# Exploring nature-positive buildings

→ *Understanding the role of buildings in the transition to a nature-positive future*

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World Business Council *for Sustainable Development*

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# Foreword

A net zero future is not enough. We need to work together to secure a future that is also nature-positive aligned with the global goal for nature - reversing nature loss by 2030 and full recovery by 2050.

WWF's recent landmark report 'A System in Peril'[1] highlights the consequences of nature loss, and the urgency for action over the next 5 years. Human activity has resulted in a stark reduction of wildlife; 73% decrease over the last 50 years. But, whilst biodiversity is how we measure the health of our planet overall, it is reliant on the health of our oceans, freshwater bodies, land and our atmosphere. The 'Planetary Health Check 2024'[2] is clear that the safe and healthy operating space for these ecosystems has been or is near to being exceeded. We have a limited window of opportunity to reverse current trends and restore planetary health – to secure a nature-positive, net zero future.

Over the last 5 years, there has been unprecedented radical collaboration by governments, businesses and civil society organizations to determine the actions necessary to drive decarbonization in the built environment leading to the Buildings Breakthrough,[3] the Declaration de Chaillot,[4] and Market Transformation Action Agenda.[5]

We have today a common language for how we integrate carbon into the decision-making of all built environment stakeholders, called Whole Life Carbon assessment. It includes all greenhouse gas (GHG) emissions across the full life-cycle. This comprehensive way of measuring emissions associated with the construction, operation, maintenance and demolition of buildings is enabling designers and developers to develop holistic strategies for the abatement of these emissions which is driving demand for lower carbon construction materials, energy efficient technology, and renewable energy. Equally, driving a transition from the current linear paradigm of new construction, a limited lifespan and demolition, to a circular paradigm based on better utilization of existing buildings, retrofitting and re-purposing, as well as recycling materials.

We need a similar approach to tackle the built environment's outsized impact on nature. Built environment actors have become accustomed to managing biodiversity impacts on site, but we need to tackle impacts on nature along the full life-cycle, from extraction of raw materials through construction and operation to end-of-life. The nature impacts occurring remotely upstream in the value chain outweigh local site-based impacts considerably.

This report sets out to raise awareness of the impact of the built environment on nature along the full life cycle of building projects. It builds on WBCSD's nature-positive roadmap for the built environment,[6] which encourages companies to assess their impacts, set targets and transform their business strategies to create a nature-positive world. It is intended to catalyse industry wide collaboration in support of a nature-positive future enabled by a common, standardized approach for measuring and monitoring impacts on nature that would also meet the highest transparency requirements of key global sustainability reporting frameworks.

The clock is ticking. The time for action and collaboration is now.

***Roland Hunziker***
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1 "System in peril": Average wildlife populations' size declined by 73% in just 50 years, warns WWF | WWF

2 Planetary Health Check 2024. A Scientific Assessment of the State of the Planet. Planetary Boundary Science. First edition

3 The Buildings Breakthrough: Global push for near-zero emission and resilient buildings by 2030 unveiled at COP28 | UNEP

4 Buildings and Climate Global Forum – Declaration de Chaillot | UNEP

5 Built Environment Market Transformation Action Agenda | WBCSD

6 WBCSD's Nature Positive roadmap for the built environment | WBCSD

# Executive Summary

The twin crises of nature loss and climate change are increasingly evident worldwide. Unsustainable patterns of extraction and consumption of finite natural resources have caused wildlife populations to decline by 69% globally in the past 50 years; over 1 million plant and animal species face extinction in the coming decades[1] while water scarcity is increasing and industrial practices have degraded more than a third of the world's soil.[2] Climate change is exacerbating these downward trends, disrupting natural systems, pushing species and ecosystems beyond their limit to adapt and unleashing extreme weather events that cause incalculable damage to nature.[3] Recognizing these risks, 188 countries came together in 2022 to adopt the Kunming-Montreal Global Biodiversity Framework (GBF). This aims to deliver on a global nature-positive goal *"to halt and reverse nature loss by 2030 on a 2020 baseline, and achieve full recovery by 2050"* and is as significant for policymakers and the private sector as the Paris Agreement 1.5°C climate goal.

**Action throughout the built environment sector is critical to achieving nature positive. The built environment is one of the three most critical systems of impact on nature, alongside agriculture & food, and energy. It is responsible for nearly 30 % of biodiversity loss globally,[4] 50% of global raw materials extraction, 40% of waste streams, and 40% of $CO_2$ emissions.[5] Real estate developers and building designers have a key role to play.**

As a starting point, this report aims to translate the global nature-positive goal into key messages and actions with a particular focus on the role played by real estate developers and building designers as the decisions they make have a significant influence. Nature positive means ensuring that there is more nature in the world in 2030 than in 2020 and continued recovery after that.[6] In the context of buildings, nature positive means that the state of nature globally (all along the value chain) is better off because of a construction or renovation project compared to a do-nothing scenario.

This requires the sector to adopt a whole life-cycle approach to nature in the same way it does for carbon, considering the embodied nature impacts that occur upstream and downstream in the value chain in addition to site-based nature impacts. For most new buildings, these **embodied nature impacts are likely to hugely outweigh the site-based impacts.**

Measuring and monitoring embodied nature impacts as such is an essential first step in managing and reducing them. Further, as global environmental, social and governance (ESG) reporting frameworks increasingly align with guidelines emerging from the Taskforce for Nature-related Financial Disclosures (TNFD), **businesses will need to measure, monitor and report on the nature impacts of their direct operations both upstream and downstream. This will include the embodied nature impacts of their building projects.**

The type and scale of embodied nature impacts vary greatly depending on the material type, how the sector extracts and processes it and where these operations occur. However, there is little data available to evaluate these impacts, even for those value chain actors that have direct operations including the extraction and processing of raw materials. As materials progress down through the value chain and become more complex products, the visibility of the upstream impacts can almost entirely disappear. Standardized, comparable data on the accumulating nature impacts of materials as they pass down the value chain, and mechanisms to share this data with downstream partners, will be essential going forward.

**To align with the nature-positive goal, a building would need to deliver a net-positive benefit for nature throughout its whole life cycle with full implementation of the mitigation hierarchy to minimize harm and regenerate nature on a like-for-like basis.**

Achieving this level of building performance is extremely challenging and all the solutions that would get the world there aren't yet available. But this is the level of ambition that is necessary if buildings are to contribute to, rather than detract from, a nature-positive future. It will require deep and far-reaching value chain transformation but many of the built environment interventions needed for nature positive are the same as those for carbon and are already underway. The Architecture, Engineering and Construction (AEC) sector may only just be beginning its journey to understand whole life nature impacts, but has the opportunity to embrace nature loss alongside carbon, whilst recognizing it is significantly more complex and will require radical collaboration across the industry.

This report identifies four key messages for developers and designers that will help kick-start action to achieve nature-positive buildings:

→ **Think global:** Nature positive is a global goal aimed at more nature globally by 2030 compared to 2020. For buildings, this means acknowledging the significant impacts that occur away from the site associated with the extraction and processing of construction materials.

→ **Think whole life cycle:** Embodied nature impacts occurring remotely from the site in the upstream and downstream value chain are likely to dwarf the nature impacts that occur on-site.

→ **Take immediate action:** Businesses across the value chain can take practical actions to reduce nature impacts across the whole life cycle of buildings, with circular approaches prioritized to minimize the extraction and processing of raw materials.

→ **Engage with the value chain:** Contribute to building knowledge and skills, measuring and managing nature impacts, increasing accountability for, and the transparency of, value chain nature impacts in conjunction with carbon, advocating for changes to policy, regulations and standards, and accelerating change along the value chain.

# Glossary

# 01.

# 01. Glossary

## Key working definitions introduced in this report

This report introduces some new terms and definitions. For ease of reference, we have included these at the start of the report and discuss them in more detail in the main text. **We intend for these to be working definitions; they are likely to evolve as they become established industry terminology.**

Appendix A suggests the further working definitions needed to progress the understanding of how and where buildings impact nature to facilitate the ongoing conversation on buildings and the nature-positive goal.

**Box 1: Working definitions**

**Nature-positive building (interim definition)**

A building that delivers a net-positive benefit for nature across its whole life cycle, with full implementation of the mitigation hierarchy to minimize harm and regenerate nature on a like-for-like basis across the value chain.

**Embodied nature impacts**

Nature impacts occurring remotely from the site, associated with material extraction, processing and transportation throughout the whole life cycle of a building [including maintenance, repair and end-of-life].

**Site-based nature impacts**

Direct and indirect impacts on nature occurring on the site of the building or within the surrounding area of influence, during construction, operation and use (including maintenance and repair) and demolition.

**Whole life nature impacts**

Sum of site-based and embodied nature impacts across the whole building life cycle.

## Established definitions for terms used in this report

We've used the following established terms throughout the report. We provide commonly accepted definitions for these terms below.

**Box 2: Established definitions for nature**

**Nature**

The natural world, emphasizing the diversity of living organisms, including people, and their interactions with each other and their environment.[7]

**Realm of nature**

The major components of the living, natural world that differ fundamentally in their organization and function.[8] These are land, ocean, freshwater and atmosphere.

**Biodiversity**

The variability among living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.[9]

**Nature positive by 2030**

Halting and reversing biodiversity loss by 2030 from a 2020 baseline through measurable gains in the health, abundance, diversity and resilience of species, ecosystems and natural processes.[10]

**Box 3: Why "nature impacts" not "biodiversity impacts" or "ecological impacts"?**

**Why "nature impacts" not "biodiversity impacts" or "ecological impacts"?**

Industry leading work by the UK Green Building Council and the Institution of Civil Engineers (ICE) with Expedition has raised the profile of embodied ecological impacts[11] and embodied biodiversity impacts of construction materials[12] respectively. In this report, we have chosen to adopt the broader scope of nature impacts, including impacts on land, air, ocean and freshwater realms, in addition to biodiversity and ecological impacts. This aligns with the scope, language and metrics emerging from rapidly evolving environmental, social and governance (ESG) reporting frameworks, including the Taskforce for Nature-related Financial Disclosures (TNFD). These frameworks recognize that business dependencies on nature extend well beyond biodiversity. Ultimately, companies will need to report on the material nature impacts, risks and opportunities associated with their assets and activities. Completing corporate-level assessments will require data at the individual building level. Therefore, it is important that the language, methods of measurement and metrics used at the building-scale align with these emerging corporate-scale reporting requirements.

# Introduction

# 02.

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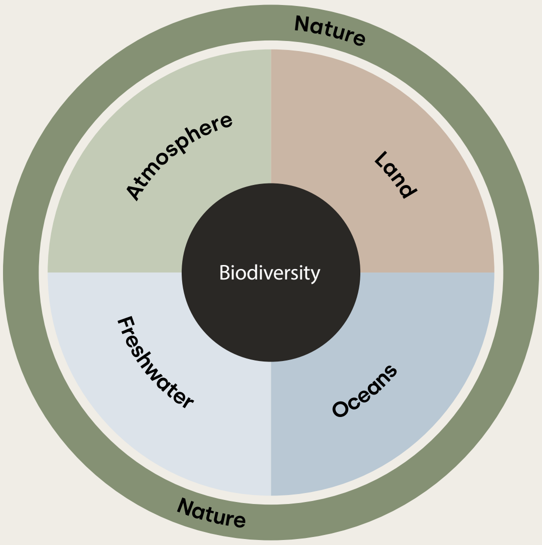
The twin crises of nature loss and climate change are increasingly evident worldwide. Human activity has caused a nature decline at rates never experienced in human history. Unsustainable patterns of extraction and consumption of finite natural resources have caused wildlife populations to decline by 69% globally in the past 50 years; over 1 million plant and animal species face extinction in the coming decades,[13] while water scarcity is increasing and industrial practices have degraded more than a third of the world's soil.[14]

Climate change is exacerbating these downward trends, disrupting natural systems, pushing species and ecosystems beyond their limit to adapt and unleashing extreme weather events that cause incalculable damage to nature as well as buildings and infrastructure.

**Figure 1: Biodiversity refers to the variety of life**




For many in building design teams, *nature* can seem like an abstract term, making it hard to know where or how to begin. When this is the case, it can be helpful to think of nature by its constituent parts, which can feel more tangible, making it easier to understand and identify what impacts a building could potentially cause.

Nature comprises the realms of land, air, freshwater and oceans and all living things. These *realms* interact in complex ways, forming ecosystems, regulating the climate and supporting all life on Earth. Biodiversity (a rich variety of life) is the outcome achieved when the natural systems in these *realms* are stable and functioning well, while a high level of biodiversity also contributes to sustaining the other realms or non-living components of nature (soil, water, air). For example, biodiversity in soil invertebrates and microorganisms is fundamental to maintaining soil fertility. Understanding how a building could impact land, air, freshwater and ocean systems will both positively and negatively also help identify how a building could impact biodiversity.

Nature is essential for human life, providing water, food and the raw materials needed to survive and thrive. Nature regulates the climate, cleans the air and water, pollinates crops and protects all beings from extreme weather events. The goods and services that nature provides underpin our economies underpins economies to the extent that the entire economic value generated by the construction sector (worth USD 6.5 trillion) depends on the resources and services that it provides.[15] Consequently, the threat nature loss poses is so severe that it is one of the top 5 threats to the global economy over the next 10 years.[16]

Recognizing these risks, 188 countries came together in 2022 to adopt the Kunming-Montreal Global Biodiversity Framework (GBF). This aims to deliver a global nature-positive goal "to halt and reverse nature loss by 2030 on a 2020 baseline, and achieve full recovery by 2050." The nature-positive goal and the GBF are as significant for policymakers and the private sector as the Paris Agreement's 1.5°C climate goal has proved to be.

The GBF is driving change that will require businesses to measure, monitor and report on the nature impacts not just on their direct operations but also along their whole value chains. This is happening as global environmental, social and governance (ESG) reporting frameworks align with guidelines emerging from the Taskforce for Nature-related Financial Disclosures (TNFD). For the real estate and architecture, engineering and construction (AEC) sectors, this will include the whole value chain nature impacts of their building projects.

Action across the built environment sector is particularly critical to achieving nature positive as one of the three most critical systems of impact on nature, alongside agriculture & food, and energy. It is responsible for nearly 30% of biodiversity loss,[17] 50% of global raw materials extraction, 40% of waste streams, and almost 40% of $CO_2$ emissions.[18a]

By 2025, the construction industry is predicted to generate 2.2 billion tons of waste annually. Of this, approximately 77 million tonnes (35%) ends up in landfills each year.[18b] With the global building floor area predicted to grow by 75% (180 billion $m^2$) by 2050,[19] business as usual is not an option. Real estate developers and building designers have a key role to play.

Transformation of the built environment value chain is already underway to decarbonize buildings. The Buildings Breakthrough[20] at the 28th United Nations Climate Change Conference (COP28) has seen countries join forces to make near-zero emissions and climate-resilient buildings the new normal by 2030, and the Market Transformation Action Agenda (MTAA)[21] for the Built Environment brings together companies along the full value chain to drive systemic interventions to decarbonize, supporting the Buildings Breakthrough. Conversely, organizations have largely ignored the full nature impacts of the value chain for buildings. The AEC sector may only just be beginning its journey to understand whole life nature impacts, but has the opportunity to embrace nature loss alongside carbon, whilst recognizing it is significantly more complex and will require radical collaboration across the industry.

As a starting point, this report translates the global nature-positive goal into key messages and actions with a particular focus on building designers and real estate developers. It identifies the collective value chain action required to initiate the journey towards buildings that restore, rather than harm, the global state of nature. Building awareness and cultivating the knowledge of whole life nature impacts is an essential first step.

