Building for the Future

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A Knowledge Product Collection
by Bauhaus Earth

Series 1 — Setting the Frame

Climate Crisis and the Role of the Built Environment

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What to Expect:

From the materials we use to the energy consumption of our buildings: every aspect of construction has an impact on the environment. The building and construction sector is responsible for nearly 40% of global CO_2 emissions – making it the colossal elephant in the climate room that we can no longer afford to ignore.

This first Knowledge Product in Series 1 “Setting the Frame” highlights key facts and figures on the built environment as a major contributor to the climate crisis. Learn about the carbon footprint of construction, how it impacts our health, and why construction needs to be transformed in order to secure a liveable future for all.

Our Planet at a Tipping Point: The Climate Crisis

We are currently faced with our most imminent planetary threat: the climate crisis. Global temperatures have risen drastically – already by more than 1.1 degrees Celsius (°C) compared to pre-industrial levels. This may not seem significant at first glance, but the consequences of even a small increase in global temperatures are devastating. As a result, the delicate balance of our planet is under immense pressure.

For millions of years, forests and plants have absorbed atmospheric carbon through photosynthesis and fossilisation, storing it in a vast carbon pool underground. This has made the Earth habitable for humans. However, with the advent of the industrial revolution less than 300 years ago, humanity has extracted and burned a significant amount of this stored carbon in the form of fossil fuels.

The concentration of carbon dioxide (CO_2) in the atmosphere has increased substantially, triggering a “greenhouse” effect where increased carbon levels trap the heat in our atmosphere. Extreme weather events and climate-related hazards such as heat waves, floods, and droughts have increased in frequency and intensity in many regions.

Political Commitments Are Still Insufficient

> “Even under the most optimistic assumptions, the world is heading for 1.8°C.”

Despite this alarming situation, efforts to tackle the climate crisis remain insufficient. In 2015, 196 countries adopted the Paris Agreement, agreeing to limit global warming to well below 2°C, and preferably to 1.5°C, by the end of the century. But today, eight years later, the world is far from reaching this climate goal. Current climate policies and actions would lead to a warming of 2.6-2.9°C by 2100, and even under the most optimistic assumptions, the world is heading for 1.8°C[1] – with devastating consequences. Each tenth of a degree increase in global mean temperature will not only trigger more frequent and intense extreme weather events but also increase the risk of climate tipping points being crossed, such as the loss of Arctic permafrost or the loss of the Amazon rainforest.
If tipping points are crossed, changes in any one of these systems could unleash a cascade of irreversible changes across all earth systems[2].

