The Economist INTELLIGENCE UNIT

The critical role of infrastructure for the Sustainable Development Goals

SUPPORTED BY

UNOPS

CONTENTS

ABOUT THIS ESSAY

The critical role of infrastructure for the Sustainable Development Goals is an essay written by The Economist Intelligence Unit and supported by UNOPS, the UN organisation with a core mandate for infrastructure. The research uses three pillars—the economy, the environment and wider society—as well as the overarching theme of resilience through which to assess the role of infrastructure in meeting global social and environmental goals.

The Economist Intelligence Unit wishes to thank the following experts, who kindly agreed to participate in the interview programme for this essay:

- Marianne Fay, chief economist for climate change, World Bank
- Jim Hall, director and professor of climate and environmental risks, Environmental Change Institute, University of Oxford
- Mark Harvey, head of profession (infrastructure), UK Department for International Development
- Morgan Landy, senior director of global infrastructure and natural resources, International Finance Corporation
- Virginie Marchal, senior policy analyst, Environment Directorate, OECD
- Jo da Silva, founder and director, International Development, Arup
- Graham Watkins, principal environmental specialist, Inter-American Development Bank

This report was written by Sarah Murray and edited by Martin Koehring of The Economist Intelligence Unit.

EXECUTIVE SUMMARY

Infrastructure is crucial for development. From transport systems to power-generation facilities and water and sanitation networks, it provides the services that enable society to function and economies to thrive. This puts infrastructure at the very heart of efforts to meet the Sustainable Development Goals (SDGs). Encompassing everything from health and education for all to access to energy, clean water and sanitation, most of the SDGs imply improvements in infrastructure.

As we argue in this essay, infrastructure plays a key role in all three dimensions of sustainable development: the economy, the environment and society. And now, as the world seeks to meet ambitious targets, such as the SDGs (as set out in the global Agenda 2030) and the Paris Agreement on climate change, infrastructure is becoming more widely recognised.

Infrastructure should not be viewed as individual assets, such as a power plant, a hospital or a water network, but as part of a system with a portfolio of assets that collectively hold great potential to deliver the three pillars of the SDGs: economic, environmental and social sustainability.

When it comes to the **economy**, infrastructure dividends range from the jobs created during construction and maintenance to the ability for infrastructure to generate economic activity (such as a bridge that links a rural village to urban markets). By connecting communities to cities, education and employment, infrastructure such as transportation and telecommunications underpins national economic goals. In fact, increasing investment in line with economic needs could add about 0.6% to global GDP, according to the McKinsey Global Institute. It suggests the effect could be more pronounced in larger countries that currently have infrastructure gaps (in the US, it puts the figure at about 1.3%, and in Brazil at 1.5%).[1]

In protecting the **environment**, infrastructure assets play a key role in conserving natural resources and reducing the impact of climate change. Clean energy generation plants, for example, are critical in reducing dependence on fossil fuels. By taking cars off roads, mass transit systems contribute to the reduction in pollution and generation of greenhouse gases. In the US, estimates are that if someone commuting 20 miles a day switches from driving to public transportation, it would lower their carbon footprint by 4,800 pounds annually.[2]

When equitable access is assured, **society** benefits from infrastructure since it delivers the services (such as power supplies, healthcare services and sewerage networks) that are essential for sustainable development. Whether by providing the public transport that makes it easier for women in rural areas to participate in the workforce or the clean water and sanitation that reduce maternal mortality, infrastructure also advances gender equality. "When systems and projects are being conceived of, that's where critical consideration of needs—who needs what from infrastructure and who gets it—and the equity dimensions of infrastructure come in," says Jim Hall, professor of climate and environmental risk at the University of Oxford.

[1] McKinsey Global Institute, *Bridging global infrastructure gaps*, June 2016, https://www.un.org/pga/71/wp-content/uploads/sites/40/2017/06/Bridging-Global-Infrastructure-Gaps-Full-report-June-2016.pdf

[2] Center for Climate and Energy Solutions, Reducing Your Transportation Footprint, https://www.c2es.org/content/reducing-your-transportation-footprint/

Meanwhile, one of infrastructure's most important roles—increasing **resilience**—runs across all three of these pillars. First, the infrastructure must itself be resilient to the shocks and stresses it will encounter. This in turn enables it to make an essential contribution to sustainable development and overall societal resilience by ensuring that the vital services infrastructure provides are less vulnerable to extreme events and disruptions.

"In the end, what people care about are services," says Marianne Fay, chief economist for climate change at the World Bank. "We look at infrastructure primarily from the point of view of providing services to people. That's the end goal, and the hope is that we can do that in a way that will be resilient and sustainable in all three dimensions of sustainability: economic, environmental and social."

What emerges from our study is that while the economic, environmental and social dividends of infrastructure are considerable, tough challenges—from governance weaknesses to financing gaps—make it difficult for countries to meet the rapidly growing demand for infrastructure. Added to this are the challenges of siloed approaches, both within government and between sectors and different parts of the infrastructure ecosystem.

What our research reveals is that sustainable infrastructure can only be delivered when all three pillars—economic, environmental and social—are considered together, while also ensuring infrastructure services are resilient and can be equitably accessed. Moreover, all stakeholders have to collaborate in planning, design, delivery and management.

Finally, infrastructure should be seen not as an end in itself but a means of delivering essential services. "We need to make a shift to thinking about infrastructure as what it *does*—protects, connects or provides essential services—not what it *is*," says Jo da Silva, founder and director, International Development, at engineering consultancy Arup. "It is infrastructure that is brokering our ability to manage finite resources and get those resources to where there are human needs."

INTRODUCTION

From the water we drink to the way we travel to work or school, infrastructure touches every aspect of human life. It has the power to shape the natural environment—for good or for ill. As the world's population expands, urbanisation accelerates and emerging middle classes in developing countries demand more services, the need for infrastructure is rising rapidly. Meanwhile, increasingly severe weather events and rising sea levels pose direct threats to infrastructure assets and the critical services these provide, with lack of precise knowledge about future climate change making long-term planning increasingly difficult.

So how can we address these challenges? Many argue that the answer lies in new approaches to sustainable infrastructure development. The New Climate Economy's Sustainable Infrastructure Imperative sees investing in sustainable infrastructure as "key to tackling the three central challenges facing the global community: reigniting growth, delivering on the Sustainable Development Goals, and reducing climate risk in line with the Paris Agreement."[3]

Indeed, the Paris Agreement, the 2030 Agenda for Sustainable Development—which supports the Sustainable Developments Goals (SDGs) developed by UN member states—the New Urban Agenda and the Sendai Framework for Disaster Risk Reduction all require investments that deliver climate-resilient infrastructure that supports sustainable development.

