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Research

Transform with technology

Shaping the future of real estate

Welcome

We would like to welcome you to JLL's first global report on the rapidly evolving real estate technology landscape.

The pandemic has provided us with an unparalleled opportunity, even a necessity, to rethink the built environment. The technologies that are now available – and others in the process of being developed – are set to radically reshape how we construct, interact with and use buildings. The increasing deployment of technologies, from connectivity and hardware advances enabling the mass use of sensors to machine learning and artificial intelligence, now mean that nearly every aspect of the property industry has the capacity to evolve more quickly than ever before.

As the real estate industry rises to the challenge of delivering a significantly decarbonized built environment, technology is likely to be the single biggest catalyst for green progress. Technology will also be essential as we seek to better manage space and its impact on people. Now more than ever, the health and well-being of the workforce are paramount to business success. The new

workplace, aided by technology, calls for more effective and dynamic use of space.

This presents immense opportunity, but the proliferation of new technologies, new companies and new operating models has made it difficult to navigate the shifting landscape. There is so much technology out there that businesses are often left overwhelmed. Where and when does a business start to invest in new technology and how do they know which area to prioritize?

This report aims to help organizations navigate the complexities of the proptech landscape and provide a strategic technology road map, so that firms can capitalize on those tech investments that will increase the value and benefit of buildings and the happiness of those who occupy them.

We would like to thank our colleagues within JLL and our partners at MIT for their invaluable perspective in the compilation of this research. We hope that it provides an objective and useful assessment of transformative technology within the built environment.



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Setting the scene

Tech adoption accelerating across the built environment

The COVID-19 pandemic has led to a rapid acceleration in the adoption of technology across societies, industries and governments. The real estate industry had been slower to integrate new technologies than other sectors, but the added impetus provided by the pandemic is taking us beyond the integration of technology solutions that help to deal with immediate challenges—such as managing remote working, health and sanitation tracking and touchless movement—as normal business practices are being upended across the industry, spurring experimentation at all levels. This shift is building on the digital transformation already underway as the technology ecosystem around the built environment matures and consolidates. Expectations from consumers and companies are rising in tandem, underpinned by demographic changes that see younger consumers and workers demanding greater technological capacity from their homes, workplaces and cities. The technologies that are now available—and others in the process of being developed—are set to radically reshape our cities and how we interact with and use buildings, and have the potential to lead to much more human-centric, resilient and responsible built environments.

Proptech becomes ubiquitous

The built environment has historically adapted slowly but, even before the pandemic, had faced mounting urgency to adjust to a rapidly evolving environmental and regulatory landscape. Maturing and new technologies—from connectivity and hardware advances enabling the mass deployment of sensors, to machine learning and artificial intelligence (AI) techniques enabling workflow automation—now mean that every aspect of the real estate industry has the capacity to evolve more quickly than ever before. The landscape of technology adoption and diffusion

“...nearly 8,000 companies offering technology-focused solutions across the built environment globally, an increase of over 300% in the last 10 years.”

has grown quickly in size and complexity over the last decade, with nearly 8,000 companies offering technology-focused solutions across the built environment globally, an increase of over 300% in the last 10 years. While this presents significant opportunity, operating models for acquiring and utilizing technology—from in-house development to third-party providers, partnerships or acquisitions—have also proliferated, making it challenging to identify key technologies, providers and engagement models that fit with individual companies or use-cases. This has contributed to many companies remaining on the sidelines as they wait for clear market leaders to emerge, or grapple with integration challenges or a lack of in-house technology capacity. However, with the right implementation strategy, many of these issues can be overcome and there are clear benefits for companies that are able to implement new solutions early.

ESG priorities come to the fore

The next stage of proptech innovation and adoption will be driven not only by new or maturing technologies, but also by the need to respond to long-term structural challenges, ranging from continued urbanization and demographic shifts to dealing with the explosion of information through cybersecurity measures, data privacy and greater transparency. Sustainability and broader ESG considerations around health and wellbeing, in particular, are moving to the fore. As governments, companies and individuals commit to more ambitious sustainability goals, technology solutions will be crucial to making buildings and cities lower-carbon and more resilient, from the introduction of new design techniques and materials to managing energy efficiency and wellbeing in existing buildings.

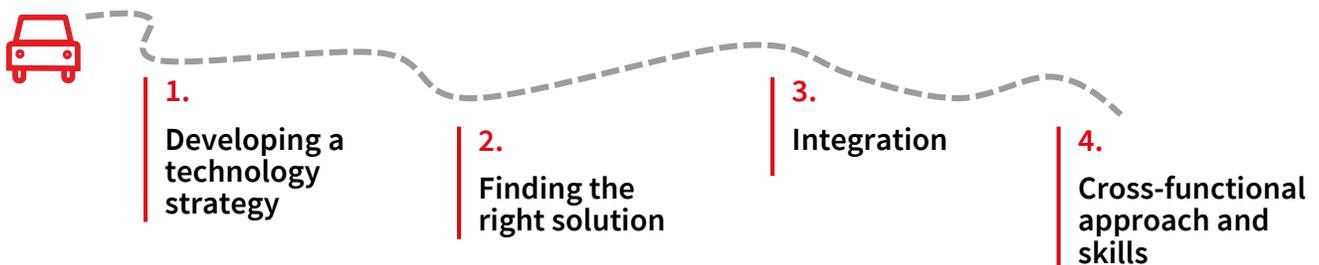


>> A call to action

Technology in the built environment is at an inflection point as COVID-19 forces the pace of change for companies to address old business models and meet the challenges of structural shifts in the market. Many market participants are still at an early stage of developing a technology strategy to respond successfully to these changes, while a fragmented industry landscape and lack of agreed standards makes the situation more complex.

As technology increasingly underpins new business models and the interaction between people and their urban environments, greater collaboration, transparency and trust will be needed between technology firms, property companies and the industries they service, as well as between individuals and governments, to ensure that real estate can respond to these challenges and create more livable, healthy and sustainable buildings and cities.

Developing a roadmap to successful technology adoption



The benefits to be gained from being a market leader in property technology solutions continue to expand as the sector and its underlying technologies mature, ranging from greater customer engagement to increased efficiencies, new sources of income and an ability to track and fulfill corporate ESG commitments. However, in a fractured landscape with many startups providing niche or overly-specific products and having difficulty measuring ROI clearly, it can be hard to find the right solution. At the same time, integrating new technologies is typically time-consuming and difficult to scale across a business.

Establishing the right solutions and integrating and scaling new technologies across the entire business to maximize impact requires a full-process technology adoption framework:

1. Developing a technology strategy:

Understanding where technology can add the most value necessitates a review of where technology can address challenges to the wider business strategy and goals, and the creation of a roadmap that aligns technical capacity-building with the overall direction of the company.

This includes:

- Developing an overview of the technology landscape and current solutions and providers, and how these fit into the company's strategy for each business area.
- Mapping out priorities to provide focus and ensure potential solutions meet critical business objectives and fit in with the wider organizational technology strategy and technical capacity.
- A framework to track solutions from emerging technologies to proven and scalable solutions, depending on strategy and the appetite for risk.
- Understanding the various operating and engagement models available, from partnerships, subscriptions or acquiring technology solutions, and how these fit into the wider strategy and impact technical requirements—such as data sharing or ongoing support from providers—as well as ensuring the right skills and governance are in place to implement the chosen model.

2. Finding the right solution: Identifying the right product and provider are key to successful integration and depends on a detailed review of both the business need and provider capabilities. Primary considerations include:

- Developing an assessment of strategic alignment, use-cases and wider business or process impacts of each solution, as well as flexibility and the potential to scale.
- Scoping technical capacity, fitting with existing enterprise technology stack and data sources, and engaging relevant teams to review privacy and security issues.

3. Integration: The integration process is pivotal to ensuring broader adoption across the business and to generating meaningful ROI and scale for new technologies. This requires developing a holistic adoption and governance strategy including:

- Generating a business-wide adoption strategy with key stakeholder buy-in, ownership and governance responsibilities, and communication to impacted teams on changes to or fit with existing technologies and processes.
- A detailed integration plan to match new solutions with existing products and processes, specifying where these will need to change, ensuring process changes fit with strategic aims and identifying KPIs to measure overall success at each stage.
- Developing pilot or proof-of-concept trials to speed up implementation and test for any issues.

- Implementing an appropriate scaling process, making sure that feedback from pilots is incorporated, solutions are applied across the business, and there is operational fit with the integration process, whether subscribing, acquiring or scaling in-house.
- Communication and onboarding, providing initial and ongoing training and communications to all relevant stakeholders.

4. Cross-functional approach and skills:

Successful adoption of new technologies demands a range of skills, from procurement to operations, maintenance and security, as well as a dovetailing with business culture and processes.

This means companies need an integrated plan for driving skills and technology (for example, through a Chief Innovation or Technology Officer), for hiring or upskilling the necessary roles across their technology strategy, as well as for education and training on how to use new solutions across the organization to support buy-in and use. Partnering with established experts in real estate technology that have the ability to provide long-term support and scale solutions across the business can significantly accelerate progress and capacity development.

Any technology solution intended to drive business performance will only succeed if it is fully consulted with the intended users—only through collaborative engagement will a technology transformation project be successful.

An evolving technology ecosystem

The evolution of property technologies

The 4th Industrial Revolution—a rapid advance in technical capacity, combining technologies across the physical and digital environment—is driving advances across industries in computing power, automation and robotics. In the real estate industry, significant growth in public connectivity during the early 2000s led to the development of mass-market ‘platform’ companies like Zoopla and Rightmove in the UK, Zillow in the U.S., MeilleursAgents in France and Beike in China, and to sharing-economy, co-living/working/staying models like WeWork which expanded rapidly, fueling considerable funding and growth in the market.

New technologies have been proliferating in the intervening years to take advantage of developments in computing power and analysis—built around data integration software and AI techniques to drive more granular analysis and process automation—and connectivity, with the Internet of Things (IoT) leading to new capabilities in understanding, managing and designing buildings and spaces. The number of startups founded grew rapidly over the last decade—from under 2,000 to over 7,800—as companies looked to apply these new technologies and operating models across the real estate industry. In common with tech ecosystems in many other industries, this has led to a fragmented market with companies

targeting a wide range of niche or specific issues and having difficulty determining the core ROI and fit with business or industry goals.

However, the number of new startups being established has declined over the last five years, with signs that funding and M&A activity are migrating to more established industry leaders. As the technology ecosystem matures and consolidates, this will help companies and governments assess which technologies or engagement models offer the most potential to fulfill their needs. Future technologies and operating models will be driven in large part by combining automation and connectivity with structural trends shaping the future of the industry, several of which are being accelerated by COVID, including environmental and social sustainability, the health of populations and tenants, and demographic changes.



Tech Tracker

Identifying emerging technologies

One way to get ahead of the curve and see into the future of real estate technology is to understand the cutting-edge science and innovation coming out of the labs and leading institutions of engineering, science and R&D. The MIT Tech Tracker is an integrated webtool developed by MIT's Real Estate Innovation Lab through an educational program with JLL. This informative application uses data science and machine learning algorithms together with insight and understanding from industry experts to scout, track and predict all of the general-purpose technologies that will most likely impact the world of real estate and change the way we live, work and play.

Led by Dr. Andrea Chegut, the Director of the MIT Real Estate Innovation Lab, this application brings together vast data sources to provide insight into where technologies come from, how they evolve from their inception in the lab to their disruption in the marketplace and ultimately how they immerse themselves into our daily lives and into the built environment. The application itself is driven by James Scott's team of industry experts who scour the globe to discover all general-purpose technologies that could conceivably affect the built environment. Once discovered, proprietary algorithms curate data from investment, academia and social media platforms to measure how these new technologies are advancing and developing, and then predict when they are most likely to become part of everyday life.

Here are just a few of the exciting inventions coming out of the lab that could have a major impact on the future of real estate.

Transformative technologies coming 'next':

1. Graphene

Graphene is a single layer of tightly packed carbon atoms arranged in a honeycomb lattice. It is only

one atom thick and at 100 times stronger than steel is also one of the strongest materials in the known universe. Graphene is flexible, transparent, highly conductive and seemingly impermeable to most gases and liquids. Graphene-strengthened concrete has the potential to achieve higher strength and impermeability with less material than traditional concrete, reducing the environmental footprint of construction projects.



2. Martian Concrete

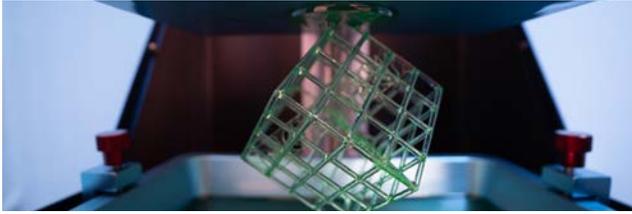
If we decide one day to construct buildings on Mars we will need concrete, but how will we do this on a planet where there is no water? One way is to produce concrete with sulfur instead of water. After adjusting for the gravity of Mars, researchers have found that this Martian Concrete has the strength equivalent to everyday concrete here on Earth. Martian Concrete is highly resistant to corrosion and currently used for non-structural applications such as plumbing and landscaping. It is also fast setting, requiring only one to two hours, while conventional concrete takes 28 hours to cure.



3. Digital fabrication

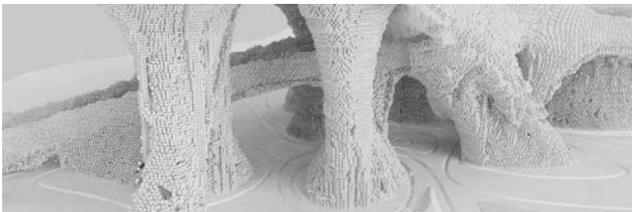
Digital fabrication is a design and production process that combines 3D modeling or computer-aided design with additive and subtractive manufacturing. Additive manufacturing is commonly known as 3D printing and consists of layering material until the completed shape is produced. Subtractive manufacturing is where objects are carved out of a solid block. Robotic and digital fabrication on building sites could revolutionize the construction industry, enabling for materials to be produced on-site, which could reduce delivery time on materials,

facilitate shorter project lengths, reduce material costs and allow for more consistent product quality.



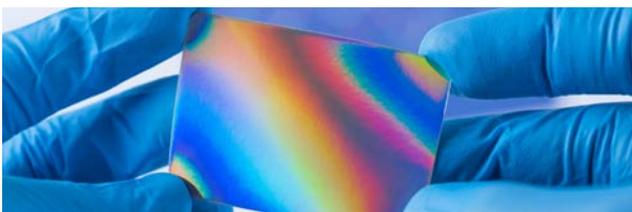
4. Hypercells

Hypercells are shape-shifting robotics cubes. Prototypes are generally 10-centimeter cubes but can morph their elastic skin into a sphere using six internal pistons. By shifting an internal weight, the ball can roll in any direction with each cell containing a tiny computer chip to sense its environment, avoid obstacles and communicate with each other. Hypercells have the potential to create robotic moving buildings that could transform spaces in a matter of seconds, allowing for a building to continuously function at its highest and best use. Hypercells could also potentially enable the self-construction of buildings.