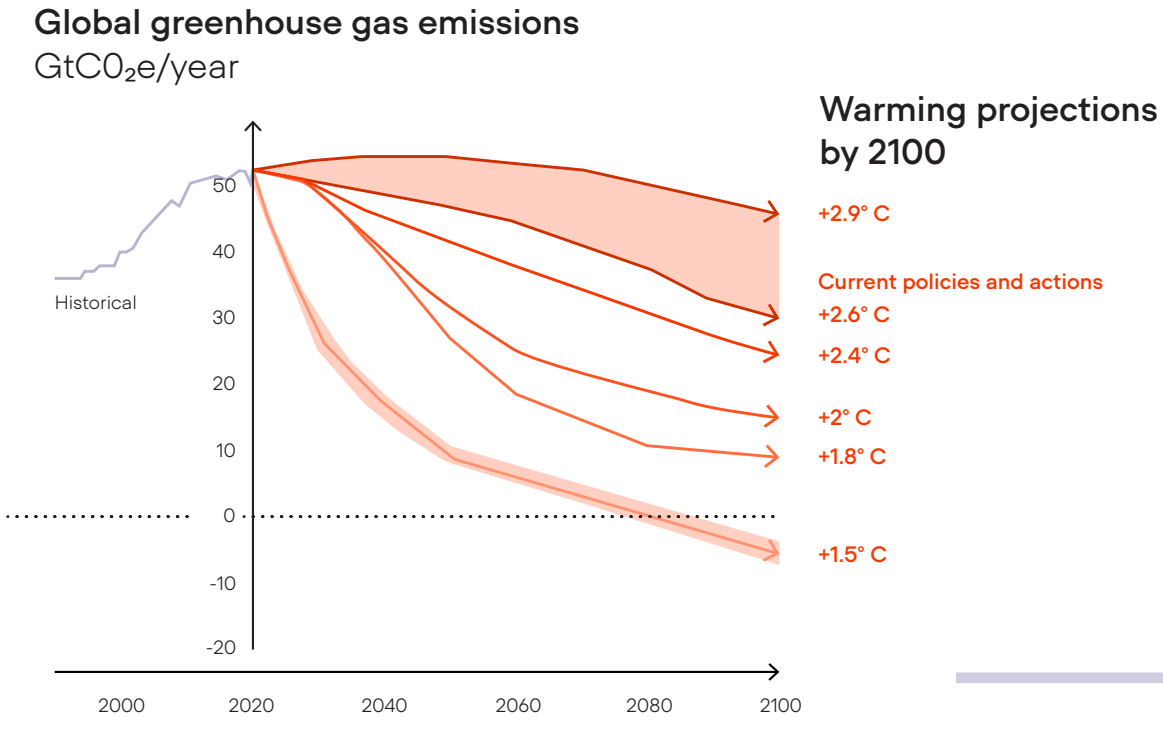

Fig. 1: Warming projections by 2100. Graphic based on Climate Action Tracker (2022)[1]

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The built environment refers to man-made structures that support human activities and provide the space where people live, work, and recreate. This includes physical features such as buildings, roads, parks or green spaces, but also supporting infrastructure such as water supply and energy networks.