The report provides working definitions for key terms that will enable the AEC industry to continue the conversation on nature-positive buildings with clarity and consistency. Wherever possible, we have adapted these from commonly accepted definitions relating to whole life carbon assessment and net-zero buildings.

Our guidance focuses on four key messages that will start the industry on the road to nature-positive buildings:

1. **Think global**
2. **Think whole life cycle**
3. **Take immediate action**
4. **Engage with the value chain**

**Box 4: Overview of WBCSD's Roadmaps to Nature Positive**

**WBCSD's Roadmaps to Nature Positive**

WBCSD's Roadmaps to Nature Positive equip companies with step-by-step how-to guides to take credible, impactful nature action, preparing them to set science-based targets and report on them based on TNFD recommendations, while ultimately working towards the Global Goal to halt and reverse nature loss by 2030. WBCSD has so far produced initial roadmaps for the agri-food system, forest products sector, built environment system, and energy system.[22] This report complements the WBCSD Roadmap to Nature Positive - Foundations for the built environment system[23] by providing guidance to real estate developers, building designers and stakeholders across the value chains of buildings to align the buildings of tomorrow with a nature-positive future.

# 1 Think global

### Box 5: Nature-positive discourse

*"Nature positive is not a slogan – it is an ambitious goal and should not be used to imply something is green or nature-friendly. It refers to measurable outcomes that contribute to halting and reversing nature loss with significant benefits to society."*[24]

Nature positive is a global goal that mirrors the Global Biodiversity Framework's mission statement. The goal is to halt and reverse nature loss by 2030 from a 2020 baseline to achieve a full nature recovery by 2050 as illustrated in Figure 2. Nature positive means ensuring there is more nature in the world in 2030 than in 2020 and continued recovery after that.[25]

In the context of buildings, nature positive means that the state of nature globally (all along the value chain) is better off because of a construction or renovation project compared to a do-nothing scenario.

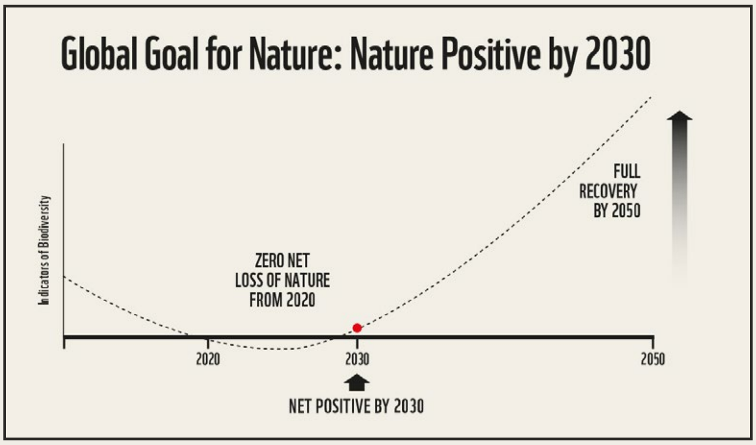
For us, that means a nature-positive building would require that the overall impact on nature, in all its complexity, across the whole life of the building, up and down the value chain, is net positive. Importantly, this would require a building to deliver a net-positive benefit for nature throughout its entire life cycle, minimizing harm and regenerating nature on a like-for-like basis across the value chain. In the absence of an established common definition that organizations are trying to achieve, we propose the following interim definition of a nature-positive building.

### Box 6: Interim definition of a nature-positive building

**Nature-positive building (interim definition)**

A building that delivers a net-positive benefit for nature across its whole life cycle, with full implementation of the mitigation hierarchy to minimize harm and regenerate nature on a like-for-like basis across the value chain.

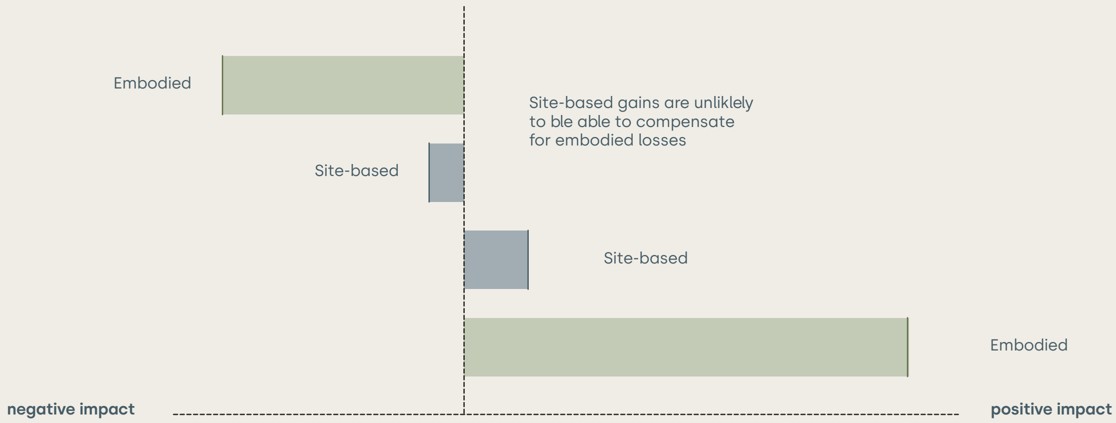
Figure 2: **Global Goal for Nature: Nature-positive by 2030**
It is essential to halt and reverse the current global trajectory of nature loss by 2030 to enable full recovery by 2050 [26]




Source: [A Nature-Positive World: The Global Goal for Nature](). Locke, H. et al. (2021)

WBCSD and other organizations, including the Nature Positive Initiative (NPI), are working to translate the Global Biodiversity Framework (GBF) and nature-positive goal into guidance for sectors and organizations. In the meantime, the working definition of a nature-positive building in this report aims to provide clarity on the level of performance that a building would have to achieve to align with the Global Goal for Nature. This will help prevent the use of the term to greenwash lower levels of performance. While nature-positive buildings are not currently possible, it is important to be clear that this is the level of ambition necessary if buildings are to contribute to a nature-positive future.

**Figure 3: The net-positive benefit for nature a building must deliver across its whole life cycle for it to be nature-positive**




## 2 Think whole life cycle

Nature impacts do not just occur on-site. They can vary substantially depending on the location of the site, scale of the building, type of materials used and methods of construction.

Building teams generally have much greater awareness and visibility of site-based nature impacts. The most significant site-based impacts generally occur during site clearance and construction, leading to habitat and soil loss and degradation and water body, air and soil pollution. During operation, water abstraction, wastewater discharges, carbon emissions and air pollution can be the most significant site-based impacts, while during demolition this shifts to dust emissions, soil and water pollution and carbon emissions.

Less recognized are the nature impacts embodied within the materials used to construct buildings. These occur off the site (often thousands of miles away) through the extraction and processing of raw materials, which cause habitat loss, fragmentation, degradation and disturbance, carbon emissions and the resulting climate change, water, soil and air pollution, and the introduction of invasive species (see Figure 5).[27]

**Box 7: Working definitions of embodied nature and site-based nature impacts**

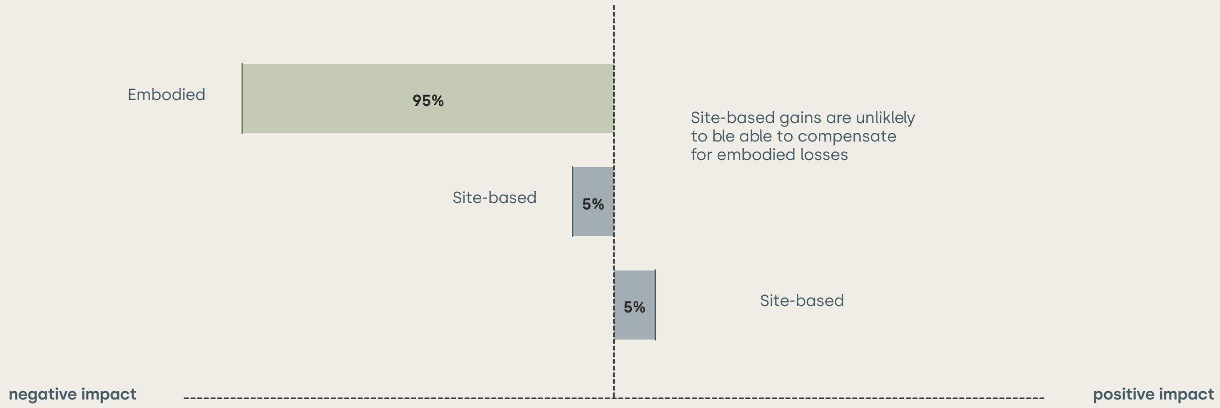
**Embodied nature impacts**

Nature impacts occurring off the site are associated with the extraction, processing and transportation of materials throughout the whole life cycle of a building (including maintenance, repair and end-of-life).

**Site-based nature impacts**

Direct and indirect impacts on nature occurring on the site of the building or within the surrounding area of influence, during construction, operation and use (including maintenance and repair) and demolition.

**Figure 4: Site-based gains are unlikely to compensate for embodied losses**




**Site-based net gain approaches**

Net gain approaches to site-based biodiversity impact are gaining popularity with planning regulators. For example, in England, Biodiversity Net Gain (BNG) regulations make it mandatory for developers to ensure they deliver at least a 10% gain in biodiversity from a pre-construction baseline. Similar legislation is being implemented or considered by other countries, including Australia and the EU, and the IUCN has published guidelines for achieving biodiversity net gain targets.[28]

While these approaches aim to increase biodiversity on-site, which is a welcome outcome and can be an important component of a nature-positive approach, *biodiversity net gain* is not interchangeable with the term *nature positive*. Biodiversity net gain does not fully cover the broader components of nature that development might impact (for example, soils, groundwater, and air). Importantly, net gain does not consider the embodied nature impacts of buildings and therefore falls short of being a measure of absolute gain for nature.

**Figure 5: Where upstream and downstream embodied and site-based nature impacts occur along a material value chain**

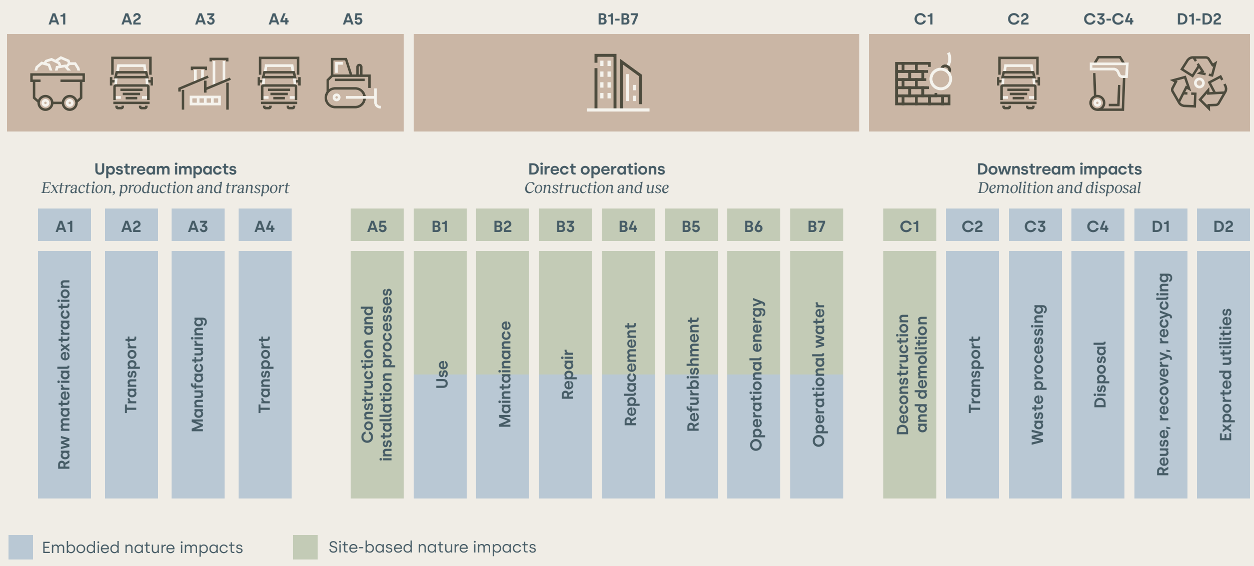
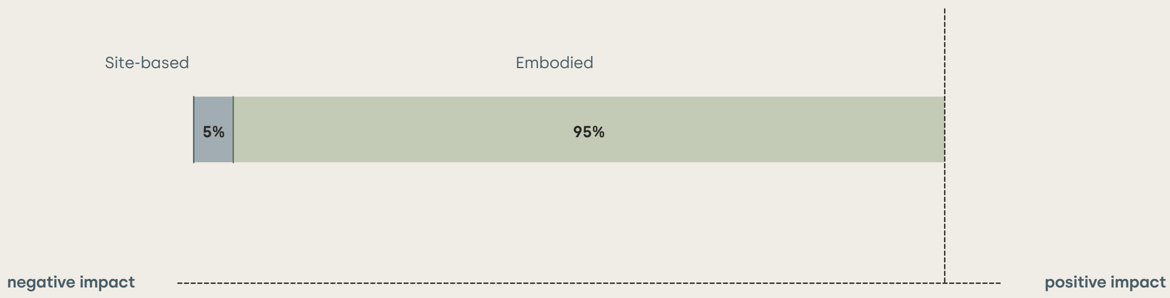


**Figure 6: Embodied impacts on nature dwarf site-based impacts**




Embodied nature impacts occurring off of the site are likely to dwarf the site-based nature impacts of a building. One study indicates that as much as 95% of the construction sector's impact on nature is associated with activity off-site[29] compared to 5% of impacts occurring at the location of the construction site.

Table 1 shows the findings of WBCSD's impact assessment for the building subsystem.

**Table 1: Summary of the most significant impacts associated with buildings as identified by WBCSD[30]**

| | | | | Upstream | Direct operations | Downstream | |
|---|---|---|---|---|---|---|---|
| | Pressure category | Impact Type referenced in figure 7 | Impact type | Material extraction and production | Design and construction | Operations and maintenance | Demolition and waste |
| *Land-/ water-/sea-use change* | Terrestrial ecosystem use | 1 | Change in habitat extent | | | | |
| | | 2 | Change in habitat condition | | | | |
| | | 3 | Change in habitat connectivity | | | | |
| | Freshwater ecosystem use | 4 | Change in habitat extent | | | | |
| | | 5 | Change in habitat quality | | | | |
| | Marine ecosystem use | 6 | Change in habitat extent | | | | |
| | | 7 | Change in habitat quality | | | | |
| *Resource* | Water use | 8 | Change in groundwater and surface water level | | | | |
| *Climate change* | GHG emissions | 9 | Climate change impact | | | | |
| *Pollution* | Non-GHG emissions | 10 | Change in air quality | | | | |
| | Water pollutants | 11 | Change in water quality | | | | |
| | Soil pollutants | 12 | Change in soil quality | | | | |
| | Solid waste | 13 | Change in solid waste quantity | | | | |
| *Invasive species and others* | Disturbances | 14 | Change in soil/seafloor characteristics | | | | |
| | | 15 | Change in sound/ lightscape | | | | |
| | Invasive alien species (IAS) | 16 | Change in habitat condition | | | | |

Very high | High | Medium | Low | Very low | No data

The most significant embodied impacts occur during the conversion of land to extract materials. The creation of quarries, mines and supporting infrastructure generally means habitat loss, degradation and fragmentation and soil, groundwater and surface water body pollution and disturbance. The extraction and processing of materials can also use large volumes of water, putting pressure on water resources, and are often energy-intensive, leading to significant greenhouse gas emissions.