Among the SDGs, SDG 9 explicitly refers to building resilient infrastructure. However, all the goals are underpinned by infrastructure development. "Infrastructure is really at the centre of the delivery of the SDGs," says Virginie Marchal, senior policy analyst in the OECD's Environment Directorate. She cites inequality as a key example. "How can you make sure that by building the right type of infrastructure you not only have a positive impact on the environment and meet climate goals but you also contribute to reducing inequality within societies?"

Achieving SDG 10—reduced inequalities—means meeting a number of the other SDGs. For example, SDG 6—availability and sustainable management of water and sanitation for all—demands investments in infrastructure of at least US$114bn a year, according to the World Bank.[4] When it comes to meeting SDG 7—access to affordable, reliable, sustainable and modern energy for all—investments needed include US$52bn per year to achieve universal electrification by 2030, only half of which is covered by planned investments.[5] And by helping empower women and girls, infrastructure contributes to meeting the objectives of SDG 5.

But what do we mean by "sustainable infrastructure"? First, while they offer solutions to sustainable development, infrastructure assets can have negative impacts. For example, infrastructure is responsible for more than 60% of global greenhouse gas (GHG) emissions.[6] The construction of large infrastructure assets, such as dams and railways, can disrupt and displace communities.

[3] The New Climate Economy, *The Sustainable Infrastructure Imperative*, 2016, https://newclimateeconomy.report/2016/.

[4] World Bank, *The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation, and Hygiene:* Summary Report, January 2016, https://openknowledge.worldbank.org/bitstream/handle/10986/23681/K8632.pdf?sequence=4

[5] UNDP, Financing Solutions for Sustainable Development, Goal 7: Affordable and clean energy, http://www.undp.org/content/sdfinance/en/home/sdg/goal-7--affordable-and-clean-energy.html

[6] World Economic Forum, *Could infrastructure investment help tackle climate change?*, February 2016, https://www.weforum.org/agenda/2016/02/could-infrastructure-investment-help-tackle-climate-change/

Sustainable infrastructure therefore needs to be planned, designed, delivered, managed and decommissioned to minimise its negative impacts and maximise its positive impacts. Meanwhile, infrastructure assets—throughout their entire lifecycle—should have positive impacts on the economy, society and the environment.

In this essay, Chapter 1 discusses the benefits of infrastructure, Chapter 2 examines the barriers to delivering sustainable infrastructure, and Chapter 3 highlights solutions and best practices.

CHAPTER 1: THE DIVIDENDS

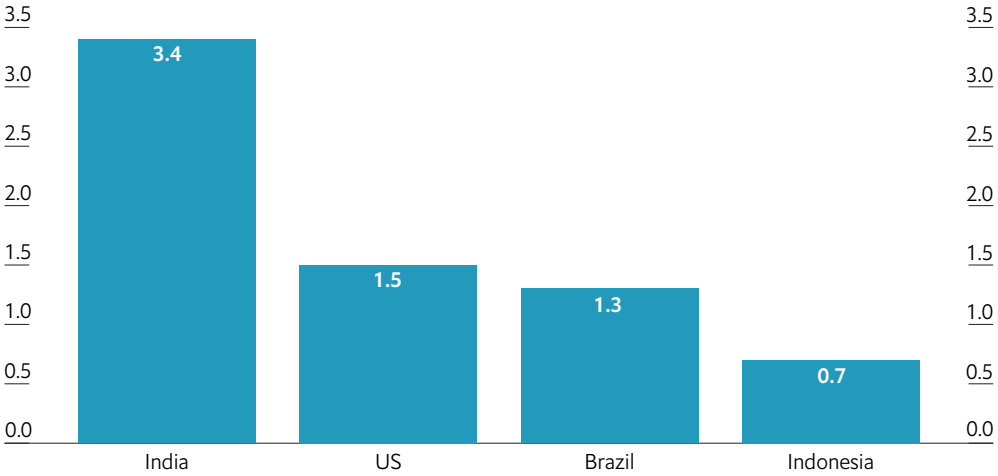
Delivering economic gains

Investments in infrastructure will be instrumental in meeting the SDGs. By creating jobs and economic activity, infrastructure enables development. It also provides the services that underpin the ability of people to be economically productive, for example via transport. "The transport sector has a huge role in connecting populations to where the work is," says Ms Marchal.

Infrastructure investments help stem economic losses arising from problems such as power outages or traffic congestion. The World Bank estimates that in Sub-Saharan Africa closing the infrastructure quantity and quality gap relative to the world's best performers could raise GDP growth per head by 2.6% per year.[7]

In the US, it is estimated that about 63m full-time jobs in industries such as tourism, retail, agriculture and manufacturing depend on the quality, safety and reliability of transport infrastructure.[8] And McKinsey Global Institute analysis suggests that increasing infrastructure investment by 1% of GDP could create major new job opportunities across the world (see chart 1).[9]

Chart 1
Additional direct and indirect jobs created if infrastructure investment was increased by 1% of GDP



Source: McKinsey Global Institute.

The failure of infrastructure is also a useful indicator of its economic value. For example, in 2013, when the Dawlish sea wall in south-west England was destroyed during storms, the repairs to the wall itself cost £35m, but the loss of a critical transport connection to the south west of England was estimated to cost the UK economy £1.2bn.[10]

[7] World Bank, *Why We Need to Close the Infrastructure Gap in Sub-Saharan Africa*, April 2017, http://www.worldbank.org/en/region/afr/publication/why-we-need-to-close-the-infrastructure-gap-in-sub-saharan-africa

[8] TRIP, *Bumpy Roads Ahead: America's Roughest Rides and Strategies to Make Our Roads Smoother*, 2016, http://www.tripnet.org/docs/Urban_Roads_TRIP_Report_October_2018.pdf

[9] McKinsey Global Institute, *Infrastructure productivity: How to save $1 trillion a year*, January 2013, https://www.mckinsey.com/~/media/mckinsey/industries/capital%20projects%20and%20infrastructure/our%20insights/infrastructure%20productivity/mgi%20infrastructure_executive%20summary_jan%202013.ashx

[10] The Resilience Shift, *Critical Infrastructure Resilience Understanding the landscape*, July 2018, https://www.resilienceshift.org/wp-content/uploads/2018/10/Critical-infrastructure-resilience_RevA_Final_011018.pdf

Infrastructure itself can also become more economically productive. The McKinsey Global Institute estimates that increasing the productivity of infrastructure can cut spending needs by 40%. Steps it recommends include optimising portfolios to avoid investing in projects that fail to meet needs or deliver sufficient benefits, streamlining processes, and implementing measures that increase the performance of existing assets.[11]

Protecting the natural environment

From renewable energy to transport systems, the environmental benefits of infrastructure are manifold. For example, in the US, estimates are that if someone commuting 20 miles a day switches from driving to public transportation, it would lower their carbon footprint by 4,800 pounds annually.[12] Sustainable infrastructure assets can help to address climate and natural disasters, reduce greenhouse gas emissions and contamination, manage natural capital, and enhance resource efficiency. "The infrastructure built in the next five years will determine how we meet the Paris climate goals," says Ms Marchal. "It's a threat but also a huge opportunity for countries to leapfrog to infrastructure that is fit for climate."

