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Arup Foresight Global Horizon Scan

New Horizons, Common Ground

Global trends impacting the built environment in the coming decade

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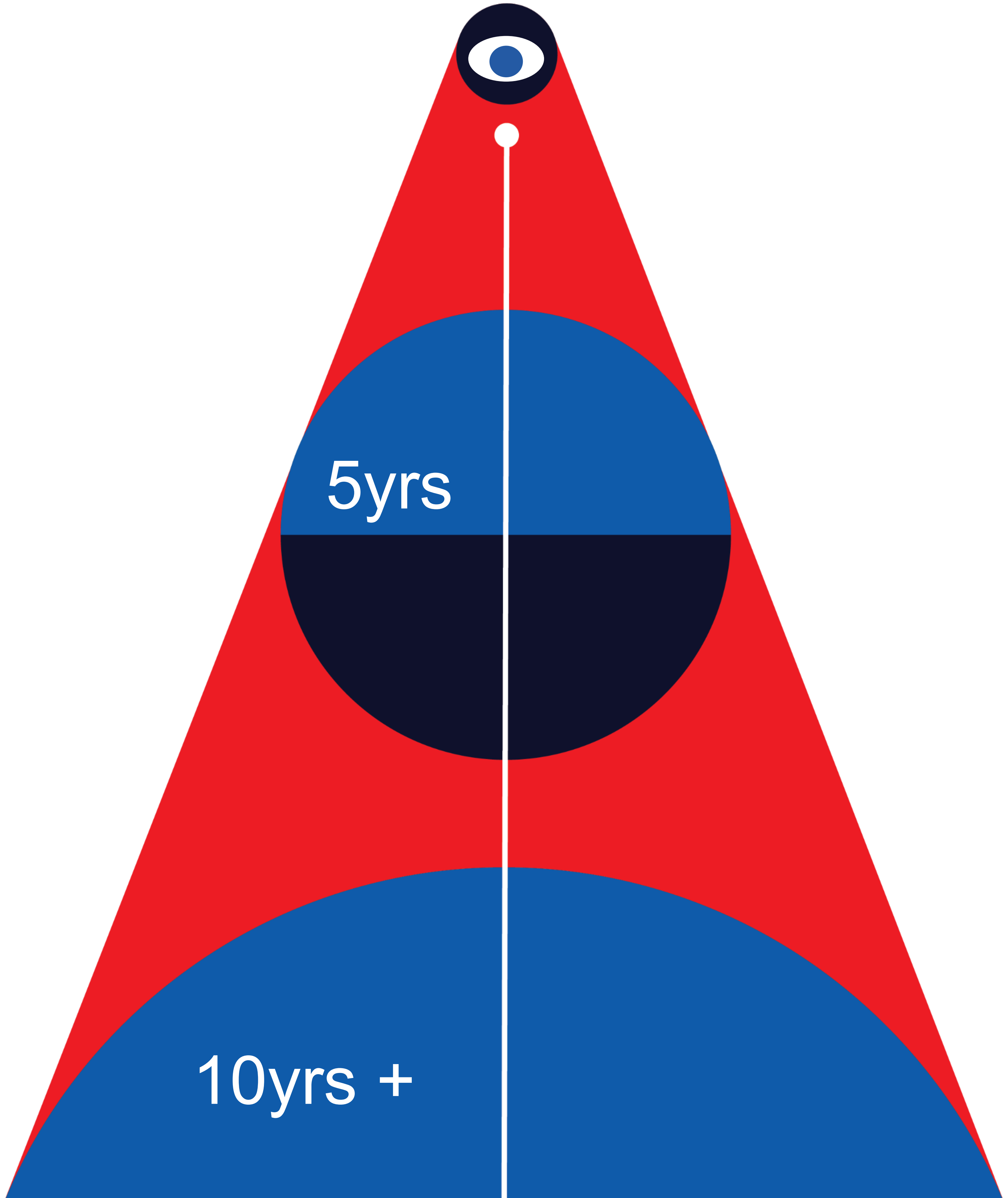
How might disrupted global patterns and flows – of species, resources, information – define the spaces and systems of the next decade? This research explores three major dynamics of change and their implications for our future built environment.

Why a Horizon Scan?

Taking a longer, and wider view
Horizon Scanning is a systematic approach to gathering intelligence about what is changing, with the aim of better understanding the forces and factors that shape our future operating context. Horizon Scanning takes a *wider* view of change by analysing social, technological, environmental, economic and politico-legal trends and data. It also takes a *longer* view of time to see deeper patterns of change, thus looking beyond the typical five-year horizon most strategies adopt and mitigating undue influence by short-term disruptions.

At Arup, we engage more deeply with context and consider holistic change over time. Horizon Scanning helps us move beyond what we *want* or *expect* to see, enabling us to identify a broader range of future risks and opportunities. We bring '*Total Design*' to our projects and clients, connecting multidisciplinary expertise with curiosity, collaboration and technical rigour to deliver integrated, purposeful solutions. This relies on taking a broader view and engaging more deeply with context.

New Horizons, Common Ground is the result of an extensive Horizon Scan across Arup's global Foresight network and subject matter experts. Our evidence base of trends and signals has been analysed and synthesised into three key themes for the next decade, each with implications and considerations for built environment stakeholders and practitioners.



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The global context

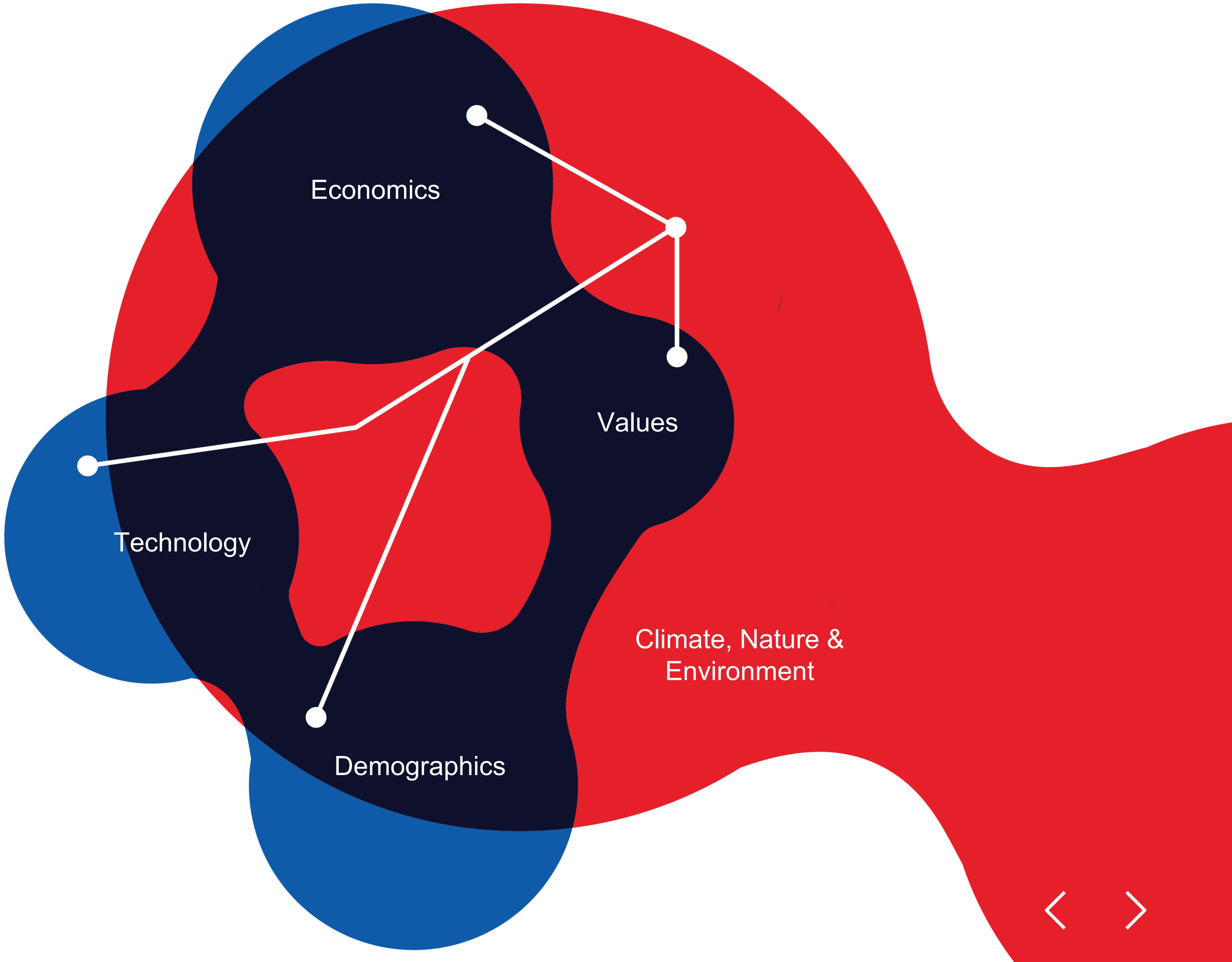
Fragile systems and complexity at scale

The only constant in the world is change. Societies are on a never-ending mission to understand change, its drivers, its pace and its impacts. The volatility, uncertainty, complexity and ambiguity (VUCA) of global shifts cannot be avoided, but it can be better understood when viewed as a dynamic interplay between different types of change. We can identify, analyse and discuss trends and shifts that follow relatively stable trajectories (e.g. demographics), that are shaped by human decisions (e.g. political agendas), or that emerge from complex modelling of dynamic systems (e.g. climate projections).

Ultimately, the most dominant forces at play (demographics, technology, economics and values) all hinge on the health of the environment. It defines what resources are available and what the climate can accommodate – as shown by the adapted Futures Diamond (1) on the right. Climate and nature crises are underlying drivers of all other trends, directly impacting the global movement of people, goods and ideas.

The result is a challenge to what we perceive as 'normal' over the next decade and beyond. The stories that once held society together – shared values, cultural norms, and common truths – are breaking down, and even the idea of objective truth is increasingly under threat. Across all societies, adaptation to a new and fluid normal will be necessary and inevitable.

The sense of urgency in this persistently VUCA world remains palpable, even as its dynamics shift and evolve. It narrows our field of vision at a time when it is more important than ever to take a systems-wide view and to acknowledge that our deep interconnectedness with the world around us will help us imagine and enact a better world: one that is safe, resilient and regenerative.



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Significance for the built environment

The challenge of delivering safe, resilient and regenerative places
Looking *back* a decade, we see evidence of interconnected, long-term trends: seismic shifts that have changed approaches to design in the built environment. The effects of a warming world have been felt in previously climate-stable geographies; human encroachment on natural ecosystems has been linked to a rise in global pandemics (2) with far-reaching consequences, and fraught relationships between liberal and autocratic regimes have created severe vulnerabilities in global energy and resource supply chains (3, 4).

Industry players and policymakers in the built environment are busily *reacting* to these physical challenges, but how often do we engage in exploring uncertainty and anticipating possible long-term futures?

The focus of our scanning and analysis in *New Horizons, Common Ground* is the convergence and emergence of trends that present critical uncertainties for built environment futures. Looking forward a decade, will we see further geopolitical decoupling, nearshoring and fragmenting regulation, or will multilateralism prevail? How will this impact supply chains, materials and costs? Which political and socio-economic regimes will dominate? What does that mean for organisations' international footprint? How will the convergence of people's physical and digital lives shape expectations and experiences of spaces and places? Importantly, what if multiple, extreme outcomes unfold at the same time?

Call to Action:
We are constantly monitoring trends and weak signals of change relating to these questions and more. Get in touch to start a conversation about how Foresight can help.

