Building within planetary boundaries: moving construction to stewardship

BUILDINGS & CITIES

BRIEFING NOTE

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ABSTRACT

The consumption of materials and energy for construction is a serious challenge to contain global warming below 2°C. Growing population, increasing per capita floor areas, more frequent extreme weather events and related repair needs, and rising sea levels are all accelerating the demand for construction and driving resource use. Rapid and drastic reductions in global carbon emissions and robust approaches to climate-related events are required urgently to remain within the planetary boundaries. Therefore, a new hierarchy for solving spatial needs is required: the Global North should avoid making new buildings, where and whenever possible. Instead, using existing spaces, renovating, adapting or extending the existing buildings would be much preferred. Such a hierarchy must be applied with context sensitivity. Especially the social needs of developing countries or communities recovering from humanitarian disasters should be adequately met, including the option of new construction. However, for most developed regions where populations are stable, new construction should require considerable justification. New design, business models and legislation are needed to successfully implement this approach. Environmental norms and architectural policies can offer a complementary set of approaches for reducing unsustainable consumption of resources in construction. Because of the historical responsibility as well as the current climate leadership, a fair transition should start from Europe.

KEY FINDINGS

- The current consumption of resources for construction is a serious threat to limiting global warming below 2°C, as well as to halting ongoing biodiversity loss.
- Several trends will push resource use further into the future. These include population growth, increasing per capita floor areas, increasing repair needs due to more frequent extreme weather events and rising sea levels.
- Decoupling the value of buildings from the environmental harms they cause is advancing too slowly, considering the urgent state of the planet.
- A paradigm shift is needed: solving society's spatial needs without considering new buildings as the first solution. Instead, existing buildings should be used and renovated as far as possible.

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- Europeans should implement the hierarchy into building regulations first, because of historic responsibility and Europe's current capacity for reducing emissions.

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1. PROBLEM DEFINITION

Ecological overshoot has been defined as exploiting the ecosphere beyond ecosystems' regenerative capacity and filling natural waste sinks to overflowing and it represents a serious threat. This means the rate of resource consumption needs to be within planetary boundaries (biodiversity loss, ocean acidification, change in land use, freshwater use, atmospheric pollution, nitrogen cycle, *etc.*). Climate change is a leading example of exceeding planetary boundaries.

Construction is the main global user of raw materials. Materials and energy used for construction pose a significant threat to limiting the global warming below 2°C. Along with the population growth and urbanisation, new buildings and infrastructure are needed. This increases the consumption of building materials and associated greenhouse gas (GHG) emissions (Figure 1). In addition, more turbulent weather, floods, and wildfires are adding repair and adaptive needs to the existing built environment, further accelerating resource consumption. Resources also need to be saved for protecting—or relocating—coastal settlements, as melting glaciers cause sea levels to rise.

Decoupling the use of resources from generated value (or gross domestic product—GDP) has been a paradigm for the overall resource efficiency of society, and it could also be applied to construction. But decoupling—be it relative or absolute—appears insufficient as the needs for construction and consumption grow. There is still no evidence of an absolute decoupling happening globally, but growth of material consumption instead. According to the EEA (2021), global decoupling or a fully circular economy may not be possible at all. Therefore, a new mindset is needed for construction, the most resource-intensive industry: avoiding building new, whenever and wherever possible.

Communicating such a paradigm shift is a challenge of its own. Several robust principles are used for similar purposes in other fields of society. For example, 'global carbon law,' 'doughnut economy', 'waste hierarchy' or the *Architects Journal*'s Retrofit First campaign give examples of simple yet powerful presentations of preferred ways forward. In this article, a similar robust hierarchy is proposed for communicating the preferences of resource-saving construction.

2. BACKGROUND

Half of annually extracted raw materials are used for construction (ECORYS 2014), which leads to significant environmental harms: 90% of biodiversity loss is associated with the extraction of raw materials, and one-third of global GHG emissions can be attributed to the built environment (IRP 2019). If the consumption of steel, aluminium, plastics and cement continued as projected, the resulting emissions by 2050 would be twice the remaining carbon budget for 1.5°C of global warming (Material Economics 2018).