## *Embodied nature impacts vary considerably for different materials*

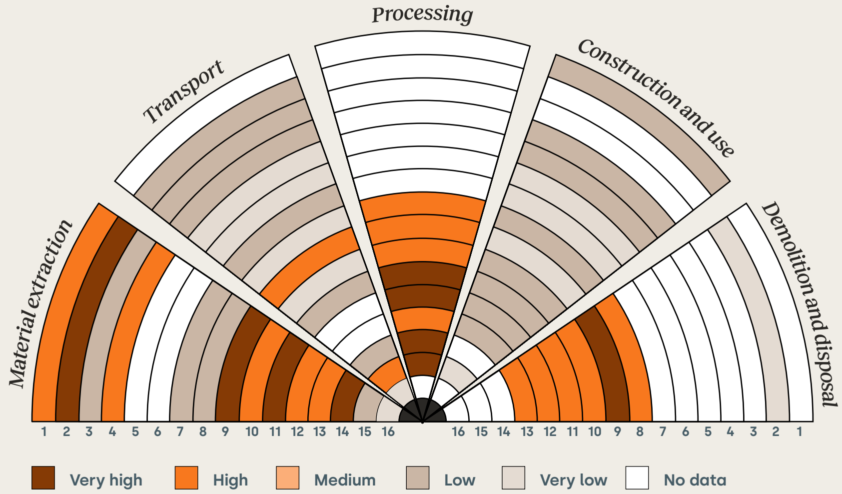
The type and scale of embodied nature impacts vary greatly depending on the material extracted and processed and where these operations occur.

We have evaluated the value chain impacts of three key construction materials: steel, concrete and timber. From these evaluations, we have created the whole life impact profiles shown in Figure 7. We include further details on the nature impact types 1 to 16 of each value chain in the tables of Appendix B for these three materials.

**Figure 7: Whole life nature impact profiles for key construction materials**

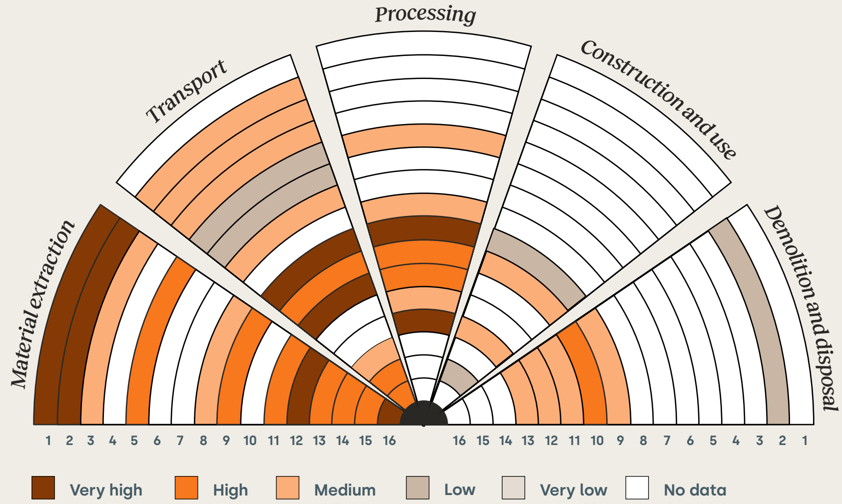
## Steel value chain

**Steel:** The most significant nature impacts of the steel value chain occur in or close to mine sites in Australia, the United States, Brazil, China and India and at steel processing plants in Europe and East Asia. The mine sites impact nature through land-use change, pollution, the introduction of invasive species and intensive resource use. The processing plants impact nature primarily through pollution.[31]



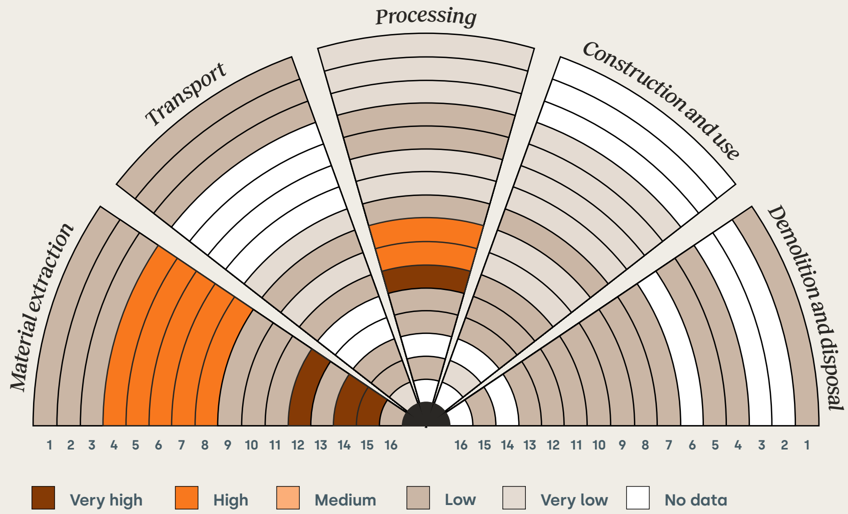

## Timber value chain

**Timber:** The nature impacts of the timber value chain concentrate on where companies harvest timber (most significantly the United States, Russia, Brazil, China and Canada) and where they process it (most significantly the United States, China, Russia, Canada and Germany).[32] The forests and harvesting process impact nature through habitat degradation/ fragmentation and water pollution, while the processing plants impact nature primarily through the release of gaseous emissions, polluted wastewater and the production of large quantities of solid waste.




## Concrete value chain

**Concrete:** The most significant nature impacts of the concrete value chain occur during the extraction and processing and manufacturing stage of the materials, particularly in the quarrying of limestone, aggregates and gypsum and the production of cement. Potential nature impacts include intensive water and energy use, land-use change and ecosystem disturbance, air pollution and, most prominently, greenhouse gas emissions.



**The nature impacts associated with extraction are the most harmful life-cycle stages for concrete**, timber and steel and contribute the most to the embodied nature impacts of these materials.

According to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (2024), mining and quarrying affect up to 12,950 species, 48% of which are at extinction risk.[33] Generally, the most severe nature impacts occur from the mining techniques used to extract iron ore, limestone, metallurgical coal and gypsum and unregulated dredging to attain sand and aggregates. These types of extraction are present in the steel and concrete value chains. These impacts arise from the removal of overburden and vegetation, acid mine drainage and heavy metal pollution, habitat destruction leading to biodiversity loss in addition to permanent alterations to land topography and hydrological flows. Rates of sand extraction have increased by 300% over the past 20 years and remain largely ungoverned in many parts of the world,[34] leading to significant environmental impacts, including coastal erosion, water pollution, depletion of aquifers and threats to freshwater and marine biodiversity.

Harvesting for mass timber typically impacts nature by altering habitats and causing temporary local degradation in water quality. Timber production reduces water use as dust abatement, washing equipment or cleaning rock and ore do not need it.

**The nature impacts associated with transport are the greatest for steel** because transportation distances are greater than for timber and concrete value chains and rely more heavily on shipping, which pollutes more than road or rail transportation modes. Typically, transportation distances are the least for concrete.

**The impacts of processing and manufacturing** are similar for all materials for the emissions of gaseous pollutants like carbon dioxide, carbon monoxide, sulfur dioxide and nitrogen oxides, contributing to climate change and lowering air quality. Additionally, intensive energy and water use for heating and cooling processes impact nature moderately. According to the IUCN Red List of Species, energy production affects 1,470 threatened species, 43% of which are at risk of extinction.[35]

While the construction stage of buildings can result in significant site-based nature impacts (see Table 1), these are not typically attributable to the use of steel, timber and concrete per se. The use of these materials during the **construction and use of buildings** is less significant than other stages of the material's life cycle. However, there is a higher risk of soil and freshwater pollution in the presence of concrete in its pre-cured, slurry form.

**The impacts associated with demolition and disposal** are greatly dependent on the disposal method. Steel has the greatest rate of recyclability and so the disposal impacts are similar for the processing stage. Recycling is more difficult for mass timber and concrete than other construction waste, with a lack of well-established supply chains, leading to contamination to facilitate reuse. Companies frequently incinerate timber waste, releasing carbon and other air pollutants and sending a portion to landfills where it will decompose and release methane, a highly potent greenhouse gas. Companies recycle some concrete into aggregate for construction uses, and this process typically results in dust emissions. Concrete disposed of in landfills can lead to toxic (highly alkaline) water and gaseous emissions with the potential to impact wildlife and public health.[36]

There is little data available to evaluate the location and severity of impacts, even for those value chain actors whose direct operations include the extraction and processing of raw materials. As materials progress down the value chain and actors manufacture them into more complex products, the visibility of the upstream impacts can almost entirely disappear. Standardized, comparable data on the accumulating nature impacts of materials as they pass down the value chain, and mechanisms to share this data with downstream partners, will be essential going forward.

### *Accelerating the understanding of whole life nature impacts*

Over the past 10 years, there have been substantial advancements in the measurement and understanding of the embodied and whole life carbon of buildings. Whole life carbon assessment (WLCA) methodologies show actors how they could start to create a framework for whole life nature impact assessments (WLNA) (see Figure 8 and Appendix A). There are many areas of commonality that actors can leverage to accelerate progress on this, including:

- The definition of value chain, building components and life cycle stages (see WBCSD's Building System Carbon Framework)[37]
- Terms and definitions (see **Appendix A**)
- Refining of the iterative approach to assessments, becoming increasingly detailed as the design progresses (e.g., BSI PAS 2080)[38]
- Established methods of life cycle assessment (LCA) for buildings (e.g., BS EN 15978)[39]
- Methods of transmitting the environmental performance data of construction products to other parts of the value chain (e.g., environmental product declaration - EPD).

The key point of divergence between WLCA and WLNA is at the level of metrics and data, which are considerably more complex than for carbon. It is possible to normalize and aggregate carbon emissions into a single Global Warming Potential metric ($kgCO_2e/m^2$) and the impact of the emissions on global heating is the same wherever they occur. This is not true for nature impacts, which are highly location-specific and the cause-and-effect relationship is much harder to determine than carbon (for example, the severity of impact caused by an activity may vary significantly depending on the time of year the actor undertakes it). It is also not possible to normalize and aggregate multiple nature metrics into a single metric.

Fortunately, considerable activity is underway to create frameworks to assess and report the nature-related risks and impacts associated with corporate activities, most notably by the Taskforce for Nature-related Financial Disclosures (TNFD) and Science-Based Targets Network (SBTN). TNFD has recently released guidance to assess the nature-related impacts, risks, dependencies and opportunities of construction materials. WBCSD is working to identify nature metrics for the built environment value chain. This will contribute to the standardization of metrics and data across the value chain which will greatly aid the development of WLNA methods.

**Figure 8:** **Key building blocks of a whole life nature assessment framework already exist**

| **Building blocks for WLNA** | **Upstream impacts** *Extraction, production and transport* | **Direct operations** *Construction and use* | **Downstream impacts** *Demolition and disposal* |
|---|---|---|---|
| **Guidance on measurement** | **Available** *TNFD sector guidance for construction materials** | **Available** *TNFD sector guidance for engineering, construction and real estate*** | **Not yet available** |
| **Metrics** | **Pending** *TNFD, WBCSD* | **Pending** *TNFD, WBCSD* | **Not yet available** |
| **Data** | **Not yet available** *Provided by design team and upstream partners* | **Partially available** *Design team and operational supply chain partners* | **Not yet available** |
| **Lifecycle assessment methodology** | **Available** *BS EN 15978***: Assessment of environmental performance of buildings* | | |

↓

**Whole life cycle nature impacts**

**Notes**
* TNFD sector guidance for construction materials
** TNFD sector guidance for engineering construction and real estate
*** BS EN 15978:2011: Sustainability of construction works. Assessment of environmental performance of buildings. Calculation method | British Standards Institutions 2024

## 3 Take immediate action

While nature-positive buildings will only become a reality with a whole value chain transformation, this will take time. There are many effective actions and approaches that design teams can implement today that will help stem the decline of nature. In most cases, these approaches fully align with efforts to deliver net-zero carbon buildings that are resilient to a changing climate.

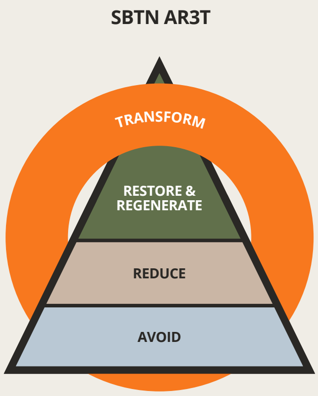
It is important to prioritize design approaches in full alignment with the mitigation hierarchy. SBTN's AR3T framework embeds this (see Figure 8), aiming to help businesses prioritize action to avoid and reduce their nature impacts, restore and regenerate ecosystems and transform the systems in which they operate.

For buildings, this means:

- → **Avoid:** Prioritize the avoidance of the negative embodied and site-based nature impacts above all other actions.
- → **Reduce:** Where unavoidable, minimize negative impacts to the greatest extent possible.
- → **Restore:** Like-for-like restoration of nature at the location where the residual negative impacts have occurred; offsets used only as a last resort (see Box 6).
- → **Regenerate:** Enhance nature above and beyond the pre-development baseline at the location where the residual negative impacts have occurred and elsewhere. Note: This is essential for the nature-positive goal.
- → **Transform:** Engage across the value chain and use wider spheres of influence to help bring about systemic change to support a nature-positive future.

To align with the nature-positive goal it, is essential to apply the mitigation hierarchy to site-based impacts and embodied nature impacts.

**Figure 9: SBTN's AR3T framework to prioritize actions to achieve nature-positive outcomes**




Source: Science-based targets for nature - Initial Guidance for Business (September 2020)

### *Reducing site-based nature impacts*

Site-based impacts are generally in the direct control of the developer and design team and, in many jurisdictions, procedures exist to identify and mitigate these. Table 2 summarizes the actions developers and designers can take to reduce site-based impacts. While developers and design teams do not have direct control over the application of the mitigation hierarchy to impacts occurring upstream and downstream in the value chain, there are practical actions that they can take to reduce the embodied nature impacts of their buildings. Table 2 summarizes these actions that are aligned with Arup's Circular Buildings Toolkit,[41] WBCSD's Roadmap to Nature Positive – Foundations for the built environment system,[42] and TNFD's Draft Sector Guidance.[43]

However, mitigation alone falls short of the ambition level of the nature-positive goal. Nature positive requires a shift from do less harm to do good. This means implementing regenerative practices that result in more nature, globally, in the future than exists now.

**Regenerative design** approaches can result in an overall improvement in site-based nature, especially on previously developed urban sites where actors have degraded nature. Some examples include green walls, green roofs, permeable concrete, sustainable urban drainage and landscape approaches that create new green spaces on-site. Many of these approaches have the added benefit of reducing energy consumption for heating and cooling, thereby resulting in lower carbon emissions and air pollution.

## *Reducing embodied nature impacts*

**Circular practices** and approaches are at the core of reducing embodied nature impacts. They keep materials and resources in use as long as possible and prioritize the use of materials that help regenerate nature. This decreases the need to extract and process raw materials and reduces waste and pollution, with the consequent reduction of the embodied (upstream) nature impacts. Circular building approaches maximize the use of existing assets (building nothing), build with less materials (such as building retrofit; lean design approaches), build with reused and recycled materials and design for disassembly of the structures at the end of their life. These strategies will avoid and reduce the use of virgin materials, consequently lowering the impacts of extraction and processing.