Inspiring action

Avoiding decision paralysis in the face of complexity

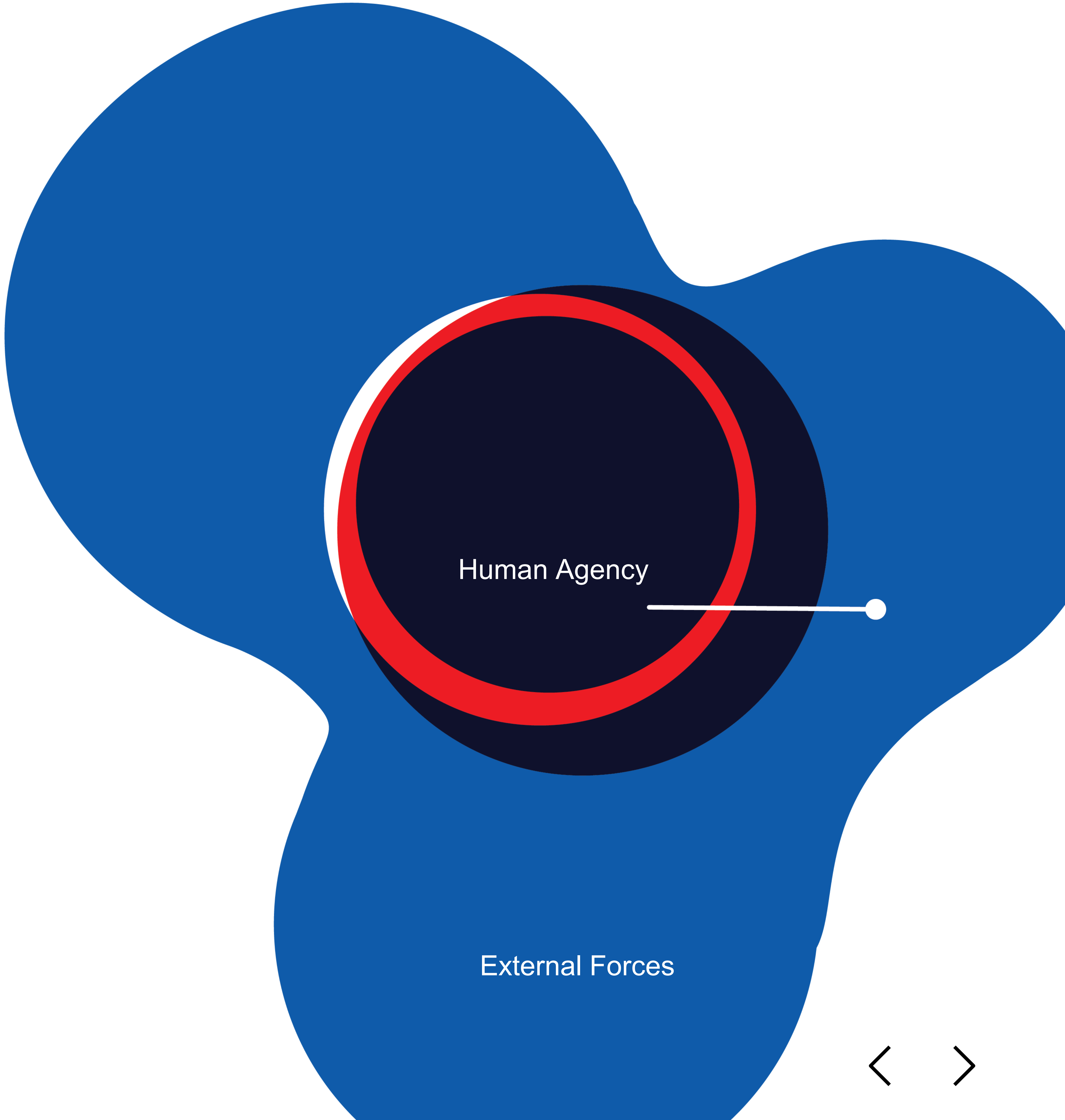
This Horizon Scan, while based on evidence, is *not* an exhaustive list of industry-agnostic change. Nor is it the last word on built environment futures. Instead, we describe three complex dynamics at play over the next decade and examine the impact these might have on the built environment. We also propose some actions that professionals in the sector can think about today to prepare for those futures.

None of the dynamics described can be fully addressed by a single actor or group of actors, whether they be contractors, designers, engineers, educators, community organisers, city leaders, or other participants.

With New Horizons, Common Ground, our aim is to:

- Provide a shared language and framework for cross-discipline, cross-industry, and cross-sector conversation.
- Guide designers, decision-makers, planners, and policymakers operating in a VUCA world, for which we must develop new approaches, skills, and capabilities.

Recession, war, divisive politics, rising tech dependence, and a pandemic have combined to frighten, isolate, and perhaps heightened feelings of external control (5, 6). Especially among young adults, who report lower levels of flourishing than older adults (7), this diminished sense of wellbeing may contribute to a perceived lack of agency. Rehearsing for a wide range of possible futures allows us to identify opportunities to effect positive change, together.



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Navigating change

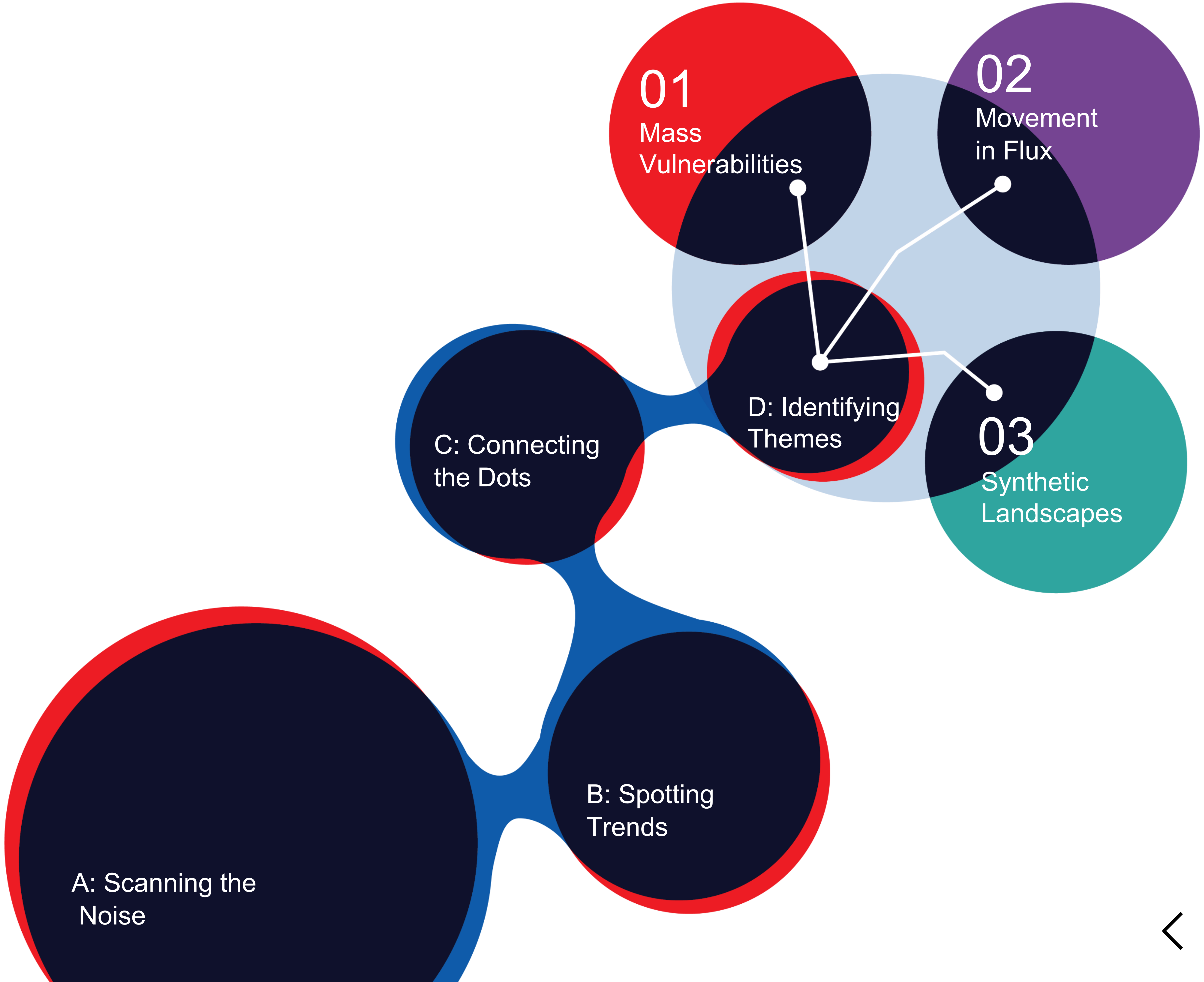
From a wide range of trends and signals, to three key dynamics

Foresight practitioners across Arup's global network contributed to our Horizon Scan. Analysis of the trends and signals gathered resulted in three dynamics of change: themes that will define our future operating context in the next decade.

These dynamics are not isolated issues, but interconnected forces reflecting the interplay of ecological, geopolitical, technological and sociocultural shifts. Together, they represent a shared framework for navigating the pressures, possibilities and actions that lie ahead for those engaged in policy or practice in the built environment – but dynamic each has a distinct focus:

1. **Mass Vulnerabilities** explores the compounding foundational disruptions affecting ecosystems, economies and communities, and the urgent need for integrated, regenerative responses.
2. **Patterns in flux** traces the intensifying patterns of migration – human and more-than-human – and the implications for infrastructure, equity and urban resilience, shaped by systemic pressures.
3. **Synthetic Landscapes** examines the convergence of digital and physical systems in shaping our environments amid evolving conditions, and the critical questions of agency, ethics and inclusion this change provokes.

Our process:



Three dynamics at a glance

Each dynamic features built environment impacts and actions, highlighting where change is most urgent and how we might begin to respond.

	Mass vulnerabilities	**Patterns in flux**	**Synthetic landscapes**
	Compounding pressures across ecological, geopolitical and social systems call for integrated responses that respect the interdependence of living systems and reimagine how we work with materials, ecosystems and economies.	Displacement of humans and other species, and disrupted movements and flows require a reimagining of infrastructure, urban form and funding to improve adaptive capacity.	The convergence of digital and physical systems in our environments raises urgent questions of agency, ethics and inclusion, and offers a chance to develop and direct novel technologies for social and ecological benefit.
Impacts	• The new normal of extreme weather • Resource constraints intensify conflict across systems • Fragile food and water systems	• Urban systems undergo intense stress tests • Human and more-than-human co-habitation challenges • Unliveable habitats and abandoned places	• Human x AI co-design and co-analysis • A new era of digital twins • Political and economic dominance of tech owners
Actions	• Improve resilience through regenerative design • Invest in bioengineering and biomaterials • Protect and enhance nutrient flows	• Co-invest in infrastructure and climate finance • Re-establish and support polycentric urban districts • Design multi-functional and adaptable infrastructure	• Prepare and plan for skills transformation • Update regulation for the physical-digital continuum • Community-specific engagement with emerging digital technology

Mass vulnerabilities

From isolated disruptions to concurrent mass vulnerability

The frequency and severity of floods, wildfires, droughts and extreme weather events are on the rise, causing widespread damage and increasing vulnerability for humans, animals and plants (8). Experts caution that we are experiencing a sixth mass extinction, with global interdependence and crises such as the lingering effects of the COVID-19 pandemic and ongoing conflicts exacerbating the situation (9).

These vulnerabilities will disproportionately affect low-income countries and communities, testing individual and community resilience across all species. Coastal areas are home to more than two billion people, with around 680 million living in the low-lying coastal zone in 2019 and that number projected to exceed one billion by 2050 (10, 11). Socio-economic development will crucially influence the impact and adaptation responses, especially in rapidly growing coastal regions. As new vectors of vulnerability emerge, disruptive events are not likely to be distinct or isolated, since we face a future where disruptive events are increasingly interconnected and compounded. ‘Mass vulnerability’ is the reality of the coming decade.

“Indigenous knowledge and wisdom offer more than cultural insight; they provide enduring models for living well within ecological limits.”

These mass vulnerabilities are compounded by the intertwined pressures of a slowing global economy, a drive for resource sovereignty, the continuous prioritisation of extractive growth above sustainability, conflicting politico-ideological movements, and collective anxiety over a possible ecological collapse (12, 13). Yet, amid these formidable challenges, there remains hope. Addressing such threats requires aligning innovation with exnovation, i.e. the careful phasing out of technologies and practices that have proven harmful, alongside robust legislation and bold political action (14). For example, rethinking our material, ecological and economic models is essential to mitigating the carbon crisis, as current practices contribute significantly to biodiversity loss and water stress, with the extraction and processing of fossil fuels, metals, and non-metallic minerals together accounting for about 35% of global greenhouse-gas emissions (15).

One particularly stark illustration of these interconnected crises is the COVID-19 pandemic, which underscores how environmental degradation can directly impact human health and global stability. Like other zoonotic diseases, it is deeply linked to biodiversity loss and ecosystem disruption, driven by human activity that fosters the emergence of new pathogens (16). Its ripple effects have strained biodiversity conservation, environmental governance, and ecosystem services. Though lockdowns briefly curbed emissions, they also exposed our dependence on unsustainable systems, risking feedback loops that could trigger future crises (17).

At the same time, the pandemic revealed psychological resilience in many adults, reflecting humanity’s capacity to adapt amid prolonged uncertainty (18). This mirrors natural systems, which often reorganise in response to disturbance. Just as societies draw on latent strengths during crises, ecosystems exhibit complex, sometimes beneficial responses to disruption. This duality of threat and adaptation reinforces an ecological truth: threats are rarely one-dimensional. Even viruses – typically regarded as harmful – can perform vital roles; for example, some marine viruses regulate microbial communities that support oceanic carbon sequestration (19). Such dynamics remind us that disruption, while challenging, can also catalyse resilience and renewal.

Rooted in a deep, reciprocal relationship with the land, Indigenous and traditional cultures understand nature not as a resource but as a living system. These worldviews embrace disruption and renewal as natural processes, reflected in practices honed over generations that sustain biodiversity, build resilience, and respect ecological disturbance. A study of life satisfaction across 19 Indigenous and local communities worldwide found that many report high wellbeing despite low monetary incomes (20), highlighting that human flourishing need not depend on extractive growth. Indigenous knowledge and wisdom offer more than cultural insight; they provide enduring models for living well within ecological limits. As we face compounding crises, these perspectives remind us that learning to live in balance with the systems that sustain us will be essential to restoring our relationship with the Earth.