Why the Built Environment System is Broken

The Built Environment's Carbon Footprint Is Disastrous

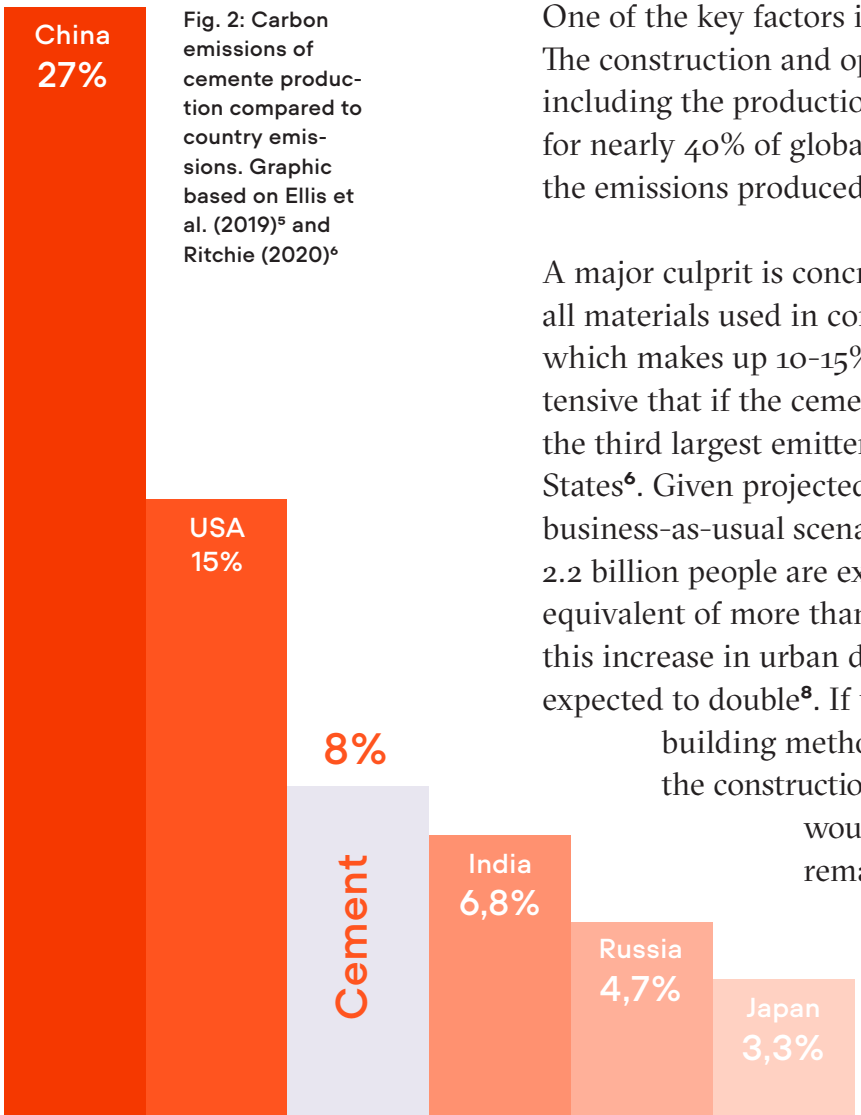

Fig. 2: Carbon emissions of cemente production compared to country emissions. Graphic based on Ellis et al. (2019)[5] and Ritchie (2020)[6]

One of the key factors in global warming is the way we build. The construction and operation of buildings and infrastructure, including the production and transport of materials, accounts for nearly 40% of global CO_2 emissions[3]. This is sixteen times the emissions produced by aviation.

A major culprit is concrete, which accounts for two-thirds of all materials used in construction[4]. The production of cement, which makes up 10-15% of the concrete mix, is so carbon-intensive that if the cement industry were a country, it would be the third largest emitter of CO_2[5], behind China and the United States[6]. Given projected urban growth, the climate impact of a business-as-usual scenario will be devastating. An additional 2.2 billion people are expected to live in cities by 2050[7]– the equivalent of more than 1.5 million people a week. With this increase in urban dwellers, the global building stock is expected to double[8]. If we continue to use currently prevailing building methods and materials such as concrete, the construction of the necessary infrastructure alone would consume about three-quarters of the remaining carbon budget of a 1.5°C rise in temperature[9].

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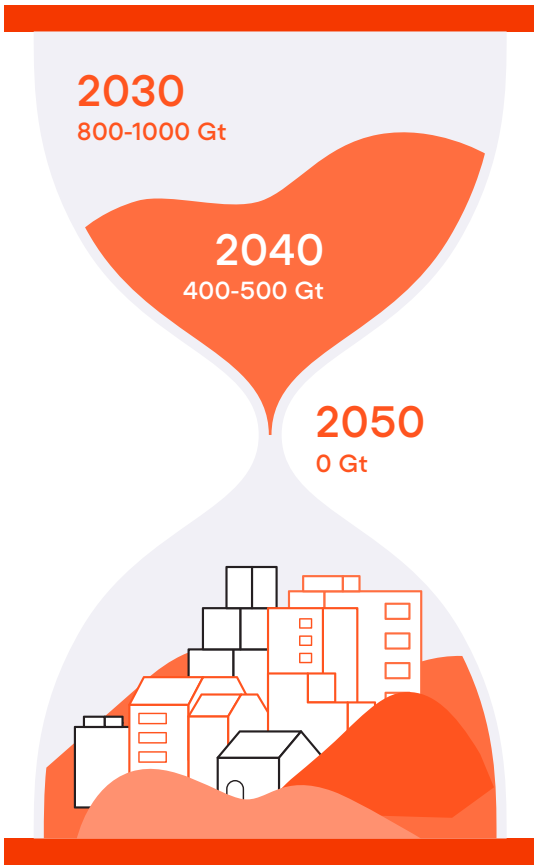
> “By 2050 humanity will be consuming the natural resources of two planets every year.”