The Further reading section of this report provides additional guidance on regenerative design and circular building approaches.

**Box 7: A note on offsetting**

### Offsetting

Carbon offsetting is an established approach to compensate for residual carbon emissions that it is not possible to abate to achieve net-zero carbon. While there is debate on the benefits of carbon offsetting, the principle that carbon emissions have the same effect on the Earth's atmosphere wherever they occur and it is possible to normalize all greenhouse gas emissions to a single standard unit ($CO_2e$) underpins them. So, in theory, it is possible to compensate for (offset) activities that result in carbon emissions in one location by activities that result in carbon removals in another.

For nature impacts, offsetting is much more complex and its implementation to produce meaningful outcomes is not yet clear. Unlike carbon emissions, there is no equivalence between different species, different habitats and different natural capital and ecosystem services. It is not necessarily possible to provide a remedy for causing detrimental harm to nature in one location by enhancing nature in another. One example is compensation for the deforestation of virgin, ancient rain forests by planting a new temperate forest in another part of the world. Impacts are location-specific and could have a temporal aspect to consider, such as the seasonality of the plant and animal life cycles or migratory timings. Offsetting negative impacts in one part of the value chain with positive impacts in another part is not always possible.

**Figure 10:** **How the AR3T Framework supports the long-term regeneration of nature**

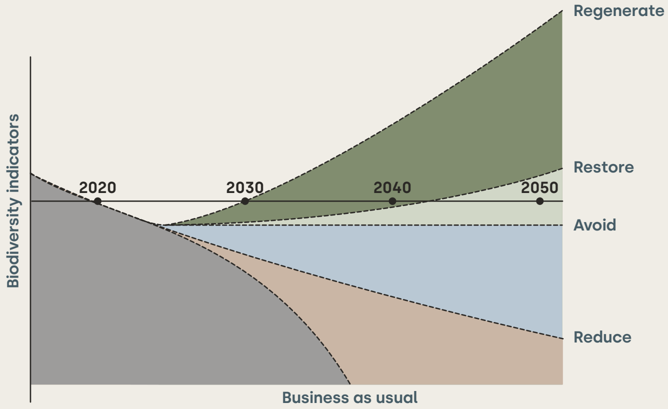



**Table 2:** **Summarized actions building designers and real estate developers can make today to reduce nature impacts across the value chain.**

| AR3T Framework | For embodied nature impacts | For site-based nature impacts |
|---|---|---|
| **Avoid** | Build nothing. | |
| | Reuse existing materials (avoid extraction of new materials). | Refuse new construction on sites of high ecological value. |
| | | Refuse new construction that requires further terrestrial, freshwater and marine habitat conversion or will fragment or otherwise degrade natural habitats. |
| | | Refuse to source materials from high-biodiversity areas or materials known to be scarce or unsustainable/critical raw materials (CRMs).[43] Map suppliers and identify those known in high-risk geographies. |
| | | Increase the density of previously developed sites in urban areas to reduce pressure for urban expansion. |
| | | Site new buildings responsibly by locating them in previously impacted areas to prevent further loss of natural habitat. |

**Table 2:** **Summarizes actions that building designers and real estate developers can make today to reduce nature impacts across the value chain (continued)**

| AR3T Framework | For embodied nature impacts | For site-based nature impacts |
|---|---|---|
| **Reduce** | Prioritize re-use and retrofit of buildings and infrastructure over demolition and new builds. | Minimize the footprint of enabling and construction works. |
| | Minimize the use of high-impact commodities where suitable alternatives are available. | Adopt best practices to limit the spread of invasive species and pests and integrate more diverse native species into landscaping. |
| | Only develop sites that will result in zero deforestation and zero conversion of natural land/coast/sea. | Undertake environmental impact assessments of the site and surrounding areas in accordance with best practices and implement recommended mitigation measures fully to minimize impacts on soils, water resources, air and biodiversity. |
| | Embed circular principles in every stage of the design process to minimize the use of virgin raw materials.<br>→ Build for longevity, maximizing durability, adaptability and resilience to future climates.<br>→ Design for efficient use of materials (lean design).<br>→ Maximize the use of reclaimed components.<br>→ Maximize the use of recycled materials and materials with recycled/ secondary content.<br>→ Design to make disassembly easier and maintain the value of materials for reuse and recycling at end-of-life. | Design to eliminate pollution risk during operation. |
| | Prioritize use of materials from sustainably-managed renewable sources over non-renewable virgin materials and include specific nature-related criteria in the selection and purchasing process of raw materials. | |
| | Minimize the use of carbon and nature-intensive materials. | Create buffer zones/ecological corridors around valuable ecosystems and design to avoid reduction of ecosystem functioning. |
| | Design out hazardous/ pollutant materials. | Design circular infrastructure by designing out waste. |
| | Localize supply chains where possible to reduce transportation. | Ensure safe waste disposal methods (e.g., regulation, planning and management). |
| | Collaborate with suppliers and demolition contractors to maximize the use of secondary/recycled materials. | Promote an efficient and circular use of water, by maximizing the recovery process and applying rainwater harvesting. |

**Table 2: Summarizes actions that building designers and real estate developers can make today to reduce nature impacts across the value chain (continued)**

| AR3T Framework | For embodied nature impacts | For site-based nature impacts |
|---|---|---|
| **Restore** | Engage in context-based landscape management approaches with value chain partners (e.g., watershed stewardship and enhancing biodiversity) to undertake the like-for-like restoration of habitats in the value chain. | Adopt nature-led design approaches that emulate and enhance nature. |
| | Support individual species recovery programs related to the habitat type affected. | Create new habitats on and around buildings and commit to actions and strategies to achieve measurable positive outcomes for biodiversity. |
| | Invest in landscape restoration at extraction/production sites. | Enhance the ecological value of the site through landscaping and nature-based solutions to reduce flood risk, clean polluted air, treat wastewater, shade and cool (reduce heat island effect). |
| | | Undertake nature restoration, e.g., water replenishment or species-specific recovery programs. |
| | | Engage in reforestation/afforestation on degraded land. |
| **Regenerate** | Support additional nature restoration and regeneration projects in and beyond the value chain. | Reconnect natural cycles where disrupted, e.g., removing impermeable surfaces, naturalizing rivers, stabilizing soils, establishing and maintaining landscape corridors, ecological connections and animal crossings for linear infrastructure. |
| | Identify and collaborate with value chain partners to pilot new circular approaches and innovative materials that have lower impact. | Undertake the additional restoration and regeneration of nature within the locality of the site. |
| **Transform** | Ask questions to your suppliers – what is the provenance of the materials you are specifying? Has your supplier assessed the nature impact of their products? What actions are they taking to reduce these?<br><br>Take into account the geographical context, transport distances and local infrastructure as the nature impact of a material may vary from one location to another. | Pilot new approaches to habitat creation and consistently consider and apply nature-based solutions, integrating natural features in the design of new and existing projects. |
| | Adopt corporate policies that encourage upstream transparency and action on nature by suppliers (e.g., by preferentially specifying materials with a nature accreditation where available). | Collaborate with Indigenous people, local communities, landowners and city authorities to identify and implement landscape-scale interventions to restore and regenerate nature. |
| | | Advocate for policies, legislation and building standards that incentivize circularity and the uptake of materials and products that reduce the nature impact of buildings. |
| | | Address climate change and nature simultaneously in any project. |
| | Collaborate with initiatives to develop centralized nature-related datasets, incorporating spatial data, traditional land uses and standardized measurement methods.[44] | |

## 4 Engage with the value chain

Nature-positive buildings will remain beyond reach without deep and radical collaboration across the building industry to mainstream circular economic models and design practices, quantify impacts and increase transparency along all parts of the value chain. This is not something that any individual or company can bring about but they can take action to engage with their supply chain partners and organizations, such as WBCSD, that bring businesses from all parts of the value chain together to accelerate change.

Many of the interventions needed for nature are the same as those identified in the Built Environment Market Transformation Action Agenda[45] that sets out the path towards halving carbon emissions by 2030 through collaboration and action along all parts of the value chain. This change has started. By bringing nature into the heart of this transformation process, it is possible to achieve simultaneously nature-positive and net-zero goals in the built environment.

However, the understanding of how and where nature impacts occur across the value chain is much less mature than for carbon. Addressing this maturity gap in the short term will enable the bringing together of the two agendas.

As immediate next steps, there is a need for value chain collaboration to:

1. **Measure: Create a framework to assess the whole life nature impacts of buildings.** Measurement is an essential first step in managing, reducing, and, ultimately, reversing the impact of new buildings on nature. It would enable the establishment of building-scale benchmarks and targets that organizations could ratchet up over time to ultimately achieve nature-positive buildings.
2. **Standardize: Identify standardized metrics across the whole value chain.** WBCSD has already started this work which will enable the disclosure of comparable data across the whole value chain.
3. **Increase transparency: Intensify accountability for, and the transparency of, value chain nature impacts in conjunction with carbon.**

This will enable the specification of construction materials and building products with lower impact profiles.

This could include consistent adoption across the value chain of:

- Third-party environmental product declarations (EPDs) to communicate products' nature impacts in a standardized and consistent way, making it easier for designers to compare products and make informed decisions;
- Material passports to share information on the provenance of materials, nature impact assessments and EPDs;
- "Nature-positive" product rating systems or certification schemes that assure real estate developers and building designers that upstream actors in the value chain have fully mitigated and compensated for nature impacts through equivalent restoration efforts in the locality where the impacts occur. Such a system would incentivize the full addressing of these nature impacts.

4. **Mitigate impacts where they occur: Wherever possible, negative impacts should be eliminated where they occur in the value chain through the application of the mitigation hierarchy**, including like-for-like restoration coupled with regenerative interventions that push nature into positive recovery.
5. **Promote circularity: Support actions to achieve a circular built environment.** The transition of business models, policies and regulations to support greater circularity in the built environment requires private and public sector action. Standardization, new forms of collaboration and co-creation processes are essential elements in the transition. Digital innovation, education and information sharing can further drive the change in mindset and culture needed to turn the circular built environment into reality.[46]
6. **Advocate: Make a collective call for changes to policy, regulations and standards** to facilitate the delivery of nature-positive buildings, including business models that support the circular economy. This should include more incentives for manufacturers to innovate across their value chain and to produce more sustainable materials and products. Policies could include, for example, minimum required percentages of recycled materials in construction products to help reduce the extraction of virgin materials.

# Conclusion


# 03.

# 03. Conclusion

The nature and climate crises intertwine and mutually reinforce each other. As such, they require joint solutions that address both crises together. The design and construction of buildings matter because they have a significant impact on nature, from extraction of materials through construction and demolition. The extraction and processing of construction materials is one of the key drivers of nature loss globally.[47]

Over the past 10 years, the AEC sector has made significant advancements in measuring and reducing embodied and operational carbon emissions from buildings while equivalent embodied nature impacts have gone largely unnoticed. Recognizing that embodied nature impacts likely far exceed site-based nature impacts is a critical first step in managing and reducing the harm to nature occurring across the whole building life cycle.

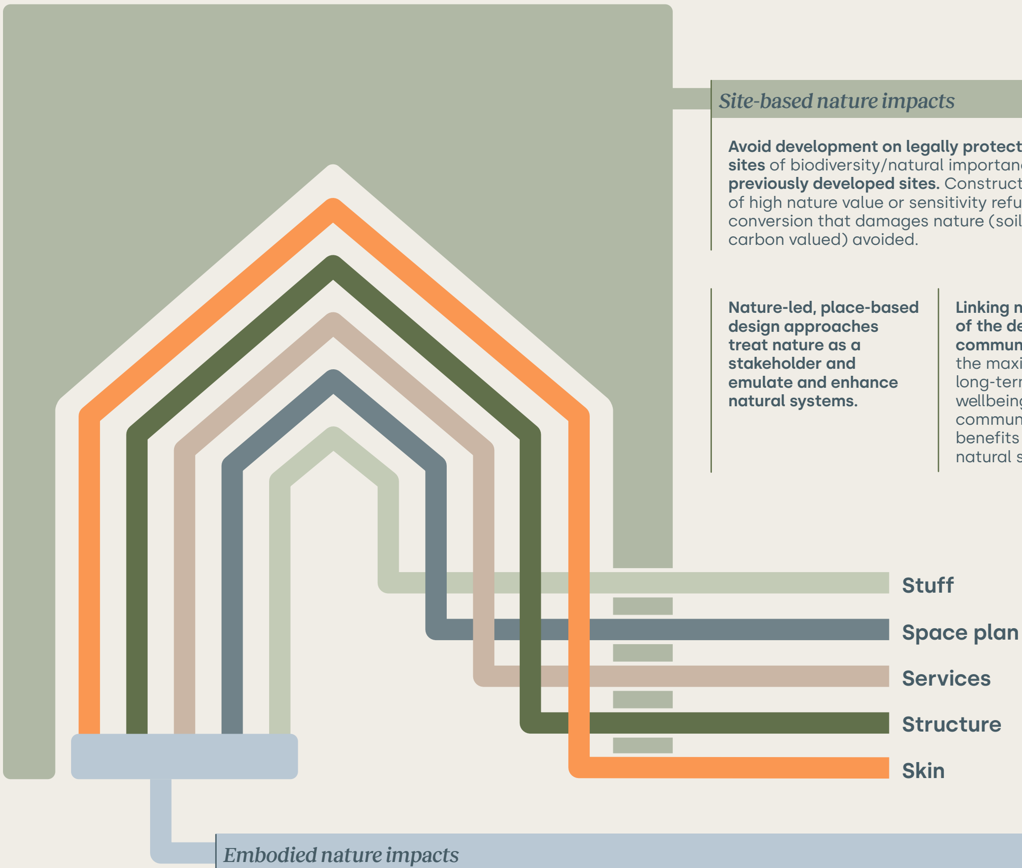
A lack of data and transparency across the value chain and the absence of a framework to quantify nature impacts across the whole building life cycle hinder the visibility of these impacts. These should be priority areas for full value chain collaboration.

There are considerable areas of commonality between methods to measure and reduce embodied carbon and those to measure and reduce embodied nature impacts.

These can be leveraged to accelerate progress toward nature-positive buildings. The key components of a measurement framework already exist. Significant activity by organizations such as TNFD and WBCSD to identify metrics to measure the nature impacts of the built environment will further aid progress in measuring the whole life nature impacts of buildings.

As a general principle underlying industry action, the mitigation hierarchy should be applied in full to eliminate negative nature impacts at the location where they occur in the value chain because like-for-like mitigation by downstream actors is usually not feasible. Additionally, regenerative interventions that push nature into positive recovery should be implemented along the full value chain. In the meantime, circular design approaches are key to reducing embodied nature impacts as well as embodied carbon. By doing more with less and eliminating waste, building design teams can minimize the harm caused by extracting and processing virgin materials. Better utilization of existing buildings and retrofitting for reuse, as well as recycling materials, will need to replace the current linear paradigm of new construction, a limited operational lifespan and demolition.

**Figure 11: Key components of a nature-positive building**




### *Site-based nature impacts*

**Avoid development on legally protected areas and sites** of biodiversity/natural importance. **Prioritize previously developed sites.** Construction on sites of high nature value or sensitivity refused. Land conversion that damages nature (soil, water, carbon valued) avoided.

**Nature protected** as a key asset during construction and operation, minimizing the construction footprint.

**Nature-led, place-based design approaches treat nature as a stakeholder and emulate and enhance natural systems.**

**Linking natural elements of the design with the community** to ensure the maximization of long-term human wellbeing and that the community directly benefits from the natural spaces.