According to the IPCC (2018), limiting global warming to 1.5°C would require 80–90% reduction of building emissions by 2050. However, recent analysis by the OECD (2019) suggests the opposite is likely to happen: the use of construction materials is projected to grow faster than the global population. Built-up areas are also expanding faster than population growth (Schiavina *et al.* 2022) (Figure 2). By 2050, cities are expected to cover two to six times more area than they did in 2000 (Gao & O'Neill 2020). This may increase urban material use up to 90 billion tonnes by 2050, nine times more than in 2010 (Baynes & Musango 2018). These trends are related to increasing per capita floor areas and decreasing household sizes (UNDESA 2019, Bierwirth & Thomas 2019).

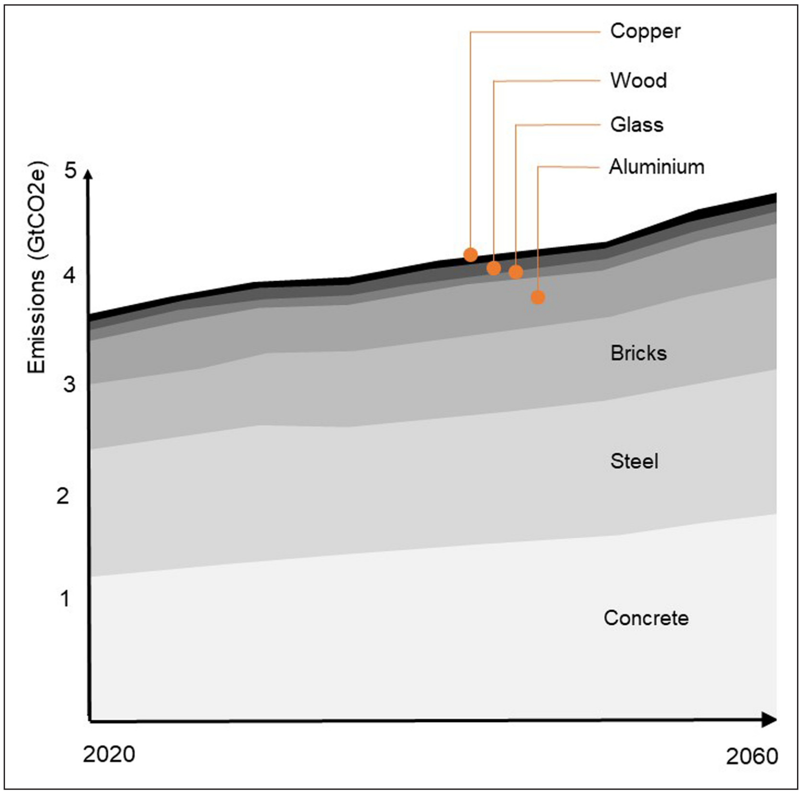

Figure 1: The projected growth of greenhouse gas (GHG) emissions from the global use of main construction materials by 2060.

Source: Zhong *et al.* (2021).

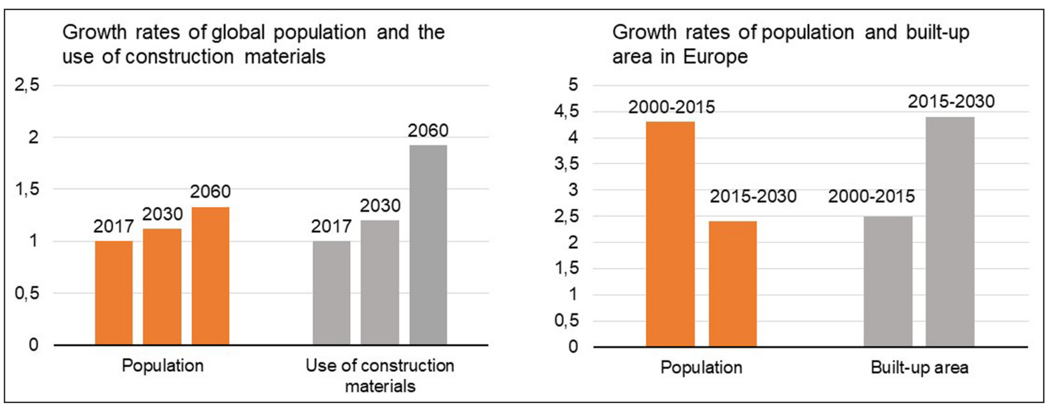

Figure 2: The use of construction products and built-up area are projected to grow faster than the population.