The Built Environment’s Use of Its Resources Is Wasteful and Destructive

The dramatic carbon footprint of the built environment does not even reflect the full extent of the problem. 60% of global resource consumption and 50% of global waste generation can be attributed to the built environment[3] – causing severe harm to natural ecosystems through air, water and land pollution, biodiversity loss, and resource depletion. In industrialized countries, each person accounts for approximately 430 tonnes (t) of building materials currently in use[3]. In developing countries, the average per capita use is 76t[3] – and overall use is increasing every year due to economic growth and a growing global population[10].

If this trend continues, by 2050 humanity will be consuming the natural resources of two planets every year[11]. Moreover, the waste generated from construction, renovation, and demolition is massive, amounting to approximately 100 gigatonnes each year[12]. This waste consists of concrete, asphalt, wood, glass, and hazardous materials such as treated wood, lead paint, and asbestos. Unfortunately, 35% of this waste ends up in landfills without any treatment[13].

Fig. 3: Estimated remaining sand and gravel volume based on current rate of extraction. Graphic based on Sobek (2022)[3]



Sand and gravel account for 60-70% of the volume of concrete and represent the most exploited solid natural resources[13]. They are formed over thousands of years by erosion processes in glaciers, rivers, and waterways - but at the current rate of extraction, the world could run out of this resource by 2050[14]. An estimated 40 to 50 gigatonnes are mined each year for construction purposes alone[15], which is enough to build a sandcastle 300 metres high over the entire area of Paris.

“
Much of today’s building stock poses a serious health hazard to our mental and physical health.”

In addition to the extraction of raw materials, highly biologically diverse or fertile land is often consumed by urban growth and sprawl. By 2030, urban areas are expected to grow by 1.2 million km²[16], roughly the size of South Africa. Cities are now growing twice as fast as their population[15]. Land and resource consumption is highly dependent on the building morphology and the spatial organization of cities. Purely residential areas with predominantly single-family housing require significantly more infrastructure and resources than compact and mixed-use neighbourhoods. This inefficient use of land and the increase in living space not only result in the loss of biodiversity and fertile agricultural land, but also in the loss of terrestrial carbon stored in vegetation biomass.

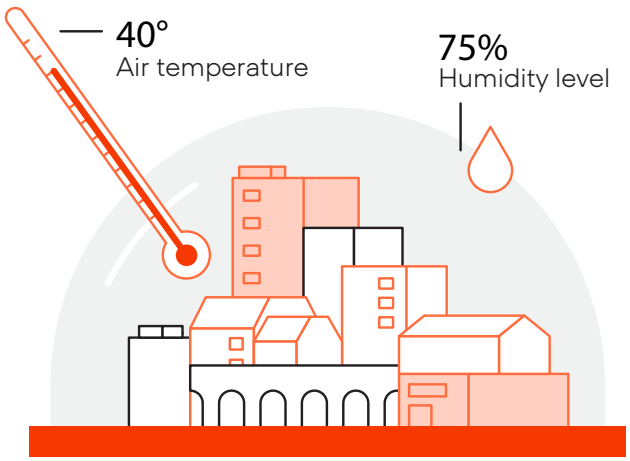
The Built Environment Is Not Conducive to the Health and Well-Being of People

The way the built environment system works is disastrous not only for the planet but also for people. Due to the large amount of sealed surface area, the structural organization of the built environment, and the types of materials used, temperatures in urban areas are much higher than in surrounding rural areas - an effect known as the ‘urban heat island effect’. This makes some cities almost uninhabitable during heat waves. With global warming, this effect will be exacerbated and directly impact human health and mortality, especially among the elderly and those with pre-existing health conditions[17]. Moreover, the sealing of urban soils through construction reduces the ability of water to infiltrate, thus increasing the risk of flooding. Cities, often located in coastal areas or along major waterways, are particularly vulnerable to these impacts[18].

'Wet bulb' temperature measures dry air temperature in relation to humidity. Once it surpasses 35°C, which equals roughly 40°C dry air temperature and a humidity level of 75%, our bodies can no longer cool down through sweating, leading to deadly overheating within a few hours[22]. If the Earth's average temperature rises to 1.5°C, many tropical regions could regularly reach this survival threshold[25].