**Additional enhancements of nature in the locality of the site** funded through planning obligations, credits or offsets linked to WLNA performance levels to foster broader nature recovery.

### *Embodied nature impacts*

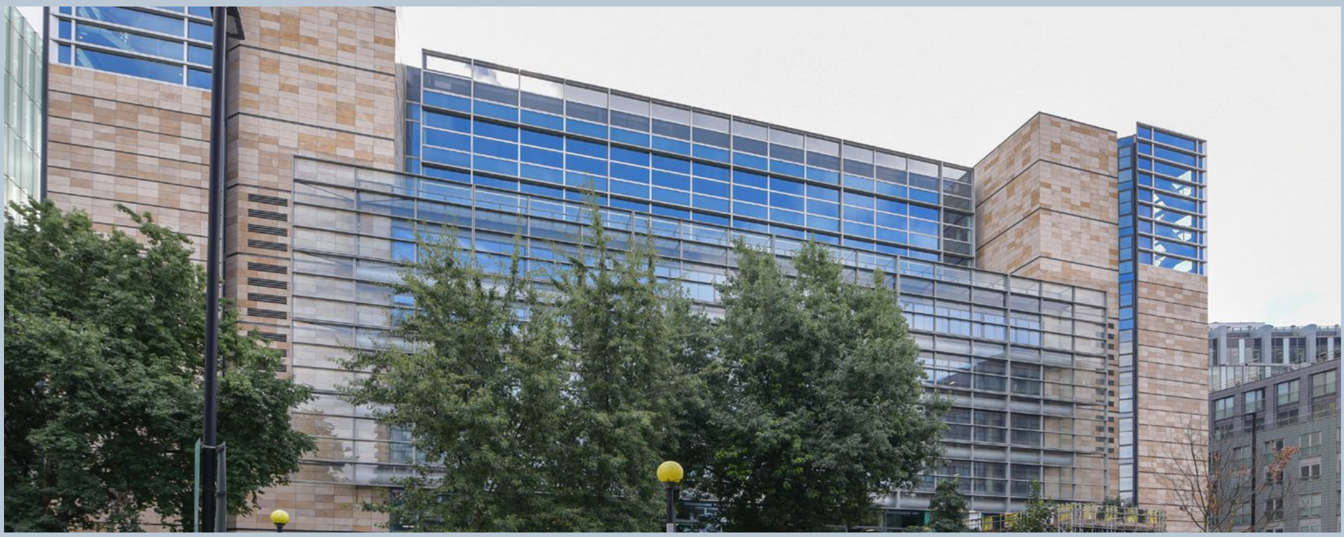
**Whole life cycle nature assessments (WLNA)**
- → Provide benchmarks and targets to guide design practices and material selection.

**Circular principles drive design**
- → Retrofit of existing building significantly reduces use of new materials
- → Efficient design minimizes use of new materials
- → New materials have high reuse/recycled content.

**Full traceability and transparency** of new materials ensure upstream nature impacts are visible and quantifiable
- → Material passports
- → Certified "nature-positive" materials
- → Product declarations.

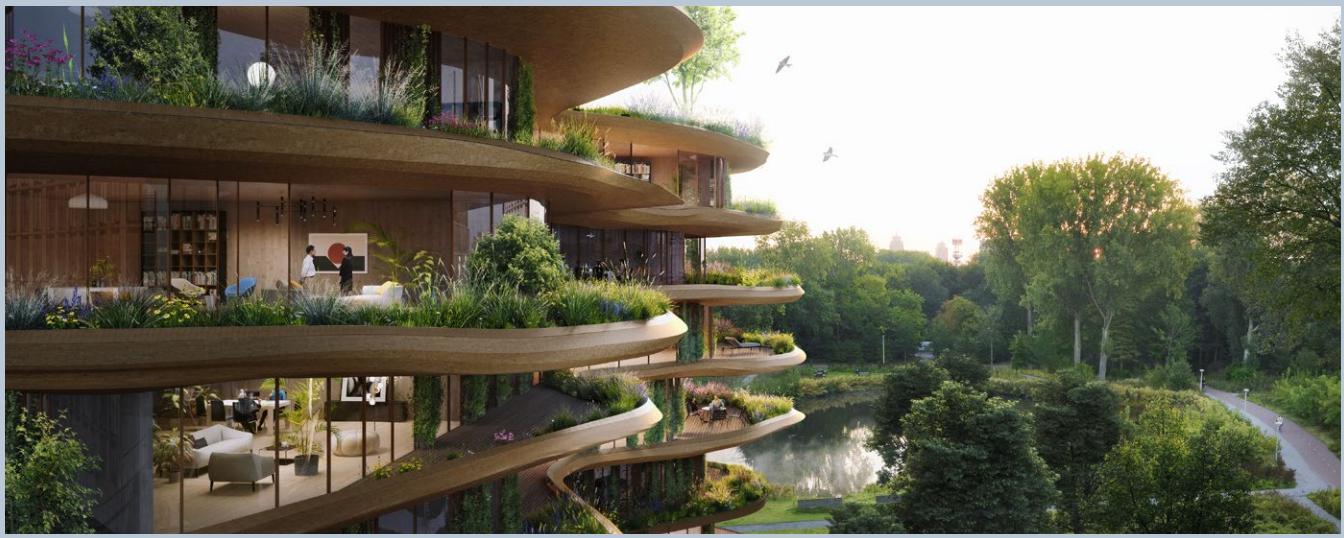
**Residual embodied impacts** balance with like-for-like regeneration of nature at the location of impact. Mechanisms to facilitate this include:
- → Value chain partnerships
- → Offsets linking back to specific parts of the value chain.

# Case studies: *Buildings contributing to nature-positive outcomes across the value chain*



### Reducing embodied impacts

**Triton Square, London, UK:** Driven by British Land's shared low-carbon and sustainability agendas, 1 Triton Square reduced embodied nature impacts by championing circular economy principles, maximizing retention and reuse over 3,000 m2 of the existing structure and façade, including limestone, concrete and steel, producing 43% less carbon during construction and operation than a typical new build alternative and saving 66% of projected costs. This helped to achieve a BREEAM Outstanding rating due to the circular approach to the façade.



### Reducing site-based impacts

**Habitat Royale, Amsterdam, Netherlands:** By integrating nature-based design and biomimicry, Habitat Royale intends to facilitate a net gain in biodiversity by connecting the site with the open green spaces of Beatrixpark. Featuring a nursery, orangery and many other microhabitats, including a flower garden, bat attics, woodland and water structures, Habitat Royale intends to connect natural elements with the residential community, supporting over 113 species of flora and fauna. The design is energy positive and uses biomaterials, such as timber, designed for disassembly and re-use.

## Reducing embodied impacts

**Recygénie, France:** A 220-unit social housing complex called "Recygénie" is currently under construction outside Paris, France. Built in partnership with Seqens and using a custom concrete made by Holcim, this is the first fully recycled concrete building in the world. Drawing on its formulation expertise, Holcim's Innovation Center developed the world's first fully recycled concrete for this project: a concrete in which all components—cement, aggregates and water—are made of recycled materials.

This unique recycled concrete was produced using ECOCycle®, Holcim's proprietary circular technology platform to recycle construction and demolition waste (CDW) into new building solutions. Overall, the Recygénie concrete with ECOCycle saved more than 6,000 tons of natural resources.

## Reducing embodied impacts (for building teams but site-based for upstream value chain actors)

**Haller Park, Kenya:** Owing to 47 years of rehabilitation and conservation efforts, Holcim Group has transformed the wastelands around its cement operation in Mombasa, Kenya into a thriving, self-sustaining ecosystem. Just 47 years ago, a barren wasteland flanked the coral limestone quarry. Today the area surrounding it has more than 400 species of indigenous trees, shrubs and lianas. Many of the indigenous species are now reproducing in the restored ecosystems and supporting a diverse animal population, including more than 180 species of birds, 80 species of butterflies, 17 species of dragonflies, 14 amphibian species and 34 different mammals.

**Reducing embodied impacts** (for building teams but site-based for upstream value chain actors)

**Hirakud, India:** Hindalco's ecological restoration program intends to restore and reforest the Hirakud fly ash dump site, significantly increasing the diversity of native flora and fauna and providing an opportunity to engage local communities. Initial actions involve removing alien invasive species such as the woody shrub Lantara camara for use as composted mulch to restore soil conditions. Adaptive management techniques incorporate a broad selection of native species to accelerate recovery, in addition to woody debris to support a range of invertebrate and vertebrate species.

# Further reading

- Arup: Regenerative design (2024)
- Arup & Ellen MacArthur Foundation: Circular Buildings Toolkit
- British Standards Institution: PAS 2080 – Carbon management in infrastructure (2023)
- Institution of Structural Engineers: Short guides to carbon factors for key materials (including steel, timber and concrete)
- Locke et al.: A Nature-Positive World: The Global Goal for Nature (2023)
- Taskforce for Nature-related Financial Disclosure (TNFD): Draft Sector Guidance: Engineering, Construction and Real-Estate (2024)
- Taskforce for Nature-related Financial Disclosure (TNFD): Draft Sector Guidance: Construction Material (2024)
- WBCSD: The Roadmap to Nature Positive: Foundations for the built environment system (2023)
- WBCSD: Measuring circular buildings – Key considerations (2022)
- WBCSD: The Building System Carbon Framework (2020).

# Appendix A: Definitions

## A.1 Established nature definitions

**Table A.1.1: Established nature definitions**

| Term | Definition | Source |
|---|---|---|
| **Biodiversity** | The variability among living organisms from all sources including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part. This includes diversity within species, between species and of ecosystems. | CBD, 1992 |
| **Biome** | Global-scale zones, generally defined by the type of plant life that they support in response to average rainfall and temperature patterns. Examples are tundra, coral reefs, or savannas. | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2019 |
| **Dependencies** | Aspects of nature, like assets and ecosystem services that people and organizations rely on to function. These can include direct physical inputs into production processes like surface water or fibers and raw materials; services that enable the production process like soil quality, water flow quality and pollination; services that mitigate the impacts of production like bioremediation and filtration; and finally, services that protect from disruption like climate regulation and disease control. | ENCORE, 2024; Taskforce for Nature-related Financial Disclosure (TNFD), 2024 |
| **Downstream** | All activities that are linked to the sale of products and services produced by the company. This includes the use and re-use of the product and its end of life, including recovery, recycling, and final disposal. | Science Based Targets Network (SBTN), 2023 |
| **Ecosystem services** | The naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity. | United Nations et al, 2021 |
| **Ecosystems** | An ecosystem is a dynamic complex of plant, animal and microorganism communities and the non-living environment that interacts as a functional unit. | CBD, 1992 |
| **Environmental assets** | The naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity. | United Nations et al, 2021 |
| **Impacts** | Any activities that positively or negatively changes the state of nature (quality or quantity), affecting the biosphere's ability to provide social and economic functions that are valued by businesses and society, or ecosystems that have instrumental, relational, or intrinsic value. Such impacts may be caused directly by business activities, for example clearing vegetation for mineral extraction or dredging to enable marine transport channels; indirectly caused by business activity for example increased surface run-off and erosion as a result of land clearance or acid rain due to sulfur dioxide and nitrogen oxide emissions; or cumulatively caused by the interaction of activities from different actors for example the accumulation of microplastics or heavy metals in food chains. | Science Based Targets Network (SBTN), 2023; Taskforce for Nature-related Financial Disclosure (TNFD), 2024 |

**Table A.1.1: Established nature definitions**

| Term | Definition | Source |
|---|---|---|
| **Climate Change** | Refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2017 |
| **Invasive alien species** | Species that are introduced or spread by human action, they can out-compete local and indigenous species for natural resources, threatening biological diversity, food security and human health and wellbeing. | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2017, Taskforce for Nature-related Financial Disclosure (TNFD), 2024 |
| **Land/freshwater/ ocean change** | The conversion from one land use category to another due to human activities, including changes in land cover, management of ecosystems and spatial. | |
| **Pollution** | The presence of substances and heat in air, water and/ or land whose nature, location or quantity produce harmful and undesirable environmental effects. | United Nations, 1997<br>Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2017, Science Based Targets Network (SBTN), 2022 |
| **Resource use** | Anthropogenic exploitation of wildlife and natural resources leading to biodiversity loss and extinctions, for example the overexploitation of marine habitats and excessive water consumption. | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2017 |
| **Material locations** | Locations where an organization has identified material nature-related dependencies, impacts, risks and opportunities in its direct operations and upstream and downstream value chain(s). | Taskforce for Nature-related Financial Disclosure (TNFD), 2023 |
| **Natural Capital** | Natural capital as the stock of renewable and non-renewable natural resources such as plants, animals, air, water, soils, and minerals that combine to yield a flow of benefits to people. | Capitals Coalition, 2016 |
| **Nature** | The natural world, emphasizing the diversity of living organisms, including people, and their interactions with each other and their environment.[48] | Diaz et al., 2015 |
| **Realms of nature** | Land, ocean, freshwater and atmosphere. These are major components of the natural world that differ fundamentally in their organization and function. | Taskforce for Nature-related Financial Disclosure (TNFD), 2023 |
| **State of nature** | Changes to the state of nature can be positive (enhancement) or negative (degradation) and refer to any activity that changes the condition and extent of ecosystems, species population size or extinction risk. | Taskforce for Nature-related Financial Disclosure (TNFD), 2023 |
| **Upstream** | All activities associated with suppliers, such as production or cultivation, sourcing of commodities or goods, and the transportation of commodities to manufacturing facilities. | Science Based Targets Network (SBTN), 2023 |

## A.2 Adopting definitions from whole life carbon assessment terminology

**Table A.2.1: Adopting definitions from whole life carbon assessment terminology**

| Term | Definition | Source |
|---|---|---|
| **Building** | Actors in construction works that have the provision of shelter for its occupants or contents as one of the main purposes usually enclose and design them to stand permanently in one place. | ISO 21931<br>BS EN 15978 |
| **Building product** | Goods or services used during the life cycle of a building or other construction works. | BS EN 15978 |
| **Building site** | A defined specified area of land for the location of a building or its future location or a defined location and construction work of the building and associated external works undertaken or foreseen. | BS EN 15978 |
| **Completeness check** | Process of verifying whether information from the phases of a life-cycle assessment is sufficient for reaching conclusions in accordance with the goal and scope definition. | ISO 14040 ISO 14044 |
| **Design life** | Service life intended by the designer. | ISO 21931<br>BS EN 15978 |
| **Disposal** | End-of-life transformation of the state of a building or facility that is no longer of use. | ISO 21931 |
| **Environmental aspect** | Element of an organization's activities, products or services that can interact with the environment characteristic of a building, part(s) of a building, processes or services related to its life cycle that can cause a change to the environment. | ISO 14025 ISO 14040 ISO 14044<br>ISO 21931 BS EN 15978 |
| **Environmental impact** | Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects. | ISO 14025 ISO 14040 ISO 14044<br>ISO 21931 BS EN 15978 |
| **Functional unit** | Quantified performance of a product system for use as a reference unit. | ISO 14025 ISO 14040 ISO 14044<br>ISO 21931 BS EN 15978 |
| **Life cycle** | Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal. | ISO 14025 ISO 14040 ISO 14044<br>ISO 21931 BS EN 15978 |
| **Life-cycle assessment (LCA)** | Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle. | ISO 14025 ISO 14040 ISO 14044<br>ISO 21931 BS EN 15978 |
| **Life-cycle impact assessment (LCIA)** | Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product. | ISO 14040 ISO 14044 |
| **Non-renewable resource** | Resource that exists in a fixed amount that it is not possible to replenish on a human time scale. | ISO 21930 ISO 21931<br>BS EN 15798<br>BS EN 15804 |
| **Renewable resource** | A resource grown, naturally replenished or naturally cleansed, on a human time scale. | ISO 21930 ISO 21931<br>BS EN 15798<br>BS EN 15804 |
| **System boundary** | Boundary representing physical, process, temporal and geographical limits of the stages of the building life cycle included in an assessment. | ISO 21931 |
| **Type III environmental (product) declaration** | Environmental declaration providing quantified environmental data using predetermined parameters and, where relevant, additional environmental information. | BS EN 15804<br>ISO 14025<br>ISO 21930 |

