).

Outcome:
Design for user control of heating, cooling, and humidity control in space to ensure optimal individual comfort in operational buildings, while maintaining energy efficiency with broad consideration of the environment. Sustainable master-planning mitigates community level thermal comfort issues, such as the (Urban) Heat Island effect.

Strategies across the lifecycle

Design:
- Use of master-planning principles in new or retrofitted buildings on community scale, offering protection from environmental elements, e.g. neighbouring buildings shading or spacing to control solar or convective gain and heat loss from wind and design to prevent Heat Islands
- Air tightness and ventilation: an airtight envelope, together with natural or mechanical ventilation, can control the indoor thermal environment by managing the air exchanges with the outside
- Passive heating and cooling (thermal massing): the materials used to construct the building have an impact on how quickly changes in weather conditions are felt. Materials with a higher thermal mass will take longer to change to ambient temperature conditions, and therefore can act as a natural heat store during daytime with slow release at night
- Design to utilise beneficial solar gain: through its overall shape, orientation, number and size of windows and the ability of surfaces to reflect heat, the building envelope can control how much heat from the sun (solar gain) is allowed to enter into the building
- Insulation: Insulating the building envelope and the use of thermally efficient glazing reduces heat loss in winter and conduction heat gains in summer
- Retain existing trees: A tree is a natural air conditioner and can help to reduce urban heat island effect. The evaporation from a single tree can produce the cooling effect of ten room-sized, residential air conditioners operating 20 hours a day. Tree windbreaks can reduce residential heating costs 10-15%; while shading and evaporative cooling from trees can cut residential air-conditioning costs 20-50%[6]
- Incorporation of Passive House Design Guidelines[7] to achieve thermal protection whilst maximising energy efficiency opportunity
- Adoption or influence of traditional, vernacular design architectural strategies

Operation:
- User policy to allow flexibility for building user to meet individual's varying comfort needs
- Aftercare initiatives to ensure occupant awareness of building management for comfort

Benchmarks:
The following organisations offer suggested benchmarks for thermal comfort:
- American Society of Heating Refrigerating and Air-conditioning Engineers (ASHRAE) Standard 55-2017 notes that for thermal comfort purposes, indoor temperatures could range from between approximately 67 and 82 °F, or 19 and 28°C[8]
- ASHRAE Standard 62.1-2016 recommends that relative humidity in occupied spaces be controlled to less than 65% to reduce the likelihood of conditions that can lead to microbial growth
- CIBSE suggests for offices that the temperature ranges for comfort should be graduated depending on geography and culture. For air-conditioned buildings this should be 21-23°C in winter and 22-24°C in summer[9]
- Higher temperatures are acceptable for buildings in tropical climates, for example the Hong Kong government recommend 25.5°C as optimum indoor temperature for air-conditioned spaces, striking a balance of comfort and energy conservation[10]
- The WHO 'Housing and Health Guidelines' (2018) recommendation indoor housing temperatures of 18°C (and over) for countries with temperate or cold climates to protect occupant health at cold periods
- Legislation and guidance around temperature depends on building use. UK law states work environments should be at least 16°C in more sedentary workplaces, and above 13°C where work requires physical effort[11]

Passive House Guidelines offer guidance and benchmarks on design elements including thermal protection and airtightness; available at: https://passivehouse-international.org/index.php?page_id=80

2.2 Maintain exemplary lighting for occupant well being, to enhance wellbeing, with natural and energy-efficient solutions prioritised

State of health

Natural light regulates the human body's circadian rhythms, impacting sleep quality and therefore overall health. This is often disrupted by technology, noise and light pollution, facets of a typical modern, urban lifestyle.

Within a building, exposure to artificial lighting can disrupt circadian rhythms, making it more difficult to be alert and to maintain healthy sleep patterns. Inadequate lighting can create eye strain and cause headaches. Studies have shown that exposure to natural light during the working day leads to 46 minutes more sleep each night[12]. Conversely, workers in windowless environments report poorer sleep quality[13], which has consequential negative effects on worker productivity.

Exposure to natural light offers additional benefits within a built environment. Direct sunlight can provide beneficial solar gain, reducing heating requirements in temperate climates, and allowing daylight into buildings can assist in the prevention of damp, mould and bacteria growth, lowering the risk of asthma and other respiratory diseases[14]. The risk of overheating from solar gain must be managed to maintain thermal comfort.

Outcome:
Provision of adequate artificial lighting that is flicker free, meets minimum requirements for lighting colour, have little glare and ideally, have localised lighting controls and is appropriate for space use. All lighting should be energy efficient.

Strategies across the lifecycle

Design:
- Maximise use of natural light, using screens and blinds to minimise glare where necessary
- Avoid the specification of glossy finishes and surfaces
- Specify light-coloured opaque shading devices (e.g. blinds) to prevent direct sunlight but allow daylight penetration

Construction:
- Require luminaires are installed at a height of 5m (16 ft) or lower meet UGR of 17 or lower, or luminaires installed at a height greater than 5m (16 ft) meet UGR of 20 or lower

Operation:
- Develop a glare control strategy in tandem with any lighting strategy; ensuring glare reduction measures do not increase energy used for lighting, by maximising the potential for daylight in all weather and ensuring that the location of shading does not conflict with the operation of lighting control
- Consider manually or automatically operated blinds to minimise glare.
- Coordinate Internal layout for comfort, e.g. location of computer screens with lighting and window locations to avoid glare

Benchmarks:
- Ensure annual sunlight exposure of ASE1000,250 is achieved for no more than 10% of regularly occupied space
- CIBSE provides international guidance on recommended indoor lighting levels (lux) based on space type[15]
- Minimum Colour Rendering Index (CIR) of 80
- Saint-Gobain 'Multi-Comfort' principles: Visual Comfort

2.3 Maintain acoustic comfort

State of health

Prolonged exposure to noise can lead to serious health effects, including cardiovascular diseases[16], elevated blood pressure, cognitive impairment, and mental health problems (including stress and burnout) as well as sleep disturbances and a feeling of discomfort affecting general wellbeing[17]. Over time these effects have a detrimental impact on wellbeing and perceived quality of life. The World Health Organization has reported noise is the second largest environmental cause of health problems, following the impact of air quality (particulate matter)[18].

The European Union has reported that people exposed to night noise levels above 40dB on average throughout the year can suffer sleep disturbance, while long-term average exposure above 55dB can trigger elevated blood pressure and lead to ischaemic heart disease[19]. Environmental noise causes approximately 16,600 cases of premature death in Europe each year, with almost 32 million adults estimated to suffer annoyance and over 13 million adults estimated to suffer sleep disturbance[20].

In the UK, a study estimated that 54% of the population was exposed to noise pollution above recommended levels of 55 decibels[21]. Exposure to air traffic noise has also been linked to a negative impact on student performance in educational institutions, recording a significant relationship to poor reading and mathematical performance[22].

Outcome:
Mitigation of steady state noise exposure: this is defined as noise, the level of which does not change by more than 5dB at a given place and during a given time period. Continuous background sound in offices is mostly generated by heating, ventilation, and air conditioning (HVAC) equipment. External noise should be mitigated with building features as far as possible, as openable windows should be optimized for ventilation control and therefore not be relied upon as acoustic control.

Strategies across the lifecycle

Design:
- Control reverberation noise: opt for natural sound absorbing products such as carpets

and thick curtains over hard flooring and modern blinds can have the effect of amplifying noise. To control reverberation time, acoustic absorption is used, usually in forms of either fibrous materials or open-celled foam[23].

- Acoustic and thermal comfort strategies can often be complementary: a well-insulated building can assist in shielding the occupant from outdoor noise sources

Benchmarks:

- The World Health Organization make the following recommendations within 'Environmental Noise Guidelines for the European Union'[26]:
  - Road traffic noise: reduce noise levels produced by road traffic below 53 decibels (dB) Lden (day evening night level)
  - Railway noise: reduce noise levels produced by railway traffic below 54 dB Lden in daytime, and below 44 dB Lnight as night noise exposure levels
  - Aircraft noise: reduce average noise levels produced by aircraft below 45 dB Lden during daytime, and below 40 dB Lnight as night-time aircraft noise exposure Leisure noise: reduce yearly average from all leisure noise sources combined to 70 dB LAeq,24h

- Saint-Gobain 'Multi-Comfort' principles: Acoustic Comfort

2.4 Consider wider comfort indicators to support occupant wellbeing, including olfactory, ergonomic, and visual comfort

State of health

The built environment can be directly responsible for a range of human health and comfort influencers that are outside 'traditional' building design conscience. Wider comfort indicators include olfactory, ergonomic, and visual comfort. Olfactory discomfort from unpleasant odours can trigger eye, nose and throat irritation, nausea, and headaches. Repetitive tasks and visual discomfort can strain muscles and ligaments, leading to decreased occupant health and wellbeing.