5. Self-cleaning materials

Self-cleaning surfaces are a class of materials with the inherent ability to remove any debris or bacteria from their surfaces in a variety of ways. The self-cleaning functionality of these surfaces is commonly inspired by natural phenomena observed in lotus leaves, gecko feet and water striders to name a few. Self-cleaning materials allow for a reduction in operational costs as the buildings can essentially clean themselves.



6. Fiberbots

Developed by Neri Oxman's Mediated Matter Group at MIT, this swarm of robots produce rapidly fabricated freestanding fiber-reinforced tubes. The tubes themselves are made of fiberglass which produces an energy-efficient, green and sustainable solution for building enclosures. It has relatively low embodied energy due to its composition and can be shaped to carry loads in multiple directions. While still in an experimental phase, this solution has the potential to allow for a faster and more efficient form of construction.



7. 4D printing

4D printing is the next stage of 3D printing that allows objects to transform into another structure when an external energy source or input such as temperature, light and other environmental stimuli are added to the object. An example of this would be printed pipe valves that have the ability to expand, contract or unfold. 4D printing could allow for not only simplistic folding objects but also programmable shape-shifting materials and hydrogel composites, which could lead to a reduction in construction costs.



What's driving the digitization of real estate? Automation and AI

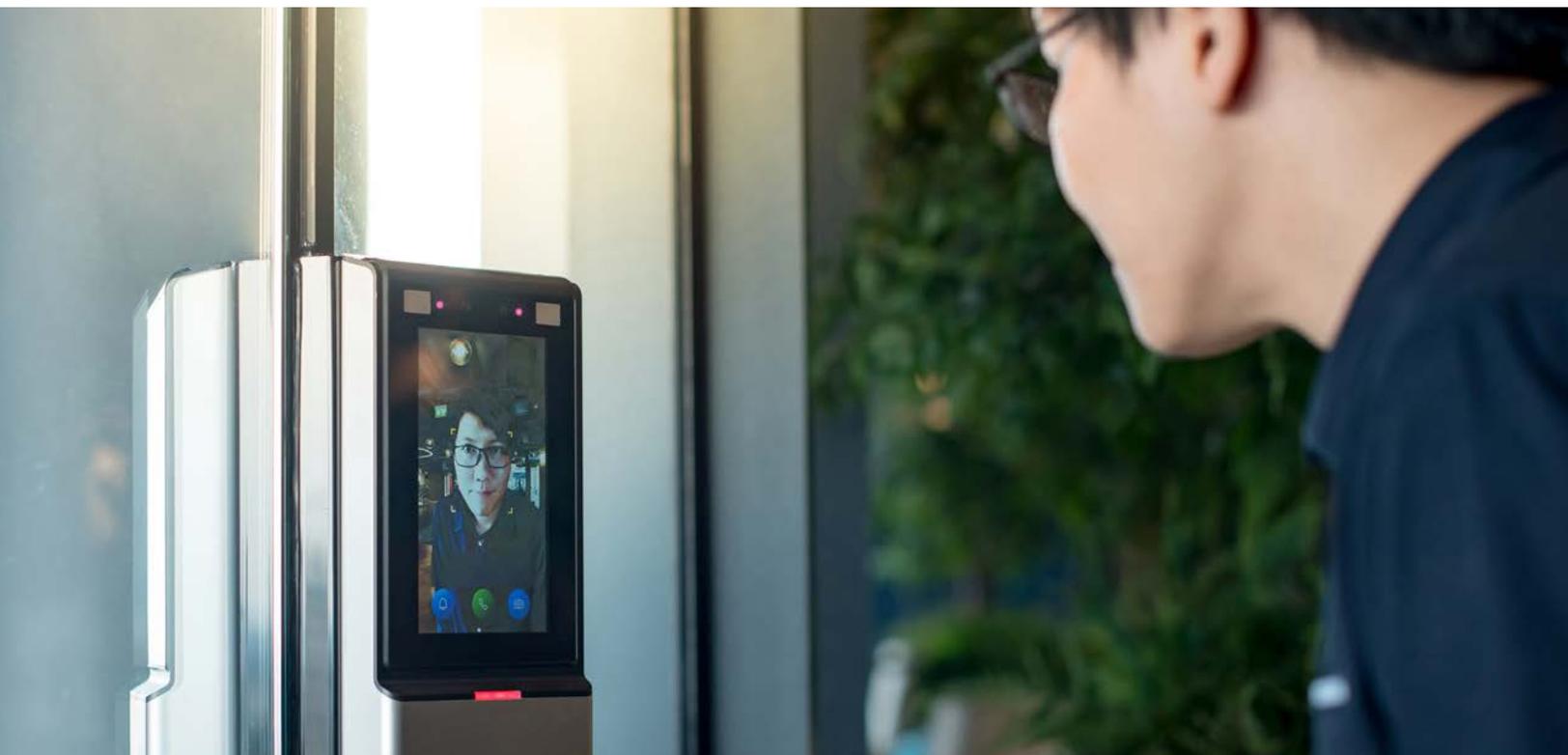
Nearly all technology applications across the built environment are based on generating or utilizing data, with advanced data processing, analytics and automation at the core of this growth in the 'digitization' of the built environment. Infrastructure and buildings are generating increasing volumes of data, and across the core set of technology types and tools—from 'smart' buildings and cities to automated workflows and even virtual reality viewings—the ability to gather, process and analyze this information in order to generate meaningful solutions is integral. Data is also one of the main issues holding back adoption of new technologies and platforms, with siloed, partial and lagged data inhibiting the ability to utilize available technology. Widespread issues include:

- **Manual data collection and storage processes**, with most data collection still carried out in Excel or legacy systems which are not connected centrally.
- **Lack of company and industry data standardization**, with varying types, levels and processes for collecting information even within the same company.

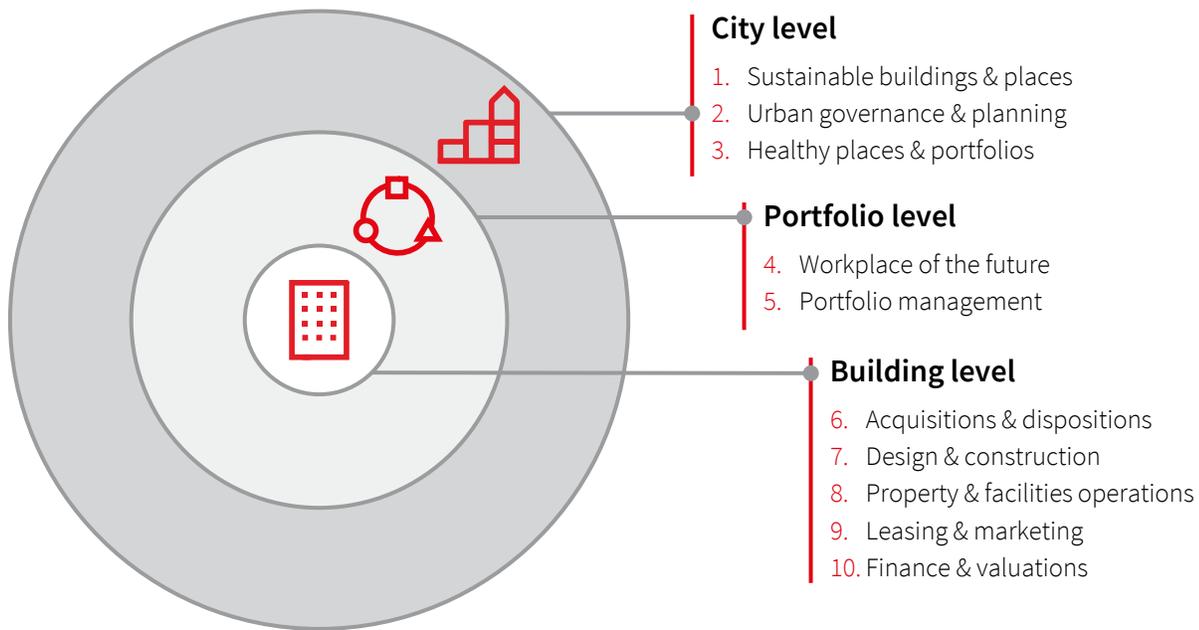
- **Decentralized and complex data privacy systems**
- **Lack of integrated software solutions**, with a fragmented landscape of providers offering a range of incompatible solutions for individual data types and use cases.
- **Limited skills within organizations** to gather data and implement new technologies.

Centralized, structured information is key to some of the most exciting applications of new technology with the greatest ability to boost efficiencies and aid decision-making, from real-time portfolio performance tracking to AI and automation. Generating trust in data and technology—particularly for AI applications where these automate processes or are public-facing—is also crucial for acceptance and adoption of new technologies.

Creating the information infrastructure to attain these benefits is a long-term challenge, but one that can be solved through a combination of industry collaboration, regulation and enterprise-wide data platforms. Collaboration efforts have made more significant progress in recent years, with the OSCRE Industry Data Model an example of an open-source effort to help structure data initiatives.



Technology applications across the built environment



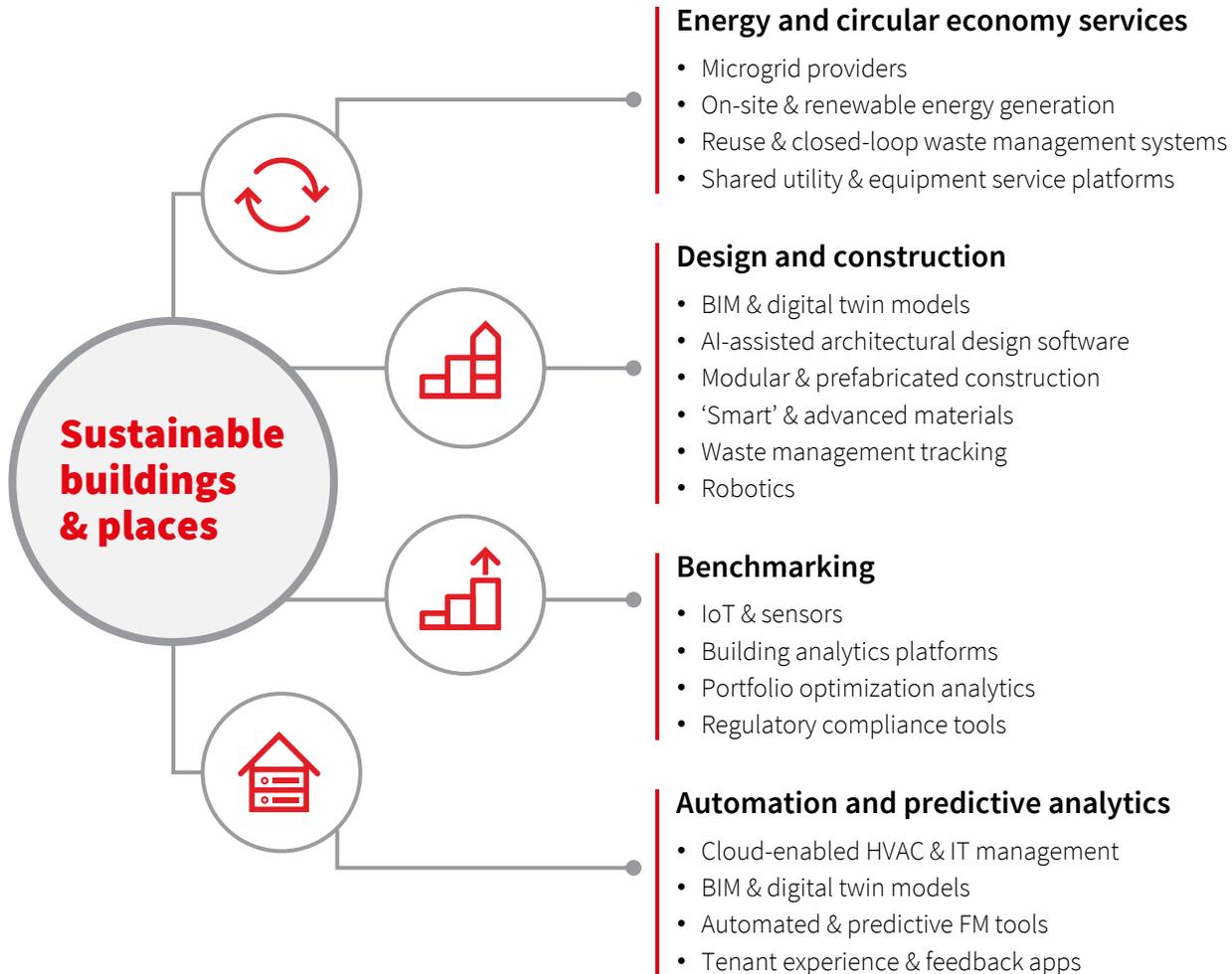


Sustainable buildings and places

Automation and analytics driving sustainable building operations

There is mounting pressure from all stakeholders in the real estate industry to contribute to lower-carbon and more resilient buildings and cities. Urban planning, regulatory initiatives and new construction techniques and materials will be an important factor in ensuring new buildings meet higher standards (see Urban Governance and Planning and Design and Construction sections), but with building operations contributing 28% of global GHG emissions, managing energy performance in existing buildings will be essential in meeting net-zero carbon commitments from investors, tenants, landlords and governments.





Enhanced tracking of energy performance and emissions, implementing higher-efficiency or new-energy systems, and combining environmental and facilities performance data with advanced analytics and modeling to automate processes and achieve higher utility are all key areas where technology is facilitating this transition:

- Energy and circular economy services:** Energy systems able to integrate renewable energy sources—such as microgrids using solar power—and performance-optimized hardware like Turntide’s Smart Motor System platform, can significantly reduce building energy use and emissions. Some providers are now also offering utility or equipment provision rental services as part of a drive towards a ‘circular economy’ model, which can incentivize the supply of maximally efficient services by providers who are responsible for power or lighting over the length

of the contract—Signify, for example, enables companies to purchase the provision of lighting services in a building rather than purchasing and installing their own lighting systems.

- Design and construction:** New design techniques will be essential to achieving net-zero carbon goals, with the EU for example aiming for all new buildings to be zero carbon by 2030. Architectural software platforms help designers to adjust layouts and materials to select the lowest-carbon options, while digital twin models can allow full-life carbon performance to be simulated and fed back into building design. More efficient construction techniques such as modular buildings and 3D printing are also gaining traction.

- **Benchmarking:** Compiling and tracking energy performance and operational data is the first step in managing building sustainability, but it can be a difficult process, with information split across multiple teams, a lack of integrated buildings or systems, differing designs between hardware and software providers, and limited ability to track and monitor in real time.

The increasing prevalence of sensors and other monitoring technology in digitally-connected buildings is leading to significant improvements, with a number of systems able to provide granular, live data on building energy performance, CO₂ emissions and HVAC systems (among other metrics) and combine these with analytical software to enable users to measure actual operating use and optimize efficiency. Crucially, some providers are now able to offer hardware and software compatible with many types of pre-existing systems. This technology is also starting to become more available to smaller companies, with Arbnco's Digital Energy Efficiency Platform, for example, aimed at providing energy performance data and tailored recommendations for small businesses.