## What value chain actors can borrow from whole life carbon assessment

**Table A.2.2: Key components of a whole life nature impact assessment (WLNA) framework and what value chain actors can borrow from carbon**

| WLNA component | Borrow from carbon/LCA? | Recommended source | Comments |
|---|---|---|---|
| **Building life stages** | Yes, fully | ISO 21931 | Directly applicable with little or no change required to the nature context. See A.2 for life cycle definitions. |
| **Building and construction systems and subsystems** | Yes, fully | Building System Carbon Framework (WBCSD, 2020<br>ICMS 3 International Cost Management Standards<br>Building Cost Information Service (BCIS) Elemental Standard Form of Cost Analysis<br>Royal Institute of Chartered Surveyors (RICS) 2023 | Bill of quantities used for LCAs in buildings structured following international measurement standards (ICMS) or their local applications (e.g. UK Building Cost Information Service (BCIS)/ Royal Institution of Chartered Surveyors (RICS). Adopt simplified generic versions such as WBCSD in lieu. |
| | Yes, adapted | Buildings:<br>ISO 21931, EN 15978 & RICS 2023<br>Responsibility reporting at organization level:<br>GHG Protocol | See A.3 for suggested WLNA terms and definitions, adapted from existing terminology from LCA and greenhouse gas (GHG) reporting standards. |
| | Yes, partially (incomplete) | Type III environmental product declarations (EPDs) – ISO 14025 & EN 15804 | Content currently restricted to the indicators and content required by ISO14025, 7.2, which is insufficient for full assessment of impact on nature . |
| **Metrics** | No | TNFD core metrics<br>TNFD Draft sector Guidance Forestry Management Dec 2023.<br>TNFD Draft sector guidance for Construction Materials<br>TNFD Draft sector guidance for architecture, engineering and real estate<br>The Forest Stewardship Council (FSC), Program for the Endorsement of Forest Certification (PEFC) and Sustainable Forestry Initiative (SFI).<br>TNFD Draft sector guidance Metals and Mining December 2023<br>TNFD Biodiversity | There are 5 main nature impact drivers: land/water, ocean-use change, resource exploitation, climate change, pollution and invasive species. The TNFD has core metrics that are common to all business sectors.<br><br>There are many different metrics to consider that are sector-specific. For example, consider metrics relating to forestry to determine the relevant metric for upstream activities relating to timber used in construction. Additionally, consider landscape-level biodiversity such as forest age or habitat connectivity. Think about considering areas at risk of deforestation and forest degradation, which could also include determining which of these areas are highly relevant to threatened species. Consider factors of ecosystem integrity at source location and surrounding areas; soil and water quality are also important to this. |
| | Yes | Environmental product declarations (EPD) | Provides data for many environmental metrics, including energy use and efficiency; content of materials; water use and efficiency; solid waste; emissions related to air, soil and water pollution; biodiversity impacts; resource depletion, including raw materials and fossil fuels. |

## A.3 New definitions for nature impacts of buildings, adapted from whole life carbon assessment terminology

**Table A.3.1: Adapting carbon terminology**

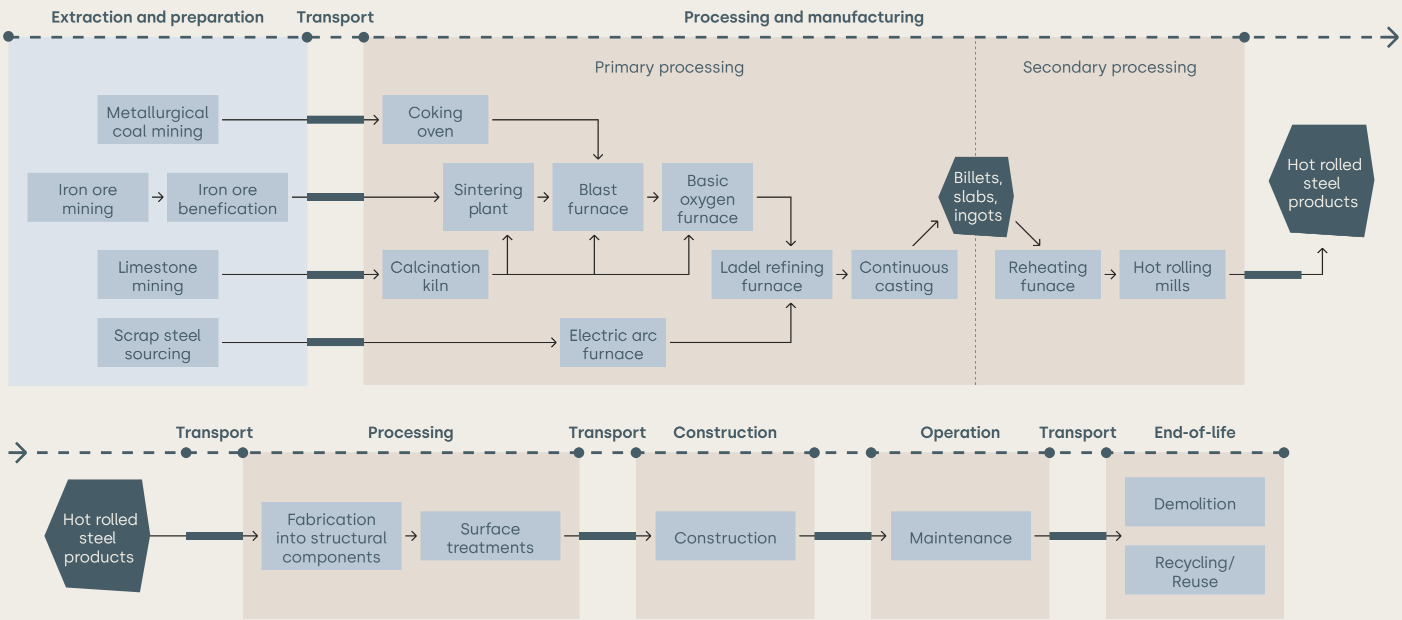
| Key carbon terminology[49] | Proposed equivalent nature terminology |
|---|---|
| **Embodied carbon**<br>Carbon emissions associated with materials and construction processes used throughout the whole life cycle of a building.<br>**Capital carbon** [PAS 2080]<br>GHG emissions and removals associated with the creation and end-of-life treatment of an asset, network, or system, and optionally with its maintenance and refurbishment | **Embodied nature impacts**<br>Nature impacts occurring remotely from the site associated with the processing and transportation extraction of materials throughout the whole life cycle of a building (including maintenance, repair and end-of-life)<br>**Capital nature impacts**<br>Negative and positive impacts on nature associated with the creation and end-of-life treatment of an asset, network or system, and optionally with its maintenance and refurbishment |
| **Site-based Impacts [EN15978]**<br>The construction of the building, i.e., installation of the materials and products (energy, water), ancillary installation materials (e.g., screw/nails/glue, etc.), plus disposal of any amount wasted. Also includes any storage requirements for the products on-site before installation, where applicable. | **Site-based nature impacts**<br>Direct and indirect impacts on nature occurring on the site of the building, or within the surrounding area of influence, during construction, operation and use (including maintenance and repair) and demolition. |
| **Operational carbon**<br>Carbon emissions associated with the energy used to light, heat, cool and power a building.<br>**Operational carbon** [PAS 2080]<br>GHG emissions and removals associated with the operation of an asset, network or system required to enable it to operate and deliver its service. | **Operational nature impacts**<br>Nature impacts associated with the operation of a building (excl. maintenance)-<br>Or<br>Negative and positive impacts on nature associated with the operation of an asset, network or system required to enable it to operate and deliver its service. |
| **Whole life carbon**<br>Sum of operational and embodied carbon emissions across the whole building life cycle.<br>**Whole life carbon** [PAS 2080]<br>Sum of greenhouse gas emissions and removals from all work stages of a project or program of works within the specified boundaries. | **Whole life nature impacts**<br>Sum of operational and embodied nature impacts across the whole building life cycle.<br>Or<br>Sum of negative and positive nature impacts from all work stages of a project and program of works within the specified boundaries. |
| **Net-zero whole life carbon**<br>When the reduction of upfront carbon and other embodied carbon, in addition to net-zero operational carbon, across the building lifecycle reaches a level that is consistent with reaching net zero at the global or sector level in 1.5°C pathways. Actors should neutralize any residual emissions that remain unfeasible to eliminate through carbon removals. | **Net-zero whole life nature impacts**<br>When, in addition to net-zero operational nature impacts, there is no net loss of nature associated with embodied nature impacts across the building life cycle. |
| **Whole life climate-positive building**<br>No established definition | **Nature-positive building**<br>A building that delivers a net positive benefit for nature across its whole life cycle with full implementation of the mitigation hierarchy to minimize harm and regenerate nature on a like-for-like basis across the value chain. |

# Appendix B: Value chain analysis for key building materials

## B1. Steel

In 2020, value chain actors produced 1,950 million metric tons of crude steel worldwide, over 50% of which was for construction of buildings and infrastructure. The nature impacts of the steel production process concentrate on mine sites in Australia, the United States, Brazil, China and India and steel processing plants in Europe and East Asia. The mine sites impact nature through land-use change, pollution, the introduction of invasive species and intensive resource use. The processing plants impact nature primarily through pollution.[50]

**Figure B.1: The main stages of the steel value chain from cradle to grave**



### *Production process*

Figure B.1.1 outlines the simplified stages of the steel value chain from cradle to gate. In practice, there is some cross-over between the output from blast furnaces (pig iron) and scrap steel as both basic oxygen and electric arc furnaces use them as inputs. The direct reduction route is also becoming increasingly important in the pursuit of lower carbon production. Steel mills tend to be closer to consumer markets than raw material extraction sites. Hence, each of these stages takes place in different geographical locations, resulting in significant volumes of material transportation worldwide, from the mine sites to processing locations. The five largest steel-producing countries are China (53% of global steel), India, Japan, the United States and Russia (less than 6% each).

### *Raw material extraction and preparation*

The most significant nature impacts of the steel value chain occur in the materials extraction phase. Key impacts include:

- The removal of the overburden (fertile topsoil, root stocks and vegetation) degrading and removing existing habitats, communities and species.[51, 52]
- Solid waste, like mine spoils and acid drainage contribute to soil and water pollution by raising the concentration of dissolved solids and lowering the pH affecting microbial and invertebrate richness and abundance.[53]
- Dewatering mines leading to local groundwater table reductions, increasing the risk of water scarcity.[54, 55]

Input scrap steel (used in electric-arc furnaces) can also be detrimental to nature depending on the sourcing location. For example, decommissioning activities like shipbreaking (where businesses run ships aground and dismantle them for parts) are common in South Asia. This process can discharge heavy metals and oils into the environment which changes the properties of seawater, including pH and turbidity.[56]

The countries most affected by the impacts of raw material extraction and preparation are Australia, Brazil and China for iron ore, China, the United States and Australia for metallurgical coal and China, the United States and India for limestone.

### *Transport*

The most significant impacts of transport infrastructure on nature include railways fragmenting habitats and reducing the ability of species to move/migrate, and maritime shipping introducing aquatic invasive species through the release of untreated ballast water.[57]

### *Processing and manufacturing*

During processing, the most significant nature impacts come from:

- The emission of gaseous pollutants, including carbon dioxide, carbon monoxide, sulfur, dioxide, nitrogen oxides and carcinogenic dust containing zinc and other alkalis from the coking oven, calcination kiln, sintering plant and blast furnace.[58]
- The release of waste slag containing ammonia, cyanide, metal residues and free acids can result in soil and water pollution from the basic oxygen and electric arc furnace.[59]

### *Construction and use*

While the construction of buildings can cause significant site-based nature impacts, the presence and use of steel on-site do not generally cause them. Air and water pollution may occur from dust generated during the cutting of steel on-site and greenhouse gases emitted during lifting and welding processes. However, the impacts of steel during the construction and use of the building are much less significant than other stages of the steel life cycle.

### *Demolition and disposal*

Steel is the most common recycled metal due to its high economic value, magnetic properties enabling efficient segregation from mixed construction waste streams and ability to convert to higher or lower-grade steel depending on the metallurgy of the required product. Frameworks such as ISO 20887:2020: Sustainability in buildings and civil engineering works - Design for disassembly and adaptability continue to drive demand for circularity in the built environment and scrap-steel recycling streams form well-established closed material loops. As a result, nature impacts are akin to those in the processing phase that reincorporate scrap metal.[60, 61, 62]

### *Steps to reduce the nature impacts of steel in building*

While actions that occur upstream are not within the direct control of building developers and designers, some actions they can still take during the design, construction and end-of-life stages to reduce the nature impacts of steel in buildings include:

→ Achieving the highest levels of circularity in existing resources, identifying building components that are reclaimable during demolition and providing incentives to ensure that happens. Reusing existing sections reduces the need for recovered scrap steel processing, which reduces energy demand.

→ Using steel more efficiently during construction, reducing the volume required in specific structures.

→ Proposing a certain percentage of recycled steel or specifying locally produced materials on projects; however, this approach has limitations considering the fixed origins of raw material deposits and the restricted availability of steel scrap (not to mention the ethical and environmental implications of some scrap steel sources).

→ Demanding greater transparency from the supply chain and selecting suppliers that demonstrate ethical practices, including the reclamation of slag, wastewater treatment and minimizing biodiversity impacts.