Wider comfort indicators can also extend to consider beyond the 'traditional' scope of design for health, wellbeing and quality of life; "Comfort alone is not enough. We need to continue to develop a deeper understanding about the effects of the environment on the health and wellbeing of people and widen our scope of design to produce more flourishing, stimulating, creative and productive places for people…" (BCO, 2018). Design and operational factors that can produce the additional 'flourish' factor may include interior design and aesthetics, colour, character, layout and functionality, space, access to views, nature, and greenery[27].

Outcome:
A built environment that incorporates strategies to improve occupant visual, olfactory and ergonomic comfort, whilst actively mitigating wider wellbeing risk to people. Visual comfort and interior design for aesthetics should be designed in accordance with guidance on hazardous chemicals in Principle 6.4.

Strategies across the lifecycle

Design:

- Design of interiors and outdoors for visual stimulation, aesthetic pleasure and comfort
- Olfactory: Limiting the spread of odours by separating source (sources may include restrooms, kitchens and cleaning products) using pressurisation, self-closing doors and design strategies (such as hallways)

Operation:

- Ergonomics: furniture interventions can include adjustable workspaces, sit to stand desks, adjustable chairs

Benchmarks:

- BCO Wellness Matters. Roadmap: 'Sense' and 'Inside' sections http://www.bco.org.uk/HealthWellbeing/WellnessMatters.aspx
- Clements-Croome 2018. 'The Flourish Framework'
- ISO 21542:2011 - Accessibility and Usability of the Built Environment
- Ergonomics: Ergonomics - BIFMA G1 standard and guidelines

2.5 Ensure inclusive design of the built environment

State of health

'Inclusive Design is the design of an environment so that it can be accessed and used by as many people as possible, regardless of age, gender and disability'; The Inclusive Design Hub[28].

Recent World Health Organization publications estimate that 15% of people worldwide have a disability[29], of whom 2-4% experience significant difficulties in functioning. Blindness and vision impairment are particularly prevalent, estimated to affect at least 2.2 billion people around the world[30]. This proportion of disability in the global population is increasing, due partially to improvements in measurement capabilities to assess disabilities, but also the ageing global population. The global population aged 60 years or over has doubled since 1980[31]. The number of older persons is expected to double again by 2050, when it is projected to reach nearly 2.1 billion.

Outcome:
Inclusive design must keep the diversity and uniqueness of each individual building occupant in mind, considering all people utilising a built environment, including those with mental and physical disabilities as well as vulnerable and ageing populations. An environment that is designed inclusively must apply to buildings, their surrounding open spaces, and local urban infrastructure and services.

Strategies across the lifecycle

Design:

- Universal design for inclusion, conscious of diversity and accessibility, increases usability, safety, health, and social participation[32]: follow principles of inclusive design for the built environment[33] published by the Commission for Architecture and the Built Environment (see More Information)
- Design strategies for dedicated populations, ranging from accessibility measures to enhanced social engagement interventions for ageing groups: Age-friendly environments should include particular measures to increase safety and security of older people and ensure continued

engagement with community; Design to cater for partially sighted people should ensure clear differences between colour of pillars and floors, between steps and change in levels

- Built environment professionals should involve potential users at all stages of the design process; from the design brief and detailed design through to construction and completion. Focus on identification of barriers to inclusion as early as possible within the design process means that good design can overcome them

Operation:

- Create a culture of accessibility: enabling environments can be physical, social and attitudinal. Accessible environments are particularly relevant for people with different levels of abilities while also benefiting the broader population
- Supportive company policies to support diversity in the workforce, including flexible scheduling, child and elder care support, diversity and inclusion and wage equity policies, paid parental leave and civic engagement and gathering input and feedback from employees

Benchmarks:

- International Organization for Standardization: ISO 21542:2011, 'Building Construction - Accessibility and Usability of the Built Environment': https://www.iso.org/standard/50498.html

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DESIGN FOR HARMONY BETWEEN THE NATURAL AND BUILT ENVIRONMENTS

3 .1 Ensure occupant access to nature within buildings, providing biophilic benefits to people

State of health

By 2050, it is expected that 68% of the developed world will be urbanised[1]. With advancing urbanisation, the human species is becoming increasingly distanced from nature. The incorporation of nature into the indoor environment is referred to as biophilic design, connecting people to nature both inside and outside buildings. Biophilic design is understood to reduce stress, enhance creativity and clarity of thought, improve our well-being and even progress healing[2].

Due to humans' affinity to the natural world, interaction with nature in and around buildings enhances a sense of wellbeing by addressing our innate psychological need to be part of natural world. Biophilic design contributes to a wider nature-based sustainability in which we aspire for buildings and cities to progress in development in symbiosis with vegetation.

There have been numerous studies within recent decades on the benefits to the built environment through improving a connection to nature:

- Commercial buildings / Offices: productivity increases of 8%, wellbeing improvements up by 13%, with reports of heightened creativity, reduced absenteeism and presenteeism
- Hospitality: rooms with views of biophilic elements command 23% higher value
- Education: reported improvements in learning by up to 25%, showing improved test results, concentration levels and reduced impacts of ADHD
- Healthcare: patient recovery times decreased by 8.5%, with 22% reduction in pain medication
- Retail: reports of customers willing to pay 8-12% higher prices for goods and services
- Homes: 7-8 % less crime attributed to areas with access to nature, can command an increase of 4-5% in property price, and create comfortable, restorative environments for the occupants[3].

Outcome:
Buildings to ensure occupant access to nature within the indoor environment, following principles of biophilic design to maximise mental and physical health and wellbeing benefits for occupant.

Strategies across the lifecycle

Design:
Biophilic design guidance includes:

- The incorporation of nature through environmental elements, lighting, and space layout – examples include terraces, indoor water features, green walls, and gardens
- The incorporation of nature's patterns and natural materials in design
- Opportunities for human interaction with nature
- Consideration of sound isolation of buildings to protect surrounding nature and outdoor environment

Benchmarks:
Biophilic design patterns are flexible and replicable strategies for enhancing the user experience that can be implemented under a range of circumstances, and also require consideration of locally appropriate design[4]. Benchmarks to standardise good practice in achieving appropriate levels of biophilia are therefore infeasible to dictate on a global scale. Design teams are encouraged to research and replicate local good practice,

in and outdoors.

3.2 Ensure occupant access to nature outdoors, encouraging biodiversity within site footprint and surroundings

State of health

There is significant evidence demonstrating the positive impacts of green space and biodiversity on both human health and wellbeing and urban space[5].
The percentage of the global population living in urban areas is set to increase to 68% by 2050[6] and biodiversity contributes to the liveability of our urban spaces. The human benefits of urban green space include reduced morbidity and improved physical health outcomes, improved mental well-being, increased social cohesion and the provision of ecosystem services that can offer human health co-benefits, such as air cooling and air quality[7].

Access to good quality outdoor green space is associated with positive health outcomes[8], including:

- improvements in mental health and wellbeing, such as depression, stress, dementia
- increased longevity in older people
- lower body mass index (BMI) scores, overweight and obesity levels and higher levels of physical activity better self-rated health

Access to green space is often impacted by socio-economic factors. People living in the most deprived areas are less likely to live near green spaces and will therefore have fewer opportunities to experience the health benefits of green space compared with people living in less deprived areas[9]. An inequitable distribution of parks and other green spaces could exacerbate health inequalities if people on lower incomes, who are already at greater risk of preventable diseases, have poorer access[10].
Green infrastructure integrates the natural world into the physical fabric of buildings, and is frequently implemented with green walls, green roofs, and vertical gardens, particularly for high rise buildings. Green infrastructure offers benefits including; the removal of air pollutants, reduction of urban air temperatures and passive thermal benefits to buildings, improvement of local biodiversity through the provision of habitat for flora and fauna, rainwater attenuation, noise reduction and improved sense of wellbeing through biophilic connection for occupants[11]. Additionally, blue infrastructure (water-focused) incorporated within urban design can further contribute to the expansion of biodiversity, as well as creating desirable habitats to encourage activity behaviours. Both green and blue infrastructure incorporated in the urban environment can support the mitigation of species loss.

Outcome:
Access to quality green space on building footprint, in addition to local community. Maximise biodiversity on site and encourage implementation of nature-based solutions at community level.

Strategies across the lifecycle

Design:

- Implementation of green infrastructure in building design, such as: shared landscaped courtyards and/or grounds, particularly in areas of social and economic deprivation; green roofs which can significantly reduce the cooling load of a building, resulting in reduced cooling requirements and therefore reduced energy consumption and associated output of atmospheric carbon dioxide[12]
- Incorporate endemic ecological planting. Ensure incorporation of native plant species to support local flora and fauna
- Incorporate ponds, waterways, and wetlands. Ponds and wetlands offer habitats to encourage biodiversity, plus function as Sustainable Drainage Systems and pollutant control resources[13]
- Rehabilitation of degraded land. Repair land degradation and protect from multiple forces of risk, including extreme weather conditions (particularly drought), and human activities that pollute or degrade the quality of soils and land utility
- Dedicated fauna underpasses at crossings to assist in avoiding collisions between vehicles and animals
- Consider and mitigate risk of introducing pathogens and pests into the environment when introducing flora and fauna

Benchmarks:

- Biodiversity Assessment: the impact on biodiversity of a project can be measured assessing the value of habitats including the quality and quantity of biodiversity gained and lost, comparing the ecological value pre, and post construction on a site by site basis.