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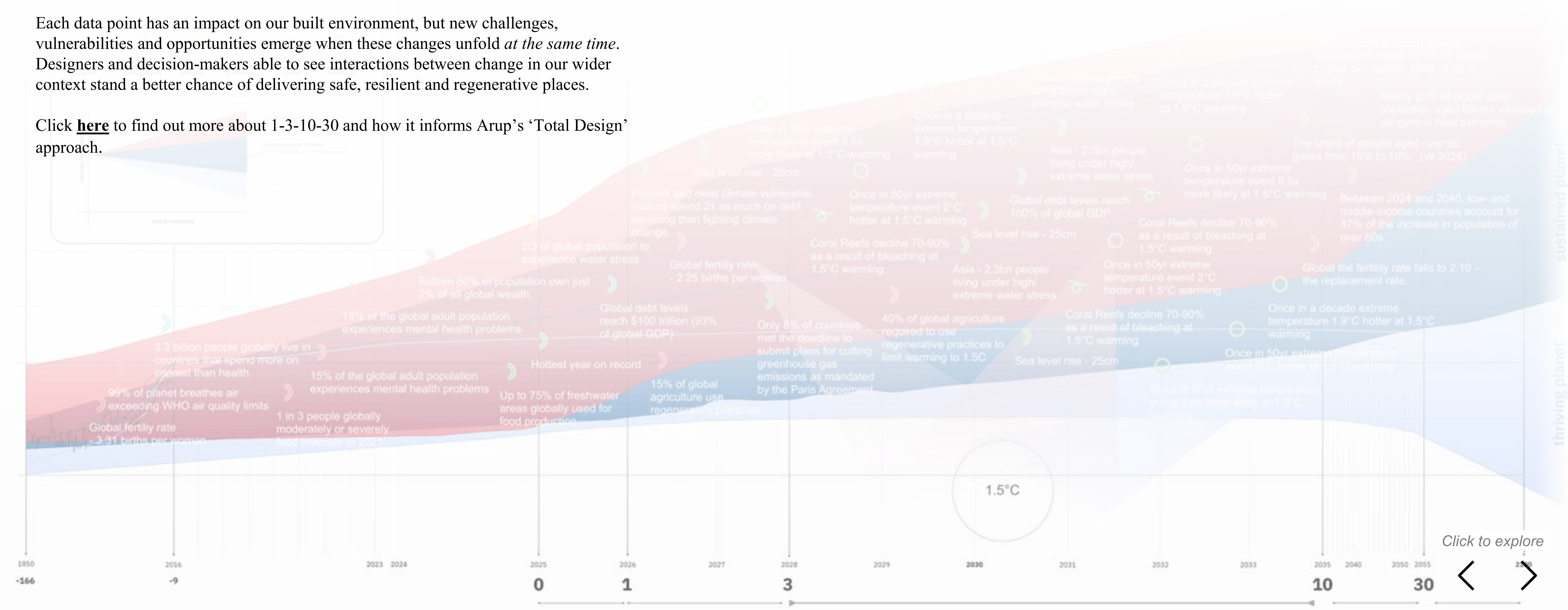
In a future of Mass Vulnerabilities, what changes should we prepare for?

Horizon Scanning explores projections: future events and tipping points, as well as historic trends. Here, we map select data points – from climate risk to socioeconomic milestones – across 1, 3, 10 and 30-year horizons.

Each data point has an impact on our built environment, but new challenges, vulnerabilities and opportunities emerge when these changes unfold *at the same time*. Designers and decision-makers able to see interactions between change in our wider context stand a better chance of delivering safe, resilient and regenerative places.

Click **here** to find out more about 1-3-10-30 and how it informs Arup's 'Total Design' approach.



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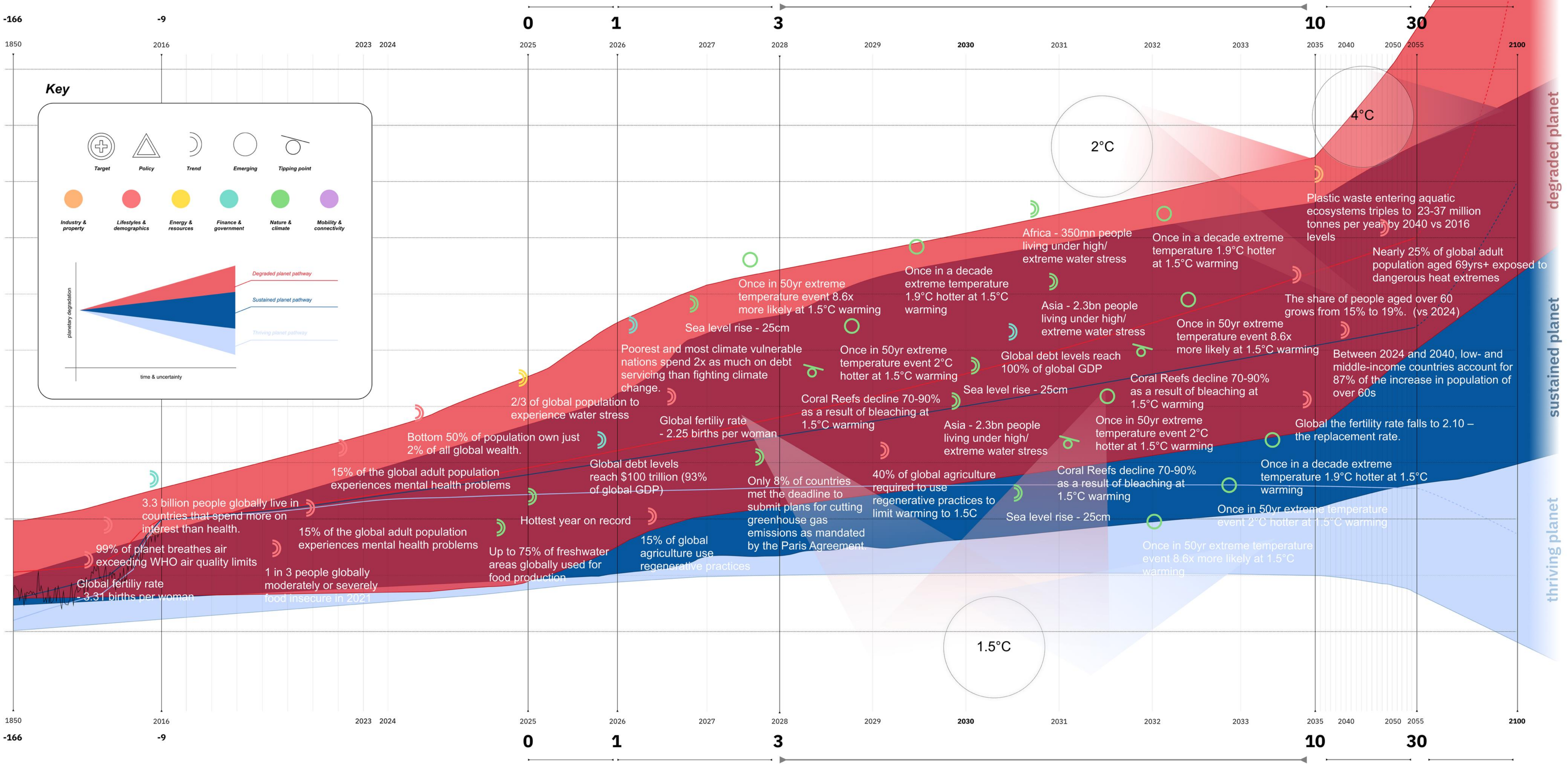
Zoom to explore



Impacts

The new normal of extreme weather

From roads and railways to energy grids, the underlying systems that enable the world to function are more frequently being exposed to heat, wildfires, storms or floods, exceeding the regional norms (e.g. unprecedented rainfall and flooding in Libya (21)) and eating into design and safety margins. Additionally, areas that are suitable for inhabitation, and the ecosystems that support them, will be concentrated in increasingly smaller areas due to desertification. Paired with an increasing growth in urbanisation, this requires a rethinking of how urban ecosystems are designed.

These challenges will manifest differently across global regions and tackling them requires tailored responses. For instance, the depletion of groundwater supplies is leading to increased land subsidence in Jakarta – often described as one of the fastest sinking cities on Earth – with recent data showing some parts of the city have sunk by over 4cm since 2018 and that over 40% of the urban area now lies below sea level (22, 23). The city often floods, which is also a challenge presented elsewhere. Bangkok is likely to be hit by serious flooding roughly once per decade, and some predictions see the city mostly underwater by 2100 (24). Beyond flooding, Sydney's 2019–20 'Black Summer' wildfires blanketed the city in smoke for weeks, straining health systems and infrastructure (25). Meanwhile, Japan has one of the most advanced water supply systems and overall use has declined since its 1990s peak, yet longer dry spells are raising drought risk even as heavy rainfall events grow more frequent (26). Elsewhere, Venice has sought to defend against rising seas with the MOSE flood barriers, installed in 2020. While currently effective at mitigating high tides, they have also altered water flows and sediment balance, contributing to increased heat stress in the lagoon (27, 28).

Call to Action:
Click here to view our 'Regenerative Design' report

Actions and opportunity spaces

Improve resilience through regenerative design

Regenerative design seeks to create nature-led systems that are integrated and resilient, enabling humans and nature to mutually co-evolve and thrive over time. The objective of this ecosystems-based approach in the built environment is not to recreate the pre-development ecosystem but to understand how infrastructure, buildings, and spaces can perform the functions that those earlier ecosystems provided. Just as each organism within an ecosystem has a role to play, each human-made component within a built system should give to, and receive from, its neighbours and participate in nature's cycles (e.g. water, carbon, nutrients) in a way that reinforces rather than damages (29). This approach echoes principles long embedded in many Indigenous and traditional knowledge systems, which emphasise reciprocity, renewal, and respect for natural cycles. Regenerative design can, for example, mitigate floods and droughts through restored wetlands (as seen in Australia's floodplain restoration projects (30)), reduce urban heat with integrated green-blue networks (31), improve water security through buildings and landscapes that capture and recycle water (32), and enhance wildfire resilience by restoring landscapes with fire-adapted species and diverse regeneration strategies that sustain ecosystems under more frequent and severe fires (33).

Regenerative design goes beyond 'sustainable' or 'restorative' design. It does not stop at minimising harm or repairing damage, but rather seeks to cause active, positive change (34). In future-proofing existing assets, integrating net-positive design into retrofits supports a shift from a mechanistic worldview, focussed on isolated components and efficiency, to a regenerative model rooted in whole-systems thinking, where buildings contribute to ecological and community vitality (35).

2bn

Around the world an estimated 5% of land, equivalent to 6.3 million square kilometres, is sinking significantly, affecting nearly 2 billion people (36).

70%

If limited action is taken, 70% of the global population can expect strong and rapid changes in extreme temperatures and rainfall in the next 20 years (37).

$855bn

Mangrove forests have been shown to provide US $855 billion in flood protection services worldwide (38). In 1-in-100-year storms, they reduce flood depths by 15–20% on average and over 70% in some areas (39).

Impacts

Resource constraints intensify conflict across systems

In recent years, there has been an acceleration in the drive towards resource sovereignty and resilience. This is a response to material scarcity and the mass depletion of materials, such as rare earth minerals (40) or sand (41), and it marks a desire to cut geopolitical risk from supply chains. Consequently, new or existing geopolitical tensions rise and collaboration dwindles.

Additionally, the extraction of metals that are critical to the energy transition occurs at vast scales, and often in ecologically vulnerable, biodiverse zones (42) and on sacred lands of Indigenous peoples (43). The biodiversity of old-growth forests, which are crucial climate regulators and often removed to access resources, tends not to recover on human timescales. For instance, once abundant in the UK, temperate rainforests now cover less than 1% of England's land area (44). Brazil's Atlantic Forest may take millennia to regenerate (45). Such ecosystems should be treated as precious non-renewables.

These challenges will cause shortages of key materials, forcing us to rethink their use in construction and to innovate in this space more radically, with a focus on viable circular economies.

Actions and opportunity spaces

Invest in bioengineering and biomaterials

Converging biological and information technologies can improve health, transform food value chains, and create innovative products and services. As part of a broader shift towards rapidly renewable resources (regenerating in years rather than decades), these approaches harness the regenerative capacities of organisms to reduce dependency on finite and extractive materials.

Organisms such as algae have biological properties that enable them to adapt to nutrient starvation, heavy metals, temperature stresses, and desiccation (46). Algae also enable the biomanufacture of sustainable alternatives such as bioplastics, biofertilisers, and biofuels, with recent trials showing promise for scalable, low-emission production (47). Unlocking algal biodiversity expands renewable resources and supports their integration into a circular economy that aligns with environmental restoration goals.

Similarly, fungal biomaterials are increasingly popular in the fields of architecture and design (48). Their adoption in the built environment requires new methods of design, planning, and construction that account for material properties across the entire building lifecycle. These biomaterials must exhibit precisely controlled traits such as load-bearing capacity and diffusion characteristics (49). Meeting regulatory standards, particularly for fire safety, remains a key challenge.

These emerging approaches sit within a broader spectrum of solutions for resilience and sustainability, ranging from advanced biotechnologies, which must be carefully managed to avoid over-extraction and intensive farming, to low-tech interventions such as swales and rammed earth that mitigate extreme weather risks. Together, they expand renewable resources, offering a diverse and adaptable toolkit for resilience within planetary limits.

81%

81% of CEOs and COOs from large organisations across the US and Europe now plan to reshore or near-shore supply chains, up from 63 % in 2022 (50).

$58tn

More than 55% of global GDP – equivalent to about US $58 trillion – is moderately or highly dependent on nature (51).

25–30Mt

Bio-based polymers are projected to reach 25-30 million tonnes annually by 2035 (up to 5% of global production), growing over five times faster than conventional plastics (52).

Impacts

Fragile food and water systems

Expanding agriculture has been the main cause of destroying the world's wildlands, with severe consequences for biodiversity and climate regulation. In what could be a positive development, the world has reached a historic moment as we have passed 'peak agricultural land' (53): while the amount of food we produce is increasing, the amount of land required to do so is not. This is driven in part by a decline in global pastureland for livestock, even as meat consumption is predicted to increase (53, 54). However, with global cropland use yet to peak (53), agriculture continues to exert substantial pressure on ecosystems.