- **Automation and predictive analytics:** These advanced sensor and analytics capabilities now have the capacity to power new forms of 'smart' building management systems (BMS). These can allow much more granular and automated management of building operations to increase efficiency, including dynamic lighting and heating based on the number of people actually using the space, predictive space management based on typical use patterns, and predictive maintenance by identifying stresses or unusual patterns within the management system to reduce maintenance and prolong the useful life of a building's many working parts. Tools like Apleona's AI system energyControl, for instance, can create digital twins of buildings to facilitate automated predictive control of heating, ventilation and air-conditioning technology in real time.

Key considerations

- 1. Consider a path to net-zero carbon.** Looking at a building or portfolio with the intention of putting the assets on a pathway to net-zero carbon can help in deciding which technology and innovation solutions will support the journey. This can aid in prioritizing capital investments and set an order in how to drive towards efficiency and sustainability. Keep a watchful eye on new technology solutions, understanding that this is a quickly evolving space and taking an iterative approach while pushing to be as bold as possible can help you stay ahead of the curve.
- 2. Establish a current baseline of energy use and emissions to act as a starting point for goals and commitments.** Develop a strategy for which metrics are important to track to ensure portfolios meet climate commitments, and for accessing or generating this information and appropriately benchmarking it.
- 3. Create integrated, standardized performance and utility measurement information across the portfolio to allow for real-time tracking, reporting and management planning.** Optimizing systems to facilitate greater automation and predictive space management can be an iterative process but is key to increasing the sustainability of existing buildings.
- 4. Design and construction processes are critical to achieving emissions goals and creating more resilient buildings.** New design techniques can help manage a building's lifetime emissions, while leveraging the latest technologies in sustainable materials, such as sequestering carbon in construction materials, is an important component of responsible procurement.

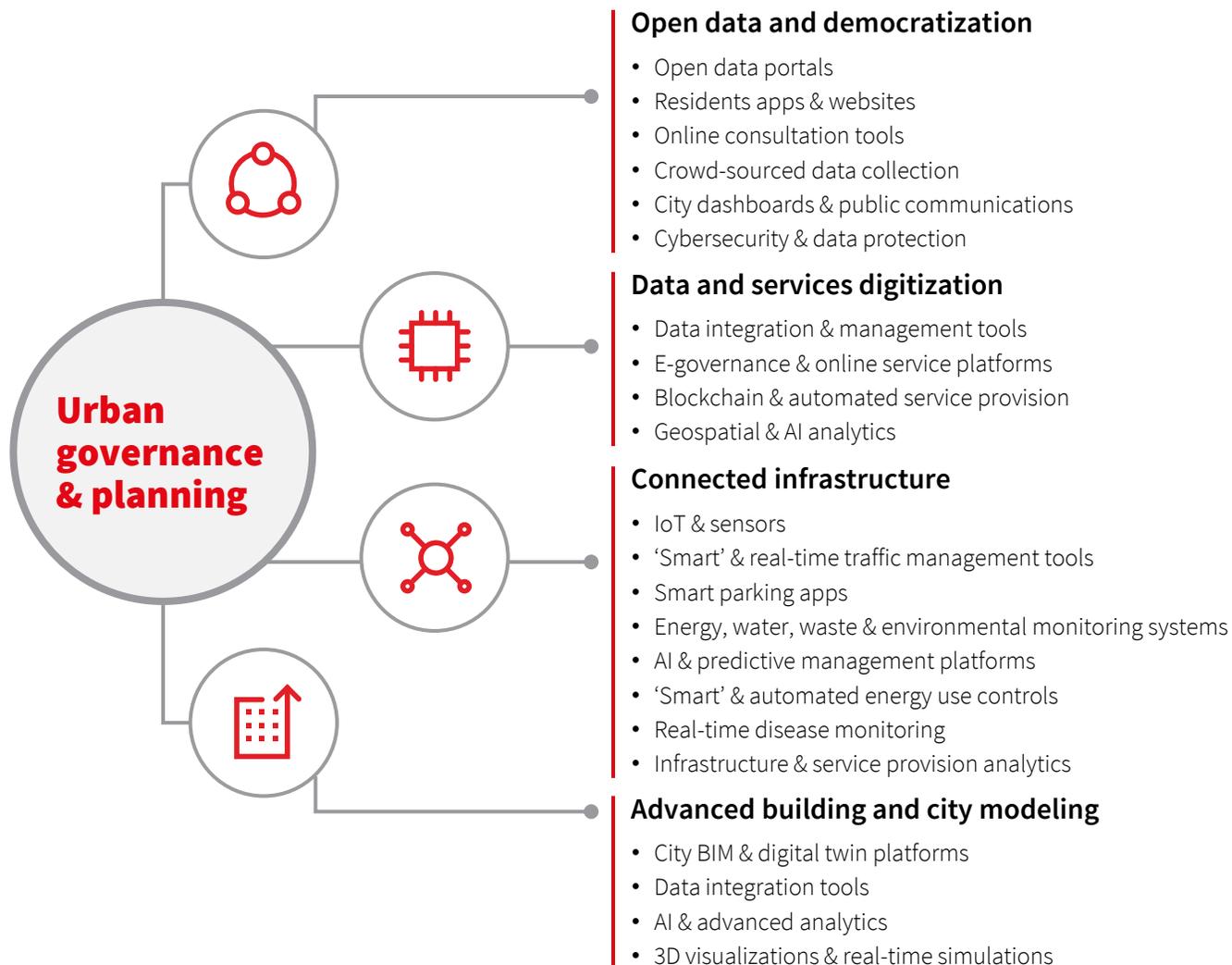


Urban governance and planning

Digitization and ‘big data’ offer potential for more responsive urban governance

Urban governance is under increasing strain as it seeks to meet the multiple challenges of rapid urban transformation. Changes to work and workplaces, changes to lifestyle preferences and the increasing emphasis on inclusivity and health, combined with the urgency to transition towards more climate-resilient, low-carbon systems, have the potential to radically alter how our cities and buildings are used.





City governments are increasingly looking to technology and data platforms to support their transition and to meet the demands for greater agility, flexibility and more hybrid uses. While the advent of fully-connected, digitally-managed ‘smart cities’ is still some way off, there are a number of technological tools being trialed and adopted by city authorities around the world to aid the transition to more human-centric, healthier and sustainable urban environments:

- **Open data and democratization:** The introduction of sensors and other types of connected infrastructure in ‘smart city’ platforms and the use of ‘big data’ analysis such as mobile phone records to track commuting patterns for service provision planning have heightened the need for a greater focus on data privacy and protection, as well as building trust with communities where these initiatives are being

used. A number of city governments are taking steps to make their data much more open and transparent, releasing information through open data portals and even providing training for residents to utilize this data. Barcelona, for example, is running a number of pilot programs, including on Digital Democracy and Data Commons (DDDC) and Citizen Science Data Governance, to encourage and train citizens in investigating and sharing open data.

Technology can also contribute to greater democratization of the planning process and wider urban governance. Companies like Commonplace have developed public online consultation tools specifically for planning purposes, while city governments are also developing their own consultation tools such as Barcelona’s Decidim and Sydney’s Your Say.

- **Data and services digitization:** The digitization of existing public data and services enables much more efficient and far-sighted planning and regulatory decisions. Many city governments are now actively digitizing and integrating their land registries and geospatial data, which can improve planning and land-use classifications systems as well as allow better integration of physical and climate risks into decisions. The Climate Ready Boston initiative, for example, has integrated geospatial and land registry data with future climate impact models to create an in-depth mapped framework for planning decisions and infrastructure provision which will be more resilient and adaptable to future climate scenarios.

The pandemic has also accelerated moves already underway by city governments to shift services such as planning applications and closing processes online, with the establishment of solutions like the government-backed Planning Portal in the UK meaning that most applications are now submitted online. Some governments are also experimenting with automated service provision, with the Dubai Land Department working on a blockchain system to store land titles and enable automated processing of property and utilities payments.

- **Connected infrastructure:** The ability to digitally connect urban infrastructure, from

streetlights to energy grids, offers significant potential for urban management. Connected energy and utilities systems involve significant upfront costs and capacity and also introduce potential cybersecurity and data protection concerns, but when managed effectively can increase efficiencies in energy use, detect defects, automate repair schedules and provide predictive analytics. They are being trialed in a number of cities from Sao Paulo to Helsinki. The Seoul Metropolitan Government, for example, has established an Integrated Public Big Data Storage system which collects information from IoT sensors around the city, tracking a range of metrics from noise to light intensity to assist with service provision and urban planning.

- **Advanced building and city modeling:** In the planning and design stages, building information modeling (BIM) provides much greater detail in assessing building design, while some companies like Cityzenith or VU.CITY have begun extending it to create city information modeling incorporating 3D models of the urban landscape, geospatial analysis and other features. It can offer new ways of analyzing the current environment in terms of traffic, energy use and climate, as well as the potential impact of new proposals for any given site, allowing for greater sustainability and resilience planning.





Key considerations

1. Get to know the digital strategies of the governments of cities in which you have an active presence and portfolio.

It may uncover potential opportunities for beneficial collaboration, policy influence, data sharing and new business prospects.

2. Monitor which urban governments have progressive human-centric digital strategies within your active geographies.

They are likely to be better equipped to ride the next cycle of recovery and to create longer-term resilience and sustainability.

3. Keep a watching brief on new government-sponsored technology initiatives

which may provide a lead indicator of which cities are likely to see improvement in real estate transparency and business operating conditions, particularly among middle-income economies. JLL's Global Real Estate Transparency Index identifies the important role that technology, and proptech specifically, will play in boosting transparency.

4. The rise of advanced platform technologies will put pressure on city governments

to partner with technology businesses in order to make 'smart' solutions that relate to the built environment more achievable.

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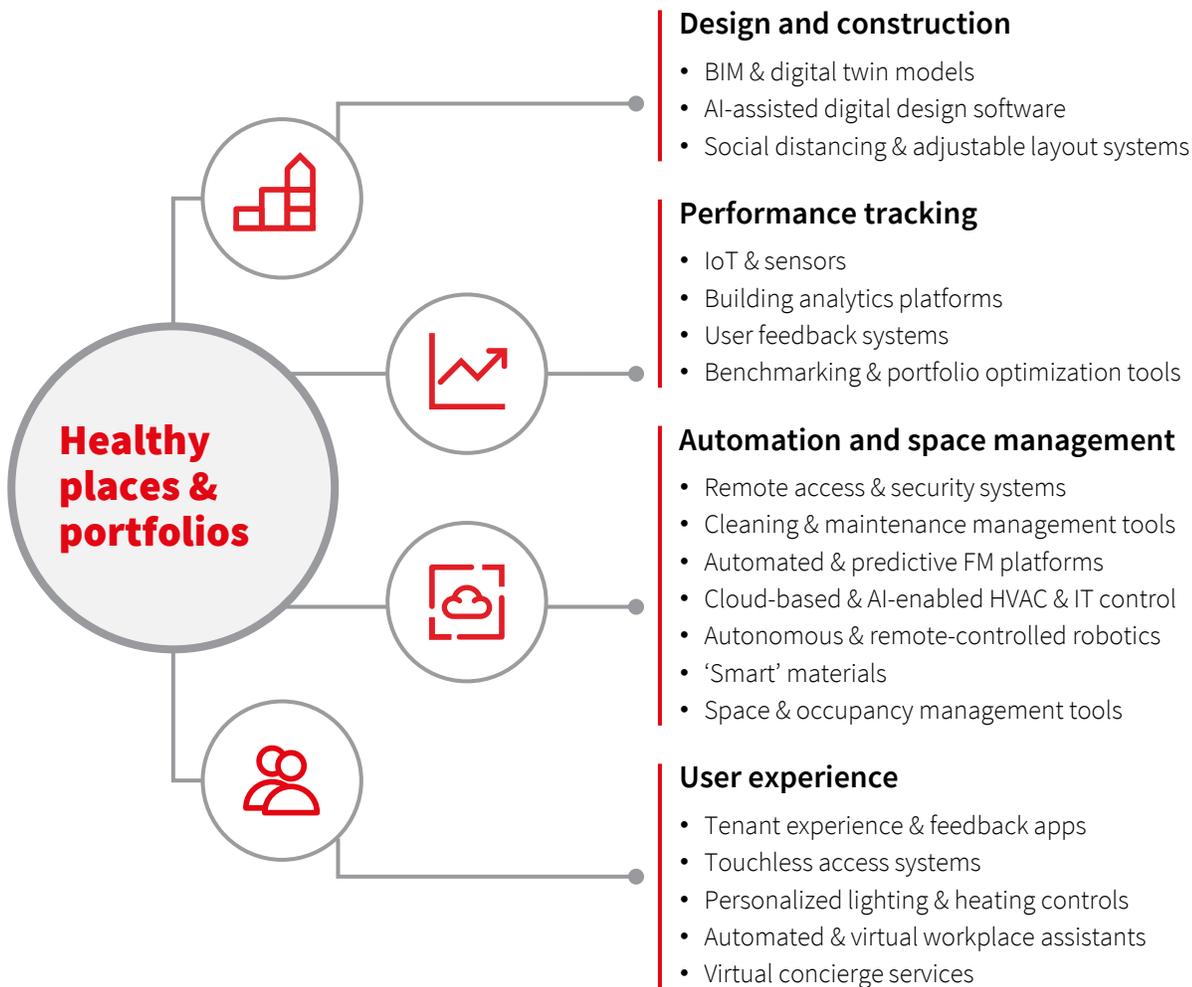


Healthy places and portfolios

Supporting healthier and more human-centric environments

The pandemic has highlighted the need for healthier, better designed and more human spaces. There is a growing recognition of the benefits presented by more healthy urban environments and workplaces, from greater mental wellbeing to increased productivity and cost savings. Organizations like WELL and FitWel now provide certifications for buildings that promote occupants' health through measures like air and water quality, thermal and sound comfort and amenities, as well as offering new ratings specifically around health and virus prevention.





These considerations are increasingly being taken onboard at the design stage, but the most prevalent technologies currently in use revolve around tracking health-related metrics within buildings, as well as communication, occupant experience and personalized control tools. The last year has also seen increasing experimentation with touchless technologies and automation to reduce infection risks and improve confidence, as well as new tools like robotic cleaners.

- **Design and construction:** Recent research has highlighted the impact of a building’s design and layout on wellbeing, physical and mental health and workplace productivity, with factors ranging from natural light to air quality, temperature, humidity and sound all playing a role. Building information modeling (BIM) and digital twin software can now be used to optimize building

design and simulate performance in different environmental conditions, while the use of new materials like ‘smart glass’—which can adjust the amount of light and heat passing through depending on external conditions—can markedly improve building performance.

- **Performance tracking:** Tracking and understanding health-related metrics provides the information needed to adopt strategies that boost safety and wellbeing. Sensors and heat cameras allow information like air quality, heat and light within a building to be tracked in real time, with more advanced systems offering the potential for real-time adjustments, such as adjusting the rate of air circulation or heating depending on the number of people currently in a building.