Much of today's building stock poses a serious threat to our health. In some regions, people are estimated to spend more than 90% of their time indoors[19]. Accordingly, the characteristics of indoor spaces are of great importance to their health and well-being. Too low indoor temperatures, for instance, lead to various mental and physical illnesses. Poorly designed lighting is also associated with an increased risk of developing depression, to name just a few of the known effects on human health[20]. In addition, many people are exposed to toxic substances in their own homes. Approximately one-third of the world's population cooks with open fires or inefficient stoves, which generate harmful household air pollution, exposure to which can cause a range of health problems and is estimated to result in the death of 3.2 million people annually[21].

Fig. 4:
Fatal 'wet bulb' temperatures



Worst of all, the built environment fails to meet basic human needs. In 2018, more than 1 billion urban residents lived in slums and informal settlements, which are particularly vulnerable to the impacts of climate change[22]. By 2030, 3 billion people – about 40% of the world's population – are expected to need adequate housing[22]. Poorly constructed and inadequately maintained neighbourhoods not only suffer disproportionately from heat or flooding. They are often built in areas where the risks of climate change are compounded. As global mean temperatures rise, the world's most urbanised regions, which are currently home to the majority of the urban poor, are likely to become uninhabitable. This could be due to droughts threatening food supplies, sea-level rise causing frequent or permanent flooding, or exposure to high 'wet bulb' temperatures increasing the risk of death from overheating[23]. Thus, estimates for the number of people forced to abandon their homes due to climate change by 2050 range from 25 million bis 1 billion[24], triggering the largest forced migration our planet has ever seen.

Rapid Urbanization and Population Growth Compound the Challenges of the Built Environment

The way we currently build and organize our cities has become the most significant source of human-made environmental crisis. The challenge of reversing the impact of the built environment and 'building better' will not be easy, given rapid urbanisation and expected population growth.

> "Our current buildings need urgent upgrading to reduce their carbon footprint and adapt them to the needs of future generations."

Asia and sub-Saharan Africa will experience the fastest urbanisation rate of all regions, while already being home to the majority of the world's urban poor today. The highest rates of urbanisation are expected in Burundi, Nepal, and Malawi, while the largest increase in the total number of urban residents will occur in India, China, and Nigeria[25]. It is in these regions that a shift to climate-positive, regenerative construction is most needed to achieve the race to net-zero by 2050, while adapting to the already unfolding impacts of climate change.

It is also imperative to address the current state of the building stock, 80% of which is likely to still exist in 2050[26]. Often poorly insulated and maintained, our current buildings need urgent upgrading to reduce their carbon footprint and adapt them to the needs of future generations. This is especially important in countries of the so-called Global North, where most of these buildings are located. By adapting these existing buildings and reusing materials that are already available, we can reduce the demand for new construction and contribute to a more sustainable future.