Soil is one of the most neglected natural resources: like old-growth forests, it is effectively non-renewable. It can take up to 1,000 years to form just 1 cm of topsoil under natural conditions (55). A global study found that more than 90% of the conventionally farmed soils were thinning, with 16% at lifespans less than 100 years (56).

At the same time, our food systems face growing pressures from climate instability and mounting water stress. Global yields of major staple crops (e.g., maize and wheat) could decline by roughly 7% to 23% by the late century (2069–2099) under the most severe emission scenario and without adaptation (57), while water scarcity and pollution are already undermining productivity in many regions. One-quarter of the world's crops occurs in areas with either highly stressed or highly fluctuating water supplies (58). Agriculture accounts for 70% of global freshwater withdrawals (59), much of it used inefficiently, leading to depleted aquifers and degraded ecosystems. These water challenges compound the threat of soil loss, making integrated management of land and water essential to maintaining long-term food security and environmental resilience (60).

Actions and opportunity spaces

Protect and enhance nutrient flows

The built environment sector faces a unique challenge to build food resilience across regions worldwide. We will need to rethink agriculture by safeguarding and prioritising community land management and local stewardship, providing space for local farms, community gardens, and domestic settings to play a pivotal role in supplying produce. Going further, we must tap into local, traditional ecological knowledge (lo-TEK) (61). Valuing and integrating Indigenous practices as well as existing local knowledge will help build regional responses to climate issues.

Agri-biotech is the other important development. It is a crucial tool as we aim to transform global food systems to meet the UN's goal of zero hunger by 2030 (62). Creating suitable infrastructure and spaces for agri-biotech integration, such as vertical farming, will require an integrative nexus approach that recognises the interconnectedness of food, water and land systems. This must be underpinned by viable digital innovation ecosystems: collaborative environments where technologies are developed, tested, and scaled by networks of researchers, businesses, and communities. Countries such as Singapore, which aims to produce 30% of its nutritional needs locally by 2030, include vertical farming as a central component (63).

Finally, achieving sustainable consumption will require carefully planned and controlled supply chains that empower consumers to make informed decisions. Consumers will have to become an active part of a circular food system, prepared for seasonal changes and able to return elements into the stream – eliminating waste (64).

75bn t

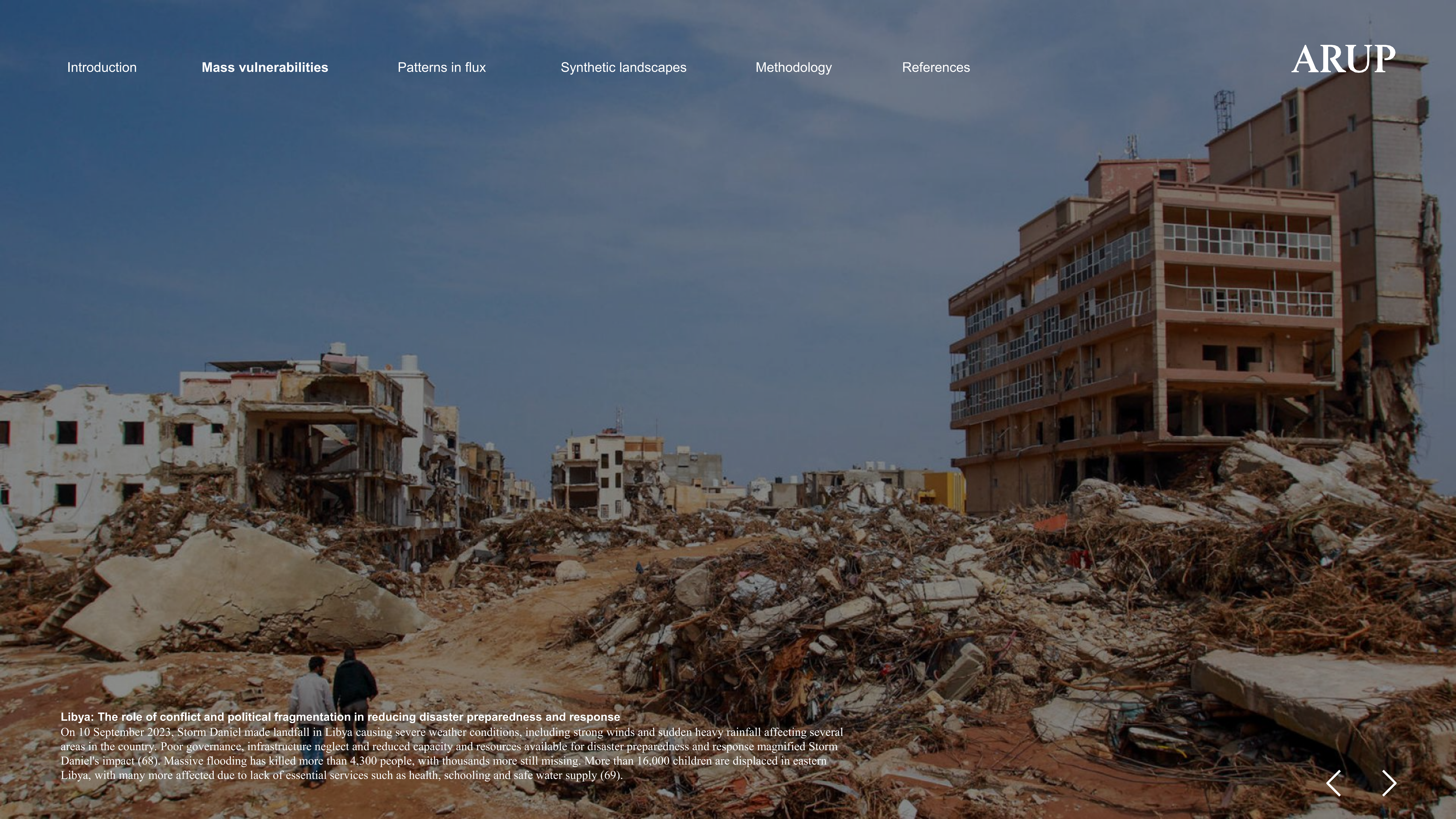
Without action, soil erosion alone may eliminate 10% of crop production by 2050, removing 75 billion tonnes of soil (65).

24%

Nearly 24% of freshwater-dependent animal species face a high risk of extinction, threatening fragile ecosystems and their nutrient cycles (66).

300bn t

Indigenous Peoples and local communities in tropical and subtropical forests safeguard nearly 300 billion metric tonnes of forest carbon, yet only 3 countries explicitly recognise their carbon rights on owned lands and 3 others link those rights to land tenure (67).



Libya: The role of conflict and political fragmentation in reducing disaster preparedness and response

On 10 September 2023, Storm Daniel made landfall in Libya causing severe weather conditions, including strong winds and sudden heavy rainfall affecting several areas in the country. Poor governance, infrastructure neglect and reduced capacity and resources available for disaster preparedness and response magnified Storm Daniel's impact (68). Massive flooding has killed more than 4,300 people, with thousands more still missing. More than 16,000 children are displaced in eastern Libya, with many more affected due to lack of essential services such as health, schooling and safe water supply (69).

Exemplar projects

Maximising co-benefits for people and planet

In response to the climate and biodiversity crises, industry and government are setting ambitious goals and funding restoration projects. The key challenge is to ensure these investments not only meet targets but also maximise benefits for biodiversity and communities, using local knowledge and resources to create resilient ecosystems that support diverse life forms and improve the quality of life for future generations.

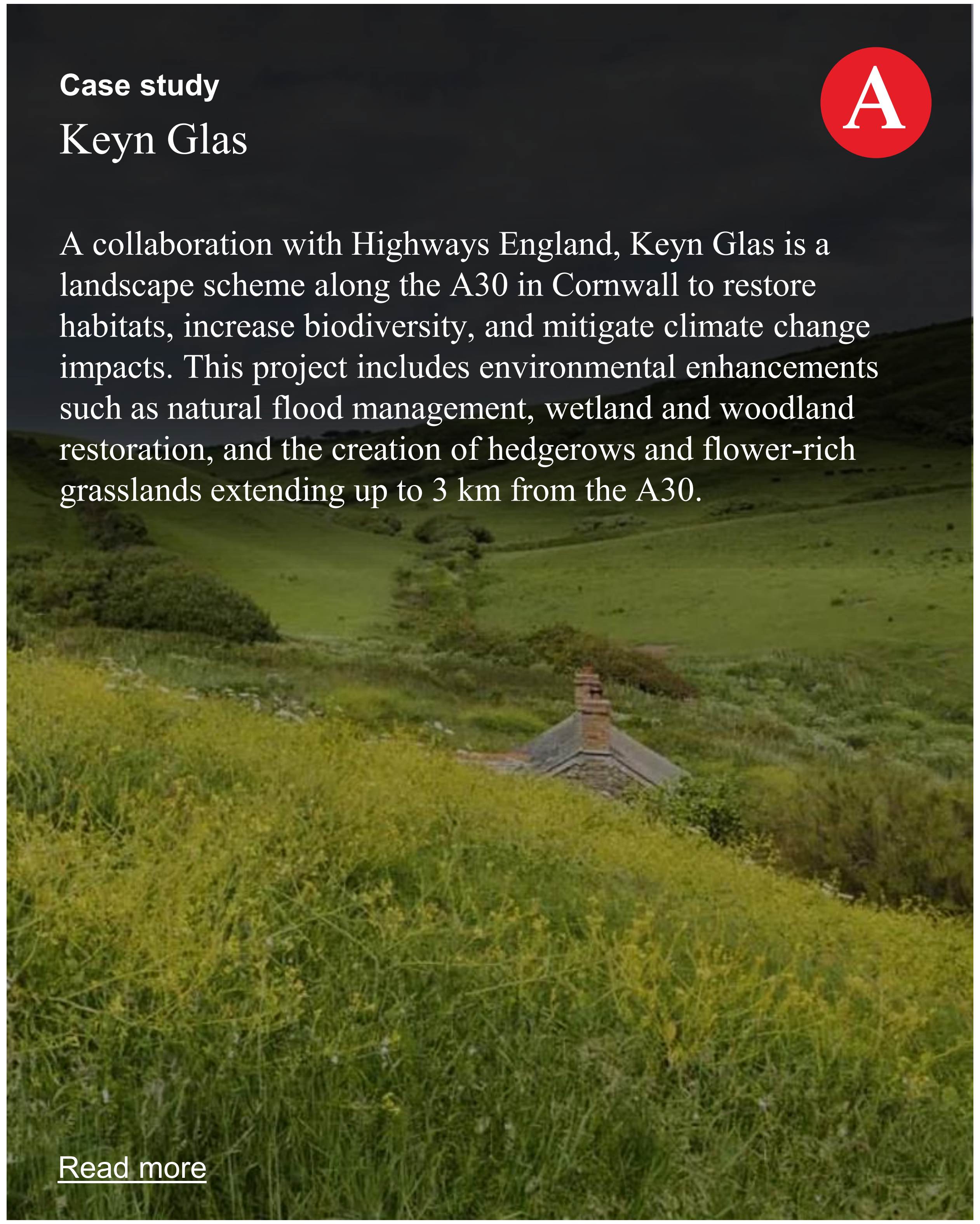
In Ukraine, where the war has severely damaged agricultural production and the infrastructure it relies on, there is now a significant effort to restore safe and productive agriculture (70). This begins with mapping farmland to document hazards and contamination, and to prioritise land for production. Cutting-edge earth observation and satellite data are being used to map agricultural farmland and support farmers, with the overall aim of restoring productivity and remediating the land. Similarly, the Keyn Glas project enhances the environment around the A30 in the UK by creating wildlife corridors, restoring wetlands and planting hedgerows. This has resulted in a 250% net gain in biodiversity and absorption of 10 tonnes of CO_2 annually. By engaging local landowners and working with Cornwall Wildlife Trust, the project fosters community stewardship and integrates effectively with agricultural practices, ensuring long-term ecological and cultural benefits (71).

Case study

Study Farms application in Ukraine

This application begins the mapping of farmland to document hazards and contamination, and prioritise land for production and remediation, thereby helping Ukrainian farmers produce food safely, efficiently, and more sustainably.

Read more



Case study

Keyn Glas

A collaboration with Highways England, Keyn Glas is a landscape scheme along the A30 in Cornwall to restore habitats, increase biodiversity, and mitigate climate change impacts. This project includes environmental enhancements such as natural flood management, wetland and woodland restoration, and the creation of hedgerows and flower-rich grasslands extending up to 3 km from the A30.

Read more

Patterns in flux

Migration, whether enforced or by choice, creates system vulnerabilities – and opportunities to better serve displaced and dense populations

Life on Earth has never stood still, but the nature and direction of movement are shifting. While public discourse often frames migration as unprecedented, evidence shows that the proportion of people living outside their country of birth has remained relatively stable for decades, at around 3 % of the global population (72). In 2020, this equated to about 281 million people (73), including 108 million classified as forcibly displaced (74). What is changing is where, how, and why people move.

Seeking resources and suitable climates – or to evade threats – humans and other species alike will be on the move. The actions we take today as built environment practitioners can support effective adaptation to these emerging 'patterns in flux'.

Most human migration occurs within countries or regions rather than across continents, with internal migrants making up an estimated 80 % of all movement worldwide (72). Those who move farther tend to be younger and of working age, contributing to host economies through employment and entrepreneurship while generally requiring less public support (75). In the United States, they are disproportionately represented among business founders, with 55 % of privately held "unicorn" companies valued at over $1 billion founded or co-founded by immigrants (76).