- Automation and space management:** Integrating health and occupancy tracking with facilities management (FM) systems can lead to much more convenient—as well as efficient—services. Touchless technologies such as voice or gesture-controlled access systems permit occupants to move around a building freely, while occupancy tracking can allow real-time cleaning schedules to be adjusted automatically; for example, triggering a cleaning order when a room has been vacated and holding bookings for that space until the cleaning is complete, or when occupancy has reached a set level. The past year has also seen experimentation with advanced robotics in facilities management, with remote-controlled and even autonomous robots able to maneuver around properties to clean or disinfect.
- User experience:** Platforms such as HqO or JLL Jet enable users to book rooms or services, provide feedback and communicate with FM staff, while also providing information on occupancy, health checks and even heatmapping to better manage health. Integrating similar tools into configured ‘smart buildings’ can allow users to set their own preferences for light and heating in different spaces.



Key considerations

- 1. The pandemic has provided an opportunity to reimagine the built environment and workplaces to support health and wellness, comfort and productivity.** Studies have shown a link between green-certified and healthier buildings and improved wellbeing, cognitive function and productivity, and workplace resets as companies plan their longer-term strategies offer the potential to ensure living and workspaces contribute to greater health. Keeping an eye on long-term goals rather than short-term, capex-heavy solutions will be key to ensuring health initiatives are aligned with the wider business strategy.
- 2. Expectations of buildings and places in terms of health and wellness are higher than they have ever been.** Utilize technologies—such as sensor displays showing air quality—to showcase your initiatives and let employees and customers know what you are doing to help them. Create a ‘sense of place’ that supports health and contributes to belonging and productivity.
- 3. With the growth in hybrid and ‘work from anywhere’ strategies, healthy workplace considerations will need to evolve beyond office-based initiatives to support employees wherever they may be working.** This can involve providing the technology to allow seamless health tracking and connectivity, as well as supporting employees’ health needs across locations.

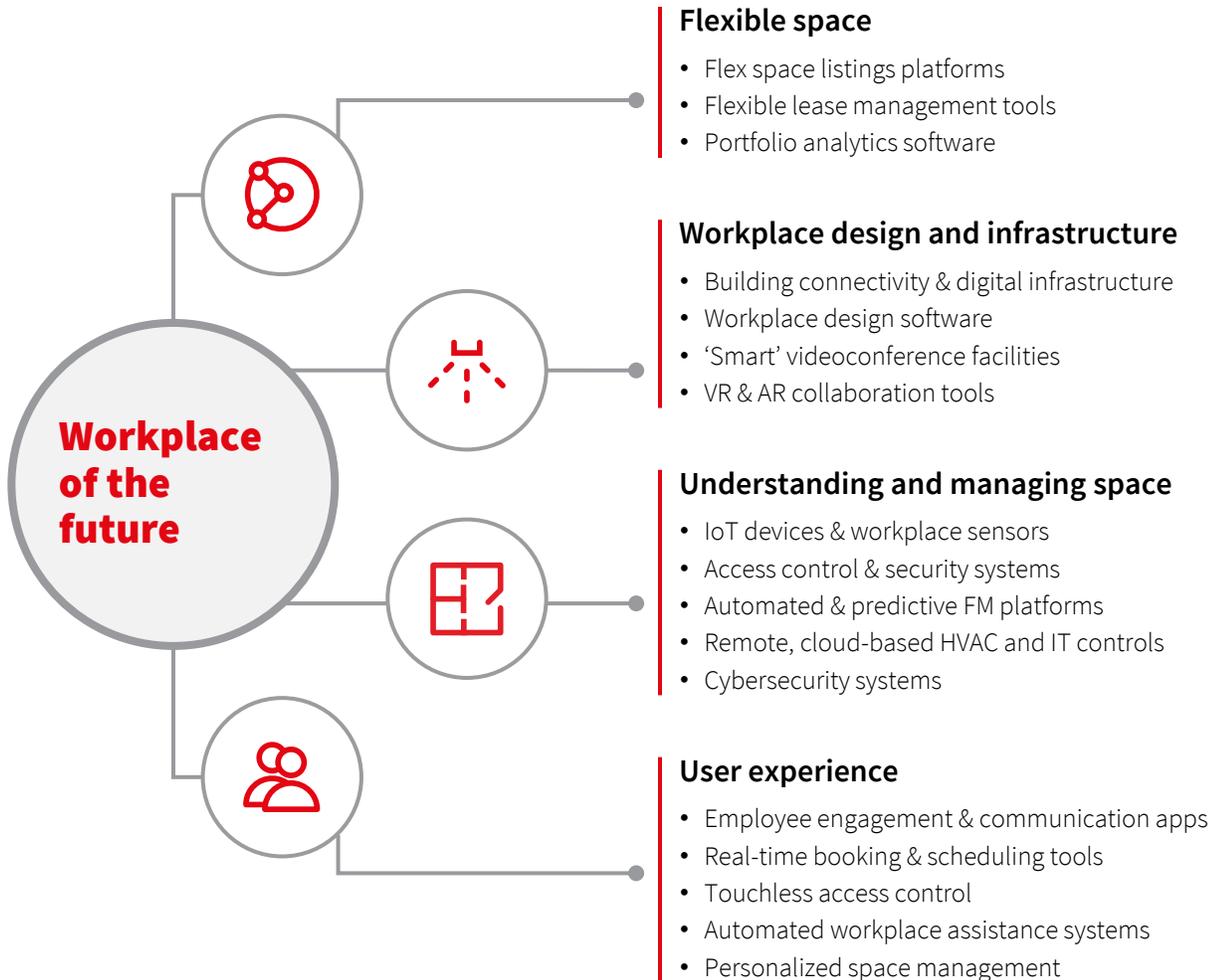


Workplace of the future

Enabling new ways of working and collaborating

The pandemic has advanced the digital transformation of businesses, and the workplace is now truly boundaryless, with employees expecting a safe, productive and seamless experience wherever they work. To achieve these aims, companies will need to find ways to enable hybrid work, empower and engage employees wherever they are, and manage variable and dynamic occupancy patterns.





Navigating the future of work will require a range of technological tools to support new ways of working and collaborating.

- Flexible space:** With 66% of respondents to JLL’s recent workforce survey indicating they want the ability to work from multiple locations, providing flexible options to enable work-from-anywhere policies will be an important component of supporting hybrid workforces. The rapid growth in coworking providers and space was slowing even before the pandemic, and the landscape is likely to shift further as institutional landlords increasingly offer their own flex space services to cater to this demand. A number of platforms, such as Hubble or Spaces to Work, now offer flex space searching tools to match businesses with space that meets their requirements, while flex lease management software can streamline some

of the complexities involved in shorter-term or highly specific contracts.

- Workplace design and infrastructure:** As the workplace is reimagined to facilitate hybrid workforces, the design and functions of the office will need to adapt, with technology playing a core role. Offices will have to support a greater range of hybrid and work-from-anywhere models, requiring robust digital connectivity and infrastructure with the capacity to adjust to new technologies, from IoT connectivity to 5G. This will place a much stronger spotlight on the digital capabilities of buildings; for example, as measured by their WiredScore rating.

The physical design of workplaces within buildings will also need to adjust to accommodate a variety of flexible functions. A

greater focus on collaboration when teams are in the office will lead to a requirement for more meeting space, with built-in capabilities for hosting virtual meetings, such as videoconference screens and software. Some emerging technologies offer the possibility of immersive or augmented-reality meetings between those joining the meeting from the office and those working elsewhere.

Offices will also play a vital role in teambuilding and in projecting a company's brand through more use of event space and enhanced amenity offers. Redesigning space has typically been a labor-intensive, analogue process with information dispersed across drawings, documents and spreadsheets, but new workplace design tools now allow this process to be digitized, integrating disparate data sources to let companies plan new designs and fit-outs digitally (on factors such as density, mobility or business line), visualize designs in virtual or augmented reality in real time and collaborate remotely.

- **Understanding and managing space:** New ways of working will provide an unprecedented challenge for companies that need to drive productivity, talent retention and collaboration across dispersed teams. Supporting this process will entail an in-depth understanding of how workplaces are being used, which will help to inform strategic decisions around portfolio

optimization, as well as the planning and organizing of space. This will require technology for monitoring how space is being utilized (for example, occupancy sensors and IoT devices), benchmarking this information and communicating key insights in an accessible way.

An enhanced understanding of how space is being utilized also enables automated and predictive facilities management – for example, sensors can track when a space has been vacated, triggering an automated cleaning order, while predictive systems can order new supplies before they run low based on previous usage history.

- **User experience:** Empowering employees to control their environments will be key to increasing productivity and engagement, as well as enabling real estate teams to understand and drive performance. There is currently a wide range of providers targeting specific elements of the tenant experience and FM services, but some platforms are now integrating these to allow for combined space management and user engagement tools that can control everything from building access and room bookings through to individualized temperature and lighting controls, maintenance and service requests, and user feedback and occupancy tracking.





Key considerations

- 1. Align your technology strategy with business and portfolio goals.** Developing a hybrid working strategy is an effort that impacts most if not all areas of the business, and there is no one-size-fits-all template for mapping it out. Defining your business goals and future workplace requirements to enable a successful transition will require cross-team collaboration involving company leadership and HR teams as well as real estate. Key steps include:
 - Assessing your current technology
 - Drafting an achievable technology strategy
 - Creating data and business intelligence roadmaps
 - Consulting on new tech and helping select additional technologies
- 2. Define the metrics that matter.** With the movement towards the hybrid workplace well underway, there will be a need to move beyond standard metrics such as space-per-person to look at a much broader range of information to help make better, faster decisions and improve experiences. Identifying the data required to drive improved decision-making, and how to access this information, will be fundamental to workplace transformation.
- 3. Partner to implement.** When considering new technologies, you must also assess the company that makes them. Will they deploy then depart, or will they partner with you and share their expertise? Partner with a company that has deep experience in workplace management and software development and can assist in mapping your technology roadmap to your business goals.
- 4. Build trust and understand how data impacts your people.** How will you calibrate this increased focus on data, technology and people without infringing on privacy? By asking people for their information—especially if it is about their experiences outside your buildings—you are obligated to make sure that you are following the right protocols and are using that information properly. Before you collect their data, communicate to them how you are using it in general and specifically how you are using it to create better experiences for them. Ultimately, people will give up their data if they receive (and understand) benefits in return.

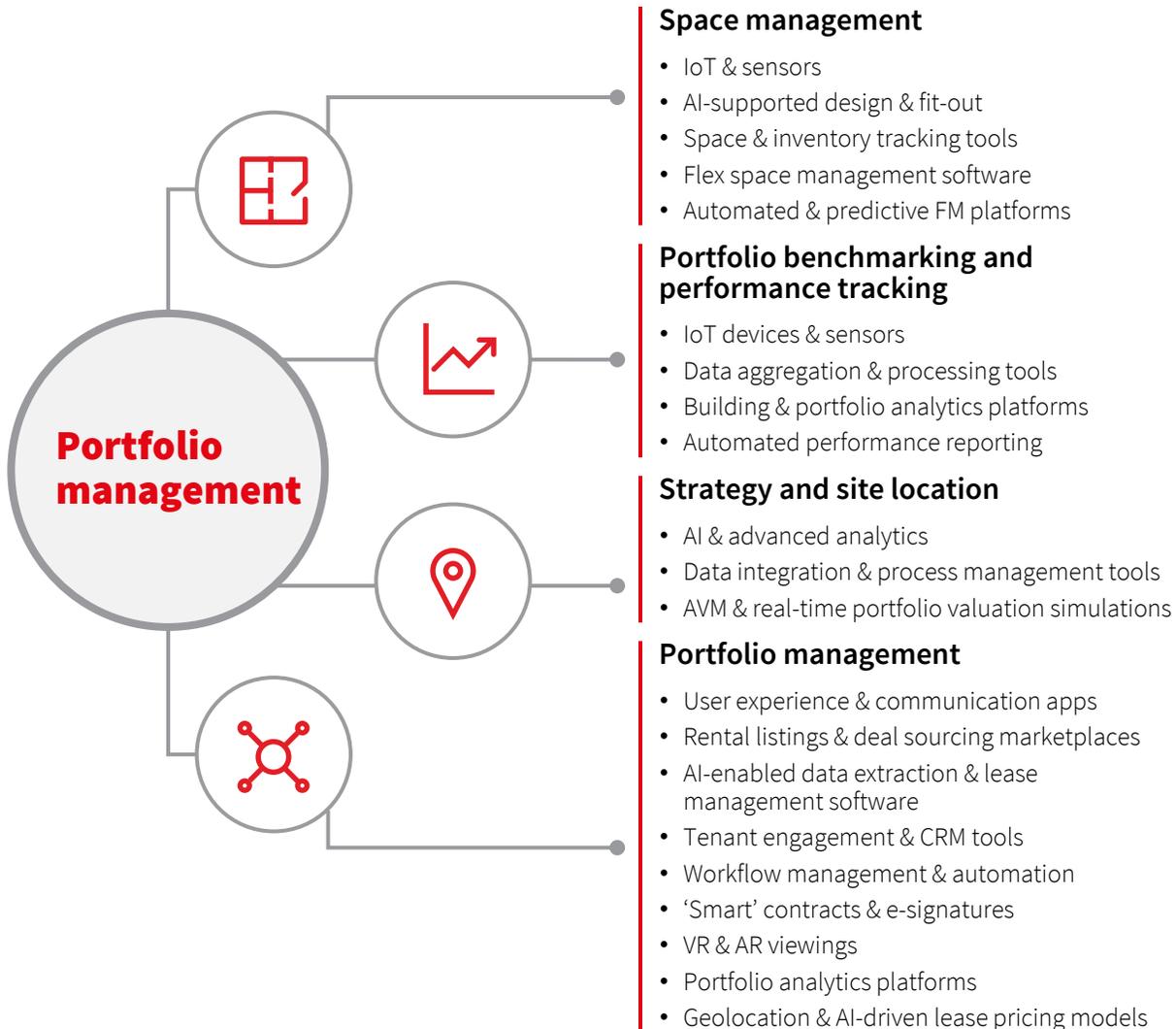


5 Portfolio management

Automation and AI for dynamic portfolio management

Improvements in automation and AI analytics offer significant scope for transforming portfolio strategy and management for both investors and occupiers. Automation of existing processes is making real-time updates available for fund benchmarking and reporting, while the use of larger and more targeted datasets will make the portfolio strategy process much more granular.





The shift towards space as a service and offering higher levels of engagement and customization is also aligning priorities between landlords and occupiers in areas such as an increased need to cater to the user, employee or customer experience across asset classes. For occupiers, tech-enabled portfolio management will be crucial to supporting more dynamic and flexible hybrid workforces, providing the right space in the right markets at the right times.

Occupier perspectives:

- **Space management:** For office users, fixed, multiyear plans will be replaced by more rapid, data-driven strategies. This will require a shift towards smart space optimization and

dynamic space planning, iterating quickly through validation, strategy, planning, design and reconfiguring phases that are based on employee feedback gathered by surveys as well as actual usage via occupancy sensors and hybrid workplace apps. Sensors with deep-learning capabilities can use organizational, environmental and people data to recalibrate and predict workplace needs.

New analytics capabilities and technologies also offer significant potential for portfolio space management in other sectors such as retail. Footfall analysis and space usage mapping can be used to adjust pricing and tenant mix by location within a retail building or portfolio,

while in-store tools like customer and inventory tracking can help to optimize shop layouts and even lead to automated experiences such as in Amazon Go stores.