Expected Urban Growth by 2035 by Continent

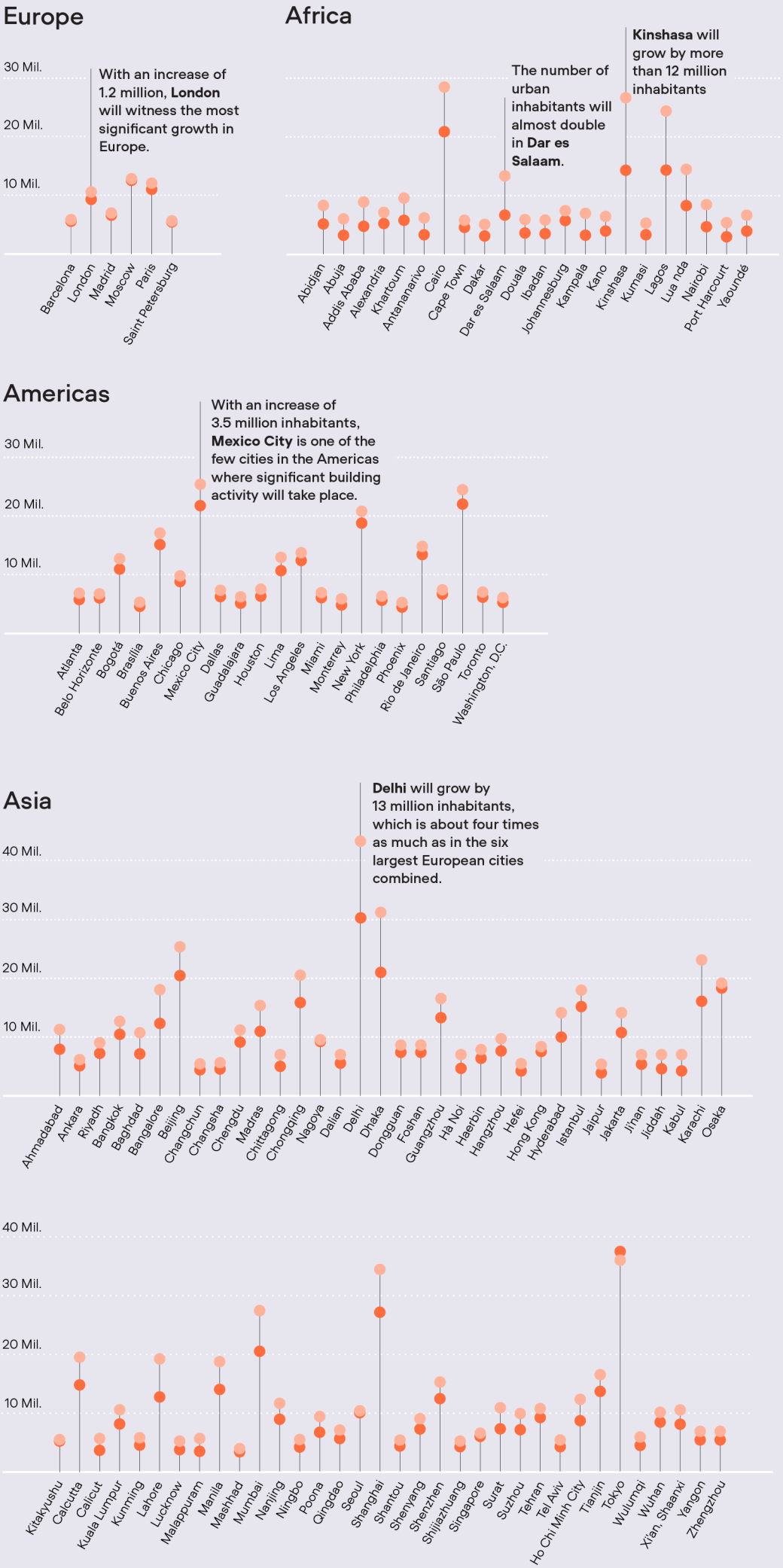


Fig. 5: Projected urban growth. Graphic based on United Nations Department of Economic and Social Affairs (2020)[26]

cities with more than **5 millions inhabitants**

6 cities in **Europe**

22 cities in **Africa**

22 cities in the **Americas**

68 cities in **Asia**

- Population in 2020
- Expected Population by 2035

Fixing the Built Environment System – A Solution to the Climate Crisis?

It is time we confront the biggest elephant in the climate room head-on. Our built environment system plays a major role in exacerbating the climate crisis, leading to catastrophic consequences for both our society and planet.

But there is hope - by transforming the built environment, we have a unique opportunity to make significant progress in reducing greenhouse gas emissions and building a more sustainable future. Not only can the built environment provide the foundation for a healthy and resilient society. Rethinking the materials and methods with which we build can also open up pathways for effective climate restoration, thereby ensuring that our planet is habitable for generations to come.

The second knowledge product in “Series 1: Setting the Frame” of “Building For the Future” delivers valuable insights on innovative approaches that can enable the successful transition towards a more sustainable built environment.

KEY TAKEAWAYS

→ The built environment accounts for nearly 40% of global CO_2 emissions due to construction, operation of buildings and infrastructures, as well as materials production and transportation.