Developed countries face growing labour shortages and represent a large share of the two-thirds of the global population whose fertility rates are below the replacement level of 2.1 children per family (77). While migration cannot counter ageing or low fertility, it could help ease their effects.

While fertility rates remain the main driver of population decline, countries with more restrictive migration policies, such as China, Japan, and Italy, are projected to shrink more rapidly, whereas those with sustained immigration, including the United States and the United Kingdom, may experience slower decline (72). China's population, for example, is projected to fall from 1.4 billion today to about 633 million by 2100, with its working-age share dropping from roughly 59 % to 36 %, raising concerns over long-term labour shortages (78, 79).

In developing economies, where populations and the rate of urbanisation are still growing, migration is more likely to be internal, from rural to urban settings, either voluntary or forced (72). The challenge is that population growth often outpaces the ability of cities to provide essential infrastructure and services such as housing, transport, health and security services, resulting in informal settlements. In Africa, over 60% of the urban population lives in informal settlements (80) – up from about 46% in the late 2000s (81).

Urban growth alongside climate change will be key drivers in the movement of flora and fauna, too. Already, half of all species experiencing minimal land use change have shifted their ranges, with 80–90% moving as expected (poleward and upward). Meanwhile, two thirds of all species have begun shifting the timing of spring events due to warming winters and springs (82).

As species move and habitats shift, growing contact between humans and animals is increasing the risk of future pandemics. Approximately, 60% of emerging human pathogens and around 75% of all emerging infectious diseases are categorised as zoonotic (83).

While much of human activity has impacted negatively on nature and biodiversity, some species are adapting to urban environments. Peregrine falcons are thriving in cities like New York, London, Cape Town, and Delhi, where tall buildings mimic the cliffs and canyons of their natural hunting grounds (84). The warmth and the abundance of food and nutrients in urban areas is drawing in animals such as foxes and coyotes and is beginning to drive evolutionary adaptation. Urban foxes have been observed developing shorter snouts and enlarged nasal regions, adaptations that enhance their ability to sniff through bins full of decaying food, as they no longer need to hunt voles, mice and rabbits of their rural settings (84).

Physical infrastructure and urban systems will need to evolve drastically to meet the requirements of life on the move.

"Life on Earth has never stood still, but the nature and direction of movement are shifting."

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In a future of Patterns in Flux, what changes should we prepare for?

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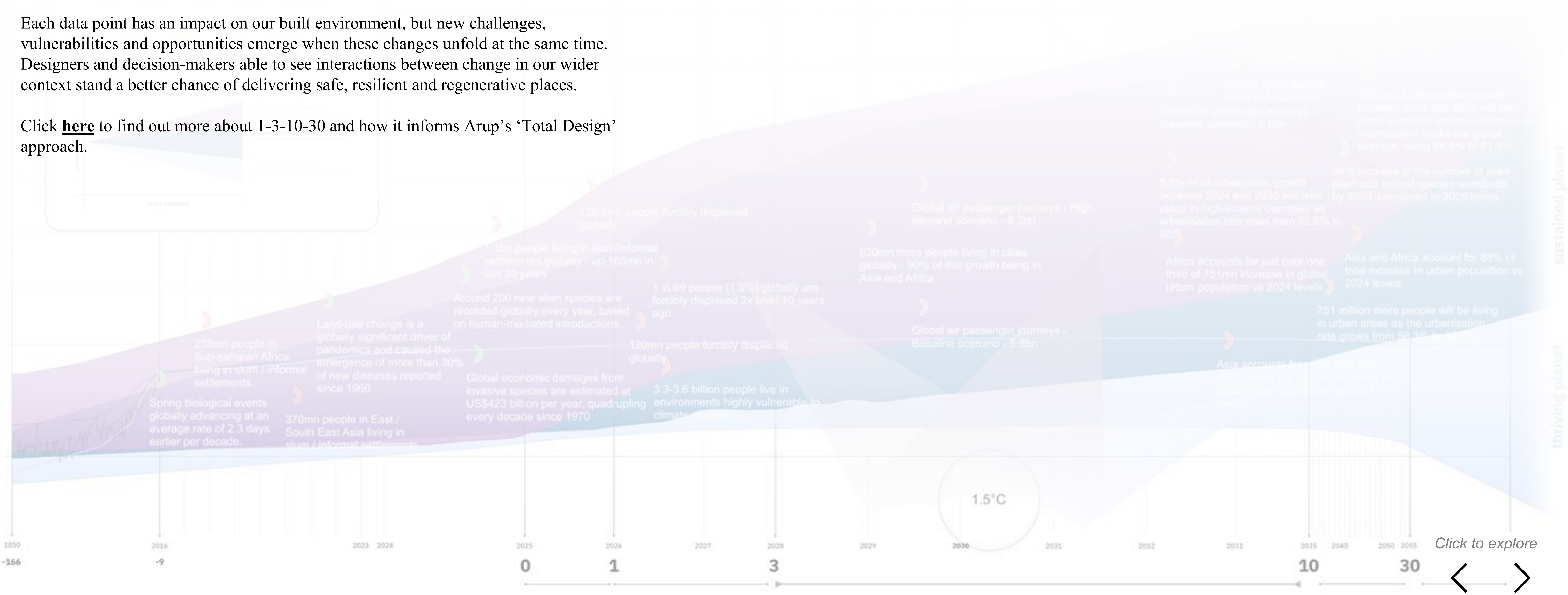

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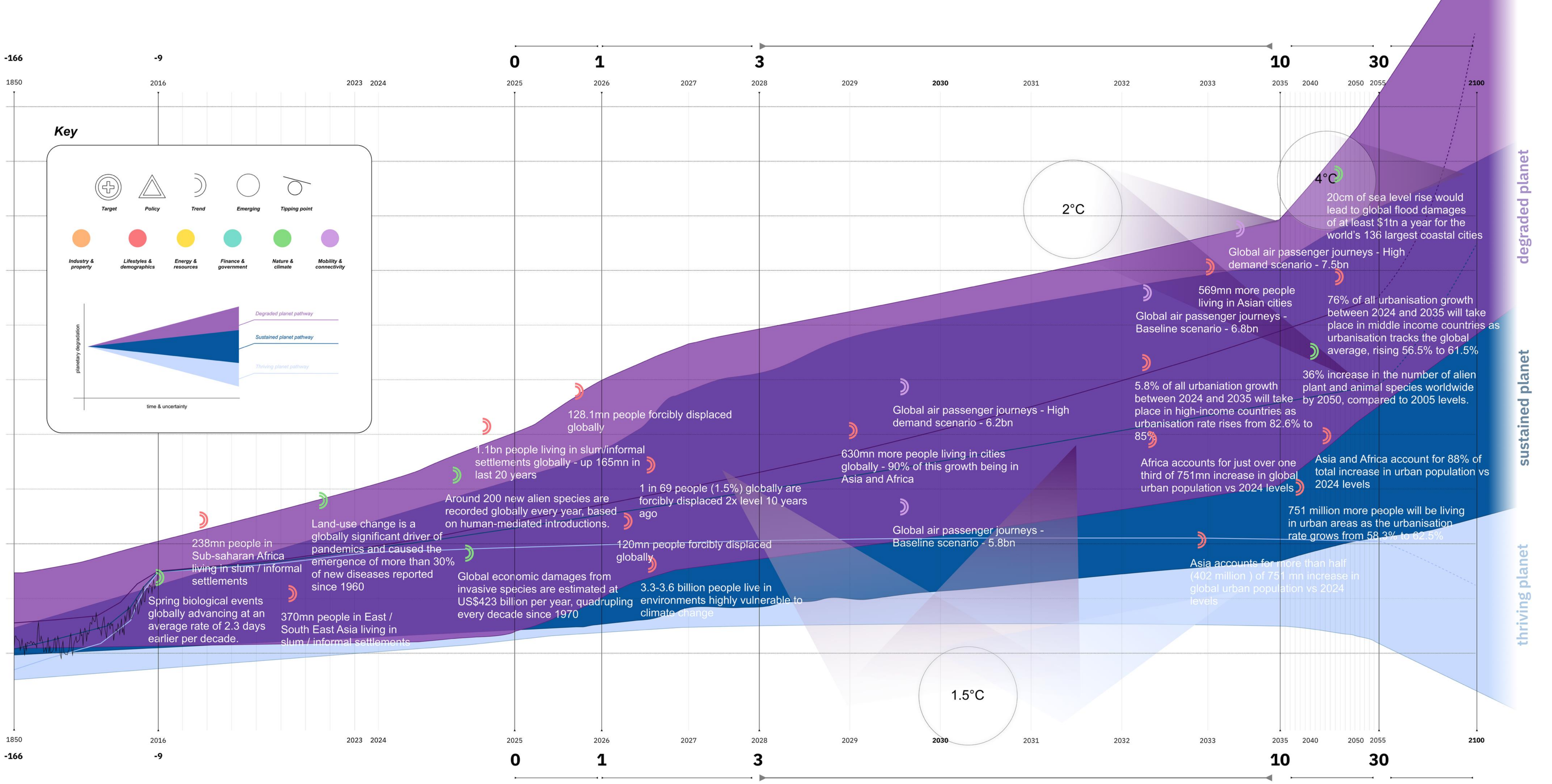


Impacts

Urban systems undergo intense stress tests

We will be living across fewer settlements, causing the populations of urban regions to swell, sometimes uncontrollably. Density will increase. In areas with the resources to plan for rapid growth, whole new cities and infrastructure are being proposed. Giga projects such as NEOM in Saudi Arabia, Nusantara in Indonesia, and Forest City in Malaysia aim to absorb or relocate populations, although these developments raise complex questions around equity, ecology, and long-term viability (85-89). In regions that are less equipped, growth will be unplanned and unstructured, hard to regulate, support or maintain.

By 2100, the Lagos–Abidjan stretch of coastal West Africa is projected to be the largest continuous zone of dense habitation on Earth, with a population approaching half a billion people (90). Worldwide, a billion people live in informal settlements, and this is forecast to double in the next decade. These settlements are often situated in political conflict zones and eco-sensitive environments. They often lack basic infrastructure to support health and wellbeing (91). Overcrowding, rapidly constructed infrastructure solutions, exponential energy requirements, and waste creation will expose vulnerabilities and push systems to their limit or collapse. These are direct challenges for the built environment sector.

Action and opportunity space

Co-invest in infrastructure and climate finance

Patterns in flux is a shared challenge where drivers in one country can have regional and global impacts. A lack of coordination and partnerships results in unplanned and increased levels of migration. Building cross-tier and cross-silo partnerships and networks between cities will be essential (92). Investing in infrastructure in other countries will help to mitigate the impacts, as 67% of refugees are hosted in neighbouring countries (93).

Tapping into various forms of climate finance including blended approaches (e.g. the Natural Capital Financing Facility (NCFF) (94) and The Land Degradation Neutrality (LDN) Fund (95)) will help to mitigate financial risk while supporting the delivery of biodiversity and climate adaptation.

Increasing the use of democratic or 'bottom-up' approaches can restructure relationships between citizens and the organisations that operate within, and govern, the urban environment. This includes approaches to financial plans, such as participatory budgeting (PB), which can be used to involve migrant communities in decision-making processes and can lead to increased ownership and measurable improvements in quality of life (96).

70%

By 2050, an estimated 2.5bn extra people are expected to be living in cities as global urbanisation reaches 70% (97), with India, China and Nigeria accounting for 37% of the projected growth (98).

2.4bn

The global urban population facing water scarcity is projected to rise from 933 million in 2016 to between 1.7 and 2.4 billion by 2050 (99).

$4.1tn

Current investments in nature-based solutions amount to $133 billion, 30 times less than the $4.1 trillion required to meet the climate change, biodiversity, and land degradation targets (100).

Impacts

Human and more-than-human co-habitation challenges

Many mammals, birds, fish, and insects undertake annual migrations to breed or seek food. As climate change alters ecosystems, these movement and breeding patterns are increasingly disrupted, leading some ecological networks to break down while others evolve (101).

For humans, a decreasing and ageing population in numerous countries is likely to create new opportunities for migration between nations. Countries with declining and ageing populations often have both the capacity and economic need to integrate migrants, as foreign workers and refugees help sustain labour markets and economic activity. Yet global labour supplies are tightening even as demand for migrant workers continues to grow (102). Meanwhile, other nations on a path of rapid development and population growth, struggling to provide the necessary infrastructure for their existing populations, may be more reluctant to accommodate new arrivals (103).

Across both human and more-than-human systems, the ability to adapt to changing patterns of movement will determine the resilience of future habitats. Being able to quickly integrate such settlements and to enable peaceful and equitable cohabitations presents a key challenge for all facets of the built environment. Too slow a response is likely to exacerbate social, health and economic inequalities.

Action and opportunity space

Re-establish and support polycentric urban districts

Urban planning models such as hyper-localised and polycentric cities will support the creation of high-density, interconnected areas that promote social inclusion and community resilience, helping to integrate diverse populations. These concepts prioritise walkability, enhance social resilience and build a sense of local community via neighbourhood hubs. Residents can easily access all key amenities such as employment, retail, schools and green areas (104). When these models are integrated into urban and peri-urban masterplans that account for social impacts and are paired with genuine community and stakeholder participation, they can accelerate collaborative innovation and equitable development (105, 106). There are also environmental and ecological benefits, as denser and more populous cities to produce less waste per capita, are more energy efficient, and place less pressure on surrounding habitats (107).

Polycentrism could provide a template for formalising informal settlements in cities where rapid development means there is a lack of road and transport infrastructure. Innovative green proposals sympathetic to the local geographical context, such as the Medellín cable cars, can tackle marginalisation and carbon emissions while fostering inclusion (108).