**Table B.1.1: Materiality rating for the pressures on nature on the steel value chain based on the updated ENCORE 2.0 knowledge base**

| | Pressure Category | Impact type referenced in Figure 7 | Impact Type | Value Chain Analysis: Steel | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Materials Extraction | Transport | Processing | Construction and use | Demolition and Disposal |
| *Land/ Water/ Sea use change* | Terrestrial Ecosystem Use | 1 | Change in habitat extent | High | No data | No data | Low | No data |
| | | 2 | Change in habitat condition | Very high | Low | No data | No data | Very low |
| | | 3 | Change in habitat connectivity | Low | Low | No data | No data | No data |
| | Freshwater Ecosystem Use | 4 | Change in habitat extent | High | Low | No data | Low | No data |
| | | 5 | Change in habitat quality | No data | Very low | No data | Low | No data |
| | Marine Ecosystem Use | 6 | Change in habitat extent | No data | Very low | No data | Very low | No data |
| | | 7 | Change in habitat quality | Low | Low | No data | Very low | No data |
| *Resource exploitation* | Water use | 8 | Change in groundwater/ surface water level | Low | Very low | High | Low | High |
| *Climate Change* | GHG Emissions | 9 | Climate change impact | Very high | High | High | Very low | Very high |
| *Pollution* | Non-GHG Emissions | 10 | Change in air quality | High | Very low | High | Low | High |
| | Water Pollutants | 11 | Change in water quality | Very high | Low | Very high | Low | High |
| | Soil Pollutants | 12 | Change in soil quality | High | No data | Very high | Low | High |
| | Solid Waste | 13 | Change in solid waste quantity | High | No data | High | Low | High |
| *Invasive Species and Others* | Disturbances | 14 | Change in soil/seafloor characteristics | Very high | Low | Very high | No data | No data |
| | | 15 | Change in sound/ light-scape | Low | High | Very high | Very low | No data |
| | Invasive Alien Species (IAS) | 16 | Change in habitat condition | Very low | Very low | No data | No data | No data |

Very high · High · Medium · Low · Very low · No data

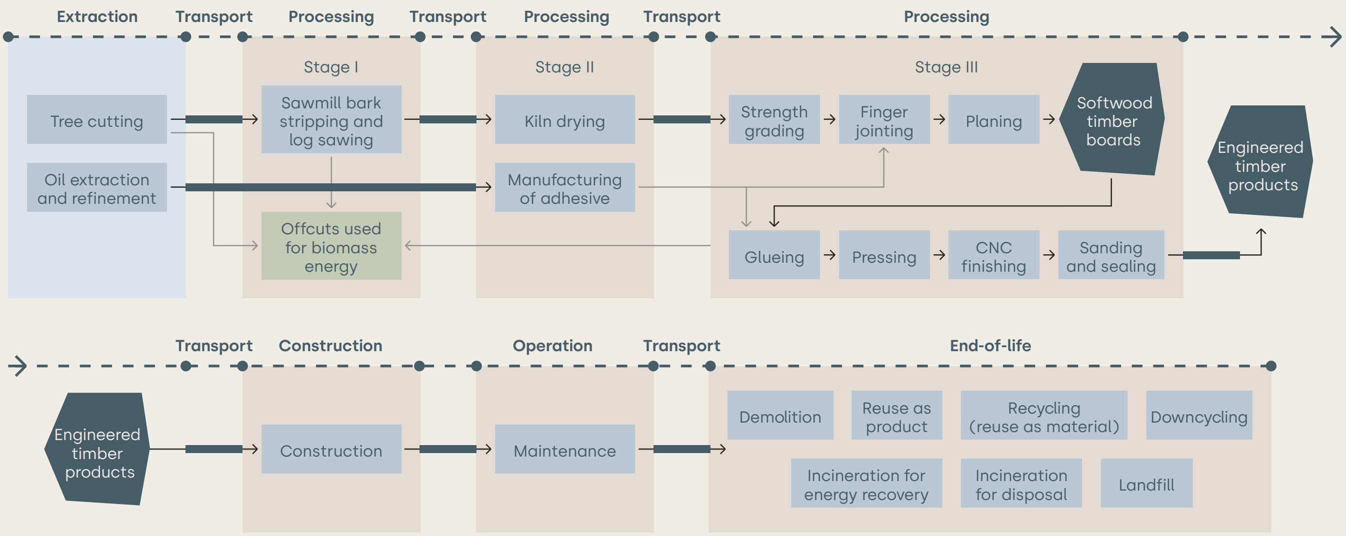
## B.2. Timber

In 2022, the top 10 lumber-producing countries produced over 1,500 million cubic meters of lumber, which is significant considering companies use 38% of global timber consumption for buildings and construction, as sawn timber boards or as engineered timber products that incorporate adhesives to create components like joists or prefabricated beams.[63, 64] The nature impacts of the timber production process concentrate on timber harvesting in the United States, Russia, Brazil, China and Canada, and processing in the United States, China, Russia, Canada and Germany. The forest harvesting process impacts nature through habitat degradation and fragmentation and water pollution, while the processing plants impact nature primarily through the release of gaseous emissions, polluted wastewater and the production of large quantities of solid waste.

### *Production process*

The wood used for timber building products comes from logging using either manual labor or machinery in forests and plantations around the world. Companies typically make the adhesives used for engineered timber products from fossil-fuel polymers and alcohol-based products requiring the extraction and refining of petroleum.[65] Wood is cut and dried in a kiln for several days before it undergoes further machine processing. Tree waste produced at every stage is collected and used either in the manufacturing of other types of timber products, or burned for energy to power the cutting machinery or kilns. Figure B.2.1. demonstrates the stages of the timber value chain, from cradle to grave.

**Figure B.2.1: The main stages of the timber value chain from cradle to grave**



### *Raw material extraction and preparation*

Timber harvesting comes with significant nature impacts, particularly in developing countries where forestry companies may not have achieved forest sustainability certifications such as Forest Stewardship Council (FSC) or Programme for the Endorsement of Forest Certification (PEFC), areas that practice clear-cut techniques (temporary deforestation of previously forested areas) and tropical forests, which have higher proportions of specialist species. These include:

- Forest degradation and fragmentation, as extracting timber changes the composition of species, vertical stratification and tree age structure affecting the local microclimate (light/moisture/soil composition). Further, these practices remove microhabitats like dead wood, cavities and mature trees, which are important habitats for birds, mammals, fungi and insects that depend on old growth features, resulting in biodiversity loss.[66, 67]
- Decreases in water quality caused by non-point source pollution[68] via nutrient run-off, following the application of phosphorous fertilizers to address nutrient deficiencies and boost forest productivity. Increased sedimentation and dissolved carbon transport following cultivation and harvesting may affect water quality. This is significant considering the sensitivity of freshwater ecology (fish and freshwater invertebrates) to background water quality.[69]
- Potential land-use change, for example, peatland drainage across Europe and degradation of primary tropical forests in Asia and the Americas.[70, 71]

The nature impacts associated with timber harvesting affect the United States, Russia, Brazil, China and Canada the most, producing nearly 1,200 million cubic meters of lumber in 2022.[72]

### *Transport*

Companies transport timber from the forest to various processing sites by road, rail or boat before moving it to the construction site and later to the recycling, incineration or landfill facilities at end-of-life, which Figure B.2.1. demonstrates. Associated nature impacts include:

- Transportation from forest to industrial site (often via haulage truck or barge) consumes significant amounts of fossil fuels, which can release organic compounds and phosphorus into surrounding watercourses and nitrogenous compounds and other greenhouse gases into the atmosphere, contributing to climate change, acidification and eutrophication.[73]

Roads and skid trails increase the rate of soil erosion by removing the surface cover and compacting soils, increasing the erosive force of rainfall and decreasing the potential for rainfall infiltration through the soil, leading to greater surface runoff and sedimentation in waterways.[74,75]

### *Processing and manufacturing*

The processing and manufacturing stage has some detrimental impacts on nature. For example:

- Common adhesives for cross-laminated timber (CLT) and glue-laminated timber (glulam) products, including PRF (phenol-resorcinol-formaldehyde), MUF (melamine–urea–formaldehyde) or MF (melamine formaldehyde), contain formaldehyde, a known toxic carcinogen. Although the quantities of formaldehyde used and their emissions are decreasing due to the introduction of strict regulations in most countries, risks to worker health from elevated exposure levels include irritation or damage to the skin, eyes, lungs and liver, where limited safety precautions exist.[76, 77]
- Gaseous emissions from the sawmilling process include carbon dioxide, nitrous oxides, carbon monoxide and sulfur dioxides. They contribute to climate change, acidification and photo-oxidant formation.[78, 79]
- Waste water from the sawmill containing high levels of organic matter (and in unregulated areas free formaldehyde) can alter the physical, chemical and microbial properties of water systems. Studies have found that the mean values for temperature, alkalinity, sulfate and fungal counts increased downstream of sawmill discharge points, significantly impacting the abundance and distribution of fish species.[80]
- The recovery of viable board and plank products from processed timber is only 50%. Companies use the remaining dust, shavings and fiber (from low-quality logs, bark, off-cuts, edge trimmings) as biofuel, feedstock for particle board manufacturing or they landfill it.[81, 82]

The countries most affected by the nature impacts of timber processing are Canada, Germany, the United States, Sweden and China, which export a combined total of USD 107 billion in industrial and non-industrial roundwood.[83]

### *Construction and use*

Companies increasingly use timber as a sustainable, low-carbon construction material with equivalent or better building characteristics than traditional materials, since it lowers embodied carbon by sequestering a net 1,700 kilos of carbon dioxide per metric ton, over and above the energy expended in growing, harvesting and processing it. In comparison, steel or concrete releases 1,240 kg and 159 kg of $CO_2$ per metric ton respectively.[84] Additional construction benefits are the opportunities for offsite manufacturing and its lightweight properties, which allow for quick installation, small installation crews and lower costs, minimal deliveries to the site and limited noise, therefore minimizing disturbances to the surrounding area.[85]

### *Demolition and disposal*

Some regions, including the EU, have established a cascade principle for end-of-life wood-based products that prioritizes reuse, recycling, bioenergy (incineration) and disposal (landfill). Buildings using timber-based components lend themselves well to design for disassembly and adaptation in the future, as it is possible to make connections reversible and easily modify the components. For example, it is easy to dismantle, de-nail and store building features like cladding, floors and frames for reuse rather than to demolish them.[86]

Companies can reuse timber products from structural timbers to flooring for the same purpose or reshape them for less demanding roles. Recycling involves the downcycling of timber for non-structural uses or to different timber-based materials such as chipboard, oriented strand board (OSB) or particleboard. However, in practice, companies often contaminate or imbue construction and demolition timber waste with adhesive substances, heavy metals or creosote, which they add as preservatives to prevent decay and fungal growth and to join wood components and increase their structural stability during the processing and manufacturing stage. Additionally, some timber pieces may have become warped, damaged or decomposed and therefore be unsuitable for recycling/reuse due to their lack of uniformity.[87, 88, 89] Subsequently, companies only reuse and recycle a small percentage of wood (around 5%), roughly 32% in the UK and 20% in Germany.[90, 91, 92]

Companies burn a large percentage (around 66% in the UK) of the remaining wood waste for low-carbon energy.[93] Without proper management, this can lead to gaseous pollutants release, including carbon monoxide, sulfur dioxide, nitrogen oxides and dioxin and polycyclic aromatic hydrocarbons which some studies show are carcinogenic.[94]

The remaining wood waste (around 1%) is landfilled. Not only does this re-release the biogenic carbon stored in the timber back to the atmosphere in the form of carbon dioxide and methane, contributing to climate change, but certain treated woods (chromated copper arsenate (CCA)) can leach arsenic, chromium and copper into soils and watercourses, leaving a negative impact on the environment and human health.[95] Additionally, a portion of the timber may not degrade but instead is preserved if the timber element is not shredded into small pieces.

### *Steps to reduce the nature impacts of timber within buildings*

With timber's increasing popularity as a structural material, particularly in the form of large-scale engineered products, there is a risk that local or regional timber supply chains cannot keep up with demand. This may lead to timber sourced at an unsustainable scale or from further afield where suppliers may be harder to regulate or monitor.

This may lead to an increase in harmful forestry practices, for example from regions that contain old-growth forests (of high conservation value) or forced labor. Subsequently, actions that companies can take during the design, construction and end-of-life stages to reduce the nature impacts of timber within buildings include:

→ Avoiding timber when it is a structurally inappropriate material, for example, in structures requiring column grids or transfer structures needing large amounts of timber.

→ Only specifying timber products that are FSC or PEFC certified, thus guaranteeing:

  - Compliance with international laws and treaties such as the EU Timber Regulation (EUTR) and the Australian Illegal Logging Prohibition Regulation;
  - Recognition of and respect for Indigenous peoples' rights to own, use and manage their lands and resources;
  - Promoting forestry management and monitoring plans that conserve biological diversity and associated values and maintain forests of high conservation value;[96, 97]
  - New regulations like the EU Deforestation-Free Regulation (EUDR) will also require companies trading in commodities such as wood to conduct extensive diligence on the value chain to ensure goods do not result from recent (post-2020) deforestation or risk prohibition from EU markets.[98]

→ Managing wood risk through certified tools, such as the Worldwide Fund for Nature (WWF) wood risk tool, which aims to tackle illegal and unsustainable logging and trade by assessing origin, species and supplier/supply-chain risks related to forest and timber.[99]

→ Designing for reuse to minimize end-of-life impacts. It is necessary to fill the research gaps regarding the quality of both sawn and engineered timber products at the end of their design lifetimes and develop the supply chain for reclaiming and reusing timber products on a large scale (rather than disposal by incineration). Keeping timber products in use for as long as possible should be the aim, both to reduce deforestation and to keep biogenic carbon locked in the timber for as long as possible to prevent or delay its re-release as a GHG to reduce its contribution to global warming.

→ It is essential to investigate the efficiency of the downcycling supply chain to divert a maximum amount of timber waste from landfills for as long as possible.

**Table B.2.1: Materiality rating for the pressures on nature on the timber value chain based on the updated ENCORE 2.0 knowledge base**

| | Pressure Catergory | Impact type referenced in Figure 7 | Impact Type | Value Chain Analysis: Timber | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Materials Extraction | Transport | Processing | Construction and use | Demolition and Disposal |
| *Land/ Water/ Sea use change* | Terrestrial Ecosystem Use | 1 | Change in habitat extent | Very high | No data | No data | No data | No data |
| | | 2 | Change in habitat condition | Very high | Medium | No data | No data | Low |
| | | 3 | Change in habitat connectivity | Medium | Medium | No data | No data | No data |
| | Freshwater Ecosystem Use | 4 | Change in habitat extent | No data | Medium | No data | No data | No data |
| | | 5 | Change in habitat quality | High | Low | Medium | No data | No data |
| | Marine Ecosystem Use | 6 | Marine Ecosystem Use | No data | Low | No data | No data | No data |
| | | 7 | Change in habitat quality | No data | Medium | No data | No data | No data |
| *Resource exploitation* | Water use | 8 | Change in groundwater/ surface water level | Medium | No data | Medium | No data | No data |
| *Climate Change* | GHG Emissions | 9 | Climate change impact | High | Very high | Very high | Low | Medium |
| *Pollution* | Non-GHG Emissions | 10 | Change in air quality | No data | High | High | Medium | High |
| | Water Pollutants | 11 | Change in water quality | High | Very high | High | No data | Medium |
| | Soil Pollutants | 12 | Change in soil quality | Very high | No data | Medium | No data | Medium |
| | Solid Waste | 13 | Change in solid waste quantity | High | No data | Very high | Medium | Medium |
| *Invasive Species and Others* | Disturbances | 14 | Change in soil/seafloor characteristics | High | Medium | No data | No data | No data |
| | | 15 | Change in sound/ light-scape | High | High | No data | Low | No data |
| | Invasive Alien Species (IAS) | 16 | Change in habitat condition | Very high | High | No data | No data | No data |

Very high | High | Medium | Low | Very low | No data

## B.3. Concrete

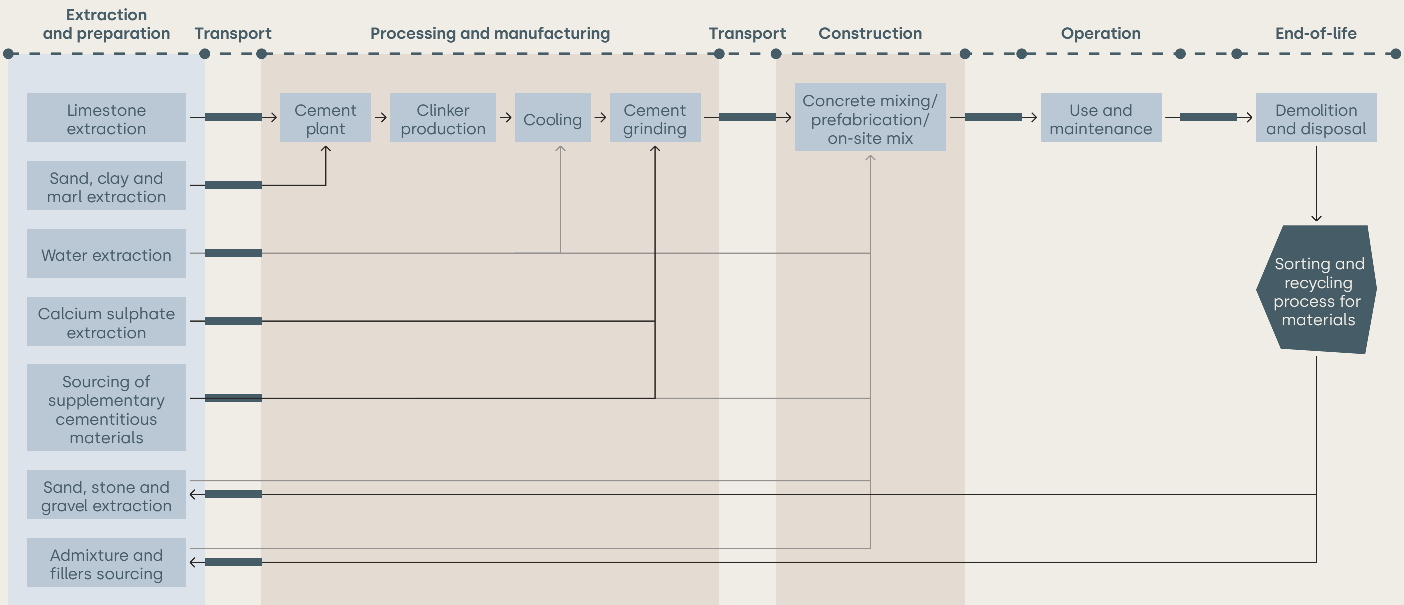
Concrete is the world's most widely used building material, with 4.2 billion metric tons of cement produced globally in 2020.[100]

The most significant nature impacts occur during the extraction and processing stages, particularly in the quarrying of limestone and gypsum and the dredging of sand and gravel. Potential nature impacts include intensive water and energy use, land-use change and ecosystem disturbance, air pollution and most prominently, greenhouse gas (GHG) emissions.