→ The built environment is the single largest consumer of resources and producer of waste.

→ Demand for materials will continue to increase drastically, even though many of the building materials used today are finite.

→ Growing consumption of raw materials and land resources results in loss of biodiversity, fertile agricultural land, terrestrial carbon stored in vegetation biomass, and higher per capita emissions.

→ The structure and location of urban areas, as well as the use of building materials, increase vulnerability to environmental hazards and impact human health and well-being.

→ The built environment fails to meet basic human needs, with many lacking access to dignified living conditions and suitable housing for an ageing society.

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References

1 Climate Action Tracker. "Temperatures: Addressing Global Warming," November 2022. Accessed February 8, 2023. https://climateactiontracker.org/global/temperatures/.

2 Lenton, T. M., J. Rockström, O. Gaffney, S. Rahmstorf, K. Richardson, W. Steffen, H. J. Schellnhuber. "Climate Tipping Points — Too Risky to Bet Against." *Nature* 575, no. 7784 (November 28, 2019): 592–95. doi: 10.1038/d41586-019-03595-0.

3 Sobek, W. *Non Nobis – Über das Bauen in der Zukunft: Ausgehen von dem was man hat.* Stuttgart: AVEdition, 2022.

4 Gagg, C. "Cement and Concrete as an Engineering Material: An Historic Appraisal and Case Study Analysis." *Engineering Failure Analysis* 40 (May 1, 2014): 114–40. doi: 10.1016/j.engfailanal.2014.02.004.

5 Ellis, L. D., A. F. Badel, M. L. Chiang, R. J.-y. Park, and Y.-M. Chiang. "Toward Electrochemical Synthesis of Cement—An Electrolyzer-Based Process for Decarbonating CaCO 3 While Producing Useful Gas Streams." *Proceedings of the National Academy of Sciences of the United States of America* 117, no. 23 (September 16, 2019): 12584–91. doi: 10.1073/pnas.1821673116.

6 Ritchie, H. "CO_2 and Greenhouse Gas Emissions." Our World in Data, May 2020. Accessed November 29 2023. https://ourworldindata.org/co2-emissions.

7 United Nations Human Settlements Programme. *World Cities Report 2022: Envisaging the Future of Cities*. Nairobi: 2022.

8 Global Alliance for Buildings and Construction, International Energy Agency and the United Nations Environment Programme. *2019 Global Status Report for Buildings and Construction: Towards a Zero-Emissions, Efficient and Resilient Buildings and Construction Sector,* 2019.

9 Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderung. *Der Umzug der Menschheit: Die Transformative Kraft der Städte*. Berlin: 2016.

10 International Resource Panel. "Assessing Global Resource Use: A Systems Approach to Resource Efficiency and Pollution Reduction." Edited by Bringezu, S., Ramaswami, A., Schandl, H., O'Brien, M., Pelton, R., Acquatella, J., Ayuk, E., Chiu, A., Flanegin, R., Fry, J., Giljum, S., Hashimoto, S., Hellweg, S., Hosking, K., Hu, Y., Lenzen, M., Lieber, M., Lutter, S., Miatto, A., Singh Nagpure, A., Obersteiner, M., van Oers, L., Pfister, S., Pichler, P., Russell, A., Spini, L., Tanikawa, H., van der Voet, E., Weisz, H., West, J., Wiijkman, A., Zhu, B., and Zivy, R. Nairobi: United Nations Environment Programme, 2017.

11 Horx, T., A. Kirig, C. Kristandl, V. Muntschick, L. Papasabbas, C. Rauch, C. Schuldt, J. Seitz, and J. Senft. *Megatrend Dokumentation: Neoökologie*. Frankfurt a.M.: Zukunftsinstitut GmbH, 2018.

12 United Nations Environment Programme. 2022 *Global Status Report for Buildings and Construction: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector.* Nairobi: 2022.