1/3

Over 600 million people (9% of the global population) already live outside the climate niche that has historically supported human life. Under current policies, this could rise to one-third by 2100 (109).

60%

Invasive alien species have been the sole driver in 16% of documented global animal and plant extinctions, and a key contributor in 60% of cases, 90% of which occurred on islands (110).

30%

Investment in transit infrastructure generates 30% more jobs than building roads (111).

Impacts

Unliveable habitats and abandoned places

Climate change will destroy key habitat elements that are essential for survival. Some species will migrate and find a range of still-habitable environments, thus becoming invasive (112). Other species will become extinct as humans hunt them and destroy their habitats through pollution, changing land use for agriculture or development (113). These impacts will cause profound disruptions to the global ecosystem, affecting both vulnerable regions and wealthier nations. For example, a potential collapse of the Atlantic Meridional Overturning Circulation (AMOC) could alter weather patterns in the UK and Europe, leading to colder, wetter conditions and increased storm surges (114, 115). Such disruptions weaken natural barriers between species and increase the likelihood of the spread of animal-to-human viruses (116).

Many countries are averse to high levels of migration but reluctant to spend enough on adaptation strategies that boost resilience in the regions which are becoming ‘unliveable’ (117). The countries most vulnerable to climate change and the loss of natural biodiversity are, generally, the most burdened by debt (118) and, thus, the least able to invest in resilience. Africa, the continent most impacted by climate change, only receives 3% of global climate finance (119). This unique challenge requires the built environment sector to rethink how these so-called ‘unliveable’ (or liveable only for certain species) places and habitats are used, preserved and regenerated.

Action and opportunity space

Design multi-functional and adaptable infrastructure

Circular economy solutions such as adaptable structures, deconstructable and transportable physical infrastructure will help cities to react quickly to shifting demographic patterns and mitigate abortive construction (120). Frameworks and sustainable, modular parts that can be standardised, upgraded and removed as needed are essential to respond to pressures (121) such as the need to increase housing density quickly or, in the worst case, to relocate a city completely. This will improve the agility of urban areas to respond and reduce the financial burden of addressing population displacement.

Developments with long delivery timelines, such as transport networks, need to be planned and operational ahead of rising demand to prevent congestion and urban sprawl, especially where population movements may be rapid or unpredictable.

Designing multi-functional and adaptable infrastructure can also create shared habitats and corridors that benefit other species, strengthening biodiversity, restoring ecosystem services, and improving the overall resilience and liveability of urban systems (122).

At the same time, multi-use spaces can enhance human wellbeing and social inclusion. Existing infrastructure can be used in innovative and inclusive ways, as demonstrated by One Green Mile in Mumbai, India, where a series of neglected spaces below Mumbai’s Senapati Bapat Marg flyover were transformed into a series of public ‘rooms’ with diverse functions (123).

216m

Up to 216 million people could be displaced within their own countries by 2050 due to climate impacts, mainly driven by water stress, sea-level rise, and crop failure (124).

60%

Approximately 60% of Africa’s rapidly growing urban population live in informal settlements (125).

39%

Circular economy strategies could reduce virgin resource extraction by 28% and cut emissions by 39% (126).

Palm oil plantations in East Kalimantan, Indonesia: Pushing entire species from their homes

The Copernicus Sentinel-2 – a two-satellite mission used mostly to track changes in the way land is being used, as well as monitoring the health of vegetation – takes us over palm oil plantations in the Indonesian part of Borneo, East Kalimantan. To meet global demand, palm oil trees are grown on vast industrial plantations, leading to acres of rainforest being cut down. Indonesia is the largest producer of palm oil, followed by Malaysia. Together they account for 84% of the world's palm oil production. To produce palm oil in large enough quantities to meet growing demand, farmers clear large areas of tropical rainforest to make room for palm plantations. This leads to a loss of habitat for species such as the orangutan, declared as critically endangered by the WWF. (127)

Exemplar projects

Supporting resilience at origin and destination

Urbanisation is accelerating, while the quality of development is lagging behind. By 2030, 60% of the world's population are predicted to live in cities, yet living conditions remain uneven (128). Already, about 1 billion people live in slums or informal settlements, and an estimated 3 billion will require adequate and affordable housing by 2030 (129).

A fire in an informal settlement can affect thousands of people; however, this global safety problem remains neglected. Recovery from fire is exacerbated in informal settlements, where a lack of insurance, financial instability and insecure tenure are common. Communities that are resilient to fire can withstand, respond to and recover from severe fire incidents, thereby contributing to residents' broader wellbeing and long-term development. Achieving this requires action and investments throughout the disaster management cycle: mitigation, preparedness, response and recovery (130).

Fire is not the only growing risk. Approximately 2.4 billion people live with water shortages, owing to the increasingly arid climates of their cities and regions (131). As the future frequency of extreme weather events increases due to climate change, so will the number of people affected globally by water shortages. WaterUp actively engages with rural communities in drought-stricken areas to understand their needs, unique challenges and opportunities. By producing language-neutral, digital educational materials, WaterUp equips these communities with techniques to catalyse landscape restoration and livelihood improvement. This approach mitigates the impacts of drought at the source, thereby reducing the need for migration (132).

Case study

A Framework for Fire Safety in Informal Settlements

The Framework for Fire Safety in Informal Settlements has been developed to facilitate collaboration and alignment of global efforts to create safer and more resilient informal settlement communities.

Read more

Case study

Creating a universal language for community water management

WaterUp actively engages with rural communities in drought-stricken areas to understand their needs, unique challenges, and opportunities. It produces language-neutral, digital educational materials for communities, providing them with techniques to catalyse landscape restoration and livelihood improvement.

Read more

Synthetic landscapes

Entering the digital-human-nature continuum

In the built environment, 'synthetic' has traditionally meant an artificial replacement for a natural material or product. Profound changes in the digital realm are leading to an era of complete integration between the real world and its digital counterpart, creating a new 'synthetic landscape'.

The built environment is undergoing a shift, with synthetic layers influencing its design, function, and experience. An obvious artefact of our emerging synthetic landscape is the rapid growth of generative AI. Its use by experienced designers, architects and engineers could revolutionise the built environment and trigger a new wave of creativity in the industry. As a result, this could boost the development of digital and autonomous systems, replacing repetitive manual tasks with the aim of improving efficiency, speed, quality and performance (133).

Technologies like these are increasingly being applied at the urban level to optimise resource consumption across energy, transport, and building sectors. Creating digital replicas of reality will enable us to analyse and manipulate physical and social phenomena in real time (134). The use of such technologies may expand across various industries, though its widespread adoption will likely vary.

These systems could reduce the need for electricity grid investment by $1.8 trillion by 2050 through extending grid lifespans, minimising supply interruptions, and facilitating the integration of renewables (135). Industry projections also estimate that the digital twin market could reach nearly US $150 billion by 2030 (136).

“As data volumes grow, prediction, simulation and automated creativity are reshaping how we design, govern and inhabit the built environment.”

However, balancing the promise of technological advancement with its risks is increasingly critical. The European Commission reports that 80% of industrial data remains unused, prompting the EU Data Act to address legal and technical barriers (137). One study found that in machine-learning image datasets, around 10% of data may be redundant (138).

Automation, too, is progressing more slowly than expected. The World Economic Forum predicted that 47% of tasks would be automated by 2025, but that estimate has been revised to 42% by 2027 (139, 140).

Despite slower automation, digital engagement continues to surge, with 5.56 billion internet users and 5.24 billion social media users globally as of February 2025, expected to reach 6.46 billion by 2029 (141, 142). ChatGPT reached 100 million users in just two months – a milestone that took Facebook four and a half years and TikTok nine months (143).

A corollary to the explosion in data and the rise of generative AI is an unsettling of traditional information sources, with only 40% of people trusting the news and 83% viewing misinformation as a serious issue (144).

This surge in data comes at a significant environmental cost, putting a strain on our resources. Global data centre electricity use reached about 1.5% of global demand in 2024 and could more than double by 2030, while major operators report significant water use in regions of scarcity (145, 146).

In a world facing multiple crises, Silicon Valley’s utopian vision, rooted in the 1990s Californian Ideology that fuses libertarianism with techno-optimism, no longer resonates globally (147). The Techlash of the mid-to-late 2010s, driven by concerns over big tech’s unchecked power, privacy breaches, and lack of accountability, marked a shift in public perception (148). Although a few dominant firms still shape the digital landscape, momentum is moving towards decentralised, democratised systems that prioritise both people and planet. Regulatory pressure, shifting markets, and new entrants are challenging incumbents and redirecting investment towards decentralised data and sustainable technologies.

Data infrastructure is also fragmenting geopolitically. Initiatives such as Europe’s Galileo network, China’s DeepSeek AI, and renewed focus on data sovereignty in the United States reflect growing concern over local control and cross-border data flows (149). This fragmentation brings risks of uneven adoption and security gaps, but also opportunities for resilience, transparency, and innovation through tools such as encryption and secure multiparty computation.

The AI race is increasingly defined by geopolitical tensions, particularly the US-China trade conflict. While the CHIPS and Science Act allocates $280 billion to US semiconductor research, China’s projected dominance in lower-end chip production by 2030 challenges Western supply chain independence (150).

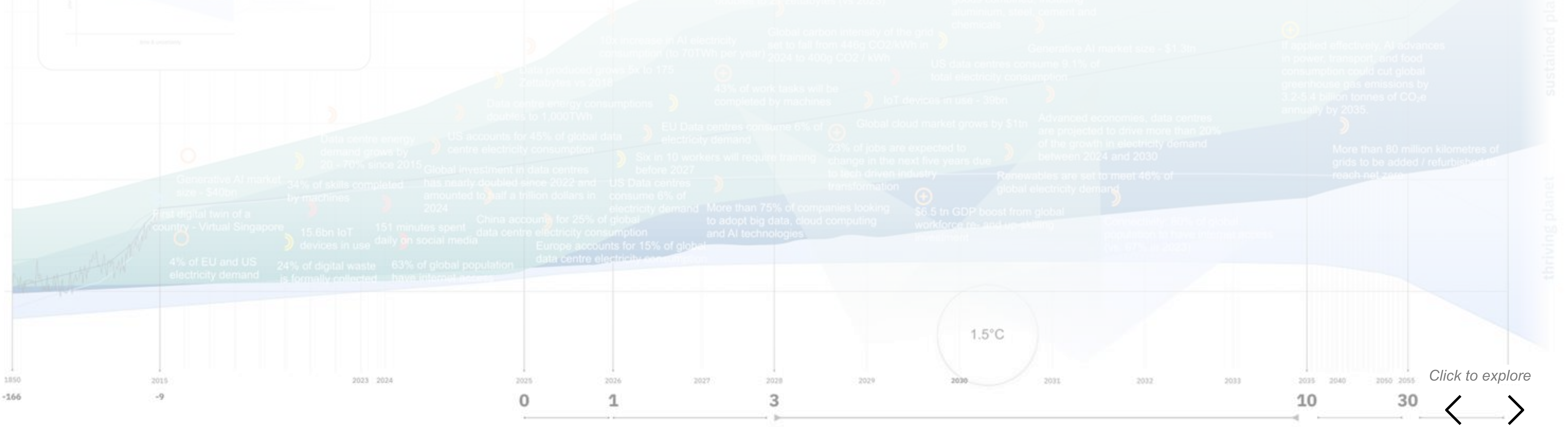
As data volumes grow, prediction, simulation, and automated creativity are reshaping how we design, govern, and inhabit the built environment.

In a future of Synthetic Landscapes, what changes should we prepare for?

Horizon Scanning explores projections: future events and tipping points, as well as historic trends. Here, we map select data points – from generative design to digital sovereignty – across 1, 3, 10 and 30-year horizons.