Professor Hall cites transportation as a tool in fossil-fuel reduction. "The transport sector needs to be largely electrified," he says. "Whether you bank on electric vehicles or invest in mass transport in urban areas, it's fundamental."

Technology will facilitate significant environmental gains. In power infrastructure, for example, smart meters allow energy utilities to manage consumption patterns, creating price incentives to use electricity outside peak times, enabling them to reduce reliance on the more polluting "peaker plants" that supplement supply at peak demand times and that usually generate power using fossil fuels.[13]

Integrating green infrastructure such as trees, plantings and forests into the portfolio of assets can improve air quality and contribute to removing carbon dioxide from the atmosphere or, in the case of mangroves, increasing flood protection and preventing soil erosion. Green roofs act as giant sponges, soaking up stormwater before it pollutes rivers and lakes, assist with flood control and, collectively, can reduce temperatures in cities during the summer. For example, one simulation study found that covering half of the available surfaces in downtown Toronto with green roofs would cool the city by up to 2˚C in some areas.[14]

However, Professor Hall argues that efforts to increase investments in green infrastructure should not eclipse work to ensure that traditional infrastructure is sustainable. This includes addressing the emissions created by constructing and operating infrastructure. Erecting and running buildings, for example, consumes 36% of the world's energy and produces some 40% of energy-related carbon emissions, according to estimates by the International Energy Agency, a research group. Meanwhile, while regulations are being introduced in many countries to reduce the environmental impact of construction, emissions generated by existing infrastructure must also be managed. In the developed world, for example, only about one in 100 buildings is replaced by a new one every year.[15]

[11] McKinsey Global Institute, *Infrastructure productivity: How to save $1 trillion a year*, January 2013, http://www.mckinsey.com/insights/engineering_construction/infrastructure_productivity

[12] Center for Climate and Energy Solutions, Reducing Your Transportation Footprint, https://www.c2es.org/content/reducing-your-transportation-footprint/

[13] Longe O M et al, "Time programmable smart devices for peak demand reduction of smart homes in a microgrid", conference paper, March 2015, https://www.researchgate.net/publication/283101576_Time_programmable_smart_devices_for_peak_demand_reduction_of_smart_homes_in_a_microgrid

[14] Pompeii II, W C, Assessing urban heat island mitigation using green roofs: A hardware scale modeling approach, Shippensburg University thesis, May 2010, https://www.ship.edu/globalassets/geo-ess/pompeii_thesis_100419.pdf

[15] "Home truths about climate change", Economist, January 3rd 2019

"If we focus only on green infrastructure, we lose sight of the amount that's being spent on grey infrastructure and the potential for locking in patterns of development that may or may not be sustainable," Professor Hall says.

Underpinning social progress

From schools, hospitals and roads to power and water networks, sustainable infrastructure enables governments and the private sector to provide services that contribute to sustainable individual livelihoods, as well as broader economic growth, while improving quality of life and enhancing human dignity. As part of this, ensuring equitable access to these services is critical, an aspiration enshrined in many of the SDGs, which call for basic services such as health, education, shelter, water and sanitation to be available to all.

When it comes to gender equality, infrastructure plays an important role, both protecting women and accelerating their advancement. For example, public transport systems both enable women to enter the workforce but also, when well designed, provides them with safety and security and ensures that they have equal access to opportunities and services.

Sanitation infrastructure is also crucial in ensuring equal participation in economic and education opportunities. If safe toilets or private hygiene facilities in schools or workplaces are unavailable, during menstruation women and girls are often forced to stay at home or leave school or their jobs altogether. The World Bank estimates that at least 500m women and girls globally lack adequate facilities for menstrual hygiene management.[16]

This can also be harmful to women and girls. "Maternal mortality rates are affected by the quality of water and hygiene. And it tends to be the girls who don't go to school because they have to go and fetch water," says Ms Fay. "Services do have these differential impacts on gender."

Infrastructure is a tool in increasing social mobility. For example, introducing solar power to Sudan and Tanzania in schools enabled an increase in completion rates at primary and secondary schools from less than 50% to almost 100%.[17]

Morgan Landy, senior director of global infrastructure and natural resources at the International Finance Corporation (IFC), argues that infrastructure's social impact is rising up the agenda. "If you are going to have a wind power project you need to bring a community lens to that to make sure the benefits are shared," he says. "That's the future. The environmental side will always be strong, but the next frontier will be social impact."

The role of resilience

Infrastructure that can withstand the shocks and stresses experienced over its lifetime provides resilience and protects development by having a positive impact across all three pillars of sustainability.

[16] "Menstrual Hygiene Management Enables Women and Girls to Reach Their Full Potential", World Bank, May 25th 2018, https://www.worldbank.org/en/news/feature/2018/05/25/menstrual-hygiene-management

[17] UNDESA, *Electricity and education: The benefits, barriers, and recommendations for achieving the electrification of primary and secondary schools*, December 2014, https://sustainabledevelopment.un.org/content/documents/1608Electricity%20and%20Education.pdf

Resilient infrastructure protects the economy by reducing disruptions to industry from shocks, such as severe storms. Similarly, when resilient infrastructure ensures the continuity of critical services such as power and water during a crisis, it offers greater stability to communities and reduced disruption to their livelihoods. "During hurricanes in the Caribbean, you lose particular bridges," says Graham Watkins, principal environmental specialist in the climate change division of the Inter-America Development Bank (IDB). "So if you strengthen those bridges that are critical, you can maintain conduits and people suffer less."

If infrastructure has to be less frequently rebuilt or repaired, governments not only save money—they also need to use fewer natural resources. Moreover, using green infrastructure to protect against climate-related floods and intense storms helps communities adapt to the effects of climate change. Examples range from street plantings, parks and green roofs in cities to wetlands and mangrove forests, which protect coastal communities from storm surge and sea-level rise.

Japan is well recognised for its ability to build highly resilient infrastructure that can withstand frequent or severe earthquakes. This includes the construction by many towns and cities of new energy infrastructure based on micro-grids—groups of interconnected and distributed energy resources that act as single, controllable entities—and decentralised power sources. Supporting such developments is the country's National Resilience Programme, established in the wake of the 2011 earthquake and tsunami.[18]

However, Ms da Silva stresses that resilient infrastructure goes beyond the assets explicitly designed for the protection and mitigation of disasters to all systems that support society—such as energy, transport and water—and how they connect with each other.