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4 FACILITATE POSITIVE BEHAVIOUR AND HEALTH

4.1 Design to promote activity, indoors and outdoors, to encourage physical health of occupants

State of health

Diets inextricably link human health with environmental conditions and sustainability. To feed a future population of ten billion people a healthy, sustainable diet whilst also operating within planetary boundaries requires the transformation of eating habits, improving food production and reducing food waste[1].

Human relationships with food, and the impact on our collective and individual health must also be examined. Obesity is the most prevalent major public health crisis relating to food consumption; in 2016, 1.9 billion adults were overweight[2] of whom approximately one third were obese. The incidences of obesity close to tripled between 1975 and 2016[2], and now equates to around 13% of the world's adult population and continues to rise.

Physical inactivity and sedentary behaviours are risk factors for other non-communicable diseases such as cardiovascular diseases, diabetes, musculoskeletal disorders and some cancers. Physical inactivity is estimated to cause more than 5 million premature deaths annually across the globe, representing 9% of all deaths[3]. The built environment is one of the many complex factors that influence peoples' activity levels and lifestyles, and consequently physical health. Research has found that low levels of neighbourhood walkability were positively associated with more sedentary lifestyles[4].

Outcome:
Buildings and local community play a supportive role in the healthy lifestyle of occupants, including the reduction of obesity, by designing the space to encourage regular physical activity, reducing barriers to accessibility, availability and affordability.

Strategies across the lifecycle

Design:

- Centrally located, visible and aesthetically pleasing stairwells within buildings and indoor public areas
- Access to end of trip facilities to promote physical activity before, during and after work (including walking/riding to work, e.g. bicycle parking, changing facilities)
- Access to public transport to reduce personal car use
- Urban master-planning prioritising safer street design to encourage heightened personal activity and exercise levels, e.g. connected neighbourhoods with pedestrian footpaths, access to public exercise grounds such as sports fields, outdoor gyms, cycle paths, central cycle parking, etc

Operations:
- Active services during work in office buildings (e.g. staircases, standing or treadmill desks in the office)
- Access to transportation and end of trip facilities to promote physical activity to and from work (including walking/riding to work, e.g. bicycle parking, changing facilities)

Benchmarks:
- The WHO recommends that adults should do at least 150 minutes of moderate-intensity aerobic physical activity per week[5]
- Urban planners should consider the principles of the Bloomberg Partnership for Healthy Cities and WHO's Healthy Cities Network

4.2 Encourage beneficial lifestyle practices for occupants, including nutrition, hydration and social connectivity

State of health

Nourishment

Nourishment is essential to good health. A growing body of population-based epidemiological evidence has shown the importance of nourishment in preventing and controlling noncommunicable diseases as well as preventable chronic diseases[6]. At the same time, changes in the production and distribution of food have meant that highly processed and sugar rich foods are in greater supply. The WHO estimates that globally, most people do not consume the recommended daily amount of fruits and vegetables, and this is leading to over 1.7 million deaths each year[7].

'Food Deserts' are regions that have lessened access to healthy food, broadly due to socio-economic factors such as income or location. People who live in regions categorised as 'food deserts' are recognised as being at a higher risk of diet-related conditions, such as obesity, diabetes and cardiovascular disease[8]. Sustainable urban planning and operational building policies, to support local communities, can be helpful factors in addressing this socio-economic health issue.

Hydration

Hydration is of fundamental importance to health and wellbeing as without water humans can survive only for days[9]. Water comprises of 75% body weight in infants to 55% in elderly people and is essential for cellular homeostasis and life[10]. Within the built environment, our priority must be to maintain a safe and sustainable supply of clean water, as outlined in Principle 1.2, consumed in necessary quantities to maintain human health and maximise wellbeing. The Institute of Medicine recommends a daily water consumption of approximately 2.7 L for women and 3.7 L for men[11].

Social connectivity

The WHO has demonstrated the link between social interaction and health[12]. Social connection improves physical health and psychological wellbeing, whereas loneliness is associated with a 26% increase in the risk of premature mortality[13]. Studies have suggested that strong social connections lead to a 50% increased chance of longevity and people who feel more connected to others have lower rates of anxiety and depression[14]. Our buildings and communities can be designed in a way that fosters social interaction[15].

Outcome:
The built environment actively contributes to the improvement of nutrition, hydration and social connectivity of building occupants and people in the local community, where possible, by supporting healthy food choices and hydration practices, and providing infrastructure for positive social engagement.

Strategies across the lifecycle

Design:
- Communal dining facilities and scheduled meal breaks in workplaces to foster interaction
- Urban planning to foster inclusiveness and social engagement with central shared areas
- Infrastructure to ensure clean water provision (see Principle 1.2)

Operations:
- The promotion and provision of healthy food options (fruits, vegetables, whole grains)
- Provision of food preparation areas (refrigeration, heating, storage and utensils)
- Onsite production of food
- Buildings operating in less developed communities must strive to address food deserts by increase the availability of healthy food to low-income population
- Provision of fresh clean water and encouraging hydration

Benchmarks:
Universal benchmarks for building and urban design specialists to encourage nutrition, hydration and social connectivity on site are not widely available. Practitioners are encouraged to incorporate strategies into projects on a bespoke basis, following local examples where possible.

The wider lifestyle factors that can contribute to reducing the risk of non-communicable diseases and can be implemented at regional policy level are outlined through the Partnership for Healthy Cities principles: https://partnershipforhealthycities.bloomberg.org/.

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5 CREATE POSITIVE SOCIAL VALUE WITH BUILDINGS AND COMMUNITIES

5.1 Protect human rights relating to health through the building and construction lifecycle

State of health

WorldGBC carried out an analysis of the United Nations (UN)'s 'Universal Declaration of Human Rights'[1] specifically for the buildings and construction industry that identifies the following fundamentally important areas for maintaining human rights within the building lifecycle:

- Worker rights and freedoms, mitigation of risks of forced labour and modern slavery
- Land and housing security, and property ownership
- Free choice, and favourable and secure working conditions with fair remuneration
- Gender equality, including equality in pay
- Right to adequate housing, and decent standard of living
- Free participation in the cultural life of community, and duties to the community for all

The UN 'Guiding Principles on Business and Human Rights'[2] outlines the state's duty to protect human rights and the responsibility of corporate enterprise to respect human rights. Companies in the built environment sector should undertake human rights due diligence measures to ensure their operations respect human rights and do not contribute to human rights abuses[3].

Guidance around human rights of direct relevance for built environment practitioners is centred around three themes:

- Employment rights and quality for construction workers and those in supply chain (specific physical and mental health risks presented in detail in Principle 5.2)
- Rights and quality for building occupants – encompassing standards and adequacy of building design and consequential standard of living, including physical health and wellbeing factors, and engagement and duties within and to community
- Rights of local communities (see Principle 5.3)

Employment rights and quality for supply chain and construction workers:
It has long been recognised that there is, within the built environment industry, a considerable variation of practices and standards relating to social sustainability and maintaining human rights standards. This includes those manufacturing raw materials, often in dangerous, exploitative and highly polluting environments, and those working on construction sites. Additionally, the reports of lack of diversity in the workforce, and minimal representation of those from marginalised communities are common[4]. In many countries, a high proportion of construction workers are migrant workers, who are at heightened risk of exploitation.

Rights and quality for building occupants
Quality standards should be met for all building types, however, the right to adequate housing is a particular social consideration with direct impact on occupant health and wellbeing. The right to adequate housing includes criteria such as security of tenure, affordability, habitability, and accessibility, as defined fully by UN Habitat.[5]

Outcome:
The ethical management of human rights relating to the construction industry and built environment should be considered and enhanced at each stage of the building lifecycle. Strategies should be incorporated by all relevant stakeholders in the value chain, with emphasis on both employment rights and quality for supply chain and construction workers, and rights and quality of buildings for the occupants.