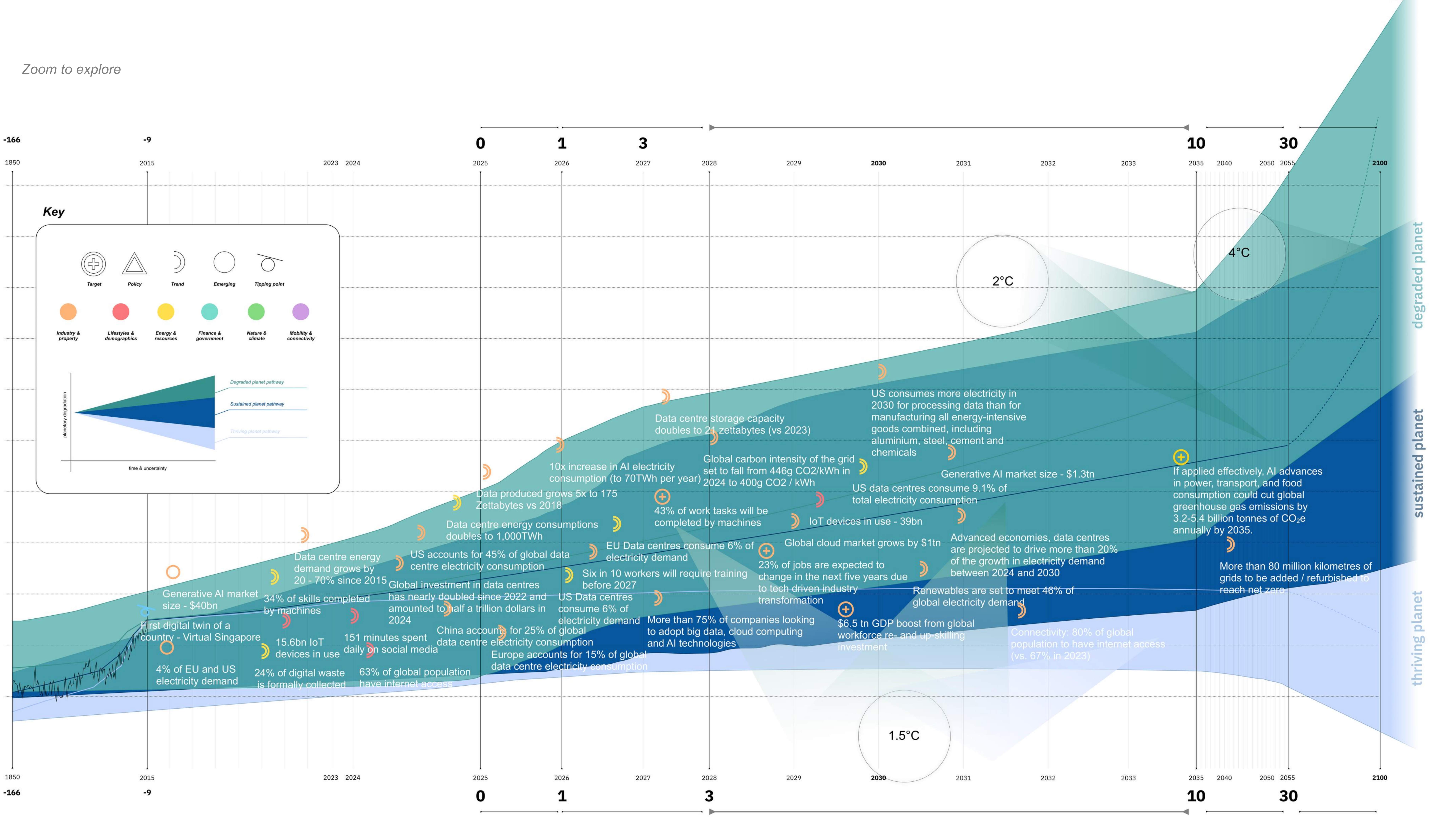
Each data point has an impact on our built environment, but new challenges, vulnerabilities and opportunities emerge when these changes unfold at the same time. Designers and decision-makers able to see interactions between change in our wider context stand a better chance of delivering safe, resilient and regenerative places.

Click **here** to find out more about 1-3-10-30 and how it informs Arup's 'Total Design' approach.



Click to explore

Zoom to explore



Impacts

Human x AI co-design and co-analysis

Unlike earlier technological shifts that displaced mostly manual labour, many of the jobs most exposed to AI are in the knowledge economy. The full scale of its impact remains uncertain, but one certainty is that the nature of work will change.

Collaboration between human expertise and AI could transform built-environment design, supporting climate resilience and regenerative approaches (151). This is especially critical in an era of destandardisation, as international standards fragment under geopolitical, climate impacts, and supply-chain pressures (152).

AI tools, including machine-learning systems, can rapidly analyse vast datasets, detecting patterns and correlations far faster and at a scale beyond human capability. This could be used to support decision-making in areas like defect identification (153); health and safety auditing (154); energy optimisation (155); integration of nature-based solutions into the existing built environment (156) and asset refurbishment (157). At scale, this is enabling large-scale geoscientific analysis (158), which could underpin future planetary-scale applications. Generative image tools will also reduce rendering workload, fostering industry creativity by freeing up designers to explore new boundaries.

The use of AI to support decision-making holds significant potential, but such tools and the data they are based upon, like humans, can be susceptible to biases (159). If neither accounted for, nor mitigated, these biases can make a problem such as discrimination and inequality worse, particularly in the built environment.

Call to Action:

Click here to view our 'Building Performance Reimagined' report, via CIBSE

Action and opportunity space

Prepare and plan for skills transformation

Built environment organisations will need to ensure that their businesses are appropriately positioned to utilise the virtual world. This will include preparing a pipeline of staff trained in machine learning tools such as 3D modelling, VR/AR development, digital twins, and sustainable data centres (160). Familiarity with decentralised platforms and blockchain-enabled systems may also be valuable where relevant. Attention to AI ethics, privacy, and security will be essential, particularly around bias in AI models and the emerging risks of shadow AI – the unsanctioned use of AI tools in organisations.

Upskilling must include senior staff, alongside training existing teams and hiring specialists from areas such as the gaming industry. AI (be it machine-learning or generative) and 4D digital twins provide new opportunities for automating design, planning, manufacturing, inspections, auditing, and management and the use of physical assets in the built environment. As certain technologies and materials, such as engineered timber, are difficult to standardise globally, skills will also be needed to apply AI in navigating local contexts (161). The Materials Project at Berkeley Lab, expanded through collaboration with Google DeepMind, is already advancing AI-driven approaches to materials discovery (162, 163).

Traditional engineering disciplines will need to be reimagined by not only expanding their technical scope but also integrating systems thinking, data science, and user-centred design as core competencies. Education in these areas should be established early to ensure a smooth transition. Companies may need to advocate for their inclusion in secondary and higher education curricula.

Traditionally, the use of most AI tools has been limited to those with coding backgrounds. However, as mass adoption of these technologies increases, design specialists will need to be involved too.

40%

40% of employers plan workforce reductions by 2030 due to skills becoming less relevant (164).

33%

Employers project that by 2030, work tasks will be evenly split between humans (33%), technology (34%), and human–technology collaboration (33%) (165).

15%

AI is projected to increase global economic output by up to 15% by 2035, adding approximately 1% to annual growth rates (166).

Impacts

A new era of digital twins

An era of complete integration between the real world and its digital counterpart is expected to be ushered in by the growth of edge computing and 6G wireless network adoption. Edge computing, a distributed framework that positions enterprise applications and data storage near IoT devices or local edge servers, promises to deliver processing power without relying solely on the cloud, while 6G enhances this with ultra-low latency and high bandwidth where cloud access is necessary (167, 168).

Digital twins, enabled by such technologies, will vastly improve the management of physical assets, thanks to real-time control and response. They will also enable the growth of autonomous energy systems, transportation infrastructure and self-driving vehicles (169). The ability to share vast quantities of data across different platforms and networks will have major impacts for smart energy usage, transportation planning, the movement of people, the control and monitoring of pollution, city governance and the planning of resources. This also provides designers and policymakers with realistic worlds where scenarios can be explored.

Existing siloed data will be consolidated into digital twins of entire landscapes, ecosystems and even countries (170). From the ability to monitor environmental health (171) to predicting the spread of wildfires (172) in real time, these digital twins will help to mitigate the impacts of climate change.

Such capabilities to optimise the consumption of resources, maintenance and planning must not overlook the importance of human beings and more-than-humans in the built environment. Cities thrive not because of their efficiency and optimal solutions, but thanks to their messiness, incoherence, opportunities and the serendipitous encounters made possible by the dense coexistence of many lives.

Action and opportunity space

Update regulation for the physical-digital continuum

Data sovereignty concerns are rising, including questions of who owns digital twin data and who is accountable when AI projects are outsourced (173). These issues sit alongside unresolved risks from generative AI and extended reality, such as offensive content, IP infringement, misappropriation, misinformation and inaccuracy (174).

In mobility, digital twins could model traffic flows using platforms such as Waze, LIDAR from autonomous vehicles, and fourth traffic light systems, but such applications require clear rules on data ownership, liability and accountability (175). In climate adaptation, digital twins could model where shade is required to counter urban heat – much like Medellín's "Green Corridors" have already reduced local temperatures by around 2 °C – helping to direct limited resources to greatest effect (176).

As with any new technology, rules and best practice will evolve. Organisations must be clear early on about how their projects may affect users' data, safety and privacy, and what the future legal ramifications could be, and how reliance on external platforms might create long-term dependencies. They should also anticipate misuse, such as the spread of misinformation, by engaging professionals in AI ethics or establishing advisory boards. Initial guides have appeared, such as the User Safety Standards by the Oasis Consortium (177).

These spaces also risk being monopolised by leading technology giants. The failure of Sidewalk Labs' Quayside project in Toronto highlighted the importance of local culture and privacy in tech-driven urban development (178, 179). By shaping regulation, the built environment sector can help cities balance technological advances with the organic, diverse and serendipitous nature of urban life.

Call to Action:
Click here to view our 'AI for Future Cities' series

90%

90% of data centre energy consumption in the UK is attributed to processors in standby mode, maintained in anticipation of demand surges (180).

$160bn

One severe outage per business per year costs the global economy an estimated $160 billion annually. Leading causes include congestion, cyberattacks, and software or configuration errors (181).

$280bn

Digital twins are projected to cut organisational costs by an average of 19% across industries (182), while urban deployments of digital twins could save cities $280 billion by 2030 (183).

Impacts

Political and economic dominance of tech owners

Technological development is increasingly concentrated amongst a smaller number of dominant firms, who control critical infrastructure, large-scale AI model development, and deployment at scale.

Just three companies dominate cloud services – Amazon, Microsoft, and Google – while NVIDIA leads in AI semiconductor design, TSMC in chip manufacturing, and ASML in the production of the machines needed for manufacturing (184). The manufacturing of AI chips is particularly vulnerable because nearly all AI chips and servers are produced in Taiwan, a country at growing risk from geopolitical tensions.

With the growth in AI and the awareness of the risks that such market concentration entails, governments have been pushing industrial technology strategies (such as the US CHIPS and Science Act (185)). These aim to diversify and bring closer to home the production of technologies that are critical to the future development of AI.

There was a surge of interest in decentralised web-based technologies between 2020 and 2022, commonly associated with the term Web3, that use blockchain systems such as cryptocurrencies and NFTs. Although interest has fluctuated since, the philosophy of decentralisation remains an active area of development and debate (186).

Examples of this include Indigenous communities globally creating data sovereignty frameworks to protect their cultural heritage (187); battery swapping EV scooter technology developed in Taiwan (188), and rural farmers in China adopting blockchain technology to prevent food safety fraud (189).

Call to Action:
Click here to view our 'Future of Making' publication

Action and opportunity space

Community-specific engagement with emerging digital technology

While technology, AI and digital twins concentrate on optimising metrics for performance and efficiency, it is essential to recognise that these innovations must be paired with a thorough understanding of local cultural knowledge, systems and social conditions. Organisations, governments and NGOs must invest time in grasping these regional factors to effectively implement and benefit from new and emerging digital technologies. In the built environment, AI-enabled simulations of crowd movement, climate shifts, migration patterns, and material flows open new opportunities to rapidly iterate designs and strengthen resilience planning when tailored to regional contexts (190). Digital tools that translate and visualise information can also widen participation, giving communities a more active role in planning (191).

In the US, legislators are proposing public cloud networks run by universities, research labs and scientific foundations to deploy AI for the public good (192). This reflects a broader shift toward digital public infrastructure (DPI) governed for public value rather than private gain (193). Elsewhere, participatory design efforts, such as urban data platforms in India and Brazil and Indigenous-led AI projects in Canada, show how digital technologies are shaped by local cultural, environmental and social priorities (194-196). Material passports and reuse platforms also offer locally grounded tools that enable circular practices and community-led resource use.

Digital technologies developed or adapted for specific communities must acknowledge and resist cultural bias. They should reflect the relationships between people, place and environment, and respect local concepts of data ownership and privacy (197, 198). Fundamentally, these tools must enhance – not exploit – the communities they serve. Even in synthetic or virtual contexts, human needs must remain central.

67%

Taiwan's TSMC controls around 67% of the global semiconductor foundry market, with its nearest competitor at 12% (199).

63%

In early 2025, Amazon, Google, and Microsoft held a combined 63% share of the cloud infrastructure services market. Amazon led with 30% (200).

$32

For every $1 invested in strengthening data systems in low- and middle-income countries, an average return of $32 has been observed, in areas like public health, education, and disaster response (201).