"When you look at the definition of critical infrastructure, it is critical if, when it fails, it has a severe detrimental effect on human wellbeing and economic development," says Ms da Silva, who leads the Resilience Shift, an initiative supported by the Lloyds Register Foundation to raise awareness of the need for infrastructure to be resilient and develop new approaches that will drive changes to current practice.

"Given the complexity of modern infrastructure and the pressures on infrastructure systems due to increasing demand, ageing and/or climate change, failure is a possibility," she says. "So infrastructure has to be resilient or it's going to have a severe effect on society."

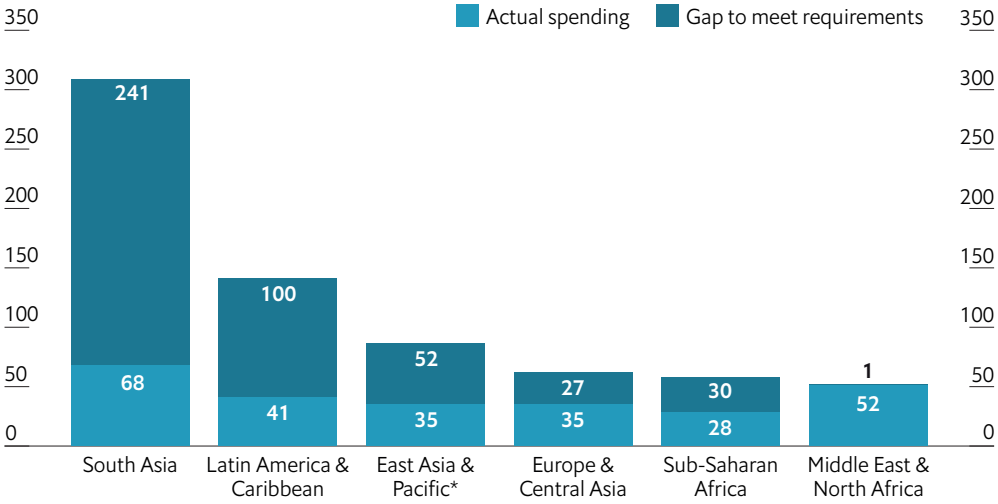
[18] "The Resilience Programme: Changing Japan's grid", *Power Technology*, February 19th 2018, https://www.power-technology.com/features/resilience-programme-changing-japans-grid/

CHAPTER 2: THE CHALLENGES

Growing demand

As the world's population expands, delivering basic services will become increasingly challenging. And as more and more people live in cities, pressures on urban infrastructure are becoming intense. By one estimate, infrastructure investment of up to US$3.2trn-US$3.7trn per year is needed between now and 2030.[19] Infrastructure investment gaps are already an issue in many emerging and developing markets, totalling US$452bn over 2014-20, with actual spending of an estimated US$259bn dwarfed by requirements of US$711bn (see chart 2).

Chart 2
Infrastructure investment requirements, actual spending and investment gap in emerging markets and developing economies, annual US$ bn over 2014-20
(US$ bn)



Source: World Bank.

Note: Excludes China, which is overinvesting in infrastructure.

The G20-backed Global Infrastructure (GI) Hub estimates that investments of US$94trn in infrastructure will be needed by 2040. More than half of these investment needs are in Asia, according to GI Hub. At US$28trn, representing 30% of global infrastructure investment needs, China will have the greatest demand over this period.

Some of the gaps look daunting. Take water and sanitation infrastructure. In 2015 some 844m people lacked even a basic drinking-water service, according to the World Health Organisation, and at least 2bn people were using drinking water sources contaminated with faeces.[20]

Meanwhile, if current spending trends continue, the US—where an estimated US$3.8trn needs to be invested in infrastructure[21]—is forecast to have the world's biggest spending gap to 2040, according

[19] World Bank, "Infrastructure Investment Demands in Emerging Markets and Developing Economies", September 2015, http://documents.worldbank.org/curated/en/141021468190774181/pdf/WPS7414.pdf

[20] WHO, Drinking-water, fact sheet, February 2018, https://www.who.int/en/news-room/fact-sheets/detail/drinking-water

[21] The United States, GI Hub: https://outlook.gihub.org/countries/United%20States

to the GI Hub.[22] This imposes a high price on Americans, with one estimate that the cost to the average motorist of poor road infrastructure is US$599 annually, or US$130bn nationally in repair costs, accelerated vehicle deterioration and depreciation, increased maintenance, and additional fuel consumption.[23]

The increasing risks and vulnerabilities brought about by climate change will also increase pressure to upgrade infrastructure and repair or replace assets damaged during extreme weather. For example, tens of billions of dollars of damage to infrastructure in New York and New Jersey was caused by Hurricane Sandy in 2012, prompting the creation of the Hurricane Sandy Rebuilding Task Force.[24]

Funding and resource gaps

Given the rate at which governments need to build infrastructure, many will struggle to secure the financing to meet demand. Tight public-sector budgets, particularly in developing countries, mean governments will need to tap into some of the trillions of dollars in global capital markets.

Yet the many risks to infrastructure investments, from complex permitting and potential construction delays to the large amount of time before assets generate cash flow and produce a return on investment, deter private investors. Of the more than US$120trn in assets under management by banks and institutional investors globally, infrastructure makes up only about 5%.[25]

Moreover, for assets that deliver public good, it is often hard to find a business model that would generate the kinds of financial returns private investors seek. "In some cases, it's easy to leverage private-sector funding," says Ms Marchal. "With power plants, you have the regular flow that makes it financially sustainable, but water is much more difficult to monetise."

Meanwhile, countries often lack human resources with the required skills to plan, deliver and manage sustainable, resilient infrastructure at the scale required to meet demand, particularly in developing countries, where the lion's share of the world's infrastructure gaps exist.

"There just aren't enough engineers, town planners and technical specialists in many of the countries that are aiming to fill their infrastructure gaps," says Mark Harvey, head of profession (infrastructure) at the UK's Department for International Development (DFID). "So capacity is money but it also means having technical expertise and staff to manage projects, finance and procurement."

He argues that much of the skills development needs to take place in government. "We still have around 85% of infrastructure globally funded through public resources and there's not as much attention paid to building that capacity as there should be," he says.[26]

In many cases it is weak governance that exacerbates the shortage of skills, with the codes and regulations that are needed to shape hiring and training decisions lacking.