Strategies across the lifecycle

Design:
- Social and demographic equity should be sought amongst design team, construction workers and those involved across the lifecycle of the building or development (applies to all stages)
- Implement standards meeting rights and quality standards for building occupant, encompassing adequacy of building design and consequential standard of living, including the universal right to adequate housing
- Inclusion of human rights and labour provisions in tendering for project and supplier contracts

Construction:
- When migrant workforces are employed, ensure that worker accommodation is adequate
- Thorough human rights due diligence process on supply chain risks, also termed Human Rights Impact Assessment and Supply Chain Mapping (covering materials, suppliers, contractors, transportation)
  - Human rights due diligence involves four steps: assessing actual and potential human rights impacts (considering all ways a company is or could be involved) integrating and acting on the findings, tracking responses, and communicating about how impacts are addressed
  - A company should seek to obtain as complete a picture as possible of its suppliers as part of the impact assessment. Where it is infeasible to conduct due diligence across the entire supply chain, companies should prioritise first the areas of the supply chain where the risks of adverse human rights impacts are most significant[6]
- Mandatory requirements of good practice within supply chain: awareness sessions and site maintenance and inspections, and adherence to International Labour Organization (ILO) fundamental conventions[7]
  - These cover human rights topics including child and forced labour, freedom of association, discrimination, and equal pay
- Educate workers and supply chain actors on their rights and benefits. Share success stories to raise awareness and demonstrate the impacts of these proposed commitments

Operation:
- Social and demographic equity of all suppliers and maintenance
- Fair management of private owned public space

Benchmarks:
- UN, Guiding Principles on Business and Human Rights: Implementing the United Nations "Protect, Respect and Remedy" Framework. 2011: https://www.ohchr.org/Documents/Publications/GuidingPrinciplesBusinessHR_EN.pdf
- UN Global Compact, Navigating the Future of Business and Human Rights: Good Practice Examples. 2019: https://www.unglobalcompact.org/library/5727
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- UN, Right to Adequate Housing Toolkit: https://www.ohchr.org/en/issues/housing/toolkit/pages/righttoadequatehousingtoolkit.aspx

5.2 Commit to protecting health and wellbeing of people in the construction industry

State of health

The people involved in a building most extensively across its lifecycle are those working in and around the building during the construction (and deconstruction) phase(s), and those living and working in and around the building once operational. However, the construction workforce is

often overlooked regarding the impact of the building and surroundings on their mental and physical health and wellbeing.

The construction industry employs approximately 7% of the global work force and it is predicted to account for approximately 13% of GDP by 2020[8]. It is a well-known issue within the industry that business operation includes a broad spectrum of practices and standards relating both to social sustainability and the maintenance of human rights standards. WorldGBC aspires for an industry evolution centred around responsible construction practices, which are managed in an environmentally and socially considerate, responsible, and accountable manner[9].

Physical and mental health and wellbeing of construction workers is a topic about which there is growing awareness worldwide. Research reveals that construction workers have a high risk of developing diseases from a number of health issues. In the United Kingdom, construction has the largest burden of occupational cancer amongst the industrial sectors. It accounts for over 40% of occupational cancer deaths and cancer registrations[10]. Exposure to hazardous substances, such as asbestos or silica dust, is a recognised cause of the heightened risk of lung and other cancers, as well as broader respiratory and cardiovascular health issues[11].

In addition to physical health, mental wellbeing is now recognised as a major risk for construction workers. The suicide rate for male labourers is three times higher than the average male suicide rate for the UK[12], and in Australia a construction worker commits suicide every second day, on average[13]. Some 20% of all cases of ill health in the sector are due to work-related stress, depression, and anxiety, and consequently over 400,000 working days are lost each year[14].

Construction is a heavy manual industry where working into later life can be a challenge[15]. A sustainable building and construction industry must be supportive of an ageing global population, creating safe and healthy work environments ensuring that practitioners are offered both professional security and personal safety.

Outcome:
Health-focused construction principles implemented, and practices standardised, particularly minimising worker exposure to hazardous materials, chemicals, and carcinogenic substances.

Strategies across the lifecycle

Construction:

- Adherence to specific responsible construction practices and programmes, such as Considerate Constructors Scheme
- Adherence to ILO standards on worker rights, covering freedom of association, elimination of forced labour and child labour, and non-discrimination
- Implement specific health and safety practices to eliminate worker exposure to hazardous materials, chemicals, and carcinogenic substances
- Increase employee and staff awareness of occupational health risks and mitigation
- Extend employee assistance programmes, occupational health checks and other initiatives to suppliers/smaller contractors
  - Education programmes for construction workers, both in improving literacy skills (targeting construction workers in certain geographies who have worked since childhood), and also in construction health and safety (including dangers of the industry, the benefits of implementing good industrial practices and environmentally responsible practices)
- Education programs should be continuous to ensure awareness of evolving low or zero carbon technologies and sustainability practices
- Main contractors should undertake effective due diligence on any agency they engage with, and have a duty of care to ensure that workers working via third parties are employed according to international standards, are not subject to exploitation and are protected in the workplace including their health and safety, and mental wellbeing

Benchmarks:

- Building Responsibly, Worker Welfare Principles. 2020: https://www.building-responsibly.org/worker-welfare-principles
- HSE, Cancer and Construction: Key points and recommendation reports: https://www.hse.gov.uk/construction/healthrisks/cancer-and-construction/...
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5.3 Provide long term value to communities and improve local quality of life

State of health

Health and wellbeing in the built environment have for too long focused primarily on the occupants of a building. Although the built environment has a remarkable impact on the health, wellbeing, productivity, and other factors relating to an occupant, its wider and less tangible impacts on those who live in the surrounding area must also be considered.

There can be a benefit to the local economy and associated social impacts from operational buildings and construction. This may include a positive multiplier effect to local businesses, enhancement of neighbourhoods (gentrification), provision of employment and development of community facilities. However, negative social impact is often created or overlooked through development, and can include community segregation, loss of culture and even an increase in crime. During construction, retrofit or deconstruction phases, the physical issues created by development, such as air, noise, light pollution, must also be considered and mitigated.

Social value, justice, and fairness:

The inequality in the distribution of income and quality of life affects countries of all levels of wealth and development. Our built environments, our societies, communities, and cities, are where inequality in health, wellbeing and quality of life can be most apparent. The trend of urbanisation, with greater than two-thirds of people expected to live in cities by 2050, is expected to add an additional 2.5 billion people to the existing urban populations[16]. Larger urban populations will increase pressure on existing systems on infrastructure, including provision of adequate housing and services, access to resources and societal, system and environmental resilience. In societies struggling with population pressures, the health, wellbeing, and quality of life of marginalised communities or vulnerable groups must be recognised as a risk. The buildings and infrastructure of our cities can contribute to these problems or they can provide solutions[17].

Social resilience:
Social equity and fairness must extend to ensuring equality in being resilient to challenges for all people. The COVID-19 pandemic has highlighted the particular difficulties and disadvantaged outcomes the built environment can trigger or enhance. Some of the many examples worldwide include the disproportionate death tolls in informal housing settlements, such as favelas in Brazil[18], the racial disparity in death toll that are closely linked to social determinants of health[19], and limited access to healthcare facilities which is considered a contributory factor to heightened death tolls of indigenous people and other marginalised communities[20].

Outcome:
The health and wellbeing of all people impacted by a building in operation should be considered, and consciously enhanced where possible, incorporating environmental, social and economic indicators of health. The creation of positive social impact should be universal, with principles of equity and fairness underpinning design and operational decisions that would impact local community. Resilience-focused design and master-planning of cities, communities and built environment should also be sought.

Strategies across the lifecycle

Design:
- Ensure non-discrimination at all stages
- Consider physical and environmental impacts on the local area, with active input from the local community: take steps to mitigate harm, and expand positive impacts such as the provision of resources and infrastructure for the local community, safety and security of surroundings, and design for a healthy community such as expanding sidewalks and improving walkability
- Plan for community participation accounting for demographics of neighbouring area; include grounding the project in a strong understanding of local social and economic context and ensure meaningful participation of the local community from the outset, to mitigate risks of harm and to identify positive outcomes
- Community engagement programmes ensuring access to information for local community members throughout the course of the project, including public engagement at phase one design, community impact assessment, social value impact assessments or equivalents

Construction:
- Mitigate air pollution, noise pollution, traffic, congestion, waste and other pollutions created on-site and in surrounding areas

Operation:
- Implement organisational level strategies to support local people and economy, e.g. no on-site food provision to encourage expenditure in local business, supporting community causes (e.g. charities, schools, hospitals, investment in public transport facilities) demonstrated through corporate social impact reporting

Benchmarks:
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6 TAKE CLIMATE ACTION

6.1 Commit to net zero whole-life emissions to contribute to climate change mitigation

State of health

Climate change will impact human life and health in nearly every way imaginable; from access to water, impact on agriculture and food supply, to jeopardising the future of our cities and infrastructure. It is termed by the WHO as 'the greatest global health threat of the 21st century"[1]. Between 2030 and 2050, climate change is predicted to lead to approximately 250,000 additional deaths each year caused by malnutrition, malaria, diarrhoea, and heat stress. The economic cost of these health impacts is estimated to be US $2-4 billion per year by 2030[2].

With the building and construction sector responsible for 39% of global carbon emissions[3], and expectations that the global building stock is expected to double in size by mid-century[4], addressing emissions across the whole lifecycle of a building is urgent. While most emissions occur from the occupational phase of the building lifecycle, referred to as operational emissions, the substantial increase in new buildings will see a dramatic rise in embodied carbon. Embodied carbon is the emissions associated with materials and construction processes throughout the whole lifecycle of a building or infrastructure[5].