Sources: OECD (2019); Schiavina *et al.* (2022).

3. CURRENT STATUS

The use of materials and energy in European buildings needs to be downscaled to their availability and in line with their associated environmental harms. Both materials and energy consumption are directly related to the use of spaces. Currently, over one-third of European dwellings are under-occupied and 16% are empty (Eurostat 2018, FEANTSA 2016). Furthermore, the material efficiency of European buildings appears not to have improved during the past century. Residential buildings in many European countries are still built with similar amounts of materials as at the beginning of the 20th century (Gontia *et al.* 2018).

Despite the apparent lack of efficiency improvement, there is only one common metric for following the resource consumption of buildings: energy efficiency. Some countries—the Netherlands, France, Sweden, Norway and Denmark—have implemented additional measures for declaring the carbon footprint of certain building types, and Finland will require a separate material declaration in addition. Yet, there are no specified limits to the consumption of natural resources in construction.

As new buildings are constructed, the manufacture of their products causes a 'carbon spike' of upfront GHG emissions. It is already higher than the emissions from energy consumption during building use because operational energy efficiency has improved, and the emissions of energy decreased (Röck *et al.* 2020). Because of the very long atmospheric lifetime of CO_2, emissions caused at the beginning of buildings' life cycle will keep on warming the planet for millennia. Therefore, maintaining and improving the existing building stock can in most cases be more climate-friendly than the construction of new energy-efficient buildings (Figure 3).

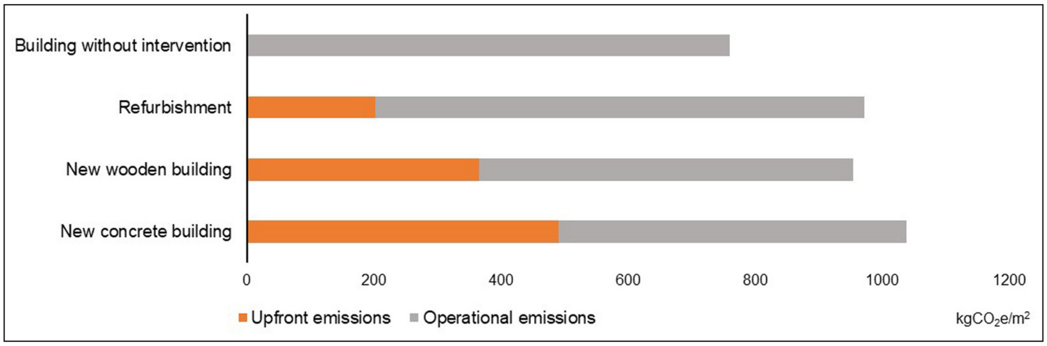

Figure 3: Would it be more climate friendly to demolish an old building and make a new one? A case study comparing the different life cycle emissions of alternatives for refurbishing a school to building a new one and continuing the use of the existing building without interventions.

Source: Huuhka *et al.* (2023).

However, refurbishments also need to be carried out with care, as materials used for them can cause considerable emissions. It may require decades before the emissions caused by the manufacturing of renovation materials are finally amortised by the energy savings, or reduced GHG emissions (Figure 4).

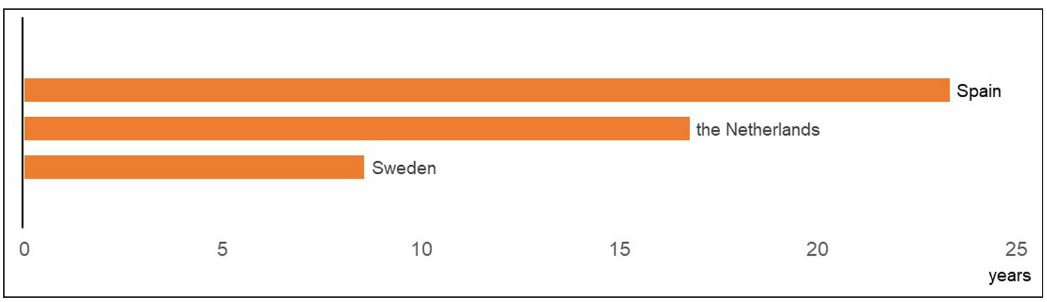

Figure 4: Carbon payback times for a facade energy upgrade in three European countries with varying climatic conditions.