[22] "Infrastructure demand: A major global challenge", GI Hub blog, https://www.gihub.org/blog/global-infrastructure-demands/

[23] TRIP, *Bumpy Roads Ahead: America's Roughest Rides and Strategies to Make Our Roads Smoother*, October 2018, http://www.tripnet.org/docs/Urban_Roads_TRIP_Report_October_2018.pdf

[24] Hurricane Sandy Rebuilding Task Force, *Hurricane Sandy Rebuilding Strategy*, August 2013, https://www.hud.gov/sites/documents/HSREBUILDINGSTRATEGY.PDF

[25] "Could infrastructure investment help tackle climate change?" World Economic Forum, February 2016, https://www.weforum.org/agenda/2016/02/could-infrastructure-investment-help-tackle-climate-change/

[26] In developing countries the figure is 80-85%. See G20, "The G20 agenda on infrastructure financing—key concerns and actionable recommendations", July 11th 2018, https://civil-20.org/c20/wp-content/uploads/2018/07/C20-policy-paper_infrastructure-financing_.pdf.

Questions of governance

A number of governance hurdles exist to the development of sustainable infrastructure, including the short-termism in policy development created by election cycles, lack of appropriate legislation, codes and standards, and lack of capacity.

Given the sums of money involved, lack of transparency and corruption often accompany the development of infrastructure assets. And even if outright graft is not involved, infrastructure can be shaped by the motives of those developing it. "Politicians are fond of vanity projects," says Professor Hall. "Infrastructure provides big opportunities for rent-seeking, and the number of white elephants and grossly over-budget or underperforming infrastructure projects around the world is disturbing."

For governments, there can also be competing priorities. Developing countries may put rapid economic growth ahead of environmental and social protection. Linking the different elements of sustainable development is harder because of the silos that exist within government and between those executing different stages of infrastructure, from planning and delivery to operation and maintenance. "Institutions are set up with their own vertical silos, and crossing those is not so easy," says Mr Landy.

Even within infrastructure sectors, silos exist. "Within the water sector, for instance, you have a whole raft of different people and institutions, some private some public, responsible for different aspects of water," says Ms da Silva. "You'll have an environmental agency worrying about flood risk and a water company worrying about potable water."

Often infrastructure investments meet single goals, rather than taking into account all stakeholders in society and the environment. For example, infrastructure focused on mitigating climate change, such as large hydro power plants or wind turbines, may meet resistance from indigenous groups or other local communities fearing disruption or loss of their land. "Even if you have some aspects of sustainability, you're tripping over other ones," says the IDB's Mr Watkins. "Unless you take the whole integrated package, it's going to slow your delivery."

CHAPTER 3:
THE WAY FORWARD

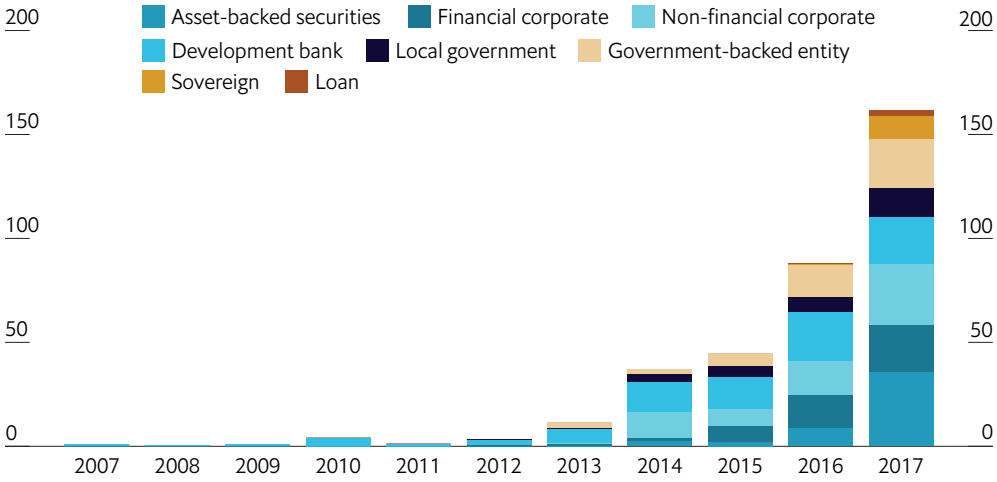
From new forms of finance to the use of digital technologies, new approaches to sustainable infrastructure are emerging. Equally important are efforts to move away from treating infrastructure projects as individual investments and to view them as part of a system that comprises a portfolio of interlinked assets that provide essential services for society. "We talk about bridges and roads when we should be talking about mobility, connectivity and ensuring the flow of goods, services and people," says Ms da Silva.

Harnessing innovative finance

While public-sector budgets may be insufficient to finance the infrastructure governments need to build, some are finding new ways to tap into the global capital markets and encourage more private-sector investment in the sector. For example, using concessional climate finance from sources such as the Green Climate Fund and the Climate Investment Funds, it is possible for governments to assume a first loss position, reducing risk for private investors.[27]

The growing interest in impact investing (investments that generate both financial and social and environmental returns) and use of ESG (environmental, social and governance) considerations to prioritise investments could also unleash new streams of funding for infrastructure. This growing enthusiasm is reflected in the gradual rise of the green bond market in recent years (see chart 3).

Chart 3
Green bonds by issuer type
(US$ bn)



Source: Climate Bonds Initiative.

Because impact investors—from individuals to institutions—are often prepared to invest with longer time horizons or accept lower than market-rate returns for increased impact, they could play a particularly important part in financing sustainable infrastructure.

[27] Meltzer, J, *Blending climate funds to finance low-carbon, climate-resilient infrastructure*, Brookings, June 2018, https://www.brookings.edu/research/blending-climate-funds-to-finance-low-carbon-climate-resilient-infrastructure/

Policymakers can pave the way for these kinds of investments. For example, in the US the NY Green Bank was set up in 2014 by the State of New York to increase capital flows into the clean energy market. The bank has developed the expertise to identify clean energy projects and, since many involve untested business models or emerging technologies, to assess their risk, making it easier to attract investors to these projects.

However, some argue that accessing more capital is not the only answer to sustainable infrastructure, particularly in developing countries. "We tend to focus on finding more financing to be able to spend more as opposed to being able to spend better," says the World Bank's Ms Fay. She argues that it is more cost-effective to improve planning and procurement. "In many cases, countries could get more out of the financing they do have," she says.

Countries can also tap into existing legislation to increase private-sector investment in sustainable infrastructure. Washington, DC, for example, has regulations that require developers in certain districts to incorporate into their developments green infrastructure (such as parks, grass roofs and plantings), which soaks up untreated stormwater, preventing it from polluting rivers and other waterways.[28]

If installing green infrastructure is not feasible, developers can purchase stormwater retention credits from those that have invested in green infrastructure in areas not covered by the regulations.[29] The project not only demonstrates the effectiveness of green infrastructure in reducing the harmful effects of severe storms. It also offers an innovative financing mechanism to accelerate the investment into these green systems.