Within occupied buildings, cooling is a growing issue that can lead to competing priorities between environment and human health, wellbeing, and development. Cooling technologies, such as refrigeration and air conditioning, emit large quantities of HFCs (hydrofluorocarbons). Although the HFCs serve as a replacement for the Ozone Depleting Substances i.e. chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), they are still potent greenhouse gases with '1,000 to 9,000 times greater capacity to warm the atmosphere than carbon dioxide'[6]. A UN report highlights that "cooling is now responsible for about 10% of global warming and growing rapidly"[7].

The volume of HFCs in the atmosphere is increasing at 8-15% per year due to population growth and urbanisation, and their use is likely to increase as our climate warms further due to climate change[8]. The importance of sustainable development is unparalleled here, with 2.3 billion people across the world expected to soon purchase an air conditioning unit or fridge, and it is likely that choices will be limited to inefficient and highly emitting appliances[9].

As the vast majority of HFC emissions occur at end of life stage for these technologies (estimated 90%6), sustainable removal and waste management of cooling appliances is an essential part of climate change mitigation in the built environment sector. This could prevent the release of HFC emissions[10] equivalent to nearly 58 gigatons of carbon dioxide, which is equal to over 63 years of global aviation emissions (based on 2019 annual data).

Outcome:
All new and existing buildings demonstrate improvements in lifecycle energy efficiency, targeting net zero operational carbon emissions in all new buildings by 2030, and net zero embodied carbon in all new buildings by 2050 (including emissions from equivalent greenhouse gases, specifically HFCs).

Strategies across the lifecycle

Strategies for the building sector recommended are aligned to the WorldGBC Advancing Net Zero global project principles[11]:

For operational carbon:

Design:

- Reduce energy demand, by prioritising efficiency and incorporating on-site renewable sources
- Consider sustainable energy concepts both within a building and at scale, for example connection to local energy networks across multiple buildings, such as a campus or city quarter, to increase the efficiency of energy assets across buildings
- Plan for the future: Set out trajectory of improvements and 'trigger points' in lifetime of investments to maximise likelihood and practicality of energy-efficient renovations

Operation:

- Measure and disclose carbon, with buildings working towards achieving annual operational net zero carbon emissions balance based on metered data
- Reduce energy demand, by prioritising efficiency in use and minimising energy waste
- Incorporate innovative business models that allow energy trading across various buildings to minimise energy waste and achieve highest efficiency
- Generate power from renewables, supplying remaining energy balance through renewables, ideally on-site, followed by off-site, then offsets
- Improve verification and rigour through expansion of sustainability scope and reporting

For embodied carbon:

Design:

- Prevent: Question the need to use materials at all, considering alternative strategies for delivering the desired function, such as increasing utilisation of existing assets through renovation or reuse
  - Passive design strategies, particularly around thermal comfort, can eliminate the need for MEP equipment which will require replacement through lifecycle of a building
- Reduce and optimise: Use low carbon design solutions in terms of upfront emission reductions and as part of a whole life approach. In early stages of design, use lifecycle analysis to target dematerialization, light-weighting of structural elements, switch to lower carbon material sources, and design for waste prevention by building with modular and prefabricated components. Such low carbon designs, zero carbon responsibly sourced materials, and low or zero carbon construction techniques will maximize efficiency and minimize waste on-site.
  - Selection of products with closed-loop or take-back programs to support a circular economy (see Principle 6.4)
- Plan for the future: Consider future use scenarios and end of life, maximising the potential for maintenance, repair and renovation and designing for disassembly and deconstruction to facilitate future reuse

Operation:

- Offset: As a last resort, offset residual embodied carbon emissions either within the project or organisational boundary or through verified offset schemes

For HFC reduction:

Design:

- Implement cooling technologies with low global warming potential (GWP) refrigerants in all new and renovated constructions
- Improve passive design measures, such as insulation, shading and solar gain prevention and community scale master planning, to avoid or reduce the use of cooling systems (such as air-conditioning)

Regulatory:

- Use policy levers and wider mechanisms to undertake ambitious measures to improve energy efficiency in the cooling sector while phasing out HCFC and phasing down HFC refrigerants under the Montreal Protocol, such as developing national cooling plans based on domestic circumstances, using energy performance standards (MEPS)

Operation:

- Refrigerant and equipment management: replace HFCs in cooling technologies with low or zero-GWP alternatives, such as propane and ammonium[12]
- Practice responsible management and servicing of existing equipment and better designs for future equipment to minimise leaks

Benchmarks:

- By 2030, all new buildings, infrastructure and renovations will have at least 40% less embodied carbon with significant upfront carbon reduction, and all new buildings are net zero operational carbon
- By 2050, new buildings, infrastructure and renovations will have net zero embodied carbon, and all buildings, including existing buildings must be net zero operational carbon
- Organisations, cities and regions can commit to climate action through the WorldGBC Net Zero Carbon Building Commitment: https://www.worldgbc.org/thecommitment

6.2 Design for resilience in preparation for the climate crisis and extreme weather events

State of health

Every year natural disasters kill around 90,000 people and affect close to 160 million people worldwide[13]. Over the past decade, disasters have been responsible for 0.1% of deaths globally, but have severely impacted the health and wellbeing of millions more across the world, often in the most vulnerable nations[14]. Natural disasters displace more people than conflict and violence[15]. Data shows that flooding caused most disasters between 1994 and 2013, accounting for 43% of all recorded events and affecting nearly 2.5 billion people[16].

Today, more people are at risk than 50 years ago, as construction in flood plains, earthquakes zones and other high-risk areas has increased the likelihood that a routine natural hazard may become a major catastrophe. Additionally, climate change is understood to lead to increased frequency and severity of extreme weather events. The Intergovernmental Panel on Climate Change Fifth Assessment Report (2014) showed that changes in extreme weather and climate events have been observed since about 1950, and attribution studies demonstrate evidence of human contribution through anthropogenic climate change in worsening these events in likelihood and/or severity[17].

One of the most devastating socio-economic outcomes of environment disasters is the damage wreaked upon infrastructure, vital services, resources, and particularly housing and livelihood of local populations. Drought, fire, and famine are also direct results of the climate crisis, and indirectly linked to the building sector due to sectoral contribution to global emissions, which will have severe impacts on human health and quality of life.

Although communities equipped for disaster resilience are challenging to implement, particularly where multiple environmental threats persist, conscious design of the built environment with climate resilience strategies and adaptation to changing situations can offer relief against worst-case scenarios and provide possible long term benefits to these vital socio-economic determinants of health.

Outcome:
The design and operation of buildings and urban areas should incorporate strategies to enhance community resilience to the climate crisis. Strategies must not exacerbate societal inequalities and should account for the needs of vulnerable populations locally.

Strategies across the lifecycle

Design:
- Resilient design strategies, considered for mitigation and adaptation to evolving environmental, social, and economic circumstances
- Environmental assessments at building planning or master planning stage, specialised for situational risks, e.g. flood risk assessment
- Design for reduced dependence on complex building controls and systems, providing manual overrides in case of malfunction or temporary power outages
- Plan resilient systems, including independent power reserves or non-centralised power generation in areas at risk of natural disaster and national grid failures
- Specify products and materials that will not off-gas or leak hazardous substances in the event of natural disaster, including avoidance of cooling systems that would leak highly polluting refrigerants in case of breakage
- Utilise vernacular design practices that were prevalent before the advent of air conditioning and central heating. Combine these design strategies with modern materials to optimise resilient design to maximise human health and comfort in situations of system failure

Operation:
- Carry out water conservation practices and rely on annually replenished water resources, including, potentially, harvested rainwater, as the primary or back-up water supply
- Practice community resilience and prepared response to natural disasters

Benchmarks:
- UNDRR. 'Sendai Framework for Disaster Risk Reduction'. 2015: https://www.undrr.org/implementing-sendai-framework/what-sf

6.3 Use water efficiently, working to avoid local shortage crises

State of health

Nearly 1.8 billion people in 17 countries, or a quarter of the world's population, are veering towards a water crisis with the potential of severe shortages in the next few years. Of the 17 nations, 12 are in the Middle East and North Africa[18]. The ongoing rise in global population will continue to place pressure on this finite resource.

Water is used at all stages of a building's lifecycle, from the extraction of raw materials, in manufacturing, during construction, and in the operational phase in buildings of all types. Water is a resource often used in the demolition process, which can include retrofit and de/reconstruction. Highest water use is typically during the in-use phase of buildings and is consequently regulated by building standards in many countries[19].

Water in developed countries is pumped, purified, treated, and heated before it reaches building occupants. This process greatly increases the amount of energy that is used. Domestic hot water usage alone is responsible for 35 million tonnes of greenhouse gas emissions in the UK, representing around 5% of national energy use[20]. When the water is wasted, so is the energy that is used in preparing it for use.