- **Portfolio benchmarking and performance tracking:** For corporate occupiers, benchmarking portfolio performance on numerous measures from environmental performance to workplace occupancy will be key to ensuring real estate contributes to climate commitments and supports workforce wellbeing and new ways of working. Analyzing relative use of space across a portfolio can help to identify growth and consolidation opportunities, while visibility into space allocation, real-time usage and ongoing servicing needs allows organizations to optimize financial performance and make strategic decisions about how best to align workspaces to the way teams want to work. Advanced portfolio management tools are able to integrate these features and leverage predictive insights to drive real-time portfolio planning.
- **Strategy and site location:** Portfolio flexibility will also be key to the success of hybrid working, with a greater use of non-traditional and geolocation analytics to select sites that meet workforce requirements around location and amenities, and a greater provision of flex or coworking space. Site selection is especially relevant for sectors undergoing major shifts, such as retail and logistics. For retail tenants, micro-location data, footfall levels and mobile phone tracking now provide new ways to assess the attractiveness of a location and a number of platforms like Placer.ai now provide these services. The need for last-mile accessible locations and the trial of new delivery options, such as autonomous vehicles or drones, mean that location is increasingly important for logistics tenants as well, with geospatial analysis able to identify spending patterns and populations within specific delivery distances.

Investor perspectives:

- **Portfolio benchmarking and performance analysis:** The fund and portfolio benchmarking and reporting process is already one of the most automated in the portfolio management process, with a range of platforms available to aggregate in-house data and benchmark it against external sources. However, few of these tools cover the entire reporting process from collating asset-level performance across sectors with differing cash-flow profiles to processing, benchmarking and building customizable reports for different stakeholders. Integration across the whole reporting process offers the potential to significantly streamline operations, while adding in real-time valuations from automated valuation models across an entire portfolio can allow more accurate and timely reporting.
- **Portfolio management:** User analytics and experience management will be increasingly central to tenant retention and leasing strategy as many office tenants adjust to a hybrid working model with greater demands for service provision and flexibility. Tenant experience, communication and feedback platforms will be an important component of a more operational portfolio management process and will be critical in the shaping of future strategies. In retail, more focused information on footfall patterns within a space will help to identify which stores are performing well.

Lease management tools such as VTS are also gaining traction; for example, with NPL and other processing techniques being used to extract information and speed up and automate the leasing process. Analytics dependent on new datasets, like footfall and online expenditure, will also be necessary to help smooth the transition to new lease types in retail as tenants demand more flexible terms. A new model developed by CACI, for instance, attempts to value the lease terms based on measuring a store's ability to attract footfall and engage on and offline consumers.



Key considerations

- 1. Technology, data and AI will continue to increase the efficiency and impact of portfolio management for investors and occupiers,** unlocking insight into more real-time performance and better positioning organizations to forecast performance and establish new strategies.
- 2. The ability to manage space more efficiently will bring forward opportunities for new or alternative uses in previously underutilized space** and ensure buildings are optimized for peak usage. This will facilitate a move towards multi-functional and mixed-use space, increasing the operational intensity of portfolio planning and facilities management and requiring joined-up processes, technology and business intelligence tools across teams.
- 3. Personalized experiences and flexibility will be key to maintaining tenant and employee retention and maximizing portfolio utilization.** Integrating AI-enabled technologies into buildings, from automating desk heights to controlling desktop arrangements to preferred lighting choices, can improve satisfaction, wellbeing and productivity but is dependent on enhanced communication, collaboration and trust.
- 4. New data offerings will be increasingly important in driving location strategy insights.** A wide range of non-traditional data can enable occupiers to assess commercial real estate offerings to ensure alignment with current portfolio needs and the broader strategy with much greater granularity and efficiency, but leveraging this information effectively will depend on holistic data management and technology strategies.

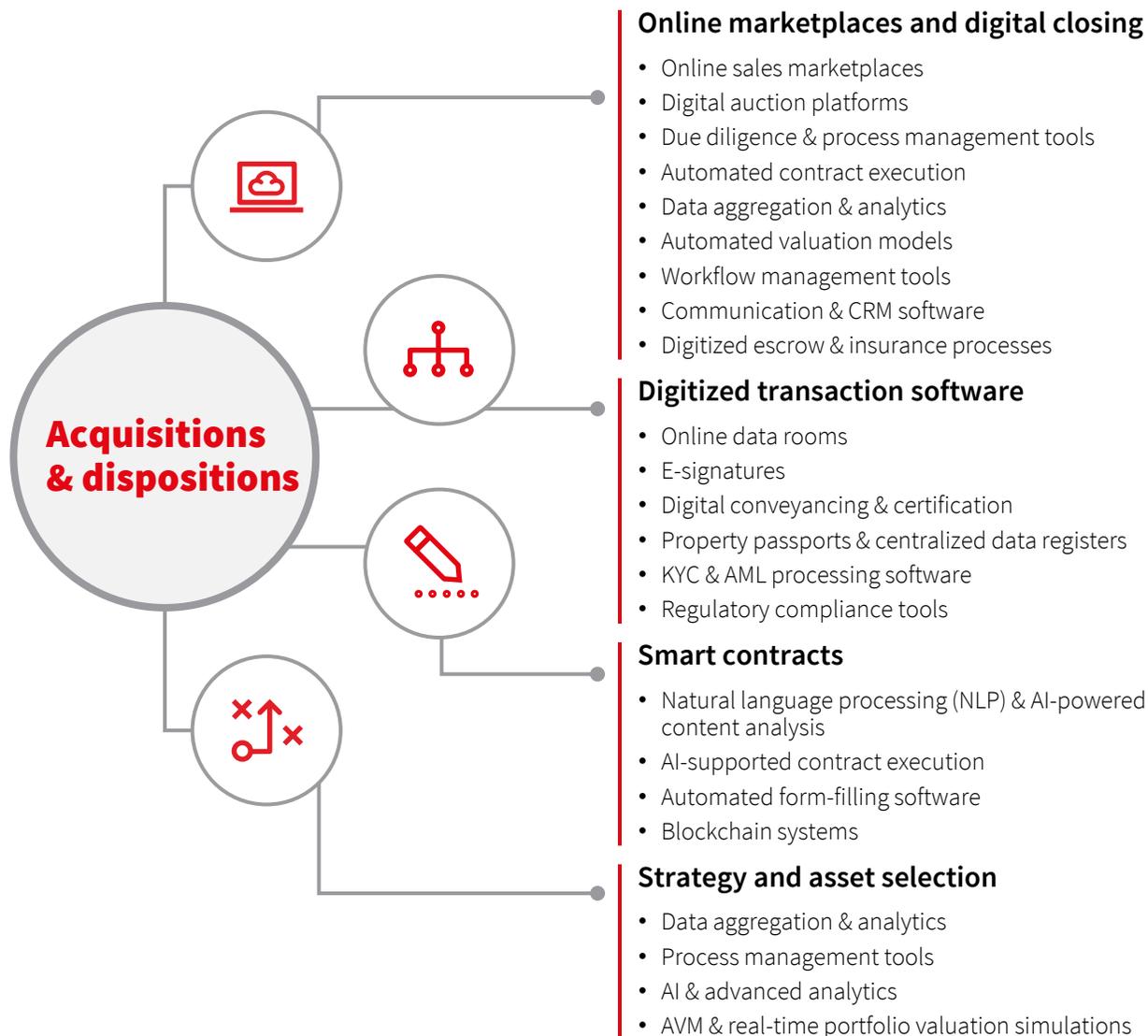


Acquisitions and dispositions

Pandemic accelerates the shift towards digitized transactions

The negotiation and closing processes are typically the lengthiest part of a real estate transaction, and where technology has so far made the least progress. This is partly due to the unique interpersonal nature of the bidding and negotiation process, while many of the technologies being trialed in the legal closing process, such as 'smart contracts' or blockchain automation, will require regulatory changes and broad-based industry acceptance before they are widely implemented.





Nonetheless, the tools are now available to significantly streamline and accelerate the transaction process, and the need to move large parts of the transaction process online, as COVID restrictions hindered more manual processes, has contributed to a number of changes that are only likely to expand.

- **Online marketplaces and digital closing:** Deal sourcing for commercial building acquisitions continues to be a predominantly analogue process, based on relationships and extensive marketing efforts. A number of online listings sites are now available, and the sector is consolidating as it grows (e.g., CoStar’s acquisition of Ten-X). However, most platforms are focused on the non-institutional market and on smaller-sized deals. It

remains difficult for investors to find a complete view of assets filtered for core criteria across sectors. The size and quality of the available listed assets, as well as the quality of information available, are key considerations to generate increased use of listings platforms. Some sites are now working to set up groups of prequalified buyers to speed up filtering and information exchange.

Some online auction systems have also been able to cut down on transaction times by requiring users to register relevant details in advance before bidding and by providing streamlined due diligence functionality. Sites like Aucspace provide summaries of legal documentation and

automated revisions and alerts if there are any changes, while some auction platforms such as Openn Negotiation and BidX1 offer registered users the ability to purchase land or property nearly instantly, with much of the due diligence and documentation registered in advance.

A number of the largest online residential marketplaces globally now offer ‘iBuying’ services, using their internal automated valuation models to price properties and provide sellers a rapid cash purchase where a potential increase in value has been identified. Digital closing services are also speeding up the execution process, in some cases offering end-to-end transaction and compliance management with live tracking of deal progress and automated form-filling and registration across a range of regulatory systems.

- **Digitized transaction software:** While comprehensive one-click solutions are still at an early stage, a number of tools are being used to digitize and speed up the transaction process and have seen demand increase over the last year, from collaboration and process platforms such as Dealpath to e-signature software. A number of regulators have also expanded their acceptance of legally valid online documentation certification and stamping for digital notarization providers. Digitizing the due diligence and closing process, in particular, through more widespread use of central platforms for connecting the agents involved in a transaction and storing all relevant documents has the potential to substantially streamline the transaction process. Versions of this have been tested in a number of countries but, with limited adoption, have so far failed to gain traction in many trials. There has been

more success in the residential sector. Australia’s PEXA is the only national-level platform currently in operation, partly due to the requirement for residential agents to switch to the system.

- **Smart contracts:** Natural Language Processing (NLP) and other techniques now allow relevant information to be extracted from legal documents and automatic form-filling to speed up the legal review process, but these systems still need additional work to be able to handle many of the bespoke contracts used for commercial buildings. The next stage of ‘smart contracts’, involving forms which are programmed to complete in sequence once digitally certified, has also been trialed utilizing blockchain technology for residential purchases in Sweden and the UK. JLL’s 2020 Global Real Estate Transparency Index identified an additional 31 jurisdictions where its use was being investigated by governments. However, without a regulatory system for blockchain transactions able to handle all of the complexities inherent in automated and immutable land registry systems, more widespread use is likely to be some way off.
- **Strategy and asset selection:** The increasing availability of large and alternative datasets and sophisticated modeling techniques means that investors able to take advantage of these tools stand to gain a significant advantage. Markets, submarkets and assets can now be benchmarked against information—such as nearby amenities, environmental quality, user satisfaction ratings and footfall patterns—to identify opportunities and target and underwrite them more efficiently.



Key considerations

- 1. Real estate capital markets are becoming more transparent.** The digitization of transactions and migration of opportunities to online marketplaces will support the accessibility of investment opportunities for investors. This shift will encourage market liquidity, and the perception of real estate as a ‘low risk, long-term hold’ will be adapted to meet the widening range of investment products available.
- 2. The influence of technology in the acquisition process will accelerate.** As investment markets become more digitally enabled, this will expand the availability and access to data to shape strategy and asset selection.
- 3. Deal execution can be improved with technology.** While commercial real estate transactions largely remain a manual process, embracing technology can improve deal flow, increase efficiencies in the closing process, and reduce the time to complete a transaction.



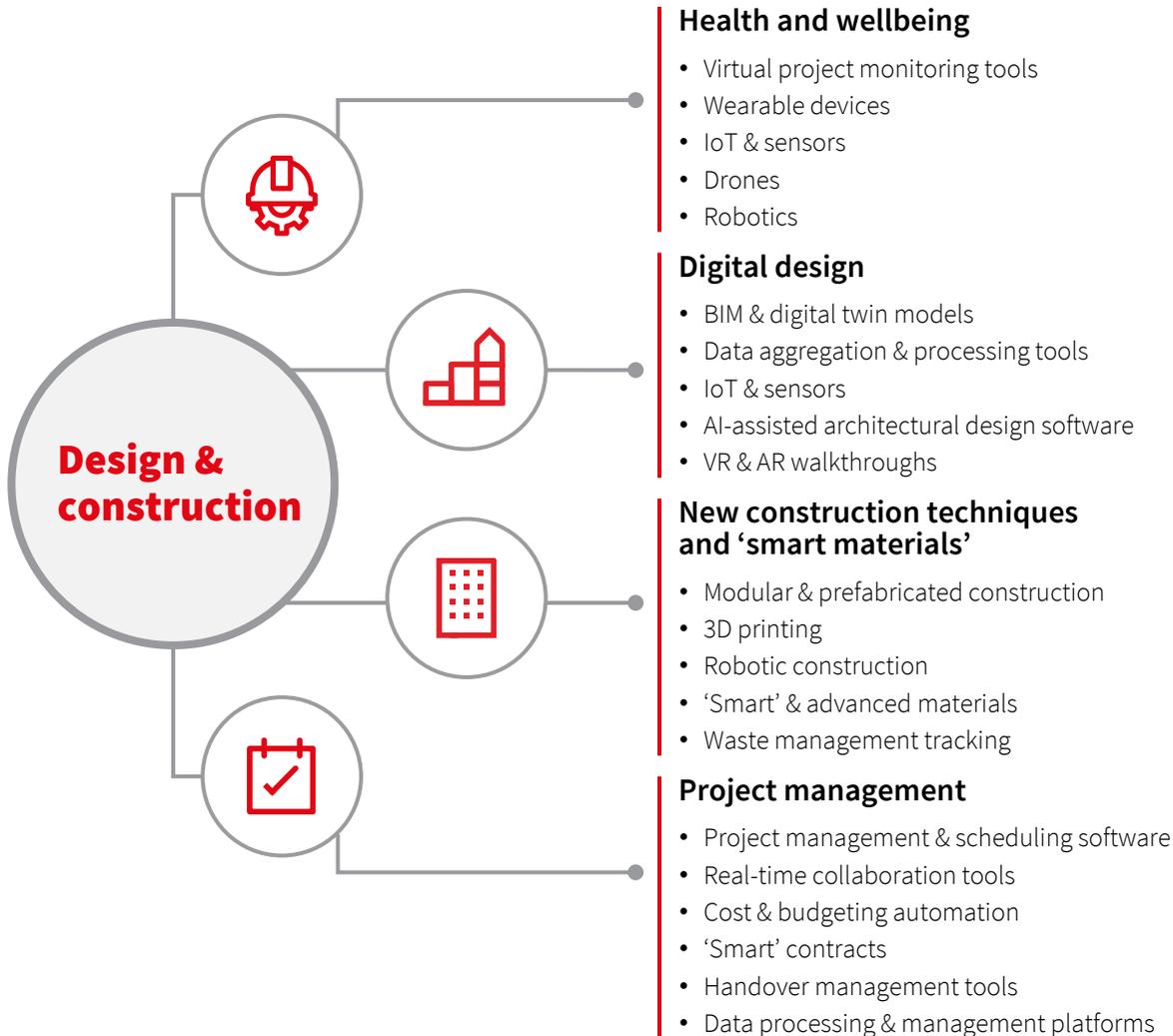
Design and construction

3D models show the future of sustainable design

Building design and construction lies at the center of several of the key factors shaping changes to the built environment, including:

- Climate change and resilience. With building materials and construction contributing around 11% of global carbon emissions, pressure is growing for the industry to contribute to lower-emission buildings and cities which are more resilient to anticipated climate impacts, with governments from the EU to Japan pushing for all new construction to be net-zero carbon by 2030.
- Health, social sustainability and wellbeing, with the pandemic highlighting the need for healthier, better designed and more human spaces.
- Demographic changes, as population aging in many advanced economies and continued urbanization lead to shifts in the amount and types of buildings and amenities needed.