CASE STUDY: TROPICAL LANDSCAPES FINANCE FACILITY, INDONESIA

Financing sustainable infrastructure often requires cross-sector collaboration. This is the case in Indonesia, where a financing facility is bringing together a number of global public- and private-sector stakeholders to foster investments in renewable energy and improved management of forests, biodiversity and ecosystem restoration services throughout the country.

The Tropical Landscapes Finance Facility (TLFF) was launched in October 2016 by the Indonesian government and is a partnership between UN Environment, the World Agroforestry Centre, ADM Capital and BNP Paribas.

With two sources of capital—a lending platform run by ADM Capital and BNP Paribas and a grant fund run by UN Environment and the World Agroforestry Centre—the TLFF provides technical assistance and co-funds early stage development costs enabling donors and foundations to harness private-sector funding.[30]

[28] CD Department of Energy & Environment, Stormwater Retention Credit Trading Program, https://doee.dc.gov/src

[29] Ibid.

[30] TLFF, http://tlffindonesia.org/about-us/

Filling the project pipeline

In many countries, the biggest challenge to infrastructure development is in the pipeline of viable projects. "One of the problems with sustainable infrastructure is that there are just not enough bankable projects in the market, especially in the poorest countries," says Mr Landy.

The problem is felt in different ways. First, the ability to develop a pipeline of viable projects—a strategic set of projects that governments plan, prioritise and implement—is often lacking. Countries need to build "upstream planning", which enables them to identify the projects that will most help them to meet their development targets. And inability to do this makes it hard to create a pipeline of projects and encourage private-sector investors to participate.

To address the pipeline problem, the UK Infrastructure Transitions Research Consortium (ITRC), a consortium of seven leading UK universities, led from the University of Oxford, is working to support infrastructure planning in the US, Australia and the Netherlands. The ITRC has created a process for developing long-term strategies for national infrastructure that includes a modelling platform and database called NISMOD (the National Infrastructure Systems Model) that will enable academia, industry and policymakers to access infrastructure datasets, simulation and modelling results.[31] A similar tool, NISMOD-Int, will be applicable in developing countries.[32]

Second, the project lifecycle—from feasibility studies to design, delivery and operation—is hampered by lack of capacity. As part of World Bank Group's efforts to address this gap, it has established a US$150m global infrastructure project development fund called InfraVentures, designed to ensure more projects become a reality.

CASE STUDY: GLOBAL INFRASTRUCTURE PROJECT PIPELINE

To help governments attract private-sector funding for their infrastructure projects, the G20's Global Infrastructure (GI) Hub has created a free digital platform providing details of government infrastructure projects across the world.

Launched in 2016, the Global Infrastructure Project Pipeline platform allows potential investors to search for projects at different stages, from the initial government announcement and feasibility studies to projects that are in the final stages of construction or already in operation.

The idea behind the platform is to give private-sector investors detailed information on potential projects and enable them to track the projects as they move from design to operation. By providing free access to this information, the GI Hub aims to make it easier for investors to evaluate investment opportunities in public infrastructure across a wide range of jurisdictions and markets.[33]

[31] ITRC, NISMOD, https://www.itrc.org.uk/nismod/

[32] ITRC, NISMOD-International, https://www.itrc.org.uk/nismod/nismod-international/

[33] GI Hub News, December 6th 2016, https://www.gihub.org/news/gi-hub-launches-project-pipeline/

However, filling the project pipeline usually requires more than funding. This is something InfraVentures takes into account, explains Mr Landy. He cites its work as a co-developer of the Nachtigal Hydropower project in Cameroon, supporting the country's goal to extend access to electricity to 88% of the population by 2022.[34] "We put on a venture capital hat," he says. "We also spent 2,000 hours of IFC environmental specialist time looking at the project to make sure it was being designed to meet our standards, and that we were baking into the design things we want to see as an investor."

Blending green and grey

Great potential is seen in green infrastructure, which can both mitigate the effects of climate change and help society to adapt to climate change through the restoration of wetlands and floodplains or the installation of grass roofs, rain gardens, parks and street plantings in cities.

Green infrastructure can often lower the cost of infrastructure development compared with traditional grey infrastructure. For example, research conducted on the cost-savings associated with the green infrastructure investments of Lancaster, a city in south central Pennsylvania in the US, found that the green infrastructure plan would deliver an estimated US$120m in savings over 25 years compared with grey infrastructure.[35]

Natural infrastructure can also be combined with traditional grey infrastructure. For example, in south-western Pennsylvania, frequent rainfall and ageing sewer infrastructure are degrading waterways and posing threats to human health. Rather than expensive expansion of the underground pipes and tanks that convey wastewater to sewage treatment facilities, it is deploying green infrastructure approaches—from permeable paving to bioswales (vegetation and layers of gravel and soil that slow stormwater movement and filter pollutants) to manage stormwater where it falls.[36]

In New York, a plan called BIG U developed by the Bjarke Ingels Group in the wake of Hurricane Sandy is designed to protect the city from flooding by creating a series of levees, a floodwall and a park that would not only help protect the island from inundation but would also provide a new green space for residents.[37]

And in San Francisco, as the Public Utilities Commission upgrades its sewer system over the next 20 years, it will use infrastructure that is both green (natural management tools that reduce stormwater impacts and beautify neighbourhoods) and grey (upgrades to pipes and treatment plants for reliability, resiliency and regulatory compliance).

Making infrastructure smart

In the move to create sustainable infrastructure, building information modelling (BIM), sensors, big data and machine learning will be increasingly important tools, improving the planning of new assets and the retrofitting of existing ones, increasing infrastructure's operational efficiency and reducing its

[34] "Cameroon: World Bank Group Helps Boost Hydropower Capacity", World Bank, July 19th 2018, https://www.worldbank.org/en/news/press-release/2018/07/19/cameroon-world-bank-group-helps-boost-hydropower-capacity

[35] Environmental Defense Fund. *Unlocking Private Capital to Finance Sustainable Infrastructure*, 2017, http://business.edf.org/files/2017/09/EDF_Unlocking-Private-Capital-to-Finance-Sustainable-Infrastructure_FINAL.pdf

[36] Washburn, M, *Green infrastructure report status*, University of Pittsburgh, March 2015, https://www.iop.pitt.edu/sites/default/files/Reports/Status_Reports/Status%20Report%20-%20Green%20Infrastructure%20-%20March%202015.pdf

[37] Rebuild By Design, The BIG U, http://www.rebuildbydesign.org/our-work/all-proposals/winning-projects/big-u

environmental impact. Smart infrastructure—which combines physical with digital infrastructure—improves the quality, speed and accuracy of decision-making while generating cost savings.