The public water supply represents 21% of the total water use in the EU – with buildings accounting for most of the usage, many initiatives are currently being implemented at local or national levels to reduce water consumption in buildings[21].

Outcome:
Reduce demand, enhance water efficiency, and ensure sustainable drainage and water management through the design, construction, and operation of built environment to reduce stress on water bodies and related ecosystems. Explore utilisation of other sources of water, such as treated greywater, on-site and at community level where feasible.

Strategies across the lifecycle

Design:
- Re-use and recycle fresh water on-site, utilising grey and blackwater systems where feasible
- Explore sustainable drainage opportunities, such aspermeable hard surfacing, to facilitate responsible_water management and reduce water waste

Construction:
- Commit to water reduction in material sourcing and construction stages of lifecycle

Operation:
- Carry out on-site water collection and conservation practices and rely on annually replenished water resources, including harvested rainwater as the primary or back-up water supply
- Include low-flow and/or water-less features within operational buildings, for example low-flow toilets, faucet aerators, and showerheads, and water-less human waste disposal and wastewater systems
- Install water leakage detection systems
- Manage on-site water in a responsible manner, with aim of increasing water infiltration into soil and return to groundwater
- Organisational advocacy around water efficiency; including water offsets, divestment from organisations that support fossil fuel pipelines across water sources, positive personal behaviour change

Benchmarks:
- Better Buildings Partnership. '2017 Real Estate Environmental Benchmarks': https://www.betterbuildingspartnership.co.uk/sites/default/files/media/attachment/REEB%20Benchmarking%202017_0.pdf
- CIRIA. 'Key Performance Indicators for Water Use in Offices': https://www.ciria.org/Resources/Free_publications/KPI_water_offices.aspx
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6.4 Ensure safe, healthy, and circular use of materials across the building lifecycle

State of health

Hazardous chemicals can be found everywhere. Modern life has brought hazardous chemicals into our homes and lives through everyday products such as clothing, electronics, and food packaging, and can increase the risk of serious illness. Exposure to toxic or polluting materials is an environmental and public health concern across all stages of the built environment lifecycle, from the production of materials to buildings in occupation and beyond.

The relationship between building materials and health in the built environment is multi-faceted; four core concepts to improve human health and quality of life are outlined below.

Safe production of materials:
Workers involved in generating materials across the supply chain needed for construction are at risk of diverse health issues, one example being the production of bricks. Brick kilns, 90% of which are in Asia, are recognised as one of the largest stationary sources of black carbon which, along with iron and steel production, contribute 20% of the total global black carbon emissions[22]. The consequential air pollution is damaging to human health on both local and global scales, as discussed in Principle 1.1. A reduction in wasted materials, both through higher site efficiencies and construction practices and the reuse of existing materials as part of a circular economy, would subsequently reduce the pollution from production.

Circular material use:
The concept of circular material use, and 'cradle to cradle' principles, are recognised as best practices in sustainability globally for the built environment, considering both materials within building interiors, as well as heavy materials utilised in construction.

The Ellen Macarthur Foundation considers the transition to a circular economy as the required 'fundamental shift in the global approach to cutting emissions', and states the implementation of circular principles in five core areas worldwide could eliminate emissions on a scale equivalent to those generated by all transport globally[23]. Heavy industries (cement, steel, aluminium) represent three of the five core areas focused on in this research, and are substantial contributors to the embodied emissions of building and infrastructure projects, thus emphasising the major role the building and construction industry must play.

Materials found within healthy, sustainable buildings should be operating as part of a circular economy of material re-use. Materials must also mitigate risk of poor indoor environmental quality through the release of airborne pollutants, such as VOCs. These materials are termed 'low-emissive'. Circular material use calls for re-use and recycling of existing resources, however, hazardous chemicals that currently exist within the built environment must be extracted through retrofit and deconstruction work, allowing reuse of non-contaminated materials only. The use of natural materials is also prioritised within a circular economy, which can be repurposed or recycled as part of a biological cycle of material use.

Non-hazardous chemicals:
Man-made toxic chemicals are common ingredients in many everyday products[24], and studies are demonstrating serious long-term impacts on human health due to this continued exposure. For example, scientists have linked the fact that men in the Western world produce half as much sperm as they did 40 years ago to the exposure to toxic chemicals[25], and that exposure to toxic chemicals can increase the risk of breast cancer in women[26]. Other studies link exposure to toxic chemicals to attributable IQ loss and intellectual disability in children[27]. Many of the hazardous substances in widespread use are replaceable with safer alternatives. For many building products, hazards in product ingredients are unknown or protected by trade secrets. Seeking greater disclosure of building material ingredients as well as finding safer alternatives are ways the building and construction industry can support the transition to safer chemicals being used and developed.

Designing out waste:
For many cities, the disposal and treatment of waste is a growing burden that is increasingly difficult to tackle. From 2000-2012, waste generated in cities approximately doubled, increasing from 680 million tonnes to 1.3 billion tonnes per year. This figure is expected to nearly double again to 2.2 billion tonnes by 202528 as a result of increasing population, urbanisation, and changing consumption patterns.

The waste problem is most severe in urbanising regions and developing countries, where collection and disposal services do not exist or cannot cope with increasing amounts of waste. As a result, waste is either disposed in open and uncontrolled dumpsites, openly burned, or leaks into the land, waterways and oceans. This represents the third largest man-made source of methane[29]. Unmanaged waste may also become a breeding ground for microbes and toxins that contaminate the air, soil, and water[30]. Waste is also a severe risk-factor to marine ecosystems and natural life, particularly plastic pollution of ocean environments[31].

These practices have deleterious impacts on public health, the environment, and the wellbeing of waste workers and nearby residents. Our buildings and communities have a central role in waste reduction, both as the locations in which we live, work and use the majority of our products and resources, but also through the construction industry's sustainable management and use of materials.

Outcome:
Building projects consciously avoid the use of hazardous materials and chemicals during construction projects (including retrofit and deconstruction), facilitating the extraction from existing materials and projects to avoid contamination and further circulation in industry. All projects support the built environment sector's transition to a circular economy with minimal waste leakage into the natural environment.

Strategies across the lifecycle

Materials

Design:

- Design for adaptation and flexibility in design and operational use of buildings, increasing lifespan of use and reduce the need for demolition and rebuilding
- Minimise use of resources using life cycle assessment (to optimise balance between materials and energy use, dematerialization, waste generation, etc.)
- Choosing products wisely based on chemical content/makeup/constitution, prioritising natural and low-emissive materials for environments occupied by people and transition away from hazardous chemical use, and utilise recovered materials to implement a circular economy of material use

Construction:
- Avoid hazardous substances, and safely remove, if feasible, to facilitate recycling and circular re-use of materials
- Close the loop: design out waste, create circular products, and prefer refurbished, remanufactured, and recycled products in purchasing

Operation:
- Material use reporting: transparent monitoring and publication of resource use, targeting and encouraging circularity in site operations

Waste

Design:
- Prevent waste from building design by using modular systems/components, eliminating finishes, and supporting manufacturers that participate in circular economy and zero waste design goals for products
- Ensure projects have multiple waste streams (including food waste) with source separation to support occupant behaviour change and reduce greenhouse gas emissions associated with operational waste

Construction:
- Support the reduction of construction and demolition waste by designing for material recovery, promoting higher-grade recovery applications where possible to facilitate longer lifespan of material re-use

Operation:
- Promote composting (food waste) and recycling on-site in buildings, from construction to operational stages of building lifecycle
- Organic waste diversion to minimize food and landscape waste to landfills can reduce methane generation and avoid unnecessary expansion of landfill to accommodate excess waste
- Prevent open waste burning: Promoting alternatives to open burning to reduce black carbon emissions and to prevent the release of cancer-causing compounds and other toxic substances.
- Litter reduction programs to prevent leakage into the environment

Benchmarks:
- Whole Building Life Cycle Assessments undertaken at design stage, benchmarked in accordance with national averages, or by comparing an innovative, low-carbon design against a similar building using traditional design and material
- Environmental Product Declarations (EPDs) and product chemical transparency labelling schemes for specific products
- Hazardous chemical lists, such as REACH restricted substances list (EU Regulation) and additional market resources

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Next steps for health and wellbeing in the built environment

The World Green Building Council network is proud to champion ambitious leadership around the expanding scope of health and wellbeing in the built environment. However, this work is far from over.

The next steps for health and wellbeing from the WorldGBC global network and industry include:

Socialisation of the expanded scope and targets for health and wellbeing

In this decade of climate emergency, many of the environmental priorities need to be implemented with urgency at policy and project level, with low-carbon design and operation standardised across the industry. Similarly, from a socio-economic perspective, concepts including social equity and justice, community engagement, transforming behaviours and human lifestyle and increasing access to nature need to be normalised, and supported by industry education and tools to facilitate practical implementation.