Google Earth: Designed to facilitate an endless construction of the earth

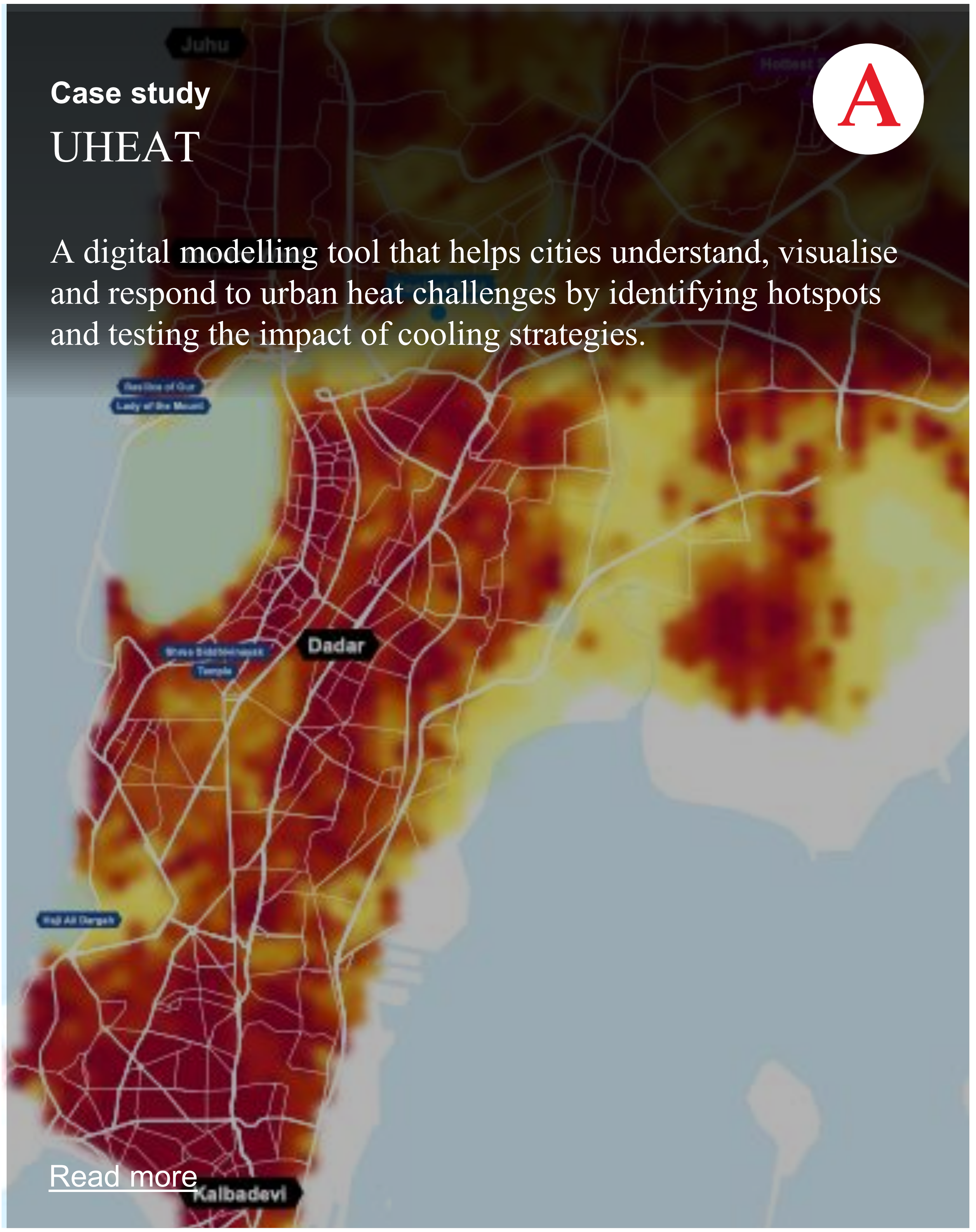
Modelling the world has involved biased choices that show none of the real imperfections of real life, as shown on the default images on Google Earth. These are not necessarily the most recent ones, but rather display what it regards as the best imagery for each location. These decisions are governed not by an essential demand for accuracy but for clarity: for a certain smoothness that makes the representation seem plausible as Earth’s replica. In earlier versions, there were rendering glitches and anomalies, which have now been smoothed by Google's Universal Texture mapping technology. (202)

Exemplar projects

Digital tools for resilience and co-design

Urban heat is one of the most rapidly intensifying threats facing cities, with some urban areas recording temperatures up to 7°C higher than their rural surroundings during heatwaves. Driven by climate change and dense urban development, the burden often falls most heavily on communities with the fewest resources to adapt. Arup’s UHeat platform uses high-resolution data and AI to generate detailed heat maps and simulations, helping planners pinpoint at-risk areas and explore a range of solutions including nature-based and passive measures. By translating complex climate data and urban processes into clear, actionable insights, UHeat supports more targeted, effective responses for cooler, healthier cities (203, 204).

Concurrently, given the scale of the climate challenges cities face, there is growing recognition of the value in involving a broader range of voices in shaping a more sustainable future. A crucial part of this engagement challenge is visualising and explaining what’s possible and desirable – and here, new technology has a valuable role to play. Arup has developed YARD, which offers a visually engaging and interactive experience, creating virtual models of possible project scenarios long before anything physical has begun. The tool aims to prompt deeper and broader conversations about the latent challenges that communities are facing and to bring people into the design briefing process, thus enabling co-creation (205).

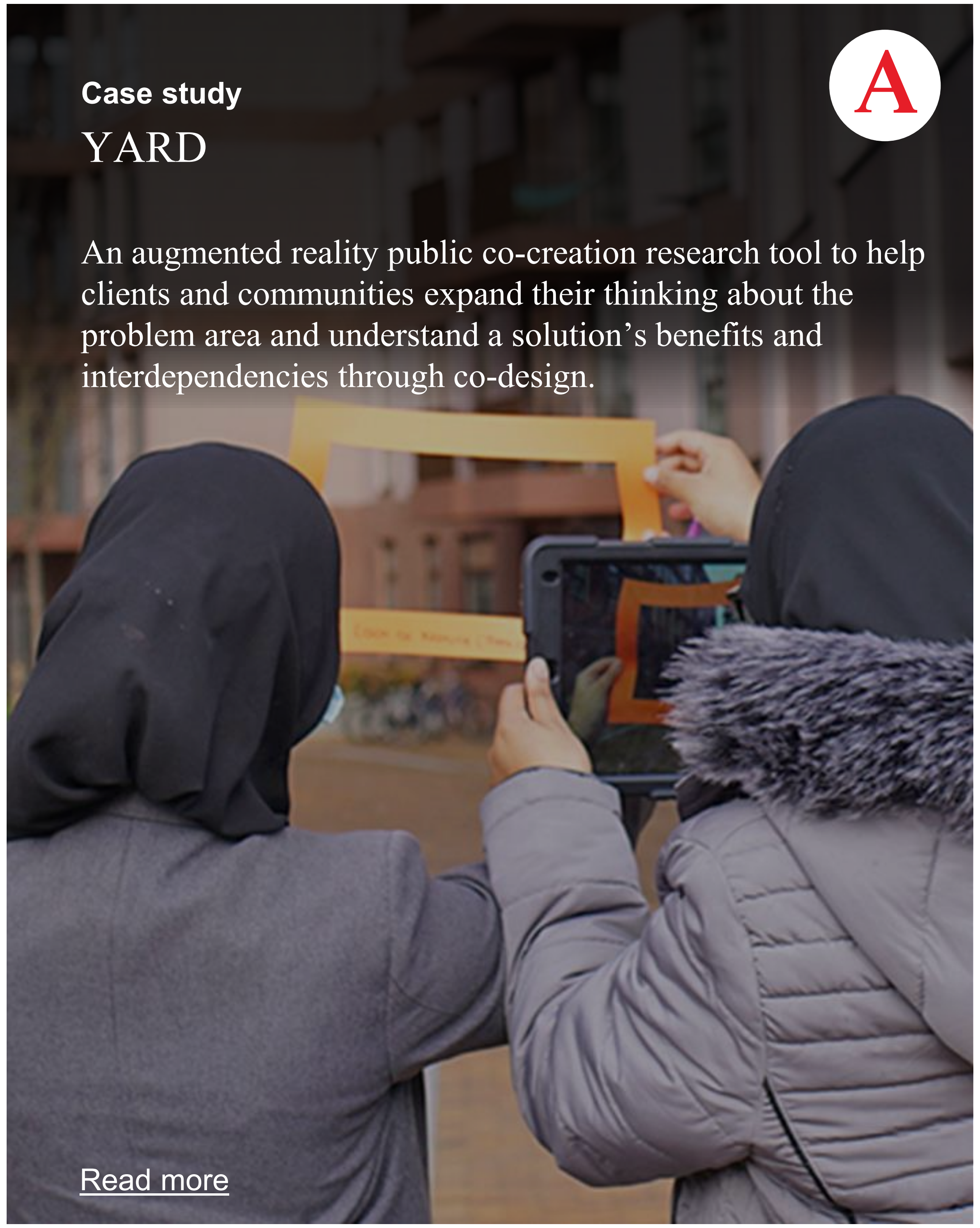


Case study

UHEAT

A digital modelling tool that helps cities understand, visualise and respond to urban heat challenges by identifying hotspots and testing the impact of cooling strategies.

Read more



Case study

YARD

An augmented reality public co-creation research tool to help clients and communities expand their thinking about the problem area and understand a solution’s benefits and interdependencies through co-design.

Read more

Methodology

A note on our methodology

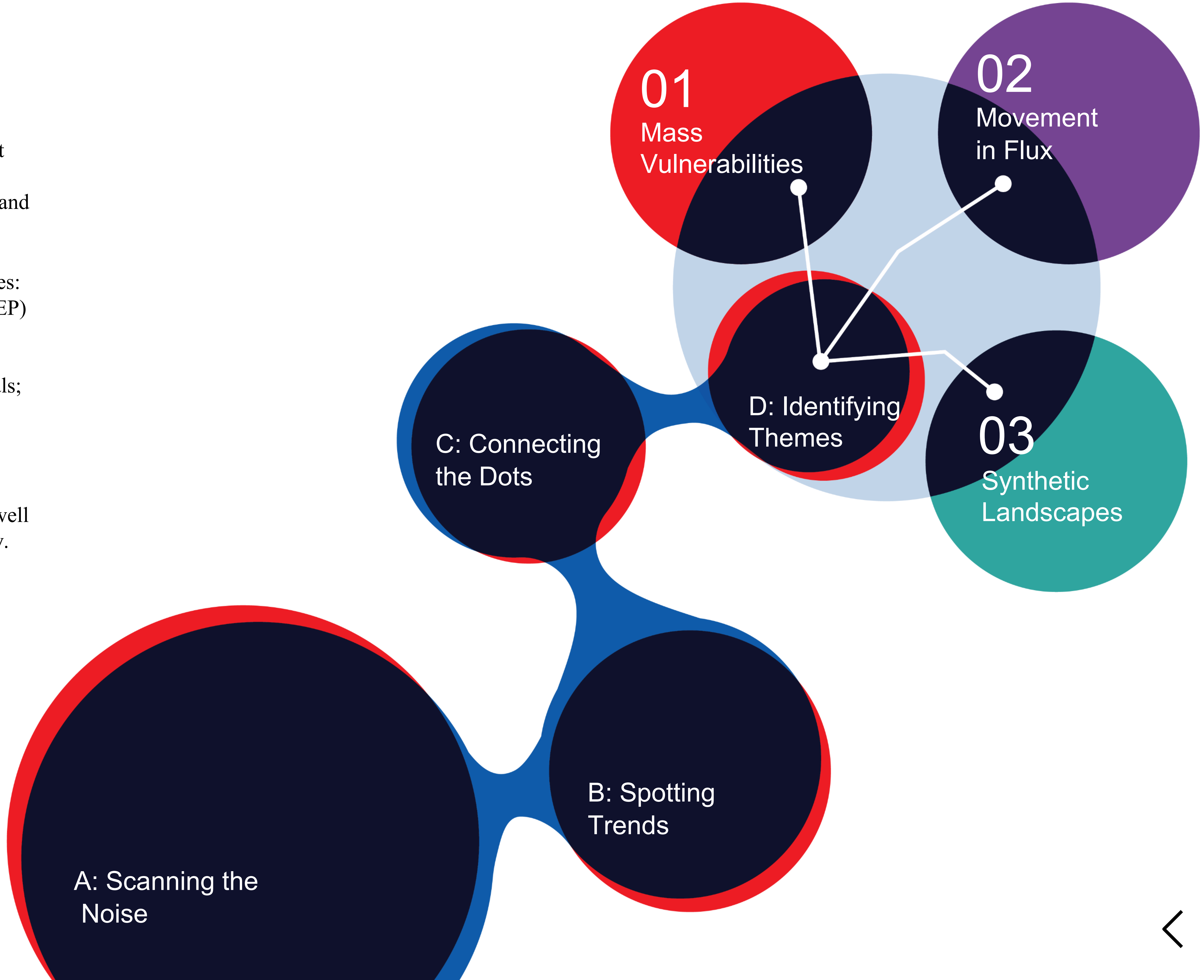
Horizon Scanning is a systematic approach to gathering intelligence about what is changing. From a wide scanning base featuring thousands of data sources, Arup's global Foresight team[1] spent a year analysing, validating and synthesising to arrive at three key dynamics.

1. Scanning via desk research and focus group sessions – from two angles:
- Top-down scan: We applied an established scanning taxonomy (STEEP) to identify an initial range of Social, Technological, Economic, Environmental and Politico-legal drivers of change in each region.
- Bottom-up scan: Foresight 'scouts' collected a long list of weak signals; that is, early signs of change manifesting in their region.
2. Through collaborative working sessions, we clustered signals and drivers, identifying thematic similarities across regions..
3. A multidisciplinary group conducted an impact analysis to map connections and dependencies between different types of change, as well as evaluate the 'depth' of change; that is, its longevity and uncertainty.
4. Finally, a core working group synthesised three key global themes, underpinned by drivers of change, and evidenced by a range of weak signals.

In developing the report, we conducted multiple rounds of reviews across regions to check for relevance, and we consulted experts across Arup's networks to find case studies and responses from the built environment. Drivers and Weak Signals can be used in strategy and planning and are available for download. Contact foresight@arup.com.

1. Arup's global Foresight team is part of Arup University and consists of ~35 futures and systems thinkers spread across regions (Americas, Europe, UK, India, Middle East & Africa, Asia Pacific)

Our process:



ARUP

What next?

Get in touch

Arup is committed to delivering safe, resilient and regenerative places. But we know that this will be challenging under volatile, uncertain, complex and ambiguous (VUCA) conditions; the problems we face cannot be solved by design and engineering in silos alone.

‘Total Design’ means bringing the best of multiple perspectives and disciplines together and applying peripheral and long-term vision. If you are interested in exploring these dynamics of change more deeply, or in developing your organisation’s Foresight capabilities, we’d like to hear from you.

Contact

Foresight@arup.com: for more information on Horizon Scanning and Foresight tools

Acknowledgments

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