### *Production process*

The first step in concrete production involves the quarrying or raw materials typically from large open-cast mines. Materials including limestone, clays and aggregates are readily available, low cost and geographically extensive, so cement plants are typically near local quarries to minimize the expense associated with transportation.[101] The next step is the production of clinker through the crushing, mixing and milling of materials, then preheating them before feeding them into the rotary kiln. In the kiln raw materials reach a temperature of up to 1,450°C and undergo physical and chemical reactions to form clinker.[102] Large quantities of air and water are used to ensure the cooling of clinker, and the additional materials at the grinding stage, like 2-5% gypsum, control the setting time of the final product. Silos store the homogenized cement before hydraulic or mechanical extraction, then on to transportation to packaging facilities and then the site.[103] When cementitious materials mix with water to form a workable paste that hardens over time, this becomes cement.[104]

**Figure B.3.1: The main stages of the concrete value chain from cradle to grave**



### *Raw material extraction and preparation*

Some of the most significant nature impacts of the concrete value chain come from the quarrying of limestone, sand, aggregates and gypsum, which can be detrimental to local ecosystems and habitats. Such impacts include:

- Land-use change due to opencast mining techniques, resulting in loss of vegetation cover and diversity, forest degradation, the excavation of fertile topsoil reducing productivity, seed banks and rootstocks, aesthetic degradation and habitat loss for native and unique species. Explosive mining techniques may also alter the topography, with blast-induced vibrations causing rock formations like stalactites and stalagmites to break off and cause cave roofs to crack or collapse.[105]
- Habitat destruction, sediment suspension and loss of biodiversity due to unregulated dredging and coastal sand mining.[106]
- Dust particles and particulate matter arising from quarrying operations, crushing and grinding can reduce visibility and air quality around the mine site, which poses an environmental and human health hazard, contributing to cardiovascular and respiratory diseases.[107]

### *Transport*

- GHG emissions and air pollution that result from the delivery vehicles and fueled either by electricity or diesel. However, companies often source the components for concrete locally, for example, aggregate sourcing at 30 km or less from the ready-mix concrete plant and limestone no further than 300 km, therefore minimizing the nature impacts associated with long travel distances.

### *Processing and manufacturing*

The processing and manufacturing stage has some detrimental impacts on nature. For example:

- GHG emissions emerge as one of the most significant nature impacts associated with processing and manufacturing, with up to 90% of emissions arising from cement manufacturing, 60-65% of these emissions are a result of the calcination of limestone, which produces clinker, a main ingredient for Portland cement, and a further 35-40% come from the thermal combustion required to heat the kiln, which typically uses fossil fuels.[108]
- The calcination kiln also emits other gaseous pollutants, like carbon monoxide, nitrous oxides, sulfur dioxide, particulate matter and other toxic gases (if they burn plastics), which not only contribute to climate change but terrestrial/aquatic acidification and photooxidant formation.[109] In addition, it is also likely to expose cement plant workers to chromium VI, which is a human carcinogen.
- Intensive freshwater withdrawal and elevated water consumption are also significant impacts at this stage, with concrete production responsible for 9% of global industrial water withdrawal (1.7% of total global water withdrawal).[110] Quarries and cement plants usually connect to local freshwater supplies. Cooling equipment and exhaust gases, wet-process kilns and washing aggregates use most of the water.

### *Construction and use*

The main nature impacts associated with concrete's construction and use phase result in the urban heat island (UHI) effect.

- A city's microclimate becomes significantly warmer than its surrounding rural areas due to the removal of vegetation, increases in impervious surfaces that absorb more solar radiation, waste heat from buildings, and air pollution. These UHI effects disrupt local biodiversity and increase the need for energy consumption to cool buildings, thereby resulting in more GHG emissions and air pollution. The widespread use of heat-absorbing materials like concrete on roads and pavements further amplifies this effect.[111, 112]
- Concrete, when used for building structures, pavement, highways, drainage channels and other impervious hard standings will also be the cause of accelerated surface water runoff, which can lead to severe soil erosion and flooding.  Additionally, companies reject or do not use and return 2-3% of ready-mixed concrete to the batching plant. Here, the plant discards the concrete into landfills. This might cause issues in terms of alkalis leaching and affecting the surrounding soil.

### *Demolition and disposal*

According to the European Commission, the generation of construction and demolition waste is about 450-500 million metric tons each year in Europe, at least a third of which is concrete.

The demolishing of buildings also leads to a risk of the release of respirable crystalline silica (RCS-a carcinogenic dust) during concrete rubble munching, manual demolition by non-powered hand tools and crushing and screening demolition debris. Exposure to and inhalation of RCS can lead to chronic lung diseases like silicosis and lung cancer.[113]

After demolition, it is technically possible to recycle 100% of concrete for use in recycled aggregates and cement. However, despite this, the level of recycling and material recovery of construction and demolition waste varies greatly. Companies could also use concrete if the setting up of supply chain and quality assurance procedures existed. When companies do not reuse or recycle it, other value chain actors typically dispose of it in landfills, which can lead to toxic (highly alkaline) water and gaseous emissions, impacting both wildlife and public health.[114]

### *Steps to reduce the nature impacts of concrete in buildings*

Building developers and designers can take several actions during the design, construction and end-of-life stages to reduce the nature impacts of steel in buildings. These include:

- Designing for circularity to reduce consumption and waste and maximize recycling/reuse;
- Optimizing geometry and structural systems, for example by reducing floor spans (between columns) and load requirements and decreasing the number of basements constructed;
- Encouraging the development of more constant (shorter) building heights, moving away from the trend for cities to have clusters of high-rises surrounded by much shorter buildings;
- Engaging with local material suppliers, considering geographical context, transport distances and local infrastructure, which may reduce the severity of nature impacts and ensure the responsible resourcing of constituent materials.
- Lobbying the wider industry to increase the accessibility and transparency of information regarding environmental impacts, including the consistent adoption of third-party verified environmental product declarations (EPDs) for all products. This would help to communicate the product's environmental performance in a standardized and consistent way, making it easier for designers to compare products and make informed decisions, and using robust metrics to quantify and compare the carbon credentials of different mixes, such as the Universal Classification system for embodied carbon of concrete.[115]
- Advocating for the updating of building codes to account for technological advances in the concrete sector is key, with more incentives for manufacturers to innovate across value chains and to produce more sustainable materials and products and supported by developing industry-wide standards and certifications for nature-positive practices. This would include facilitating the use of lower performance/strength concrete where applicable or incorporating fewer transfer structures.

The wider concrete industry is also implementing measures to reduce upstream nature impacts, including promoting the use of renewable energy and alternative fuels such as biomass and green hydrogen to reduce greenhouse gas emissions released during production; trialing carbon capture infrastructure to facilitate further decarbonization; improving water stewardship across the value chain, replacing wet-process kilns with dry-process technologies and collaborating with other sectors to reuse and recycle water; and strengthening reclamation and rehabilitation approaches through biodiversity management plans that restore degraded habitats.[116]

**Table B.3.1: Materiality rating for the pressures on nature of the concrete value chain based on the ENCORE 2.0 as applicable and desk studies**

| | Pressure Category | Impact Type referenced in figure 7 | Impact Type | Value Chain Analysis: Concrete | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Materials Extraction | Transport | Processing | Construction and use | Demolition and Disposal |
| Land/ Water/ Sea use change | Terrestrial Ecosystem Use | 1 | Change in habitat extent | Low | Low | Very low | No data | Low |
| | | 2 | Change in habitat condition | Low | Low | Very low | No data | No data |
| | | 3 | Change in habitat connectivity | Low | Low | Very low | No data | No data |
| | Freshwater Ecosystem Use | 4 | Change in habitat extent | High | No data | Low | Very low | Low |
| | | 5 | Change in habitat quality | High | No data | Low | Very low | Low |
| | Marine Ecosystem Use | 6 | Marine Ecosystem Use | High | No data | Very low | Very low | No data |
| | | 7 | Change in habitat quality | High | No data | Very low | Very low | Low |
| Resource exploitation | Water use | 8 | Change in groundwater/ surface water level | High | Very low | Low | Low | Low |
| Climate Change | GHG Emissions | 9 | Climate change impact | Low | Low | High | Very low | Low |
| Pollution | Non-GHG Emissions | 10 | Change in air quality | Low | Very low | High | Very low | Low |
| | Water Pollutants | 11 | Change in water quality | Low | Low | Very high | Low | Low |
| | Soil Pollutants | 12 | Change in soil quality | Very high | No data | Low | Low | Low |
| | Solid Waste | 13 | Change in solid waste quantity | Low | No data | Low | Low | Low |
| Invasive Species and Others | Disturbances | 14 | Change in soil/seafloor characteristics | Very high | Low | No data | No data | No data |
| | | 15 | Change in sound/ light-scape | Very high | Low | Low | Very low | Low |
| | Invasive Alien Species (IAS) | 16 | Change in habitat condition | Low | Very low | No data | No data | No data |

Very high | High | Medium | Low | Very low | No data

# Appendix C: Metrics

The table below identifies some widely adopted metrics referenced by three or more reputable reporting frameworks and standards. They belong to the different impact types outlined by WBCSD's Nature Positive Roadmaps for the Built Environment, indicating where we can begin to measure how our activities along the value chain interface with nature. This table is not exhaustive. For example, Freshwater and Marine Ecosystem use metrics do not feature as there is significant overlap with the metrics used for water pollutants and the overall extent of ecosystem use change. Climate change is also not in it, despite numerous metrics focused on the Kyoto 6 emissions factors and greenhouse gas intensity since other publications, including WBCSD's Building System Carbon Framework and PAS 2080 have already covered extensively. Finally, due to the lack of convergence around specific metrics, the measurements of disturbances relating to light and noise are not part of the metrics.

**Table C.1: Possible metrics from existing frameworks measuring nature impact**

| Pressure Catergory | Impact Type | Possible metric | Referencing standards/ frameworks |
|---|---|---|---|
| **Terrestrial Ecosystem Use** | **Change in habitat extent** | Extent of land/freshwater/ocean ecosystem use change (km$^2$) | TNFD, ICE, GRI, SASB, BS EN ISO 14044 2006, BS EN 15804:2012+A2:2019, roduct EPDs |
| | **Change in habitat condition** | IUCN Red List species with habitats in affected areas | TNFD, UKGBC, IUCN Urban Nature Indexes |
| | **Change in habitat connectivity** | Connectivity metric | UKGBC, AUSGBC, WBCSD,IUCN |
| **Resource use** | **Change in groundwater/ surface water level** | Water withdrawal and consumption from areas of water scarcity (m$^3$) | TNFD, SASB, ENCORE, GCCA |
| **Non-GHG Emissions** | **Change in air quality** | Change in groundwater/ surface water level | AUSGBC, WBCSD, BS EN 15978:2011, BS EN 15804:2012+A2:2019, BS ISO 14025:2006, product EPDs |
| | | Non-GHG air pollutants by type (tonnes) | TNFD, ICE, WBCSD, BS EN ISO 14044 2006, BS EN 15804:2012+A2:2019, BS ISO 14025:2006 |
| | | Depletion of stratospheric ozone ODP (kg CFC 11 equiv) | BS EN 15978:2011, BS EN 15804:2012+A2:2019, BS ISO 14025:2006, product EPDs |
| | | Formation of tropospheric ozone POCP (kg Ethene equiv) | BS EN 15978:2011, BS EN 15804:2012+A2:2019, Product EPDs |
| **Water Pollutants** | **Change in water quality** | Volume of water discharged (m$^3$) | TNFD, ICE, WBCSD, GRI, encore, IUCN urban nature, bs en iso 14044 2006, bs en 15978: 2011, bs en 15804:2012+a2:2019, bs iso 14025: 2006, product EPDs |
| | | Acidification potential (kg $SO_2$- equiv) | bs en 15978:2011, bs en 15804:2012+a2:2019, bs iso 14025: 2006, product EPDs |
| | | Eutrophication potential (kg PO4 3- equiv) | BS EN 15978:2011, BS EN 15804:2012+A2:2019, BS ISO 14025: 2006, product EPDs |
| **Soil Pollutants** | **Change in soil quality** | Pollutants released to soil (tonnes) | TNFD, WBCSD, BS EN ISO 14044 2006, BS EN 15804:2012+ A2:2019, BS ISO 14025: 2006 |
| | | Volume of spills of diesel, paints, solvents, and toxic chemicals (m$^3$) | TNFD, AUSGBC, GRI, ENCORE |
| **Solid Waste** | **Change in solid waste quantity** | Weight of hazardous and non-hazardous waste generated by type (tonnes) | TNFD, UKGBC, AUSGBC, WBCSD, GRI, SASB, BS EN ISO 14044 2006, BS EN 15978:2011, BS ISO 14025: 2006 |
| | | Weight of waste disposed of (tonnes) | TNFD, BS EN ISO 14040 2006, BS EN 15978:2011, BS EN 15804:2012+A2:2019, product EPDs |
| | | Weight of waste diverted from landfill (tonnes) | TNFD, BS EN ISO 14040 2006, BS EN 15978:2011, BS EN 15804:2012+A2:2019, product EPDs |
| **Invasive Alien Species (IAS)** | **Change in habitat condition** | Proportion of high-risk activities operated under appropriate measures to prevent unintentional introduction of IAS | TNFD, WBCSD, GRI, SBTN, IUCN Urban Nature |

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# Acknowledgements

## Disclaimer

This publication has been developed in the name of WBCSD with the support of Arup. Like other WBCSD publications, it is the result of collaborative efforts by representatives from member companies and external experts. Input from the stakeholders listed was incorporated in a balanced way. This does not mean, however, that every member company or stakeholder agrees with every word.

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