Measuring progress for a healthy, sustainable built environment

We need consistent metrics for health and wellbeing to track progress on a global level, but also account for the diverse range of determinants of health that can impact gross data, such as life expectancy or death rates. Within the digital version of the Framework, a range of benchmarks and indicators are presented as an interim step to equip project, city or national level measurements and tracking of health and wellbeing parameters.

Localising health

Human health and wellbeing is a highly personal situation, but research on determinants of health emphasises the role of our buildings and community surroundings, including culture, economic development and environmental factors that can be shared on regional or national scales. We recognise the Framework principles will have different weights of importance across different geographies. Therefore, the role of the WorldGBC network, operating in around 70 countries through the Green Building Councils and their members, is to demonstrate leadership around identifying and pursuing national and regional priorities for health and wellbeing in the built environment, building on the available resources and progress on the topic led by GBCs to date.

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Resource List:

Disclaimer: The resource lists for each sub-principle are a non-exhaustive set of references provided from the WorldGBC network, peer review panel and industry through the Framework consultation period. A regular update of resource lists will be undertaken by WorldGBC to ensure updated information is available.
WorldGBC supports all certifications and is proud to unite a network that runs over 40 rating tools, plus support the uptake of all tools across the industry. Rating scheme inclusion within the Framework is based on submission from global GBC network and consultation responses, with aim of amalgamating a host of resources for a global audience to offer further detail for users beyond the high-level outline of each principle.
Regarding specific certifications, eg. BEAM or Green Star, there are often a number of versions or tools available for different building types (eg. Design, As-Built, Interiors, Communities). To maintain brevity of Framework document, one building level tool (eg. Design or New Construction) and one larger scale tool (eg. community level) is included within the Resource List of each sub-principle. Users with alternative building projects in mind are encouraged to acquire the appropriate version of the tool for most applicable guidance.

Resource List for 1.1:

- American Society of Heating Refrigerating and Air-conditioning Engineers (ASHRAE): ASHRAE Standard 62.1-2019, 'Ventilation for Acceptable Indoor Air Quality, Atlanta': https://ashrae.iwrapper.com/ViewOnline/Standard_62.1-2019
- Beam Plus New Buildings V2.0, 'Health and Wellbeing, Materials and Waste, Integrated Design and Construction Management': https://www.hkgbc.org.hk/eng/beam-plus/file/BEAMPlus_New_Buildings_v2_0.pdf
- Beam Plus Neighbourhood V1.0, 'Outdoor Environmental Quality': https://www.beamsociety.org.hk/files/Manual/BEAMPlusNDManualWithCorrigendum-No1.pdf
- BREEAM International New Construction Standard, 'Hea 02 Indoor air quality' and 'Pol 02 NOx emissions': https://www.breeam.com/discover/technical-standards/
- BREEAM International In-Use Standard, 'Hea 16 Indoor air quality management' and 'Pol 03 Local air quality': https://www.breeam.com/discover/technical-standards/
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- Chartered Institute of Building Service Engineers (CIBSE). 'Indoor Air Quality, An outline of guidance': https://www.cibse.org/getmedia/8c7fe54c-b712-49e3-9bb1-44bf9f3fdaa0/An-outline-of-CIBSE-guidance-on-IAQ.pdf.aspx
- DGNB. 2019. 'Liveable and Fit for the Future': https://www.dgnb.de/en/council/publications/index.php
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- Green Building Council of Australia: Green Star, 'Design & As Built 'Indoor Environment Quality': https://new.gbca.org.au/rate/rating-system/design-and-built/
- Green Building Council of Australia: Green Star, 'Communities 'Environment": https://new.gbca.org.au/rate/rating-system/communities/
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- Indian Green Building Council: Green Interiors Rating Tool, 'Fresh Air Ventilation', 'CO2 Monitoring' and 'Indoor Air Quality Management': https://igbc.in/igbc/redirectHtml.htm?redVal=showgreeninteriorsnosign#GreenHomes
- Indian Green Building Council: 'Health and Wellbeing Rating Tool: 'Indoor Air Quality': https://igbc.in/igbc/redirectHtml.htm?redVal=showHealthWellBiengnosign#Resources
- International Living Future Institute. Living Building Challenge, 'Health and Happiness Petal' https://living-future.org/lbc/basics4-0/
- Dr. Allen, J. et al. 2017. 'The 9 Foundations of a Healthy Building': https://forhealth.org/9_Foundations_of_a_Healthy_Building.February_2017.pdf
- J. Allen and J. Macomber. 2020. 'Healthy Buildings. How Indoor Spaces Drive Performance and Productivity' Harvard University Press. https://www.hup.harvard.edu/catalog.php?isbn=9780674237971
- Jordan GBC. 'Your Guide to Green Building in Jordan': https://drive.google.com/file/d/13IvMnkqoi09FhuNenh_j58sq_HRB4TjT/view
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- U.S. Environmental Protection Agency. 2012. 'A Citizen's Guide to Radon: The Guide to Protecting Yourself and Your Family from Radon': http://www.epa.gov/radon/pdfs/citizensguide.pdf
- USGBC: LEED v4 Building Design & Construction (BD+C), 'Indoor Air Quality Assessment': https://www.usgbc.org/credits/new-construction-commercial-interiors-core-and-shell-schools-new-construction-retail-new-c-8
- USGBC: LEED v4 BD+C, 'Minimum indoor air quality performance': https://www.usgbc.org/credits/new-construction/v4-draft/eqp1?return=/credits/New%20Construction/v4
- USGBC: LEED v4 Homes, 'Air Filtering': https://www.usgbc.org/credits/homes-high-rise/v4-draft/eqp5?return=/credits/Homes/v4
- USGBC: LEED v4.1 BD+C, 'Low-emitting materials': https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-healthc-178?return=/credits/New%20Construction/v4.1
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- World Green Building Council. 'Air Quality in the Built Environment': https://worldgbc.org/clean-air-buildings/
- World Green Building Council. 'Plant a Sensor': https://worldgbc.org/plant-a-sensor
- World Health Organization. 'Air Pollution': https://www.who.int/news-room/air-pollution
- World Health Organization. 'Air Quality Guidelines': https://www.who.int/phe/health_topics/outdoorair/outdoorair_aqg/en/
- World Health Organization. 'WHO Guidelines for Indoor Air Quality Household Fuel Combustion': https://www.who.int/airpollution/guidelines/household-fuel-combustion/IAQ_HHFC_guidelines.pdf
- World Health Organization. 2005. 'WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide. Geneva: World Health Organization': 9, 14. https://apps.who.int/iris/handle/10665/69477WHO indoor air quality guidelines: household fuel combustion.
- World Health Organization. 'Guidelines for household fuel combustion': https://www.who.int/airpollution/guidelines/household-fuel-combustion/recommendation1/en/
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- World Health Organization. 'Housing and health guidelines': https://www.who.int/publications/i/item/who-housing-and-health-guidelines
- World Health Organization. 'Guidelines for indoor air quality: dampness and mould' https://www.who.int/airpollution/guidelines/dampness-mould/en/

Resource List for 1.2:

- Beam Plus New Buildings V2.0, 'Health and Wellbeing, Water Use, Integrated Design and Construction Management': https://www.hkgbc.org.hk/eng/beamplus/file/BEAMPlus_New_Buildings_v2_0.pdf
- BREEAM International New Construction Standard, 'Hea 09 Water quality': https://www.breeam.com/discover/technical-standards/
- BREEAM International In-Use Standard, 'Hea 18 Legionella risk management': https://www.breeam.com/discover/technical-standards/
- CABR & CSUS: Green Building Research Centre, 'Healthy Building Evaluation Standard 'Water' Chapter' & Zeng Jie, Lü Shilei. 2018. 'Interpretation of the water chapter of "Healthy Building Evaluation Standard' [J]. Building Technology, 49(05): 486-489.
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- Emirates Green Building Council. 'Emirates Coalition for Green Schools': https://emiratesgbc.org/technical-programs/green-schools/
- Green Building Council of Australia: Green Star, 'Design & As Built, 'Indoor Environment Quality'': https://new.gbca.org.au/rate/rating-system/design-and-built/
- Green Building Council of Australia: Green Star, 'Communities 'Environment'': https://new.gbca.org.au/rate/rating-system/communities/
- Indian Green Building Council: Health and Wellbeing Rating, 'Water Quality': https://igbc.in/igbc/redirectHtml.htm?redVal=showHealthWellBiengnosign#Resources
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- United States Environmental Protection Agency. 2018. 'Drinking water standards and health advisories' March 2018: 11-12.: EPA 2018 Edition of the Drinking water standards and heath advisory tables
- World Health Organization. 2011. 'Water Safety Plan, Water Safety in Buildings': https://www.who.int/water_sanitation_health/publications/2011/9789241548106/en/
- World Health Organization. 'WHO Guidelines for drinking-water quality (GDWQ)': https://www.who.int/water_sanitation_health/water-quality/guidelines/en/
- Why is access to clean, safe drinking water so elusive?'Article: https://gresb.com/why-access-clean-safe-water-