Source: Zhang *et al.* (2021).

4. CONCLUSIONS

Decoupling environmental impacts from the value of construction and the principles of the circular economy are both important, but too slow considering the urgency of climate change and biodiversity loss. Neither is intended to address the important aspect of sufficiency—reducing the overall consumption of resources, regardless of how efficiently they might circulate in an economy. Therefore, considering the growing spatial needs and consumption of resources described above, and the timely importance to act, the reduction of emissions from the construction sector should be started without delay and proceed with tens of percentages per decade to reach a 90% reduction (from present levels) by 2050.

In future, construction in developed countries needs to be rerouted towards adaptation to resource scarcity and stewardship (Ness 2023). To communicate the implications of such development, a new hierarchy for building within planetary boundaries is needed. Similar to the well-known 'waste hierarchy', it would be useful for communicating the required change (Figure 5).

This hierarchy would set the highest priority as 'not building at all' by solving spatial needs by enhancing the use of existing spaces. The next preferred option would be to 'renovate existing buildings for new uses', and the least to 'construct new buildings'. However, this hierarchy must be sensitively adapted to the local context. To achieve this, the collaboration of clients, building designers, constructors, as well as building and planning authorities will be essential. In practice the client's initial brief would not have to state whether a renovation or new building would be needed. Instead, designers and developers should begin by exploring various alternative options for meeting the needs—or for finding users for existing spaces.

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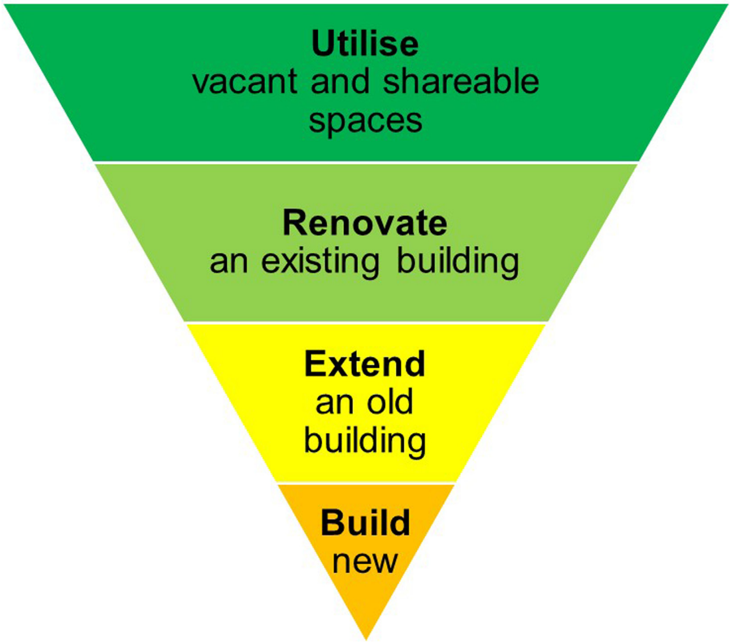

Figure 5: Hierarchy for resource-efficient construction.

Source: Author.

5. RECOMMENDED ACTIONS

5.1 FIRST PREFERENCE: UTILISE

Instead of building or even renovating, organisations and individuals with spatial needs should seek to use existing spaces by adjusting their needs to them. This would lead to extending their service lives, which would reduce the need for new resources for construction and hence mitigate both climate change and biodiversity loss. Not all existing spaces may, due to their design or location, suit society's needs perfectly. Therefore, tolerance for some imperfection would be needed, as well as creativity to reimagine new ways of using available spaces.

5.2 SECOND PREFERENCE: RENOVATE

If existing buildings do not match with the needs, they can be renovated to do so. Despite consuming some resources, renovation would bring considerable savings when compared with new construction. A renovation, or an adaptive reuse, may also improve the functional and technical performance of the building and increase its value.