For example, 3D visualisation and BIM software enable planners to consider different design alternatives and take into account the impact of conditions, such as local climate, before starting construction. Meanwhile, advances in virtual and augmented reality as well as computer simulations and BIM are enabling engineers and architects to visualise designs at an early stage to model their resilience to climate shocks and measure their impact on the environment.[38]

"Systems of digital modelling enable you to plan and design infrastructure assets before they get built, and you can then monitor how that infrastructure performs and behaves when it is used," says DFID's Mr Harvey. "Big data can tell us how people are behaving in relation to that infrastructure. And when you put these together, that's powerful for improving performance, value for money and sustainability."

Technology can also increase the environmental sustainability of existing assets while cutting costs associated with maintenance. This is the aim of Singapore's WaterWiSe system. Using a combination of hardware and software, the system monitors in real time the city's water distribution network. Sensors track indicators, such as pressure, flow rate, pH levels, turbidity and dissolved organic matter. The system enables quicker detection of leaks or burst pipes and facilitates long-term planning for maintenance and system expansion.[39]

Smart technologies not only get more out of key assets—they make infrastructure a more appealing investment opportunity. According to the University of Cambridge's Centre for Smart Infrastructure & Construction, smart infrastructure is worth up to £4.8trn globally.[40]

Smart sustainable infrastructure does not necessarily require sophisticated technologies, but can also be the result of smart planning. In some cases, creative thinking can avoid substantial costs. For example, to cope with rapid growth of the Brazilian city of Curitiba, planners had originally called for the construction of a subway system. Instead, the city pioneered the development of bus rapid transit (BRT) systems, where buses run along dedicated routes not used by other vehicles, avoiding the high cost of building a subway network.[41]

Improving transparency

Given the traditionally poor transparency in the infrastructure sector and the opportunities it offers for corrupt practices, international attention has focused on increasing visibility into how funds spent on infrastructure are distributed. "Corruption is the biggest obstacle to sustainable development," Neill Stansbury, director of the Global Infrastructure Anti-Corruption Centre, told delegates at the recent Global Engineering Congress in London. "The infrastructure sector and engineering are probably one of the biggest areas where corruption takes place internationally because of the amount of money which is spent on it."[42]

[38] Arup, Virtual and Augmented Reality changing the way we design and build infrastructure, https://www.arup.com/perspectives/virtual-and-augmented-reality-changing-the-way-we-design-and-build-infrastructure; "From algorithms to virtual reality, innovations help reduce disaster risks and climate impacts", World Bank blog, August 5th 2017, http://blogs.worldbank.org/sustainablecities/algorithms-virtual-reality-innovations-help-reduce-disaster-risks-and-climate-impacts; "How Are Buildings and Infrastructure Changing in Response to Climate Change?", engineering.com, July 26th 2018, https://www.engineering.com/BIM/ArticleID/17327/How-Are-Buildings-and-Infrastructure-Changing-in-Response-to-Climate-Change.aspx

[39] National Research Foundation, WaterWiSe, https://www.nrf.gov.sg/innovation-enterprise/innovative-projects/urban-solutions-and-sustainability/waterwise-water-monitoring-system

[40] Bowers, K et al, *Smart Infrastructure: Getting more from strategic assets, Centre for Smart Infrastructure & Construction*, https://www-smartinfrastructure.eng.cam.ac.uk/files/the-smart-infrastructure-paper

[41] "How Curitiba's BRT stations sparked a transport revolution – a history of cities in 50 buildings, day 43", The Guardian, May 26th 2015: https://www.theguardian.com/cities/2015/may/26/curitiba-brazil-brt-transport-revolution-history-cities-50-buildings

[42] Institution of Civil Engineers, GEC 2018: Closing Plenary session, Day One, October 22nd 2018, https://www.ice.org.uk/knowledge-and-resources/global-engineering-congress-2018/gec-2018-closing-plenary-session-monday

A number of initiatives are emerging to tackle the problem. For example, in 2012 CoST—the Infrastructure Transparency Initiative, also known as the Construction Sector Transparency—was launched with the support of the World Bank to encourage the disclosure, validation and interpretation of data from infrastructure projects. Working with governments, industry and civil society, CoST promotes reforms that can reduce mismanagement, inefficiency and corruption in building projects.[43]

"Transparency and open procurement [are] critical if governments are to persuade the private sector to invest in infrastructure," says the OECD's Ms Marchal. "You need to provide ongoing monitoring and reviewing of the efficiency of public-private partnerships in the process and to implement safeguards to avoid corruption."

Professor Hall points to Nigeria as an example of good practice. "The Infrastructure Concession Regulatory Commission has made all the contracts for public-private partnership concessions publicly available," he says. "That serves the purpose of transparency, but it also helps competition because concessionaires are aware of the prices that their successful competitors are bidding."

In some cases, capacity-building initiatives can also increase transparency. For example, the Africa Infrastructure Development Association (AfIDA)—part of the Africa Finance Corporation (a development finance institution)—was set up to foster increased project development activities in Africa. The AfIDA does this is by creating standardised project development template documents, fostering knowledge-sharing between members, and setting ethical and professional standards—measures that also serve to increase transparency.[44]

Similarly, the International Infrastructure Support System, an online tool developed by the Sustainable Infrastructure Foundation and the Asian Development Bank gives countries templates on which to prepare projects, and enables project teams to work together online—but it also has features that enable the sharing of information with investors and the public.[45]

Managing infrastructure

Increased climate uncertainties, growing demand and tightening finances all demand a more flexible, adaptive approach to infrastructure development than has been seen in the past. "People are increasingly focusing on how different kinds of infrastructure interrelate to create systems of infrastructure," says Mr Landy.

He sees much of the progress on this front taking place in cities. "Thoughtful mayors are working across those boundaries and pushing their systems to connect the dots," he highlights.

A systems approach also means looking at infrastructure from more than one angle. For example, with their extremely high temperatures, cement plants can be used as incinerators if municipalities locate waste-management facilities near them. Fibre optic cables can be run along rail lines. Lampposts equipped with sensors and motion detectors can monitor and manage traffic and pollution and save energy by illuminating only when a vehicle or pedestrian approaches.

[43] ICoST, Our story, http://infrastructuretransparency.org/about-us/our-story/

[44] AfIDA, https://www.afida-africa.org/about.php

[45] World Bank, The International Infrastructure Support System—A Project Preparation, Collaboration and Information Sharing Tool, https://olc.worldbank.org/content/international-infrastructure-support-system-%E2%80%93-project-preparation-collaboration-and

This systems approach demands strong institutions, the breaking down of silos need and the de-linking of planning from political cycles. Part of this means putting in place long-term strategies, such as the Investing in Canada infrastructure plan, the objectives of which are to create long-term economic growth, to support a low-carbon, green economy and to build inclusive communities.[46]

Others have established dedicated infrastructure departments designed to work across political cycles. In Australia, the latest incarnation of such a dedicated department is called Department of Infrastructure, Regional Development and Cities (founded in 2017). And in 2015, the UK launched an independent National Infrastructure Commission (see case study).[47] "If we could begin to replicate that sort of thinking in some of the countries where we work, that would be no bad thing," says DFID's Mr Harvey.