13 Menegaki, M., and D. Damigos. "A Review on Current Situation and Challenges of Construction and Demolition Waste Management." *Current Opinion in Green and Sustainable Chemistry 13* (October 1, 2018): 8–15. doi: 10.1016/j.cogsc.2018.02.010.

14 Rentier, E.S., and L.H. Cammeraat. "The Environmental Impacts of River Sand Mining." *Science of the Total Environment* 838 (September 2022): 155877. doi: 10.1016/j.scitotenv.2022.155877.

15 United Nations Environment Programme. *Sand and Sustainability: Finding new solutions for environmental governance of global sand resources*. Geneva: 2019.

16 Seto, K. C., B. Güneralp, and L. R. Hutyra. "Global Forecasts of Urban Expansion to 2030 and Direct Impacts on Biodiversity and Carbon Pools." *Proceedings of the National Academy of Sciences of the United States of America* 109, no. 40 (October 2, 2012): 16083–88. doi: 10.1073/pnas.1211658109.

17 Heaviside, C., S. Vardoulakis, and X. Cai. "Attribution of Mortality to the Urban Heat Island during Heatwaves in the West Midlands, UK." *Environmental Health* 15, no. S1 (March 8, 2016). doi: 10.1186/s12940-016-0100-9.

18 Dpietri, Y., K. Dahal, and T. McPhearson. "Multi-Hazard Risks in New York City." *Natural Hazards and Earth System Sciences* 18, no. 12 (December 21, 2018): 3363–81. doi: 10.5194/nhess-18-3363-2018.

19 United Nations Environment Programme and Global Alliance for Buildings and Construction. *The Importance of Building Decarbonization and Benefits for the SDGs*. 2022

20 Hoisington, A. J., K. A. Stearns-Yoder, S. J. Schuldt, C. J. Beemer, J. Alcaraz Maestre, K. A. Kinney, T. T. Postolache, C. A. Lowry, and L. A. Brenner. "Ten Questions Concerning the Built Environment and Mental Health." *Building and Environment* 155 (May 15, 2019): 58–69. doi: 10.1016/j.buildenv.2019.03.036.

21 World Health Organization: WHO. "Household Air Pollution," November 28, 2022. Accessed February 8, 2023. https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health.

22 United Nations Statistics Division. "Sustainable Cities and Communities: Make Cities and Human Settlements Inclusive, Safe, Resilient and Sustainable" Accessed February 8, 2023. https://unstats.un.org/sdgs/report/2019/goal-11/.

23 Timperley, J. "Why You Need to Worry about the 'Wet-Bulb Temperature.'" *The Guardian*, July 31, 2022. https://www.theguardian.com/science/2022/jul/31/why-you-need-to-worry-about-the-wet-bulb-temperature.

24 International Organization for Migration. *Outlook on Migration, Environment and Climate Change.* Geneva: International Organization for Migration, 2014.

25 Zhang, Y., I. M. Held, and S. Fueglistaler. "Projections of Tropical Heat Stress Constrained by Atmospheric Dynamics." Nature Geoscience 14, no. 3 (March 8, 2021): 133–37. doi: 10.1038/s41561-021-00695-3.

25 United Nations Department of Economic and Social Affairs. *World Urbanization Prospects: The 2018 Revision.* New York: 2019.

26 World Economic Forum. "For Net-Zero Cities, We Need to Retrofit our Older Buildings. Here's What's Needed," November 9, 2022. Accessed February 8, 2023. https://www.weforum.org/agenda/2022/11/net-zero-citiesretrofit-older-buildings-cop27/.

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About Bauhaus Earth

We envision a future where buildings, cities, and landscapes proactively contribute to climate restoration and have a positive impact on the planet and its inhabitants. Our mission is to transform building and human settlements from a driver of climate and societal crises into creative forces for systemic regeneration.

Only a complete systemic overhaul of our built environment will prevent a global climate catastrophe.

The Knowledge Product Collection “Building for the Future” is an ongoing project. The present publication is part of Series 1: “Setting the Frame.”

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