Upgrading the existing building stocks towards a net zero emission future is highly important. As most of the GHG emissions of the existing building stock are related to their operational use of energy, a thoughtfully executed energy refurbishment can save energy which can then be allocated to critical societal and industrial needs. Nevertheless, renovation also comes with costs and environmental harms that can take decades to amortise. Therefore, it is important that clients, construction companies and designers work together to compare the impacts of renovation alternatives, using methods such as life cycle assessment.

5.3 THIRD PREFERENCE: EXTEND

The production of foundations and load-bearing frames is usually the most emission-intensive process in construction. Using them to add new stories to an existing building, or even as a platform for new structures, would help to reduce GHG emissions and the need to process demolition waste. Another benefit is that no new land would need to be converted for building, and the existing municipal infrastructure could be used. Light and low carbon construction materials that can be used for a high degree of prefabrication (such as timber or carbon-neutral steel) would be especially suitable for such extension projects. As operating in and on old buildings requires surveys and iterative design optimisation, a close collaboration between designers, construction companies and developers would be essential.

5.4 LEAST PREFERRED OPTION: BUILD NEW

New buildings are inevitably linked to resource consumption, leading to environmental and social harms. As the current economic practices seldomly recognise these environmental or social costs, new construction projects often appear financially lucrative. This distortion is harmful for justifying the costs of renovation and accepting lower income from old property portfolios when compared with the potential gains from new developments. But as discussed above, the current resource use in construction is unsustainable.

However, there are cases where it may be necessary to build. These include addressing substandard housing needs in regions where populations increase, or ensuring the safety and health of users, as well as the specific needs that have high societal importance. These may include care for children, the elderly or sick; producing affordable and clean energy and products for society; or rebuilding after a war or a natural disaster. New buildings, whenever eventually deemed justifiable, need to be designed so that the societal value of the building can be decoupled from the environmental and social harms that its construction, operation and end of life will inevitably cause. In addition, their carbon footprints should be kept minimal, and their potential for long service lives and circular economy maximised.

6. IMPLEMENTATION IN A FAIR AND CONTEXT-SENSITIVE MANNER

The approach to resource-efficient construction described above is a simplified model, which is intended for communicating the preferences in building commissioning and design. And like any model, its application in practice requires sensitivity to the context.

Reduction of emissions from construction by avoiding construction is closely related to socio-economic drivers of growth or a desire to maintain gained benefits (so-called 'business as usual'). However, a liveable future may not be for granted if the consumption of resources construction grow—or even stay at the current level—everywhere, and all the time. For a just transition, a globally acceptable reallocation of resources and emissions will be necessary in construction as well. In addition, a fair transition should contain an explicit allocation for developing countries to provide sustainable housing and infrastructure for growing populations.

This will require emission quotas. These can be allocated in various ways, usually either in relation to historical responsibility, capability for emission reductions or equally in relation to needs per capita (Horup *et al.* 2022). Currently, the richest 10% of people are accountable for around 50% of GHG emissions globally, whereas the poorest half only account for only 10% (Oxfam 2021). Although population growth and increase in floor areas mostly happen in developing countries, many developed countries have high construction-related emissions that need to be reduced. By way of example, a proposed allocation for carbon budgets for construction in Denmark and Finland would require a reduction of over 80% by 2050 (Horup *et al.* 2022). Such dramatic effort will require exceptionally strong and politically challenging top-down interventions.

Because Europeans have a historical responsibility for large-scale emissions of GHGs since the onset of the Industrial Revolution, and as the EU seeks global leadership in carbon neutrality, it would be logical to start the application of the proposed hierarchy in Europe. The recommended actions (Table 1) are therefore aimed primarily at policymakers at local, national and EU levels. In addition, recommendations are also suggested for building designers, as there are opportunities for conducting good, through creative design in every project. A logical decision-making tree is presented that can be used in the early stages of a project for identifying options (Figure 6).

The hierarchy proposed in this policy brief is admittedly challenging and would require significant determination to pull through. It may not support the profitability of those companies that rely on continued growth through new construction. But to maintain the liveability and health of the planet, it is critical that society adjusts its preferences, policies and business plans to Earth's carrying capacity.