"Infrastructure involves resource allocation and decisions about building things in people's backyards, so you can't depoliticise it," argues Professor Hall. "But these are more technocratic bodies that also have a mandate to look for the long term and to bridge different political administrations so you don't get the stop-start of projects whenever there's a change of government."

Establishing an integrated cross-sector planning process and a long-term national plan has another advantage: increasing market confidence, making it easier to attract private-sector financing and supporting the creation of a project pipeline of viable and bankable projects.

Future-proofing infrastructure

Recognising the importance of infrastructure and adopting a systems approach is what will underpin the resilience not only of infrastructure itself but also of society and the planet. "One side of the sustainable development agenda is linked to one planet-living and finite resources," says Ms da Silva. "The other side is about resilience. But over the past decade, we've become more aware of how complex and interconnected the world is, how much uncertainty is out there, whether it's climate change or economic downturns like 2018, and how we're all interconnected. We cannot predict the future, but the ability for critical infrastructure to continue to function and provide essential services for society whatever happens is what matters."

First, because infrastructure assets may need to be in place for decades, it is critical to "future-proof" those assets. This can be done by anticipating changes in climate, use patterns and growth in demand over their lifecycle as well as by building in flexibility and the potential to add capacity over time.

London's Thames Estuary 2100 strategy, to manage tidal flood risk in the Thames estuary over the next 100 years is one example of infrastructure design that uses an adaptive capacity approach to not only current risks but also future climate adaptation. Milestones and reviews are scheduled at defined points, along with a plan for how to enhance capacity of not only a specific flood barrier but also of the wider system over the next century.[48]

Ms da Silva argues that this approach—looking at resilience within and between critical infrastructure

[46] Infrastructure Canada, Investing in Canada Plan, https://www.infrastructure.gc.ca/plan/about-invest-apropos-eng.html

[47] "Chancellor announces major plan to get Britain building", UK government, October 5th 2015, https://www.gov.uk/government/news/chancellor-announces-major-plan-to-get-britain-building

[48] Critical Infrastructure Resilience Understanding the landscape, The Resilience Shift, July 2018: https://www.resilienceshift.org/wp-content/uploads/2018/10/Critical-infrastructure-resilience_RevA_Final_011018.pdf

sectors—has yet to become widespread. Developing resilience, she says, means not only thinking about how to deliver services but also how to prevent collapse. "It's a mind shift and one of the fundamental shifts is to contemplate failure," she says. "Resilience engineering is about ensuring that assets can continue to function even if all sorts of things happen. It's designing for the ordinary and then thinking about the extraordinary."

CASE STUDY: THE UK'S NATIONAL INFRASTRUCTURE COMMISSION

Countries often struggle to disentangle infrastructure plans from other national and private-sector interests and implement plans beyond election cycles. Launched in 2015, the National Infrastructure Commission is designed to address such challenges. "It's still set up through political and democratic processes, but its intention is to get the politics out of long-term infrastructure investment," explains Mark Harvey, head of profession (infrastructure) at the UK's Department for International Development.

The commission provides the government with impartial expert advice on major long-term infrastructure challenges. It assesses the UK's national infrastructure assets and needs, and the technologies that may change over time. At the start of each five-year parliament, it produces a report with recommendations for infrastructure project priorities.[49]

[49] "Infrastructure at heart of Spending Review as Chancellor launches National Infrastructure Commission", HM Treasury press release, October 30th 2015, https://www.gov.uk/government/news/infrastructure-at-heart-of-spending-review-as-chancellor-launches-national-infrastructure-commission

CONCLUSION

Seen individually, sustainable infrastructure assets perform an essential role in providing people with the services they need, improving quality of life and protecting the environment. Some of this is delivered through construction of new infrastructure. However, creative ways can be found of making current systems more efficient—through smart meters, for example—without the need for disruptive and resource-intensive new construction.

Ensuring that infrastructure is sustainable also means approaching it not as a series of assets but as a system. For example, cities that are well equipped with public transport systems increase social mobility and equality, making it easier for people to go to school, work and access healthcare services. Shifting energy sources from coal-fired power generation to renewables not only cuts greenhouse gases but also reduces air pollution, improving health.

A systems approach to infrastructure can also deliver cost savings or avoid unnecessary expenditure, such as the construction of highways to borders with countries where trade agreements have yet to be secured or micro-grid solutions have yet to be developed in rural areas where people cannot afford to purchase electricity. Smart investments in public transit systems can reduce the need to build more roads, as is the case in Curitiba's BRT systems.

Treating infrastructure as an interlinked portfolio of assets also enables more to be done to build resilience into the system. For instance, this can involve combining green and grey infrastructure while creating assets, such as parks, that not only contribute to clean air and stormwater retention but also provide public amenities that improve quality of life, as is the case in Washington, DC, where the stormwater retention programme fosters the development of parks that can be used for recreation.

The need to build resilient and sustainable infrastructure is urgent. Climate change is already disrupting life on the planet, something that is unlikely to change even if the world manages to achieve its climate goals. In the face of increasing risks to communities and their environments, resilient infrastructure will play a key role in shoring up energy and water systems and ensuring that communities can survive shocks and recover from them more quickly. In doing so, infrastructure is not just a means of delivering services; it is a critical enabler and guardian of sustainable development.

The Economist INTELLIGENCE UNIT

LONDON
20 Cabot Square
London
E14 4QW
United Kingdom
Tel: (44.20) 7576 8000
Fax: (44.20) 7576 8500
Email: london@eiu.com

NEW YORK
750 Third Avenue
5th Floor
New York, NY 10017
United States
Tel: (1.212) 554 0600
Fax: (1.212) 586 1181/2
Email: americas@eiu.com

HONG KONG
1301 Cityplaza Four
12 Taikoo Wan Road
Taikoo Shing
Hong Kong
Tel: (852) 2585 3888
Fax: (852) 2802 7638
Email: asia@eiu.com

GENEVA
Rue de l'Athénée 32
1206 Geneva
Switzerland
Tel: (41) 22 566 2470
Fax: (41) 22 346 93 47
Email: geneva@eiu.com

DUBAI
Office 1301a
Aurora Tower
Dubai Media City
Dubai
Tel: (971) 4 433 4202
Fax: (971) 4 438 0224
Email: dubai@eiu.com