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Resource List for 1.3:

- Beam Plus New Buildings V2.0, 'Integrated Design and Construction Management': https://www.hkgbc.org.hk/eng/beam-plus/file/BEAMPlus_New_Buildings_v2_0.pdf
- Beam Plus Neighbourhood V1.0, 'Community Aspects': https://www.beamsociety.org.hk/files/Manual/BEAMPlus-NDManualWithCorrigendumNo1.pdf
- BREEAM International New Construction Standard, 'Man 05 Aftercare', 'Hea 01 Visual Comfort' and 'Hea 06 Accessibility': https://www.breeam.com/discover/technical-standards/
- BREEAM International In-Use Standard, 'Man 02 Management Engagement and Feedback', 'Hea 06 View out', 'Hea 11 Provision of Rest Areas' and 'Hea 12 Inclusive Design': https://www.breeam.com/discover/technical-standards/
- Buro Happold. 'Design for Student Mental Health and Wellbeing': https://www.burohappold.com/wp-content/uploads/2019/06/BuroHappold_HEDQF_-student_mental_health_thought-piece.pdf
- CABR & CSUS: Green Building Research Centre Healthy Building Evaluation Standard, 'Humanities Chapter' & Hong, J. et al. 2018. 'The interpretation of "Healthy Building Evaluation Standard; Construction Technology'
- Centre for the Built Environment. 'Occupant Indoor Environmental Quality (IEQ) Survey': https://cbe.berkeley.edu/resources/occupant-survey/
- The Centre for Urban Design and Mental Health. 'How Urban Design Can Affect Mental Health': https://www.urbandesignmentalhealth.com/how-urban-design-can-impact-mental-health.html
- Chrysikou, Evangelia. 2015. 'Ill performing buildings for mental health': https://www.researchgate.net/publication/280007782_IILL_PERFORMING_BUILDINGS_FOR_MENTAL_HEALTH
- Colloqate. 'Design Justice for Black Lives': https://colloqate.org/design-justice-for-black-lives
- DGNB. 2019. ' Liveable and Fit for the Future': https://www.dgnb.de/en/council/publications/index.php
- Green Building Council of Australia: Green Star, 'Communities Liveability': https://new.gbca.org.au/rate/rating-system/communities/
- Indian Green Building Council: Green Interiors Rating Tool, 'Occupant Well-being Facilities': https://igbc.in/igbc/redirectHtml.htm?redVal=showgreeninteriorsnosign#GreenHomes
- WELL Building Standard. 'Mind': https://standard.wellcertified.com/mind
- World Health Organization. 'Mental Health Evidence Research': https://www.who.int/mental_health/evidence/en/
- World Health Organization. 'Building Back Better: Sustainable Mental Health Care After Emergencies': https://www.who.int/mental_health/emergencies/building_back_better/en/

Resource List for 1.4:

- American Society for Microbiology. 2019. 'Novel Coronavirus (COVID-19) Pandemic: Built Environment Considerations to Reduce Transmission': https://msystems.asm.org/content/5/2/e00245-20
- The American Institute of Architects. 2020. 'Re-occupancy assessment tool': http://content.aia.org/sites/default/files/2020-06/STN20_%20344901_ReOccupancyAssessmentTool-V02_sm_v09.pdf
- Archinect News. 2020. '"Hygiene ventilation" and the case for green stimulus' https://archinect.com/news/article/150195914/hygiene-ventilation-and-the-case-for-green-stimulus
- American Society of Heating Refrigerating and Air-conditioning Engineers (ASHRAE): 170, 'Ventilation of Health Care Facilities - including Hospital Spaces, Outpatient Spaces, and Nursing Home Spaces'
- BREEAM International In-Use Standard, 'Man 03 Maintenance policies and procedures', 'Hea 16 Indoor air quality management', 'Hea 18 Legionella risk management' 'Rsl 06 Emergency plans and climate-related physical risks'
- Centers for Disease Control and Prevention (CDC). 'Guidance for Reopening Buildings After Prolonged Shutdown or Reduced Operation': https://www.cdc.gov/coronavirus/2019-ncov/php/building-water-system.html
- GOV.UK. 'Transmission characteristics and principles of infection prevention and control': https://www.gov.uk/government/publications/wuhan-novel-coronavirus-infection-prevention-and-control/transmission-characteristics-and-principles-of-infection-prevention-and-control#section3
- Harvard University. 2020. 'Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study': https://projects.iq.harvard.edu/covid-pm
- Fast Company. 2020. 'How we can redesign cities to fight future pandemics': https://www.fastcompany.com/90479665/how-we-can-redesign-cities-to-fight-future-pandemics
- Interact Lighting. 'Re-inventing the workplace after COVID-19': https://www.interact-lighting.com/global/iot-insights/workplace-post-covid-19
- Passive House Accelerator. 'Hygiene Ventilation, Heard of it's: https://passivehouseaccelerator.com/articles/hygiene-ventilation-heard-of-it
- Perkins & Will. 'Understanding antimicrobial ingredients in building materials – COVID-19 Statement': https://healthybuilding.net/reports/22-covid-19-statement-understanding-antimicrobial-ingredients-in-building-materials
- Recovery Readiness. 'A 'how to' guide for reopening your workplace': https://www.cushmanwakefield.com/en/insights/covid-19/recovery-readiness-a-how-to-guide-for-reopening-your-workplace
- Science Daily, University of California. 'COVID-19 and the built environment - Examining how building design can influence disease transmission': https://www.sciencedaily.com/releases/2020/04/200410162450.htm
- USGBC: LEED 'Safety-First' Pilot credits: https://www.usgbc.org/about/building-re-entry-resources
- World Health Organization. 2017. 'Keeping The Vector Out: Housing Improvements for Vector Control and Sustainable Development': https://apps.who.int/iris/bitstream/handle/10665/259404/9789241513166-eng.pdf?sequence=1

Resource List for 2.1:

The list below is a non-exhaustive list of further resources, put together by inputs received by WorldGBC global network members.

- American Society of Heating Refrigerating and Air-conditioning Engineers

(ASHRAE): Standard 55-2017, 'Thermal Environmental Conditions for Human Occupancy': https://www.ashrae.org/technical-resources/bookstore/standard-55-thermal-environmental-conditions-for-human-occupancy

- American Society of Heating Refrigerating and Air-conditioning Engineers (ASHRAE): 1999, 'An Investigation Into Thermal Comfort at High Humidities': https://www.researchgate.net/publication/245347428_An_investigation_of_thermal_comfort_at_high_humidities
- Beam Plus New Buildings V2.0, 'Health and Wellbeing, Sustainable Site': https://www.hkgbc.org.hk/eng/beamplus/file/BEAMPlus_New_Buildings_v2_0.pdf
- Beam Plus Neighbourhood V1.0, 'Outdoor Environmental Quality': https://www.beamsociety.org.hk/files/Manual/BEAMPlusNDManualWithCorrigendum-No1.pdf
- Bogdanovic, V. et al. 2018. 'Improving Thermal Stability and Reduction of Energy Consumption by Implementing Trombe Wall construction in The Process of Building Design - The Serbia Region. Thermal Science': https://www.researchgate.net/publication/325468453_Improving_thermal_stability_and_reduction_of_energy_consumption_by_implementing_Trombe_Wall_construction_in_the_process_of_building_design_-_The_Serbia_Region
- BREEAM International New Construction Standard, 'Hea 04 Thermal comfort': https://www.breeam.com/discover/technical-standards/
- BREEAM International In-Use Standard, 'Hea 07 User comfort control', 'Hea 14 Thermal comfort': https://www.breeam.com/discover/technical-standards/
- CABR & CSUS: Green Building Research Centre, 'Healthy Building Evaluation Standard 'Thermal Comfort' Clauses' & Yu Wei, Zhao Xuyuan, Li Baizhan. 2018. Construction Technology. Interpretation of the Comfort Section of 'Healthy Building Evaluation Standard-Thermal Comfort'
- DGNB. 2019. 'Liveable and Fit for the Future': https://www.dgnb.de/en/council/publications/index.php
- DGNB. 2018. 'The Cost Trap of Refrigerants': https://www.dgnb.de/en/council/publications/index.php
- Emirates Green Building Council. 'Emirates Coalition for Green Schools': https://emiratesgbc.org/technical-programs/green-schools/
- Green Building Council of Australia: Green Star, 'Design & As Built, 'Indoor Environment Quality': https://new.gbca.org.au/rate/rating-system/design-and-built/
- Green Building Council of Australia (GBCA). 2018. 'Building with Nature, Prioritising Ecology and Biodiversity for Better Buildings and Cities': https://new.gbca.org.au/rate/green-star-strategy/building-nature/https://new.gbca.org.au/rate/green-star-strategy/building-nature/
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