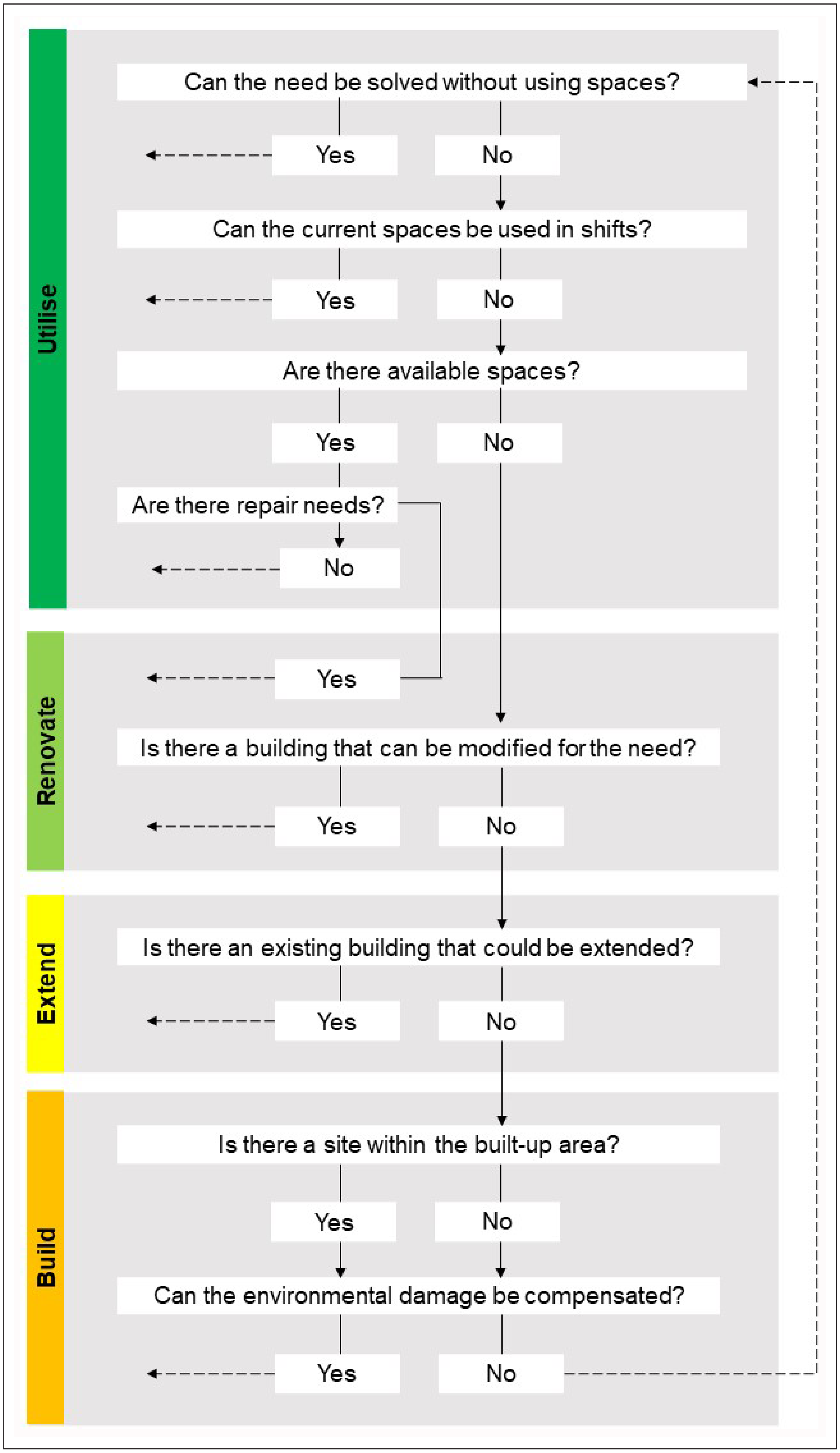

Figure 6: Decision-making tree for a building within planetary boundaries.

Source: Author.