Advances in the technology used in design and construction will be increasingly important in addressing these challenges as well as in how buildings are utilized and transacted.

- **Health and wellbeing:** Social distancing and limited number of on-site staff following the onset of the pandemic have contributed to greater adoption of technologies which facilitate virtual tracking of construction progress and health and safety, including scanning tools and drones for virtual walkthroughs and wearable monitoring devices to ensure the safety of staff. Even in a post-pandemic world, these technologies can help to reduce travel needs and integrate with long-term building management tools by providing a clear and accurate record of what is behind the walls of any project.
- **Digital design:** Advances in design software including Building information modeling (BIM)—creating digital replicas of buildings including 3D floorplans and utility infrastructure—or digital twins, which integrate real-time monitoring of conditions from sensors and other devices, enhance the ability to design more efficient buildings, reduce waste and increase resilience. These tools can be used to simulate building operations, fine-tune design features, check that construction meets design standards, and track performance even after the building is completed.
- **New construction techniques and ‘smart materials’:** Maturing construction techniques include modular or prefabricated construction which improve efficiency and drive cost savings by standardizing and producing building components off-site (in climate controlled

environments) and then fitting them together on-site. Prescient in the U.S., for example, is able to translate 3D BIM drawings into automated assembly instructions and produce structural components such as exterior wall panels and elevator shafts off-site. While modular construction is one of the more advanced construction innovations, a range of others are at an early stage of development including 3D printing, in which components or entire buildings can be created using large concrete printers, and the use of robotics for repetitive tasks like bricklaying or transporting equipment on-site. The use of ‘smart materials’ like self-healing concrete or climate-adaptive ‘smart glass’, which changes opacity to control the level of light and heat passing through, can also reduce emissions and capital expenditure requirements over the building life cycle. Leveraging the latest technologies in sustainable materials is an important component of responsible procurement, with methods of sequestering carbon in construction materials, for example, gaining in prominence.

- **Project management:** Workflow management software has been devised for almost every aspect of the construction process, from overall project management to cost estimates and communications tools such as Procore which facilitate real-time communication between on and off-site project teams and customers, as well as specifically for sustainability criteria—for example Green Badger, which helps contractors track and report on LEED compliance.

As the quantity of data produced on construction sites proliferates, a new suite of AI-based tools enables live efficiency tracking of existing construction techniques, and real-time suggestions to increase productivity. By wringing greater efficiency from existing methods, rather than a wholesale change to new processes such as modular construction, incremental change can be quickly achieved on projects today. A prime example is CraneView, which uses a predictive AI model and live alerts to increase tower crane efficiency.





Key considerations

- 1. A central integrated platform is critical to achieving the greatest value from a disparate collection of construction tech tools.** This often takes the form of a digital design model coupled with a project management platform, into which all other tools can connect.
- 2. In today's construction technology environment, virtual project monitoring tools have among the highest and fastest returns on investment.** By providing immediate tangible outputs that everyone on a project team can easily use in the form of virtual walkthroughs, they help build momentum for a rollout of construction technology tools that may have a more challenging adoption and longer cycle to maturity.
- 3. New construction techniques, like modular construction or 3D-printing, are by far the most difficult implementation to get right** and will demand support and specialized skills throughout the entire construction team. Although they require large upfront investment today, teams that develop the experience to execute them successfully will stand to benefit when overall adoption rises in the future.



Property and facilities operations

Managing flexible and personalized space

The shift towards greater user engagement and more intensive property management is gaining speed across asset classes, from the move to hybrid workplaces requiring more dynamic asset management for office users to interactive, personalized experiences in retail, to a greater focus on amenities and employee wellbeing in logistics.





Robotics and 'smart materials'

- 'Smart' materials & facilities
- Autonomous & remote-controlled maintenance robotics
- Automated & robotic packaging systems

Performance tracking

- Building connectivity & digital infrastructure
- IoT devices & workplace sensors
- Building analytics & reporting platforms

Automated and predictive management

- Automated & predictive management systems
- Remote, cloud-based HVAC and IT controls
- BIM & digital twin simulations
- Cybersecurity systems
- Automated inventory tracking & management

Tenant and user engagement

- Employee engagement & communication apps
- Real-time booking & scheduling tools
- Touchless access control
- Automated workplace assistance systems & concierge services
- Personalized space management
- Interactive VR displays & personalized ads
- Self-checkout & POS systems

Requirements to track sustainability and health metrics are also putting more pressure on facilities management, exacerbated by cost pressures and the need to perform remotely during the pandemic.

- **Robotics and 'smart materials':** The pandemic has resulted in a greater use of 'smart' or health-focused facilities within buildings such as ultraviolet light sources for disinfecting spaces, while autonomous cleaning robots have also been trialed in a number of locations. Logistics facilities are also becoming far more operationally focused, with a stronger spotlight on staff wellbeing leading to more on-site amenities. The increasing use of automation and robotics within the order-fulfillment process also means warehouse facilities require new levels of technology support and security.
- **Performance tracking:** Hybrid-enabled workplaces will require more flexible and

dynamic management than in the past. Greater use of collaboration space, for instance, will necessitate more frequent cleaning and different maintenance procedures. Investing in IoT devices and sensors to monitor everything from occupancy levels to equipment usage can help to ensure smooth operations and drive savings. Environmental and health metrics have emerged as key measures of building performance, but many building analytics tools remain difficult to integrate with legacy systems and offer limited flexibility, automation or reporting capabilities. Effective FM solutions include comprehensive platforms that connect systems, sensors and assets as a single source of truth, with some platforms such as Corrigo now providing services compatible with a wide range of legacy systems and able to automate the reporting process.

- **Automated and predictive management:** Advanced analysis techniques incorporating real-

time tracking of system performance and machine-learning can now automate some management tasks, and even provide predictive functions such as notifications of unusual activity or alerts when conditions are likely to lead to systems failure. Fully integrated BIM or digital twin models can take this a step further and provide whole-building analytics and simulations in real time; however, they are operationally intensive and require significant investment to manage.

- Tenant and user engagement:** Tenant experience and feedback apps are becoming increasingly prevalent in office and multifamily management, enabling users to have the ability to contact management directly or report issues. For office users, mobile apps can permit technicians to access work orders, while on-site or remotely, and make it easier for employees to submit work orders as well. In retail, user engagement is emerging as a key feature of ensuring a seamless omnichannel experience. Online 3D replicas of malls allowed some shopping centers to continue selling goods remotely during the pandemic, while interactive or immersive virtual reality displays within retail locations now cater to the need for enhanced experience. Linking users to their online store accounts or anonymized tracking through a retail space allows for personalized ads or promotions to be displayed, while shelf-tracking technologies facilitate real-time or automated restocking and even checkout, with Amazon's Go stores one of the early examples of a near completely automated shopping experience.

Key considerations

1. Identify technology that generates actionable data.

With the stakes so high, it is critical to invest in tech that delivers strong ROI and helps inform decisions and lowers costs. Shorten response times and reduce downtime by putting data to work in your FM program to see opportunities for improvement; separate the hype from reality and focus on tech that will have a useful, measurable impact on operational performance.

It is also imperative that your FM software is user-friendly. If people who interact with your FM software have to expend a great deal of effort to report a problem, going to multiple apps or portals to resolve their issue, they are less likely to report it at all. And your team will miss out on valuable insights. Make sure that it is straightforward and simple for people to use your FM technology—the worse the user experience, the worse (and less) data you will get. Having the right technical skills in the right teams is also essential to ensure that your data is analyzed and communicated effectively in order to drive tangible improvements.

2. Choose technologies that enable remote work.

Choose solutions and devices that do not require you to be in a dedicated location—internet-connected smart sensors and cameras, temperature controls and other devices that connect to the cloud, and mobile FM apps that help you to submit, access and complete work orders from anywhere.

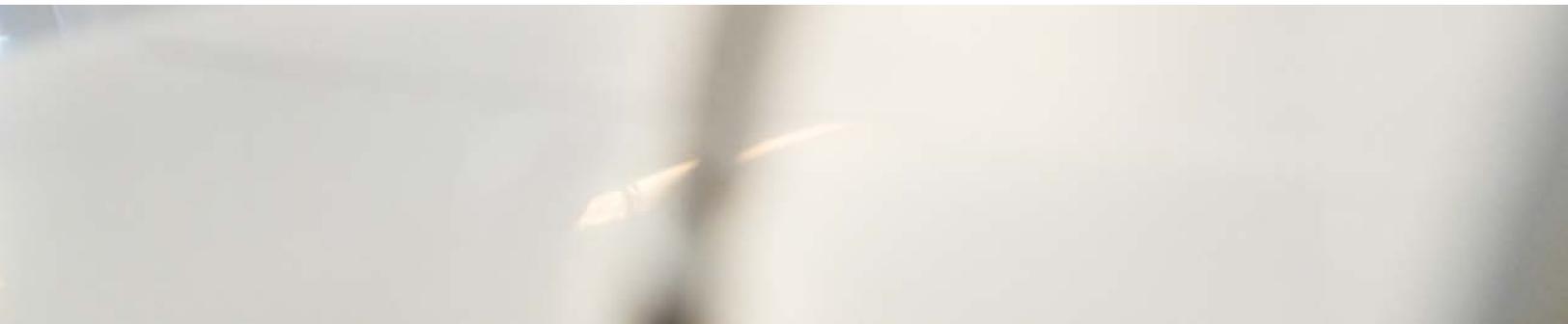
3. Find technology that keeps stakeholders empowered and informed.

Stakeholders, your management teams, the business' leadership and building occupants want information to make key decisions, such as whether to work in the office or remotely, or deciding if an area is safe to use after it has been cleaned and sanitized. You will need a strategy to keep everyone involved apprised of the latest developments. Opt for technological solutions that offer distribution lists, notifications and mobile apps that are easy to use and understand—so that everyone who is in the know can swiftly inform everyone who needs to know.



Leasing and marketing

Commercial real estate for-sale and leasing marketplaces have been slower to develop than residential listings platforms, with the added complexity of large commercial buildings and transactions holding back progress. Many existing platforms are focused on smaller, less complex transactions or specific asset classes, with significant changes needed to meet the requirements of large institutional clients.





Marketing and analytics tools

- Integrated CRM & communication tools
- Digital marketing
- VR/AR tours & site inspections
- Virtual data rooms
- Data aggregation & analytics
- Marketing impact & review management

Online marketplaces

- Online listings sites
- Integrated marketplaces & deal tracking tools
- Online brokerage solutions
- KYC & AML tracking

Digital leasing solutions

- Lease management software
- Leasing data aggregation & reporting
- AI-enabled contract automation
- E-signatures
- CRM & counterparty communication tools
- Workflow digitization software

Shared service platforms

- Online marketplaces
- Flex space design & layout tools
- Integrated high-frequency FM software
- Specialized accounting & reporting solutions
- Visitor management tools
- Space & occupancy analytics
- Marketing & CRM platforms

However, this is changing as the sector consolidates, gains scale and branches out into new areas, and as digital marketing techniques—from advanced analytics to data rooms and CRM tools—allow for more focused engagement with potential clients. Numerous existing solutions remain focused on specific aspects of the marketing or leasing process, offering significant scope to further compress deal times, improve visibility of marketing effectiveness and increase client engagement.

- **Marketing and analytics tools:** Digital marketing tools are also decreasing the time and effort needed to market commercial properties. Advanced CRM tools and analytics now allow sellers and brokers to more accurately identify

and target potentially interested investors or tenants in real time for more focused marketing campaigns. Once deals are in process, online data rooms permit relevant information to be shared privately, while virtual viewings based on immersive AR/VR and drone technologies let interested parties assess buildings remotely.

- **Online marketplaces:** Online residential leasing marketplaces are now well-established in many markets but are beginning to gain traction across other sectors, with the difficulty of in-person marketing and touring during the pandemic adding impetus. Tools such as LoopNet, VTS Marketplace, CREXi, TenantBase and many others enable tenants to search, view and share listings,

while also allowing landlords to integrate listings and marketing content with lease management solutions or match space with prequalified tenants.

- Digital leasing solutions:** Lease management tools can significantly streamline the listing and leasing process, as brokers and agents increasingly shift from paper and manual to digital approaches to shorten deal times. The market for these solutions is currently dominated by a few major providers, but owners and tenants still face issues ranging from lengthy deal times and fragmented back-office processes to limited tools for tenant relationship management or insights into the effectiveness of marketing in driving leads. There are still few solutions covering the entire leasing management process; however, a number of providers are now offering services such as ‘crowdsourced’ leasing data provision or AI-enabled contract execution tools, while tools like Azara gather and centralize leasing information across cities around the world, allowing firms to proactively manage lease events and transactions.

Increasing demand for flex space has also required specialized software to deal with high-

frequency tenant turnover and real-time space tracking and booking. Several of the larger flex space providers have developed their own in-house management tools, while specialists such as Essensys provide dedicated flex space and lease management software allowing landlords to quickly establish and manage flex space offerings.

- Shared service platforms:** The number of listings sites specifically catering for ‘shared service’ offerings like hospitality, coworking and co-living has increased rapidly in recent years. This growth has given way to a period of consolidation in some countries following the onset of the pandemic. Coworking providers, in particular, came under pressure from work-from-home policies, but the shift towards greater flexibility and customer choice across real estate sectors means shared service provisions are likely to continue to expand and become more institutionalized in the future. Airbnb is among the best-known examples, but listings sites for coworking or other types of flexible space are now available in almost every country and cater for nearly any type of requirement, from co-living accommodations to pop-up shops.





Key considerations

- 1. Tenant expectations for seamless and personalized experiences are evolving.** The greater reliance on virtual touring during the pandemic has accelerated demands for more personal and transparent marketing and tenant management, and being able to proactively track and engage with tenants and prospects will be increasingly important as real estate becomes more operationally intensive.
- 2. Focus on data and process integration.** Online marketplaces and digital leasing solutions offer significant scope to improve conversion rates, shorten deal times and increase efficiencies, but many landlords currently face a lack of information and visibility into leasing pipelines and in-progress deals. Integrating fragmented systems and processes is key to leveraging the potential of lease management tools, yet requires a focus on comprehensive, end-to-end software that can increase transparency and automate manual tasks rather than provide stopgap solutions.
- 3. Employees and consumers increasingly seek fluid living and working situations.** The pandemic has upended established routines, placing a greater emphasis on flexibility, ease of use and convenience. Platforms supporting new models of flexible space provision and shared co-living and coworking space are set to benefit.