STAKEHOLDER	PRIORITY 1: UTILISE	PRIORITY 2: RENOVATE	PRIORITY 3: EXTEND	PRIORITY 4: BUILD NEW
EU policymakers	• Include the priority of using existing buildings into relevant policies (*e.g.* the EU's Taxonomy for Sustainable Activities and Transition Pathway for Construction) • Offer regional support for matching the available spaces with users' needs	• Introduce a comparison of material consumption and energy savings into renovation legislation and funding	• Launch research calls for developing architectural and technical solutions for extending buildings	• Limit greenhouse gas (GHG) emissions and consumption of non-renewable virgin materials • Require actions that restore habitats or compensate for the environmental harms of construction
National policymakers	• Develop a national strategy for the use and maintenance of public and private spaces • Include the hierarchy into national architectural policies • Ease legislation for allowing the agile use of existing spaces for multiple purposes • Conduct surveys on the vacancy rates of buildings • Offer national support for matching spaces and users	• Support or require renovation instead of demolition • Require life cycle assessments for comparing alternative renovation options	• Enable the use of existing load-bearing frames through building codes • Launch design competitions to explore the possibilities of extensions	• Require stricter environmental performance criteria than for renovation projects • Require a survey for alternatives to new buildings • Require the design for flexible use and relocation or easy disassembly • Set mandatory minimum levels for regenerative actions
Building approval authorities	• Keep a record of underused or empty spaces and advise builders to consider them • Ease the use of empty spaces for multiple purposes	• Offer information about alternative renovation options and their environmental impacts • Inform about the reuse of products in interior architecture and design	• Consider possibilities for easing the requirements, where possible • Advise pre-demolition audits to enhance the level of resource efficiency • Inform about the reuse of products	• Offer information about alternatives to new construction • Offer information about local compensation opportunities • Inform about the reuse of products and use of land masses on site
Building designers	• Seek to solve clients' needs without building in collaboration with, *e.g.*, developers and municipalities	• Conduct life cycle assessments on different renovation options • Seek to extend the service life of the building through life cycle strategies	• Develop architectural and technical approaches for extending building frames • Conduct pre-demolition audits, aiming at reuse and recycling in the same building	• Propose alternatives to new building to the client • Use reused or low carbon products • Integrate restoring solutions and compensations to every project • Ensure flexibility during use and reusability thereafter

Table 1: How can different stakeholders promote the hierarchy?

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COMPETING INTERESTS

The author has no competing interests to declare.

FURTHER READING

This list provides a few key sources, which also direct the reader to other material covering specific topics in more detail.

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An online tool for developing a construction project towards the principles of circular economy.

Cooper, I. (1999). Which focus for building assessment methods—Environmental performance or sustainability? *Building Research & Information*, 27 (4–5), 321–331. DOI: https://doi.org/10.1080/096132199369435

An evergreen article that discusses the needs for reducing construction related environmental harm in developed countries.

IPCC. (2022). *Buildings*. Intergovernmental Panel on Climate Change (IPCC). https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_Chapter09.pdf

Part of IPCC's Sixth Assessment Report that explains the emissions and their mitigation options in the building stock.

IRP. (2018). *The weight of cities*. International Resource Panel (IRP). https://www.resourcepanel.org/reports/weight-cities

A global report that describes the trends of global urban resource consumption as well as decoupling strategies.

Jackson, T. (2017). *Prosperity without growth: Foundations for the Economy of tomorrow*, 2nd ed. https://timjackson.org.uk/ecological-economics/pwg/

A book that analyses the outcomes of continued growth and proposes new ways of living within planetary boundaries.

LETI. (2023). *LETI unpicker: Retrofit vs rebuild*. Low Energy Transformation Initiative (LETI). https://www.leti.uk/retrofitunpicker

A guide for considering options when deciding on alternatives to new buildings.

OneClickLCA. (2022). *Construction carbon regulations in Europe*. https://www.oneclicklca.com/wp-content/uploads/2022/10/Construction-Carbon-Regulations.pdf?vgo_ee=WB39WaJgSTshXu3lsdWWrrsso2YcFExhMbgdcDDUFoc%3D

A review of the status and best practices of carbon regulation in European countries.

Saheb, Y. (2021). COP 26: Sufficiency should be first. *Buildings & Cities*. https://www.buildingsandcities.org/insights/commentaries/cop26-sufficiency.html

A policy brief that addresses the importance of applying the concept of sufficiency to today's environmental challenges.

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