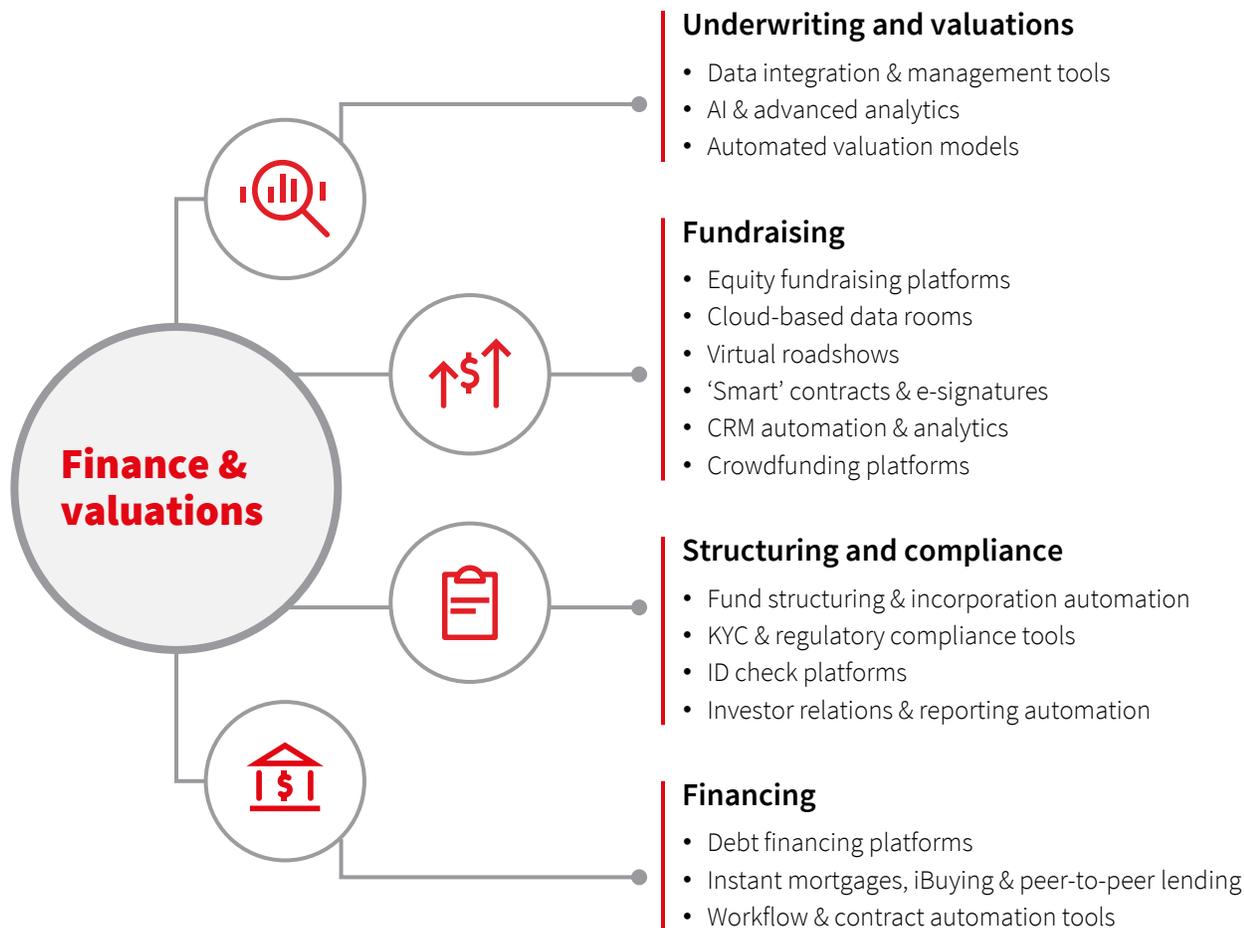


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Finance and valuations

COVID-19 has triggered immediate pressures in how investors source capital and finance assets, as travel restrictions, in particular, have hindered mobility. A host of supporting technologies—from data rooms to regulatory support software to automated valuation models—are now available to facilitate digital processes across the funding, financing and valuations landscape, although many of these remain in the early stages of adoption by the industry.





Looking ahead, technology is supporting underwriting and enabling alternative financing options which hold the possibility of increasing access to the sector and to market liquidity, from crowdfunding to fractional ownership and tokenization.

- **Underwriting and valuations:** Sophisticated valuation models have quickly made progress in the mass-market residential markets in recent years, with significant volumes of transactions and supplementary data allowing for fine-tuning of AI valuation techniques. These are being used increasingly by online listings sites, some of which now have ‘iBuying’ services that offer to purchase homes at their automated valuation price for resale. The heterogeneity of commercial assets mean that automated valuation models (AVM) have made less progress, but a number of platforms and providers such as GeoPhy now offer AVMs for commercial assets. These sorts of models are integrating new types of data,

from local amenities to transport services, ESG accreditation and occupant satisfaction ratings to supplement and enhance the analysis, offering the potential for automatic updating of portfolio valuations in real time. Integrating these ‘big data’ benchmarks with real estate market and in-house portfolio data has the potential to provide significant gains in underwriting efficiency, accuracy and strategy formation. However, it is also a time-consuming and complex process and many providers offer limited ability to customize methodologies.

- **Fundraising:** Capital-raising platforms such as LendInvest bring together funds or operators with potential investors, speeding up the process through filtering and analytics capabilities to better identify potential matches for private investors, in particular. Once a potential funding is under discussion, sensitive documents can be shared and tracked in online data rooms, while

regulatory requirements such as KYC (know your customer) or AML (Anti-money laundering) checks can be expedited with the use of ID platforms that store investor details or provide full process management including step-by-step regulatory checklists by jurisdiction.

Crowdfunding peer-to-peer lending platforms are opening up the possibility of wider participation in real estate funding, from smaller institutions and individuals. Cadre, for example, offers investors the ability to participate in crowd-funded transactions which are then managed by the company. On the horizon, efforts to increase secondary market liquidity through tokenization or fractional ownership are being trialed, but in many countries the regulatory system to effectively support these types of initiatives is still lacking. The more recent re-emergence of single-asset REITs reflects an additional structure for accessing liquidity.

- **Structuring and compliance:** Compliance and regulatory checks continue to be a highly manual process for most funds, but potentially offer significant scope for automation. Investor relations and reporting tools can now automate some aspects of the client onboarding and

reporting process through digital identity-checking software or report generation. However, highly disparate regulatory requirements and the lack of a standardized system for KYC/AML checks for example, mean that many processes are still time-consuming.

- **Financing:** Online debt and mortgage origination providers for the residential market have flourished in recent years, offering different types of solutions from down-payment security to instant mortgages to home-equity lines of credit. However, debt financing for the larger and more complex deals typical in commercial real estate remains a largely interpersonal process involving a considerable number of stakeholders and processes. The share of lending by alternative, non-bank sources has increased substantially since the Global Financial Crisis as regulatory requirements have constrained lending from banks, opening up opportunities for new sources of funding across the value stack. Some platforms such as RealAtom are working to eliminate manual processes and speed up timelines by capturing relevant deal information, auto-uploading lending criteria and automating workflows.





Key considerations

- 1. Technology is expanding market liquidity.** Liquidity is experiencing a secular expansion as the commercial real estate investment markets become more accessible. New sources of capital for debt and equity are emerging through evolving technology products and structures, introducing a host of new market participants, including retail investors, into the financing market. This will support the accessibility of commercial and residential investment opportunities to more sources of private capital as well as benefitting managers who have the capacity to utilize new financing tools and models.
- 2. Transparency will benefit operational efficiency and strategic decision-making.** Growing transparency and the introduction of automated underwriting and valuation technologies are increasing operational efficiency and allowing investors to become more targeted. This will enable investors who are able to implement an integrated data and technology strategy to work smarter across a greater set of opportunities in more markets and allow for deeper analysis and understanding of current market dynamics.
- 3. The spectrum of accessible product will evolve as the market matures.** Improved transparency and liquidity will benefit alternative sectors and more operationally intensive assets for non-institutional investors, in particular, who have historically lacked access to the necessary depth of data and market intelligence.

The global proptech landscape

Sizing the market and key geographies

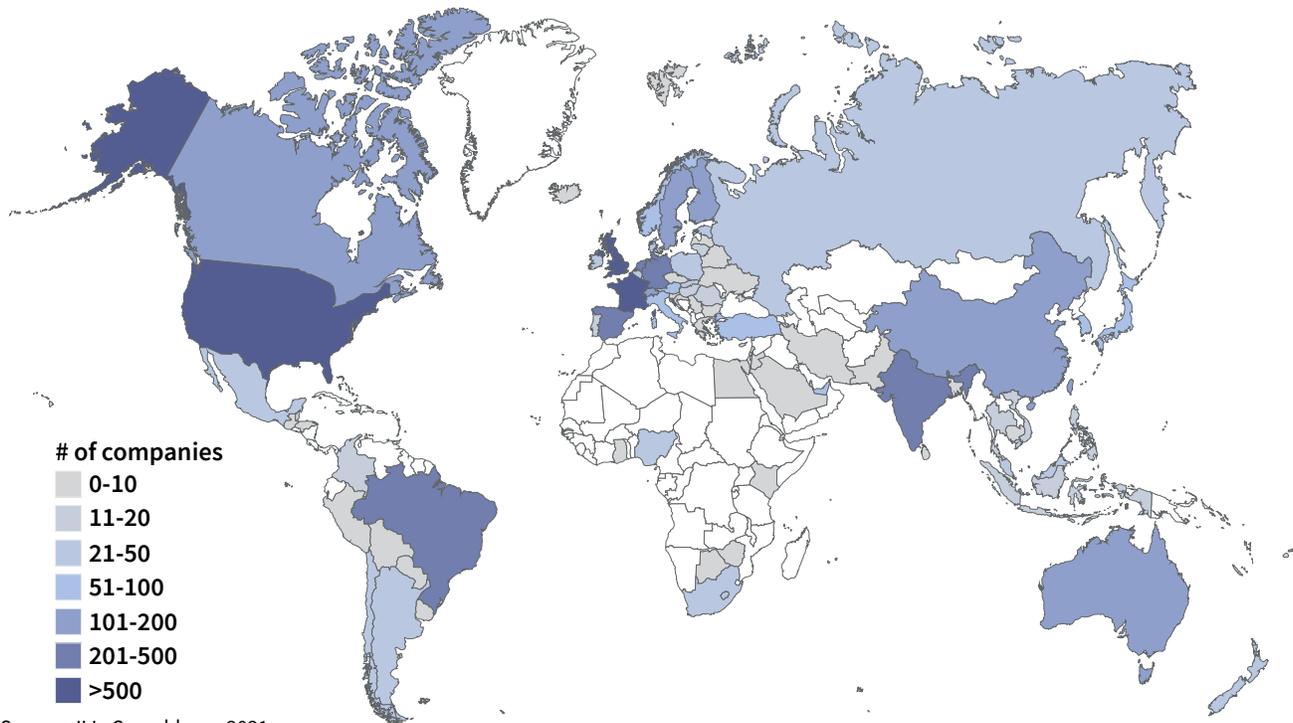
The number of companies providing technology-based services across the real estate industry and built environment has expanded dramatically over the last decade, increasing by over 300% since 2010, while venture capital and other funding has also risen significantly. However, it remains a relatively young technology ecosystem, with around three-quarters of these companies founded in the last 10 years.

The number of relevant companies varies widely depending on definitions, but JLL has identified over 7,800 providing technology solutions in various parts of the built environment, which have collectively raised over US\$97 billion of equity funding in the 10 years to H1 2021.

As the technologies being used become more widely embedded and the industry matures, consolidation and in-house investment by established property companies has meant the number of new startups being founded has slowed over the last five years. At the same time, funding to the sector and the number of companies being funded continue to be at elevated levels, driven by a variety of capital sources.

“...JLL has identified over 7,800 (companies) providing technology solutions in various parts of the built environment...”

Key geographies | Proptech companies by country



Source: JLL, Crunchbase, 2021

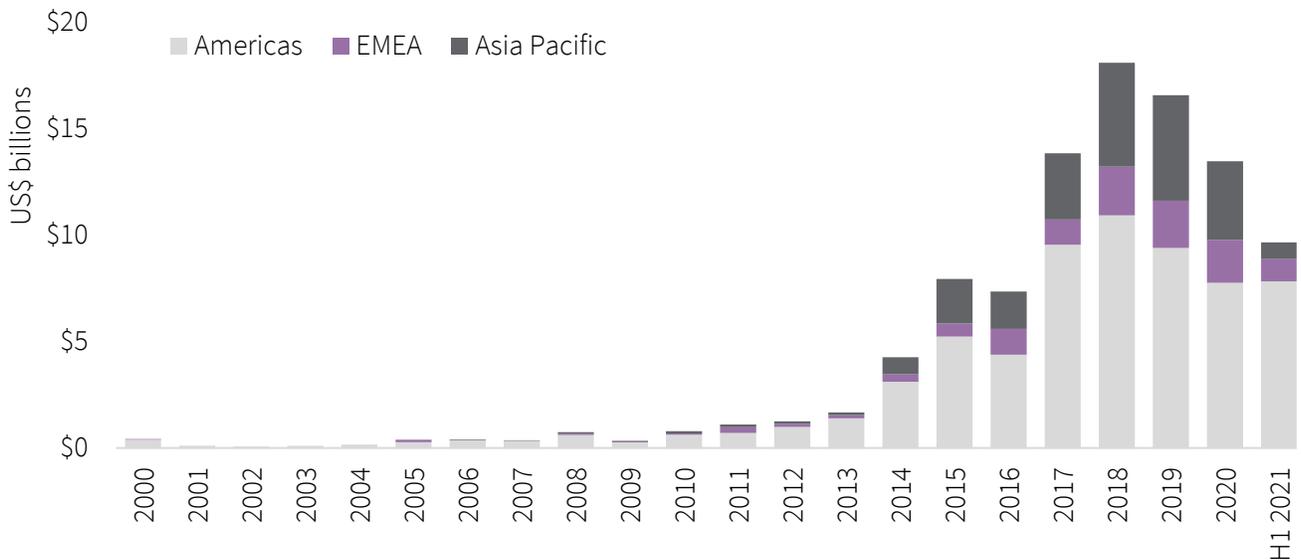
Built environment technology startups can now be found in most countries around the world, and many of the more established companies in the sector now have global operations and customer bases either through direct expansion or acquisitions, with inter-regional M&A activity in the sector rising to a new high of US\$7.6 billion in 2020, representing over one-third of total M&A volumes.

However, in keeping with the wider tech ecosystem, the U.S. continues to account for the majority of company conceptions and fundraising and is home

to over 50% of funded companies over the last decade. China has significantly fewer companies but is the next largest market in terms of funding with over US\$16 billion raised since 2010.

A number of Western European and other major Asia Pacific countries also have clusters of startups. In Europe, the UK and Germany make up the majority of fundraising across the region followed by France, Spain and Sweden. India, Singapore and Australia have been the principal markets for fundraising outside China in Asia Pacific.

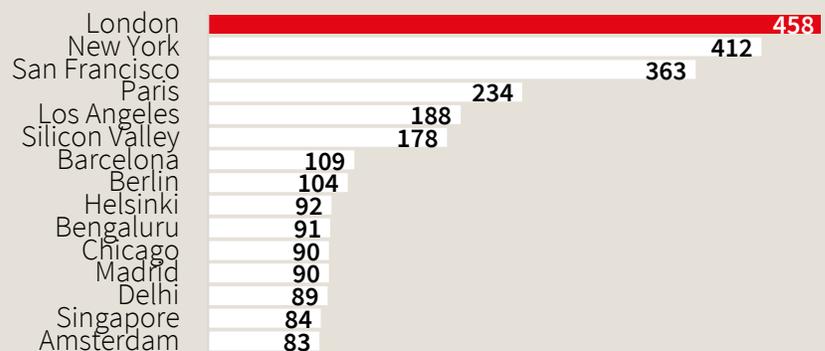
Annual funding by region



Source: JLL, Crunchbase, 2021

The cities hosting the greatest number of property technology startups are among the most-established tech ecosystems in each region, including New York, San Francisco and Silicon Valley in the U.S.; London, Paris and Berlin in Europe; and Beijing, Singapore and Sydney in Asia Pacific. Delhi and Bengaluru also feature among the top set, primarily due to a large number of listings sites and shared service providers.

Number of proptech companies, top 15 cities

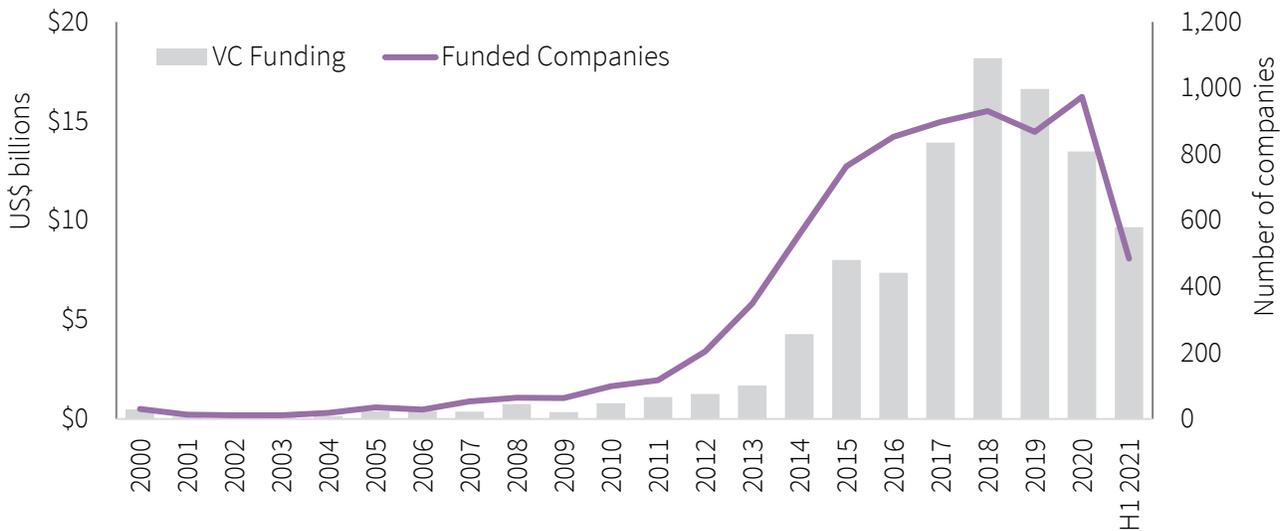


Source: JLL, Crunchbase, 2021

Venture capital funding and post-COVID trends

The pandemic has accelerated many companies' engagement with new technologies, while simultaneously impacting the funding for early-stage companies in the sector. Venture capital equity funding to build environment technology slowed in 2020 to US\$13.4 billion, down from US\$16.6 billion the previous year. However, investment has accelerated in 2021 with H1 funding activity of US\$9.7 billion, up from US\$8.8 billion in H1 2020 and the most active first half on record.

Venture Capital (VC) investment & number of companies funded



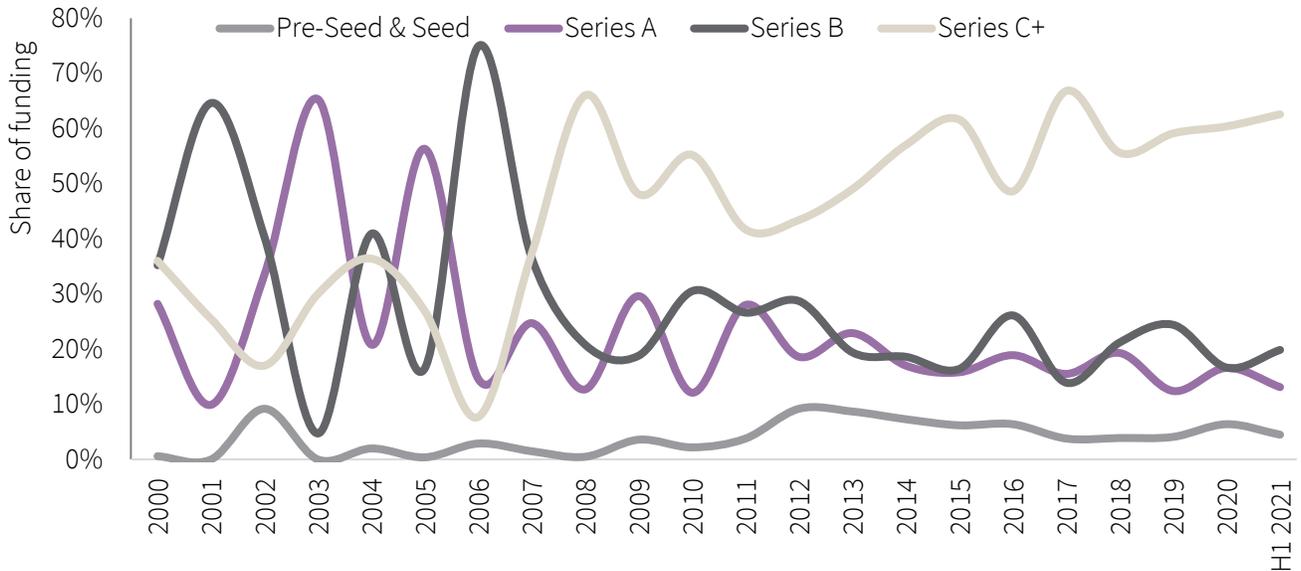
Source: JLL, Crunchbase, 2021



As the sector matures, funding is migrating towards more established companies, with the majority of capital invested in later-stage funding rounds and in products with strong adoption post-COVID. A maturing market and significant available capital from funding raised in recent years are contributing

to greater consolidation in the sector, with M&A activity at a record high of US\$21.9 billion in 2020 and already above US\$18 billion so far in 2021. IPO activity has also been elevated with several large listings over the last two years including Airbnb, Opendoor, Vivint Smart Home, Lemonade and Beike.

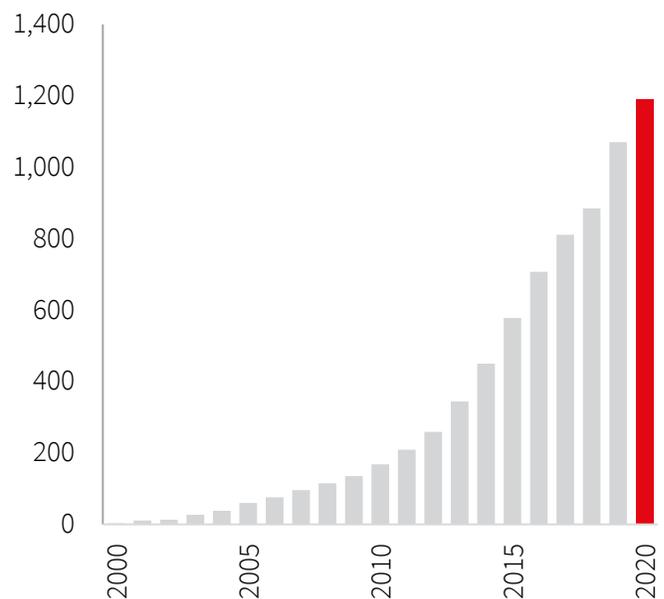
Venture capital funding continues to shift towards later-stage companies



Source: JLL, Crunchbase, 2021

Themes which have been accelerated by the pandemic—including the growing focus on ESG considerations—have also been evident over recent months. With an increasing need for technologies centered around environmental and social sustainability considerations, corporate and venture capital (VC) investment into technologies for tracking and managing health-related metrics and emissions performance has continued to grow, while a number of VC funds have set specific criteria or announced funds targeting these technologies. Company formations and funding for design and construction-focused startups have gathered pace at the same time, as environmental considerations push the need for new construction techniques and materials and higher energy efficiency. The requirement for remote operations during the pandemic has also increased the pace of adoption for project management and virtual inspection tools.

Cumulative contech companies founded



Source: JLL, Crunchbase, 2021

Outlook: The challenges and opportunities

A maturing technology ecosystem

COVID-19 is providing an opportunity to experiment and accelerate technology adoption across the real estate industry, with the potential to make built environments, workplaces, homes and cities more sustainable, healthier and human-centric. A range of issues—many common to other industries in the early phases of technology adoption—are slowing progress:

- **Implementation and integration:** Adopting new technologies and processes and ensuring that these align with long-term goals and strategy can be complex and time-consuming. Many companies and governments remain at a relatively early stage in understanding and developing a framework to respond to the new landscape provided by technology, which can be compounded by a lack of qualified staff to implement new solutions.
- **Fragmented technology landscape:** The heterogenous nature of the built environment means that standardized technologies appropriate across building types and applications are difficult to develop, while many solutions continue to have use-cases limited to a few specific problems or extensive competition, with few dominant market leaders. This results in a highly fragmented industry landscape, making it difficult for companies to find the best solution or provider for their needs, and slower and longer decision times as a consequence.
- **Lack of industry standards:** The fragmented industry landscape and rapid pace of technological capacity across the sector has resulted in a dearth of industry standards across a range of core issues from data collection and processing to software design—for example, many BIM developers have proprietary programs with limited interoperability. Some progress is being made here with the International Organization for Standardization launching new international BIM reference standards in 2019. However, greater standardization and interoperability of data and systems will be necessary for the full potential of many technologies to be realized.
- **Privacy and security:** The requisite strategy, skills and technologies for maintaining security continue to be at a relatively early stage of development across the industry, while the amount of data being generated is set to expand rapidly. This has implications for all data-driven technologies, from data collection and



integration software to IoT sensors to ownership and liability issues for 3D printing or CAD files. The advent of more advanced AI systems—particularly where these are public-facing around FM operations or customer interaction—also requires a high degree of trust which will be crucial to widespread acceptance and adoption.

- **Rapidly evolving regulatory systems:** The growing divergence in technology regulatory ecosystems has the potential to further fracture the proptech landscape between companies and technologies adhering to different regulatory standards or a required duplication in development to satisfy the criteria of multiple regulators. Operating models are also coming under increasing scrutiny in a number of jurisdictions, particularly for ‘large gatekeeper platforms’.
- **Overly narrow technical focus:** At the urban governance level, trust, transparency and consultation are critical to ensuring technology solutions are adopted and understood by individuals as well as governments. Notable recent examples of cancellations of ‘smart city’ projects or ‘big data’ projects, such as mobile phone records to investigate travel patterns, have highlighted the need for technology companies and governments to first take into account wider social and cultural considerations before focusing on narrow technical solutions.

Responding to these challenges to create sustainable solutions that harness the full potential of the rapidly expanding technologies available will necessitate greater cooperation and collaboration between technology firms, property companies and the industries they service, as well as national and urban governments.



Sustainability and responsible real estate shaping the future

The future of built environment technology will be driven by some of the key structural themes shaping the world today, including the need for lower-carbon and more resilient cities; supporting the health and wellbeing of citizens and workforces; and evolving demographics and consumer preferences which will require the ability to manage these changes at both the building and city level.

COVID-19 has accelerated a number of these trends, including safety, remote working, process digitization and automation and sustainability, and is pushing companies to experiment with new solutions. Taking advantage of developments in IoT connectivity and AI over the past several years, technologies which enable automation, respond to the real needs of businesses and governments with demonstrable improvements, and can integrate with existing systems or replace them with end-to-end solutions are best-positioned to become established.

Several of these themes will continue to evolve and shape the future of how technology interacts with the built environment:

- **Data, analytics and automation:** Data underpins technology platforms, but much of it remains unstructured and unusable at present, so enterprise architecture and end-to-end integration will become increasingly important areas of focus, with many companies currently concentrating on single use-cases. Automation enabled by data and analytics will drive process improvements across the real estate industry, from back-office paperwork to fund structuring

to portfolio strategy and even construction techniques. Automation tools are crucial to improving current processes and facilitating expansion into new areas of operation; for example, tools allowing investors to structure and manage single-family rental portfolios.

The massive increase in data collection made possible by new technologies will also demand significantly enhanced cybersecurity, privacy and transparency capabilities from both companies and governments.

- **Sustainability and wellbeing:** The focus on how the built environment can contribute to lowering carbon emissions and making cities more resilient is growing. New regulations are increasingly coming into force relating to both new construction—for instance, the EU's Energy Performance of Buildings Directive, requiring all new buildings to be nearly zero-energy—and existing stock, such as New York City's Climate Mobilization Act, which mandates carbon reduction targets for all buildings larger than 25,000 feet. These goals will require a significant shift in technology adoption spanning the full spectrum of the industry from urban planning to building design, new construction techniques and advanced energy performance management.

The pandemic has also highlighted the impact of the built environment on health and wellbeing, from ensuring buildings are clean and have suitable filtration to the impact that design can have on subjective wellbeing and productivity, and in providing access to inclusive spaces and

services. This is leading to a need to rethink how design and functionality can support users' health and will require stronger understanding and communication between designers, owners and users of buildings, as well as a greater ability to track health metrics and provide more tailored experiences.

- **Engagement, personalization and experience:** As institutional real estate shifts increasingly to a service-oriented model focused on user experience, technologies that support tenant and customer engagement and personalization—from office customization apps and retailer consumer engagement to 3D visualizations and residential tenant services—will be crucial in meeting expectations and maintaining performance.
- **Infrastructure and design:** Advanced design techniques, such as BIM, are still at an early stage of development but have the potential to radically improve the functionality and longevity of buildings as they mature and common standards are developed. Combining advanced design techniques with urban planning and 'smart city' infrastructure, as the technology for digitally connecting buildings with the wider urban fabric evolves, also holds significant promise for improving how cities are planned and managed, especially around climate impacts and resilience.





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